



**Facilitating access to specialist care for patients and  
carers living with motor neurone disease using  
telehealth**

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## Abstract

Care of patients with motor neurone disease (MND) is best provided by a specialist, multidisciplinary team but access to this care is not universal. Technology-enabled care has the potential to improve access to specialist care in MND.

A telehealth system (TiM: Telehealth in Motor neurone disease) was developed to allow patients and carers to share information about their condition using the internet with a specialist MND nurse.

An 18-month, mixed methods, randomised, controlled pilot and feasibility study was conducted and a process evaluation explored the use, feasibility, acceptability and potential impact of the TiM system. Clinical outcomes (such as quality of life) were collected and semi-structured interviews with participants and clinicians were conducted. 40 patients and 37 carers were recruited and randomised to receive usual care or usual care plus the TiM system.

Participants and clinicians felt that the TiM system was an acceptable and feasible way of improving access to specialist care and thought it could have the potential to improve their care. Formal comparisons of the two treatment groups were not aims of the trial but only modest differences were observed. The study identified further necessary improvements to the TiM, particularly focusing on the way clinicians act upon the information received and interact with patients and carers.

The trial methods appeared to be feasible. The main challenge posed by a definitive trial appeared to be how to effectively measure impacts of the TiM on participants and the clinical service.

This thesis recommends that the next step of TiM development should include further iterative improvements to TiM system in parallel with research that explores how the system would be used best in different MND services. If these evaluations also suggest the TiM system offers value, a definitive randomised controlled trial may be feasible. However, this thesis identifies better ways to further evaluate this complex intervention.

## Introduction

Specialist, multidisciplinary care for patients with motor neurone disease is associated with better outcomes but access to this care is not universal. This thesis describes the work to develop a new service that could use technology to improve access specialist multidisciplinary care for patients living with motor neurone disease and their carers.

The project's aims were:

- To develop a better understanding of the unmet needs of patients with MND and their carers and how these needs could be better met by improving healthcare services;
- To explore how technology-enabled care could facilitate better access to specialist multidisciplinary care in motor neurone disease;
- To develop a new service using technology-enabled care to facilitate better access to specialist care (the TiM system);
- To conduct a pilot and feasibility randomised controlled trial of the TiM system in patients with MND and their carers;
- To conduct a process evaluation of the TiM system exploring the acceptability and feasibility of the TiM system to patients, carers and healthcare professionals;
- To explore the wider acceptability and feasibility of technology-enabled care in motor neurone disease
- To use the findings to determine if and how the TiM system should be developed, evaluated and implemented in the National Health Service.

Chapter One describes the clinical features of motor neurone disease, the aims of multidisciplinary care and highlights the need for better access to patient-centred specialist care. Chapter Two explores the existing evidence for the use of technology-enabled care, in particular telehealth, to facilitate access to specialist care in motor neurone disease and describes some of the complexities of implementation and evaluation of these services in clinical practice.

Chapter Three describes the development of the TiM system. This is a telehealth system for patients with motor neurone disease and their carers that aimed to improve access to specialist care. Chapter Four describes the aims and methods of evaluation and the rationale for this approach. It describes a mixed-methods, pilot, randomised controlled trial which had two aims: to conduct a process evaluation to examine the feasibility, acceptability and the potential mechanisms

of impact of the TiM system on patients, carers and clinicians and to determine whether and how a larger, definitive trial would be successful in assessing the effectiveness of the TiM system.

Chapter Five, Six and Seven describe the results. Chapter Five describes and discusses the results of the process evaluation, which examined the use of the telehealth in a clinical practice. Supporting quotes from this chapter are available in Appendix A. Chapter Six describes the results of the pilot trial and explores the feasibility of a definitive randomised controlled trial. Additional results and supporting quotes are available in Appendix B. Chapter Seven describes additional work conducted to further examine the feasibility and acceptability of technology-enabled care services in motor neurone disease. Chapter Eight draws from the results of all chapters, discussing the future of the TiM and makes recommendations for future development and evaluation of the TiM system.

Volume Two of this thesis contains Appendices C to F. These include publications related to Chapter Two (Appendix C) and Chapter Seven (Appendix E). Appendix D contains documents relating to the trial methods (Chapter Four): the trial protocol, statistical analysis plan, patient information leaflet, topic guides and an example participant questionnaire. Appendix F contains a list of tables and figures and abbreviations.

# Chapter One

## Motor neurone disease

### 1.1 Introduction

Motor neurone disease is a progressive, incurable, neurodegenerative disease causing physical and psychosocial morbidity and, eventually death. Chapter One will discuss the clinical features of motor neurone disease and the impact the disease has on both patients and informal carers. It will describe the management, the role of the multidisciplinary team (MDT) and the important care needs of patients that are not always met by existing services, particularly those associated with difficulties accessing specialist care. It will describe the current UK services and challenges associated with delivering this specialist care.

### 1.2 The clinical features of motor neurone disease

#### 1.2.1 Definition and epidemiology

Motor neurone disease (MND) is a neurodegenerative disease causing progressive weakness of skeletal muscles leading to disability and eventual death, usually due to respiratory failure. The incidence of MND in England and Wales is 1.66 per 100,000 per person years, peaking in the late 60s and is higher in men (female 1.34, males 2.04) (1). The lifetime risk of MND is 1 in 472 in women and 1 in 350 in men (2). Survival is limited to an average of 2-4 years and, as a result, the prevalence of MND in the UK is only approximately 5 000 (7 in 100 000) (3). However survival is highly variable and a number of patients experience a more slowly progressive course, with some living for over a decade.

#### 1.2.2 Classification

Amyotrophic lateral sclerosis (ALS) is the principal variant of MND, with dysfunction of both upper motor neurones (causing weakness and spasticity), and lower motor neurones (causing weakness and wasting) (4). Less common clinical variants include a pure lower motor neurone disorder (progressive muscular atrophy, PMA, approximately 10%) and a pure upper motor neurone disorder (primary lateral sclerosis, PLS, approximately 5%).

### 1.2.3 Pathology and aetiology

It is likely that multiple genetic, environmental and molecular processes interact to cause dysfunction, and consequent degeneration, of the motor neurone (5,6). Proposed mechanisms involve oxidative stress, excitotoxicity, protein aggregation and damage to axonal transport and mitochondrial activity as well as changes in inflammatory cascades and non-neuronal cells. Many environmental factors have been proposed but supporting evidence is lacking (7).

5-10% of patients exhibit a family history of ALS. A specific genetic aetiology can be identified in approximately two thirds of these patients and some sporadic cases also have an identifiable mutation (7). By far the most common mutation is a variable length hexonucleotide repeat expansion (GGGGCC) in the C9ORF72 gene on chromosome 9p21, evident in 45% of those with familial MND and 5-11% of sporadic cases (8,9). The C9ORF72 repeat expansion is also associated with other neurodegenerative diseases, most commonly frontotemporal dementia (10-12).

### 1.2.4 Clinical features

Limb involvement causes loss of fine motor skills, strength and loss of mobility (4). Trunk and neck involvement causes head drop and poor posture. Spasticity, cramps and spasms cause pain, sleep disturbance and pressure sores. Dysfunction of the bulbar muscles causes dysphagia and dysarthria. Worsening dysphagia results in aspiration of food and fluids and eventual complete loss of swallow. Dysphagia, upper limb weakness and the increased calorific requirements observed in MND can result in malnutrition and weight loss and these complications are well recognised poor prognostic factors (13-16). Dysarthria worsens until eventually patients are unable to communicate verbally and must rely on alternatives such as writing pads or communication devices.

Respiratory failure is the most common cause of death in MND (4). It presents insidiously. Initially, nocturnal respiratory insufficiency occurs causing orthopnoea, disturbed sleep and daytime sleepiness. Later, daytime respiratory insufficiency results in breathlessness. Dysphagia, combined with a poor cough due to inadequate glottis closure and respiratory ex-sufflation weakness, causes excessive oropharyngeal and respiratory secretions. Approximately half of patients attending the MND clinic experience excessive secretions, and of these, half have uncontrolled symptoms. Uncontrolled secretions are common and are distressing and cause social embarrassment and aspiration of secretions can cause pneumonia (4,17).



Psychological symptoms are common. These symptoms, including depression (between 11 and 75% of patients), anxiety (up to 33%) and fatigue (75-83%), and have a negative impact on quality of life (18-20). Whilst motor neurone dysfunction is the most prominent feature in many patients with MND display other neurological deficits (21). Emotional lability is present in approximately half of patients (22). 10-15% of patients show signs of frontotemporal dementia and a further 50% experience mild cognitive or behavioural changes (23,24). 14% have been found to display other neurological signs such as autonomic dysfunction or ataxia (21). These additional deficits are associated with a poorer prognosis (25).

### **1.2.5 Disease progression and prognosis**

The presentation and progress of MND varies between individuals. Patients tend to present with disability in one region and later the disease progresses to involve contiguous regions. In 75% of cases, the disease starts in the limbs (3). In 20% of cases, disease starts in the bulbar muscles and in approximately 5% of patients, disease begins with respiratory insufficiency (3). Patients usually develop respiratory failure in the later stages (26). Average survival from symptom onset for typical ALS is two to four years however, survival can range from months to decades. Factors that predict poor prognosis include older age at onset, rapid progression between clinical milestones, presence of other neurological deficits and the presence of some genetic mutations (27). Phenotypes associated with more slowly progressive disease typically include PLS and PMA, whereas those with bulbar or respiratory onset disease tend to have a worse prognosis (4).

### **1.2.6 Living with motor neurone disease**

The day-to-day experience of MND changes as the disease progresses (28). There may be a considerable delay between symptom onset and diagnosis, often many months to years during which time patients will experience uncertainty, psychological and physical distress as they see themselves deteriorating along with a failure to have their needs met (29). The impact of receiving the diagnosis of this terminal condition can be highly stressful, distressing and profoundly upsetting (30). Patients experience the disease as a series of functional losses (physical but also in vocational, occupational and family roles) (31). They also describe a loss of normality as well as their sense of self and social identity as they become increasingly dependent on others (28,32). Patients express feelings of uncertainty and powerlessness whilst others feel defiant and want to challenge the disease (28,32). Adapting to the disease can be difficult but maintaining a sense of agency and control, faith and dignity and their relationships with family

and social support appear central to enabling patients to accept the diagnosis, maintain hope and adapt to the challenges faced (31,32).

Along with the diagnostic delay, even when diagnosed, patients described a lack of knowledge of the disease, interpreting information from different sources and not knowing whom best to turn to for support (28). Both patients and professionals identified the need to improve the knowledge of healthcare providers along with more coordinated care and communication between hospitals and the community (28).

Near the end of life patients not only experience physical symptoms but also emotional distress and uncertainty (32). The terminal phases can often be unexpected and rapid, leading to unplanned interactions with emergency care or hospitalisation which may be against the patients' wishes, many of whom wish to die at home (33). Even those with advanced care plans had difficulty accessing the appropriate care at key times (33). Patients may consider euthanasia or assisted suicide. These are legal in some countries but not in the UK (25). Patients welcome the opportunity to discuss end-of-life choices and the desire to end their lives appears to diminish as they discuss their underlying fears and concerns (34,35).

### **1.2.7 Diagnosis**

The El Escorial criteria (Box 1.1) for ALS was developed through an international consensus and is used in research to ensure a consistent diagnosis (36). It has several limitations: a "clinically definite" diagnosis relies on extensive evidence in different regions of both upper and lower motor neurone signs. Extensive disease may not be present in many of those attending an MND clinic, particularly early in the disease, or those with PLS or PMA (37). Some patients die without ever fulfilling these criteria (37). Relying on these criteria means many patients are excluded from clinical trials (37). Alternative criteria which have recognised other clinical features of MND (such as the presence of a genetic mutation or frontotemporal dementia) have been proposed to better reflect the different disease phenotypes but these still do not identify all those with MND (38).

Box 1.1: The El Escorial criteria. Adapted from (Brooks et al. 1994)

**Clinically Definite ALS:** clinical evidence of the presence of upper motor neurone (UMN), as well as lower motor neurone (LMN) signs, in three regions.

**Clinically Probable ALS:** clinical evidence of UMN and LMN signs in at least two regions with some UMN signs necessarily rostral to the LMN signs.

**Clinically Probable - Laboratory-supported ALS:** clinical signs of UMN and LMN dysfunction in only one region, or when UMN signs alone are present in one region, and neurophysiological LMN signs are present in at least two limbs

**Clinically Possible ALS:** clinical signs of UMN and LMN dysfunction are found together in only one region or UMN signs are found alone in two or more regions; or LMN signs are found rostral to UMN signs and the diagnosis of Clinically Probable - Laboratory-supported ALS cannot be proven clinically or using laboratory studies.

### 1.3 The management of motor neurone disease

The focus of MND care is to promote survival, minimise morbidity and maximise quality of life (25). Due to the variety of bio-psychosocial complications of MND, management requires a holistic, multidisciplinary team (MDT) approach involving both patients and their family and carers. Whilst management guidelines are available (such as the National Institute for Clinical Excellence guidelines, published in 2016 (39)), the evidence for most interventions is very limited and mainly based on expert consensus (25,39-41). As the patient progresses, the focus of care shifts from promoting function and independence to palliation of symptoms and psychological support (25).

#### 1.3.1 Disease modifying therapies

Riluzole is the only drug that has been shown to prolong survival in patients with ALS, by an average of three months (42,43). Its effects are likely due to its action on sodium and potassium currents causing inhibition of repetitive neurone firing as well as inhibition of neurotransmitter release (44). Phase three trials of other potential disease modifying therapies (e.g. lithium, dextramipexole) have been disappointing with other treatments currently in early experimental phases (45-48).

#### 1.3.2 Physical symptoms

There are many pharmacological and non-pharmacological strategies used to treat and prevent physical symptoms but evidence for their effectiveness in MND is limited (25). Table 1.1 outlines the approach to these symptoms.

Table 1.1 The management of common symptoms in MND

Adapted with permission from Macmillan publishers Ltd. © 2016 (25).<sup>1</sup>

<b>Problem</b>	<b>Pharmacological treatments</b>	<b>Grade of evidence</b>	<b>Non-pharmacological strategies</b>	<b>Grade of evidence</b>
<b>Cramps</b>	Quinine Levetiracetam Mexiletine	Grade B Grade C Grade B	Physical therapy, exercise	Grade D
<b>Spasticity</b>	Baclofen, tizanidine, dantrolene Benzodiazepines Intrathecal baclofen	Grade D Grade D Grade C	Prescribed exercise Hydrotherapy Cryotherapy	Grade B Grade D Grade D
<b>Pain</b>	WHO Analgesic Ladder Opioids	Grade D Grade C	N/A	N/A
<b>Emotional lability</b>	SSRIs Dextromethorphan/ quinidine Amitriptyline	Grade C Grade A Grade C	N/A	N/A
<b>Depression</b>	Selective serotonin re-uptake inhibitors	Grade D	Psychological therapy, counselling	Grade D
<b>Anxiety</b>	Benzodiazepines	Grade D	Psychological therapy, counselling	Grade D
<b>Fatigue</b>	Modafinil	Grade B	N/A	N/A
<b>Respiratory failure</b>	N/A	N/A	Non-invasive ventilation Cough augmentation	Grade A Grade D
<b>Excessive respiratory secretions (thick)</b>	Carbocysteine Nebulised saline	Grade D Grade D	Cough augmentation Humidification of NIV Suction Reduction in dairy product intake Pineapple juice	Grade D Grade D Grade D None None
<b>Excessive oral secretions (thin)</b>	Hyoscine patches Amitriptyline Atropine drops Glycopyrrolate Botulinum toxin	Grade D Grade D Grade D Grade D Grade B	Radiotherapy Suction	Grade C Grade D

<sup>1</sup> SSRIs: selective serotonin re-uptake inhibitors, NIV: non-invasive ventilation Grading of recommendation proposed by the Oxford Centre for Evidence-based Medicine, 2009 [www.cebm.net/oxford-centre-evidence-based-medicine-levels-evidence-march-2009/](http://www.cebm.net/oxford-centre-evidence-based-medicine-levels-evidence-march-2009/) Grade A: systematic review or individual RCT with narrow confidence interval. Grade B includes systematic reviews or cohort or case-control studies or extrapolations\* of level A studies Grade C: case-series or poor quality cohort studies or extrapolations\* of level A or B evidence Grade D: expert opinion or inconsistent research from level A, B or C evidence. \*extrapolations: where data is used in a situation with potentially important differences from the original study situation.

### **1.3.3 Psychological and cognitive symptoms**

Currently, there are no current proven therapies for psychological, cognitive or behavioural problems and a holistic approach involving early recognition, counselling, education and advanced planning is recommended for patients and their families (25).

### **1.3.4 Communication and assistive devices and rehabilitative strategies**

An array of rehabilitative strategies, aids and assistive devices are available to help patients maintain independence. These range from simple switches or call bells to bespoke powered wheelchairs and eye-gaze systems (49). As the patient progresses, their needs change (25). A physiotherapist's role may change from promoting independence and maintaining walking to providing specialist seating and preventing pressure sores. As a patient's function may change rapidly, timely recognition of deterioration and provision of the correct solution is important. However access may be limited with barriers including cost, functionality and acceptability of devices along with lack of awareness of what is available and required by both health care professionals and patients (49,50).

### **1.3.5 Respiratory management**

In patients with respiratory failure, use of non-invasive ventilation (NIV) to support breathing can improve survival by on average seven months, whilst sustaining quality of life and improving symptoms of respiratory failure (51). NIV improves sleep architecture by reducing hypoxia and hypercapnoea. Early initiation may lead to better outcomes (52,53) so patients require regular monitoring to detect the symptoms and signs of respiratory failure (39). There has been considerable variation in the way physicians monitor and refer for NIV and it appears that patients attending specialist centres are more likely to be referred for, and use NIV than those attending a general neurology clinic (54,55).

The variation in patient use of NIV demonstrates the importance of specialist staff to initiate and support NIV use. Even within a research trial, half of patients did not manage to use NIV for at least four hours per day, meaning they are unlikely to gain the full benefit (56). Many patients find it difficult to adhere to NIV, facing barriers such as claustrophobia and dry mouth, excessive airway secretions and increased carer strain (57,58). Frontotemporal dementia and bulbar dysfunction also pose challenges but even in these circumstance NIV may offer symptomatic and survival benefit (51,59). Successful use of NIV requires perseverance by patients and their carers and intensive specialist support, monitor use and adjust the equipment address barriers to adherence and accommodate for further disease progression (57,58).

There is insufficient evidence to recommend any other respiratory interventions. Devices that have been explored include lung volume recruitment or mechanical insufflation-exsufflation devices (“Cough Assist”) (60). Clinical trials have faced difficulties with small sample sizes, difficulties delivering the intervention and measuring outcomes. Oropharyngeal suction and mechanical cough assist devices are available in some centres but the pathways to access and provision may vary.

It was proposed that stimulating the weakened diaphragm muscle using an external pacing system might improve diaphragm muscle function and restore coordination of respiration, thereby improve sleep quality and survival. Early, non-controlled data led to approval for the therapy in the US under the Humanitarian Device Exemption process (61). However, two randomised controlled trials have demonstrated that it is associated with poorer survival (62,63). This highlights the importance of clinical trials to avoid patients suffering harm from dangerous, untested treatments.

### **1.3.6 Nutrition support**

In patients whose swallow becomes unsafe, or are unable to maintain adequate nutrition or hydration orally, gastrostomy insertion can enable enteral feeding (64). There is no convincing evidence that enteral feeding improves survival, nutritional outcomes or quality of life but some patients and carers report that enteral feeding relieves the anxiety associated with poor oral intake and many perceive it to have had survival benefits (65). In order to reduce the risk of complications and increase likelihood of benefit, it is recommended that gastrostomy is inserted early, prior to respiratory failure or significant weight loss (65). Delay in identifying swallowing difficulties or respiratory failure (which makes gastrostomy insertion more risky) could result in patients being too unwell to undergo the procedure or failing to gain the benefit of enteral feeding. Therefore it is recommended that patients require early and regular counselling and monitoring of swallow, diet, nutritional status and respiratory function to enable early intervention should these deteriorate (65). Monitoring is also required after feeding is commenced to treat complications such as gastrointestinal disturbance and insertion site infections (65). Patients who decline gastrostomy feeding also need support as they may encounter risk of dehydration, malnutrition and aspiration in the later stages of their disease (25).

### **1.3.7 Palliative care**

At the end of life patients develop distressing physical and psychological symptoms such as dyspnoea and anxiety whilst carers may experience additional strain. This experience can have a significant impact on patients and their

families (58,66,67). It is recommended that specialist palliative care services should work with the MDT to provide support early, and throughout the disease (39). Access to palliative care for those entering the terminal phases of the disease can reduce fears associated with end-of-life events and improve the likelihood a comfortable death in the patient's location of choice (34). However, access to specialist is not universal and often lacks continuity (67,68). Without coordination and advanced planning, palliative services are accessed too late (67). Even with specialist support, complexities such as anticipatory prescribing, advance decision making and declining or withdrawing medical interventions means management may not be straightforward (69).

### **1.3.8 Improving quality of life**

Complications of MND impact negatively on patients' quality of life (QoL). These include dysarthria (70), dysphagia (71), pain (72), respiratory failure (73) and fatigue (74). A small number of interventions have been shown to improve QoL. Improving communication using assistive technology appears to have a positive influence (70,75) and NIV sustains QoL in patients with respiratory failure (51). Other interventions aim to improve patients' psychological wellbeing by promoting interpersonal relationships, self-efficacy and coping strategies by using therapies such as hypnosis and meditation (76,77). These have yet to be evaluated in controlled trials.

## **1.4 Healthcare resource use in motor neurone disease**

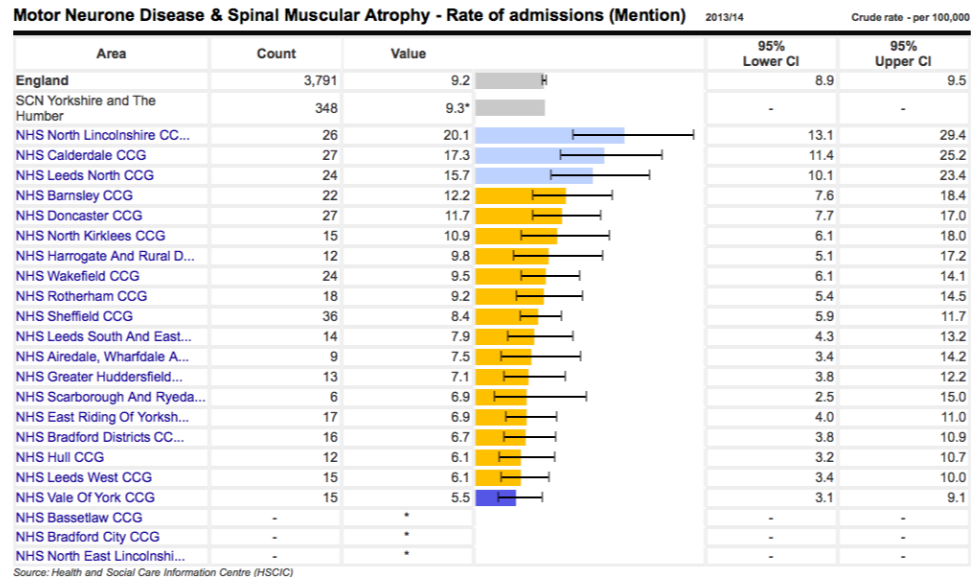
The health costs associated with MND include direct costs (e.g. MDT care and equipment) and personal/social care. Informal carers (usually family members) tend to provide most of this care. Costs associated with MND are higher than other neurological diseases (78). An assessment of medical costs in Ireland estimated the cost of MND care per month was €1795 (and higher in those using NIV and gastrostomy) (79). 72% of costs were due to community based care rather than hospital care (21%), aids and appliances (7%) (79). The estimated annual total cost per patient in other countries range widely (\$13,667 Denmark, to \$ 69,475, US) (78). There is a major drive in the NHS to move care into the community and reduce emergency hospital admissions (80). The elderly and those with pre-morbid conditions such as MND are at a much higher risk of needing emergency admissions (80). Emergency hospital admissions (for problems such as respiratory infections) present a high cost to the health service and the cost of a single emergency admission can be far greater than any other aspect of a patient's care (81). Proposed ways to reduce avoidable admissions include promoting self-management, improving and integrating hospital, local

and out-of-hours services and providing specialist case-monitoring and management services, particularly to groups of patients with a high risk of admissions (80).

In 2013/2014, NHS England hospital admission statistics recorded 3791 emergency hospital admissions for patients with MND (although this also includes a smaller group of patients with a rarer disease- spinomuscular atrophy) (82). This is approximately 9.3 admissions per 100 000 residents in Yorkshire and Humber (approximately 0.8 admissions per year per person with MND). There is significant regional variation amongst patients who attend the Sheffield MND clinic (Figure 1.2) from 5.5 admissions per 100 000 in York to 20.1 per 100 000 in North Lincolnshire. The reasons for this regional variation are unclear. It is possible that a small number of patients requiring multiple admissions could be influencing the figures, but this pattern appears consistent over several years. It is possible that the variation in regional variations in emergency admissions of patients with MND could be related to the quality of community services available locally. It should be noted that patients living in the area with the lowest admission (York) receive care from an experienced community MND nurse whereas a general rehabilitation team leads the community care of those in North Lincolnshire with no nurse specialist. However, there is no evidence to suggest whether one community model of care is superior to another. A randomised controlled trial of community case management in addition to usual MDT care in MND failed to demonstrate any benefit (83).



Figure 1.2 Number of emergency admissions (count) and rates per 100 000 population living in each area (value) in Yorkshire and Humber compared to the England average. Dark blue indicates the lower 25% percentile, light blue the higher 25% percentile.<sup>2</sup>



## 1.5 The experience of informal carers

Informal carers provide the majority of day-to-day care for patients with MND. This is commonly the spouse or another family member. It is estimated that informal carers provide an estimated £110 000 worth of care to a patient with MND in one year (84).

### 1.5.1 Carer quality of life

Caring for someone with MND has a significant impact on carers' physical and emotional quality of life (66,85). Carers report practical difficulties including physical demands, managing with unfamiliar equipment and being continually tired (58,66,86). They describe worries for patients' safety, distress and fear when witnessing suffering and feelings of anger, frustration and uncertainty about the future (87). Carers report difficulties with the loss of intimacy, change in their roles and relationships and having to cope with a progressive series of losses (66,86). After death, carers experience both relief and also regret, guilt and self-criticism, particularly when the death did not occur as preferred, and lack of bereavement support has often been reported (33,67).

Caring restricts carers' own lives, time, freedom and finances (87). Carers may

<sup>2</sup> Reproduced with permission. © Crown copyright 2016. Supplied by Public Health England (82).

bear many financial costs of MND as they are often financially interdependent on the patient and may be required to give up work to provide care resulting in lost earnings (at an age where earnings are often at their highest), pension, and careers (88). Financial support is usually limited, for example carers' allowance in the UK is only £62.50 per week (89).

Carer reporting poor quality of life are not necessarily those caring for the most disabled relatives (90). Carer distress does appear to be worse when patients experience behavioural changes (e.g. apathy, dis-inhibition, impulsivity) which may have negative impact on relationships and coping strategies (91). It appears that factors less directly related to health are also important in determining carer quality of life, for example religion (92), problem solving skills (93), hours of care (94), marital relationships and social support (95,96). As the disease progresses, carer psychological distress increases (97). This study suggested that the factors influencing their distress also change. Initially, distress appeared to be related to the psychosocial impact of the patient's disease, emotional lability experienced by the patient and the number of other dependents for whom the carer was also responsible (97). Later in the disease, carer distress was best predicted by a lack of social support and by their initial satisfaction with their social relationships (97).

### **1.5.2 Current support for carers**

Carers are offered support by the patients' multidisciplinary team and there is also support available from charities and through the social care system (98). One randomised controlled trial of 132 patients in the Netherlands of community based case management examined carer outcomes (83) but it did not identify any impact on carer strain. The interaction between carers and healthcare services appears to influence carer wellbeing (98). Carers may be unaware of the services available and yet find it challenging to accept the help of professionals and allowing others to take over caring duties (98). They may face difficulties related to the way care is organised and provided such as the timing of equipment provision and service delivery (98). Carers' quality of life and carer strain scores appear to be related to the number of problems with the care they receive (99). Problems include a lack of the opportunity to discuss the amount of caring with a professional, not being as involved in care planning as they would like and not having enough help with providing physical care (99). Another study suggested that the single biggest impact on carers' quality of life appears to be related to the amount of time they feel is required to carry out caring duties (100). However the study found this impact did not appear to ease when substitute carers were present.

### **1.5.3 Interventions to improve carer wellbeing**

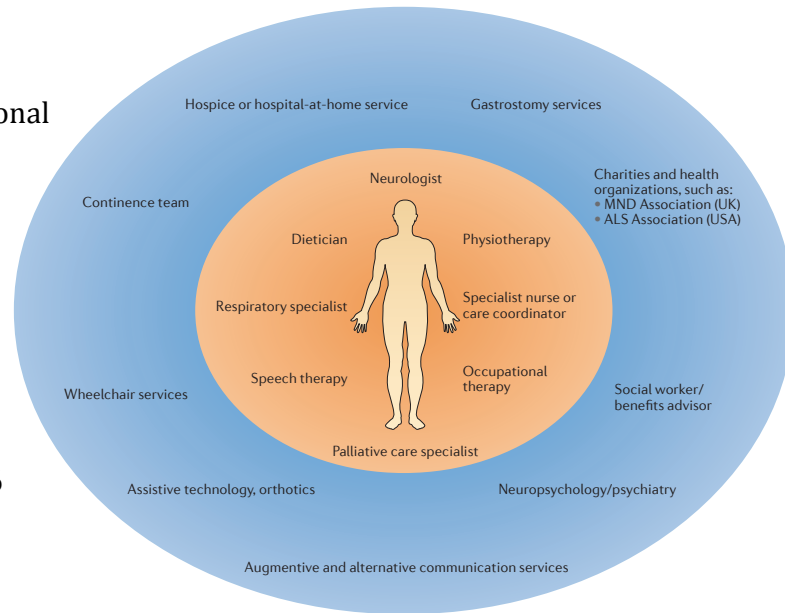
Despite the growing evidence identifying carer difficulties, to date, no interventions specifically target carers of those with MND. A recent review of the evidence of carer experiences also emphasised the need to support carers in their roles (98). It suggested four ways in which carer wellbeing may be improved: early access to palliative care; providing disease specific information and signposting to services; and teaching carers caring skills (98). It also suggest encouraging a supportive relationship between patients and carers (98) which may explain why two small studies of assistive communication technology suggested this may improve both patient and carer wellbeing (75,101).

It is important to recognise that interventions could inadvertently have a negative impact on carer wellbeing. Interventions that improve coping strategies may mean carers take on more tasks, thereby increasing carer burden. Carers are often required to conduct complex tasks such as using NIV and gastrostomy feeding with little training (68). Whilst these might improve the patient's condition and may address some carer concerns (e.g. by reducing the anxieties related to poor oral intake) they may increase carer burden. One study observed that carer QoL deteriorated following NIV initiation with the physical strain and impact on carer time being highlighted as potential factors (58). Similarly, carer strain was observed to increase after gastrostomy insertion (65) and a negative impact on both physical and time requirements was also reported (102). When evaluating any new intervention, it should assess the impact on both patients and carers.

### **1.6 The specialist multidisciplinary team**

Given the complexity of the care needs of patients, carers and their families, guidelines recommend that care is provided by a specialist multidisciplinary team (MDT) (39-41). It is recommended that a core team of specialists with experience in MND care provide care throughout each stage the disease who can access a range of other specialist and community services as required. Figure 1.3 describes the core and the additional components of an MND MDT. In the UK, over the last decade, 22 specialist MDT MND Care Centres have been established (103,104). Approximately 70% of patients in the UK attend one of these centres at some point in their illness (105). Similar models are employed in other developed countries (55,106-108).

Figure 1.3 The core (orange) and additional (blue) components of a MND care team (39). Reproduced with permission from Macmillan publishers Ltd. © Macmillan publishers Ltd 2016 (25)



Attendance at a specialist MDT is associated with improved survival, independent of the use of non-invasive ventilation, riluzole and gastrostomy feeding (55,109-111). Furthermore, MDT care may also reduce the number of, and shorten inpatient stays (106). It is also associated with increased use of proven therapies i.e. riluzole and non-invasive ventilation as well as assistive aids and devices (55). One study also suggests that MDT care has a positive impact on patients' QoL (106). Patients value the convenience and quality of unified care and single appointments could reduce travel time required to visit multiple specialist (112). Patients and carers report positive experiences when they are able to be involved with the MDT in making decisions about their care (68). They also report that clinicians provide them with the practical and emotional support required to cope with the disease (113,114).

The cause of the observed survival benefit associated with MDT care is uncertain. MDT care is a complex intervention consisting of many component parts and the outcomes will depend on each of these components (115). It is therefore likely that there are multiple factors that influence the success of MDT care. There are considerable variations in the structure of MDT services and this does appear to impact on patient survival (54,55). A study comparing models of care in the Republic of Ireland and Northern Ireland found that centralised multidisciplinary hospital clinic care was associated with better survival than coordinated care through a community specialist care network (55). It was suggested that the survival benefits may relate, at least in part, to the complex decision-making processes and communication that can take place within a centralised team (55).

However, further research is required to determine which are the important factors that improve outcomes and how these factors can be consistently delivered to ensure all patients can access high quality care.

Whilst a centralised, hospital-based MDT appears to be the most effective way to deliver care, there remain problems with this model. Given the low prevalence of MND, the clinics cover a large geographical area, for example, until recently six specialist nurses were providing care for 300-400 patients in Scotland, covering an area of over 78 000km<sup>2</sup> (116). Even a short journey to a hospital clinic can be extremely difficult.

Between visits, or when travel to clinic becomes impossible, much of the day-to-day care is provided by non-specialists (117,118). The accessibility, structure and expertise of community services vary greatly (119). Staff may have a special interest in MND (e.g. neurology matrons), many of whom have close links with the local MDT. Many local services are more generalist and are not integrated with the MDT making coordinated care a challenge (68). Some teams consist of one key worker who coordinates the involvement of other specialists. In other areas, care is less coordinated and patients and carers have to engage with many different healthcare professionals.

When access to specialist staff and equipment is limited, patients and carers experience significant difficulties (33,67,99,119-121). As described in 1.3.7, a lack of coordinated care and advanced planning makes continuity of care and access to services such as palliative and social services more difficult (68). Non-specialist staff may be unfamiliar with the needs of the patients or with medical equipment, such as NIV (33,67). Difficulties accessing specialist services may also lead to delays in accessing appropriate equipment and medical treatments (68). Without specialist support interventions may not be used correctly, decision making may be more difficult and patients and carers can become more distressed (33,57,67,99).

There are other barriers to accessing specialist services. Older patients, women and those bulbar onset disease appear less well represented in specialist clinics, although the reasons for this are unclear (55). Clinic appointments can be lengthy and tiring, particularly if the patient needs to see multiple specialists. The traditional model of hospital care means hospitals are usually arranged at fixed, often-inflexible intervals and appointments usually scheduled at their previous appointment. This schedule may not reflect the patient's current needs and services not prioritised to ensure patients receive the right care at the right

time. Patients whose disease changes rapidly may require more intensive support and unexpected complications may arise between scheduled visits. On the other hand, patients with slowly progressive disease may attend unnecessary appointments when their condition is stable whilst others find it difficult to access care at short notice. Finally (as discussed earlier), there is increasing pressure on services at a time when budgets are limited, with pressure for healthcare to be delivered in the community rather than in hospital. This is further compounded by a likely increasing prevalence of patients with MND caused by an ageing population and interventions such as NIV which increase survival in patients later in the disease, many of whom are very disabled and have greater care needs. Should additional disease modifying therapies become available, MND may become chronic disease, further increasing the prevalence and resource requirements.

### **1.6.1 The Sheffield Motor Neurone Disorders Care and Research Clinic**

The specialist multidisciplinary MND team based at the Royal Hallamshire Hospital, Sheffield Teaching Hospitals NHS Trust was established in 2006. It provides care primarily to patients with MND across South and East Yorkshire, North Derbyshire and Lincolnshire. Due to its reputation as a centre for clinical and research excellence it attracts patients from areas throughout the Midlands and North of England.

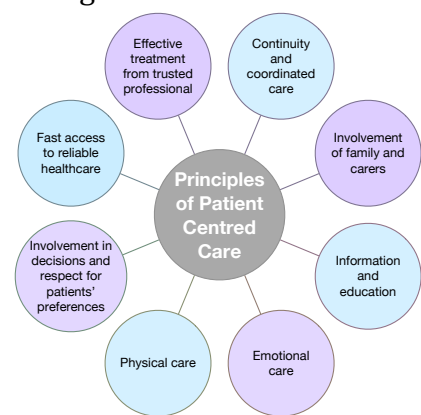
Patients are reviewed regularly, usually at intervals of two to six monthly. At each clinic they see, at minimum, a specialist neurologist and nurse and their disease is monitored using functional rating scales, weight and respiratory measurements. They also have access to a weekday telephone advice line to the specialist MND nurse. Community teams in close proximity to Sheffield meet regularly with the specialist MDT to share information about patients and share experience and good practice. The MDT also provides opportunities for learning and development through study days and outreach teaching. Patients who attended the Sheffield MDT clinic survived longer than those who attended prior to the establishment of an MDT clinic, even when accounting for NIV use (111).

## **1.7 Discussion: the unmet needs in MND care**

Chapter One highlights the complex and changing needs of patients with MND, which are best met by patient-centred, coordinated service that can provide regular monitoring, and timely identification and management of problems through the course of the disease. Holistic MDT care should ensure that the patient and their families remain the central focus at all times. The Picker

Institute defines eight core principles of patient-centred care and many unmet needs may reflect situations where care is not patient-centred (Figure 1.4) (122). This is reflected in the 2016 the NICE guidelines for the management of MND which recommends that care is patient-centred and delivered through an MDT of coordinated, trusted specialists which aims to meet the physical, emotional and practical the needs the patients and their carers and families (39). However, as highlighted in this chapter and in the NICE guidelines, at present patients often lack knowledge and education, timely access to expert and trusted professionals and continuity of care, particularly where care shifts from hospital/specialist care to community/non-specialist care, for example, near the end of life. Specialist MDT services which address all these eight aspects will promote patient-centred care. This may be one reason why patients attending an MDT have better outcomes.

Figure 1.4 The 8-core principles of Patient Centred Care identified by the Picker Institute (122).



Despite an increase in specialist MDT services, access to this standard of care is not universal. Research to date has focused mainly on the hospital MDT, but this is unlikely to be the only factor that influences outcomes. Poor experiences of community care, high costs of community care along with the widely varying emergency admission rates of patients suggests that there needs to be more focus on what occurs between clinic visits and make high quality specialist care more accessible and patient-centred.

## 1.8 Conclusion

Chapter One has highlighted the need to address the complex and often unmet needs of patients and their carers by improving the standard of and access to specialist MND care. It is therefore important to explore ways in which existing services can be improved or alternative services offered. The rest of this thesis aims to explore one way in which this could be achieved: by using technology to enable better care by facilitating better communication between patients, carers and their healthcare team. Chapter Two will describe what is already known about the use of technology to enable care for patients with MND and in other chronic diseases. Following this Chapter Three describes how a technology-enabled service for MND was developed and later chapters explain how this service was tested in clinical practice.



## Chapter Two

### Using technology to improve access to specialist care in motor neurone disease: a review of the evidence

#### 2.1 Introduction

Chapter One described the need to address the unmet needs in MND by increasing access to specialist MND care. Technology-enabled care refers to services that use digital technology to support the delivery of care to patient and includes systems such as telehealth and telemedicine that can enable interactions between patients and clinicians in order to deliver clinical care at a distance. This chapter will describe a literature review focusing on technologies which have been used to increase access to MND care (123). It will then describe relevant services in other disease areas, focusing mainly on telehealth services. It will examine the challenges to evaluation and implementation they face and how these findings can be applied to future MND services.

#### 2.2 Background

Chapter One argued that there is a need to improve access to care to patients with MND who experience complex and specialist needs. There is also a wider drive in the UK to redesign care pathways to ease the pressure caused by the increase in the population who are elderly or have chronic ill health (124). In 2012 the UK Department of Health created the “*3millionlives*” initiative which aimed to promote the use of digital technology to support more innovative, cost-effective ways to deliver healthcare along with encouraging patient education, empowerment and self-management (124). This project aimed to foster NHS, academic and industry collaboration in order to provide telehealth services to up to three million people with chronic health and social care needs in the UK. Continuing this theme, in 2014, NHS England set out its Five Year Forward plan identifying the clear need to radically change the way in which people are cared for by spanning community and hospital services across both the health and social care sector and make it more effective and reduce costs (125). Innovations utilising digital technology were felt to be important ways in which to assist with these changes.



Digital technology is now a prominent and growing part of everyday life and digitalisation within healthcare reflects these trends as it becomes increasingly part of routine clinical care. Systems are now affordable and accessible meaning clinicians and service users can access medical records online, order tests and medication or make appointments (126). More sophisticated services (referred to as technology-enabled care) use technology to allow patients and carers direct access to medical and social care and health professionals. This chapter will focus on telemedicine and telehealth services. Video conferencing (*telemedicine*) along with email and telephone can allow a patient and clinician to communicate remotely and can be particularly valuable in time-critical situations (e.g. emergency stroke thrombolysis (127)) or where travel to hospital is difficult either because of the distance or because of frailty or disabilities (123). *Telehealth* services (sometimes called telemonitoring) are interactive systems that provide clinicians with real-time data in order to monitor health in patients' own home (123). This may involve monitoring of physical measures such as blood pressure or of patient reported outcome measures. Telehealth has also been used to promote care coordination, communication and relationships between patients and their healthcare specialists and empower patients to better understand and manage their own disease (128).

Use of other health-related technologies is also growing. *Telecare* facilitates independent living, using equipment such as emergency call bells or falls monitors. Health-related "apps" use mainstream technology to monitor activity, diet and other health and lifestyle measures but most of these are not sufficiently tested, reliable or secure to enable communication between clinicians and patients and will not be the focus of this thesis.

An understanding of how these technologies could be best used within the NHS has grown over the last decade with a large number of evaluations of different services being conducted. A lot can be learnt from examining the use of technology enabled care in other diseases as there will be barriers and incentives to its use of which are common amongst all diseases. However, MND has some particular challenges: it is a rare disease with only a small number of specialist clinicians; patients are often elderly and disabled and their needs are complex and changing and require the involvement of multiple specialists and technical equipment. The role of the carer and shifting focus from active management to promoting survival and independence to palliation and end-of-life care adds further complexities (25). However, technology also offers ways to overcome some of the challenges of MND care such as geographical barriers and the need

for frequent contact with multiple specialists. The internet already offers a wealth of information and education in MND; through charities such as the Motor Neurone Disease Association that provide patients and their families with reliable information about living with and managing MND. Websites such as MyMND and MyTube can help people learn about the disease through the experiences of others who live with MND as well as enabling peer support (129,130). Along with providing education, technology-enabled care could provide better links to specialist services that may also promote better self-management. This is important in MND as patients and carers already need to self-manage their condition, by learning how to cope with the diagnosis and their disabilities, use highly complex medical devices (such as NIV and gastrostomy feeding), accessing peer support and by making choices about their treatments, planning their future care (131). This chapter examines the available evidence for services that use technology to facilitate access to specialist care in both MND and in relevant services for other chronic diseases. It also identifies evidence explaining how and why these services had the outcomes observed as well as potential lessons to guide future development, evaluation and implementation.

## **2.3 Technology-enabled care in motor neurone disease: a systematic review**

### **2.3.1 Aims**

A literature review aimed to identify technologies which have been used to facilitate access to specialist care for patients with MND and/or their carers (123). It aimed to identify academic papers and other evaluations that described the clinical services and technologies, their use, feasibility and acceptability and the impact on patient and carer clinical outcomes, quality of life, medical services and health resource use.

### **2.3.2 Search strategy**

A search was conducted using Pubmed, Google Scholar and the Cochrane library up to the end of 2014. Following publication of this literature review, the search was updated to include recently published articles up until November 2016. The search strategy is described in detail in the published paper in Appendix C. Projects involving MND that were not published were identified using internet searches, Twitter and through information gathered by word-of-mouth and conferences. This identified a number of services that did not fulfill the inclusion criteria for the published systematic review but were relevant to the project. It would be impossible to describe all telehealth/telemedicine projects but those

felt to be relevant to the research question (NHS based neurology/MND services, outpatient management of chronic neurological diseases in adults) are described.

Studies selected involved:

- Patients and/or carers of those with any form of MND;
- Technology that enabled communication between a patient and/or carer and the clinician who were not in the same location;
- Reports in English describing original research or service evaluation where sufficient information was available about the intervention, population and outcome.

One aim of the review was to describe the range and feasibility of interventions, including those in the early phases of development. This meant that the quality of evidence was examined and reported but was not an inclusion criteria. Interventions and study designs were diverse, so statistical analysis was not appropriate and narrative synthesis was undertaken. The author of one study was contacted to obtain further information about the results (132).

## **2.4 Results**

The initial search strategy identified 445 academic references, of which 31 full text articles and one conference abstract were reviewed for eligibility (123). Sixteen original articles were selected for review: 12 described telehealth services and four telemedicine. No interventions targeted at carers of those with MND were identified. Tables summarising the search results are included in the published paper (Appendix C). An update in November 2016 revealed no additional papers.

### **2.4.1 Telemedicine in neurology and MND**

Four papers were identified describing service evaluations of telemedicine in MND care (108,133-135). A Dutch study used an internet chat room and video link to enable four patients to conduct individual consultations with a rehabilitation team (133). Discussing most aspects of care using telemedicine was acceptable to patients and reduced travel to hospital, but patients still expressed a preference for face-to-face consultations when discussing emotional and psychological topics, including end-of-life decisions. Two services in the United States published service evaluations suggesting that using telemedicine had avoided outpatient visits resulting in patient travel cost savings (134,135). An Australian study described using telemedicine between a tertiary centre and local community hospitals to facilitate the care of patients living far from the

MND clinic (108). The Australian telemedicine service focused on symptom control and end-of-life care and enabled contact for an extra year with patients who would otherwise not have been able to access these services.

An NHS Scotland initiative, the Scottish Centre for Telehealth and Telecare, details six services in Scotland that use telemedicine in outpatient neurology clinics between a central hospital and rural areas (136). No telehealth services in neurology were identified. None of the projects had been formally evaluated but 14 different clinics now use teleneurology and in 2015/2016 over 15 000 people accessed services such as falls prevention, chronic illness management and psychological therapies through its systems.

A number of other studies using telemedicine in Parkinson's disease were identified. These often used trained assistants at the bedside to facilitate communication and examination. One randomised controlled trial was identified which suggested that telemedicine could reduce travel whilst offering the same level of care as face-to-face visits (137). Online speech therapy also appeared to be non-inferior to face-to-face visits and satisfaction was high (138). Services were described as expanding in scale and scope to include not just care delivery but also training of remote providers (139). The main barrier identified was the difficulties with reimbursement for these new service models. Facilitators included improving technology and the development of integrated care and education networks. Descriptions of the extensive use of telemedicine in acute stroke thrombolysis and in palliative care were identified but few have been formally evaluated (127,140-145). Those that did suggested that it could be an acceptable alternative to face-to-face consultation, particularly when travelling to clinic is difficult, but some limitations were identified such as problems with technology and the limitations of examinations using video instead of in-person assessments (137,141,146,147).

## **2.4.2 Telehealth in respiratory failure in MND**

### **2.4.2.1 Study characteristics**

Five telehealth systems are described in 12 papers. All these used telehealth to intensively manage patients with chronic respiratory failure as an alternative to outpatient appointments. Some projects limited to MND, whilst others were services providing care for a wider number of diseases. The interventions and studies are described first, following which the clinical, cost and feasibility outcomes are discussed.

#### ***2.4.2.2 Study quality***

Only two trials involving patients with MND were identified where telehealth was compared to usual care. Only one was a randomised controlled trial (148). A pilot trial and economic analysis was identified which was described as randomised but actually assigned patients on the basis of their geographic location (81,149). Both trials have been included in this review but were assessed to have a high risk of bias and neither was sufficiently powered to detect clinical or economic benefits. The other papers identified were observational studies but have been included in the review because they describe the feasibility and potential economic impact of telehealth on the clinical service.

#### ***2.4.2.3 Studies included in the review***

##### *Tele-assistance in patients with chronic respiratory failure*

An Italian rehabilitation service evaluated a complex telehealth system for patients with respiratory failure. Pulse oximetry data was collected and patients were assessed weekly by a respiratory nurse using a predefined clinical algorithms (150). A 12-month randomised controlled trial followed which involved 240 patients with chronic respiratory failure, 22 of whom had MND and 50 of whom had other neurological disorders (148). One hundred and one patients used non-invasive ventilation and 43 used tracheostomy ventilation. The primary outcome was rate of hospital admissions. Secondary outcomes included mortality, respiratory exacerbations, emergency room admissions and urgent general practitioner calls. Patients were randomised to usual care (routine three-monthly hospital appointments) or to the telehealth service with no scheduled outpatient appointments.

A five-year observational study and economic analysis of the same telehealth service examined the staffing and financial impact of caring for 396 patients, 91 of whom had MND (151). Two papers describe the use of this service in MND patients alone: a pilot, non-randomised observation study (40 patients) and a five-year service evaluation (73 patients) (152,153). It is unclear whether the same patients were involved in more than one of these evaluations.

The same Italian telehealth system was used to monitor 39 patients with ALS (154). When the telehealth system identified a respiratory exacerbation, a mechanical insufflation-exsufflation device (“Cough Assist”) was provided. The same group conducted a pilot study using long-term monitoring of peak cough flow (a measure of a patient’s capacity to cough effectively), oxygen saturations and symptoms to identify respiratory deterioration in 12 patients with ALS using

non-invasive ventilation (155). The patient recorded these measures daily and reported bi-weekly via a telephone call to a physiotherapist.

#### *Home telemonitoring of non-invasive ventilation in patients with amyotrophic lateral sclerosis.*

A telehealth service based in an MND clinic in Lisbon (Portugal) tested a telehealth system which used data collected from NIV ventilators relayed to the clinical team via the internet. A set of algorithms and guidelines were developed to enable clinicians to assess patients and schedule telephone calls or hospital visits (156). Forty patients with MND commencing NIV were recruited into a pilot trial and economic evaluation (81,149). Primary outcomes were; the number of visits to hospital and the number of ventilator setting changes needed to reach full compliance. Whilst the trial was described as randomised, patients were assigned a study arm according to whether they lived within Lisbon (usual hospital appointments) or outside Lisbon (intervention: telehealth plus usual three monthly appointments)(149). Furthermore, whilst limited clinical characteristics collected at baseline suggested the groups were similar, baseline health resource use, socio-economic status and co-morbid diseases were not reported.

#### *Other feasibility studies*

The literature search identified two other feasibility studies that also used telehealth to manage patients with MND using NIV. Both services were felt to be feasible and acceptable to patients but no comparative trials of the services were identified (157,158). Telehealth can also be used to monitor adherence to non-invasive ventilation: a pilot trial in MND is in progress in Sheffield (159). Another pilot trial of telemonitoring of NIV in MND is also underway at the Liverpool MND care centre (160).

#### **2.4.2.4 Outcomes**

##### *Clinical outcomes*

The Italian randomised controlled trial of 240 patients (22 of whom had MND) reported that telehealth care was associated with significantly fewer hospitalisations (the primary outcome), respiratory exacerbations and urgent calls to general practitioners (148). Mortality and emergency room attendance rates did not differ significantly (148). These differences only reached significance in the group of patients with chronic obstructive pulmonary disease. No significant differences were detected in the 22 patients with MND (although the study was not powered to detect a difference in this sub-group).

The Lisbon pilot trial of 40 MND patients reported that telehealth was associated with significantly fewer outpatient, emergency room and hospital visits (the primary outcomes) (81,149). Conclusions should be made with caution given the limitations in methodology described earlier. There was also a trend towards longer survival in the telehealth group. However, median time between patients developing symptom and requiring NIV was much longer in the telehealth group suggesting these patients had a slower disease course (and therefore likely to survive longer) than those in the control group.

#### *Cost effectiveness*

Whilst the Italian randomised controlled trial was not powered to provide a cost-evaluation, the authors did suggest that, given the significant reduction in hospitalisations in the telehealth group, the healthcare costs for patients using telehealth would be less. (132,148). However, estimates were imprecise and no formal statistical comparison was possible. Half of all cost savings were due to a small difference in the small number of very costly intensive care admissions (14 vs. 16) (148). Given that there were no significant differences in outcomes in the MND patients, no cost savings were demonstrated (148).

When the service was evaluated over five years, cost savings were reported (151,153). The savings were made in staffing costs as nurses took over the roles of physicians. One nurse was able to manage a caseload of 25 patients, costing an estimated €105-108 per patient per month. Cost savings were also reported when the same telehealth system was used to detect respiratory exacerbations in order to supply Cough Assist machines when required (154). The service was reported to have prevented 30 hospital admissions and was estimated to be 59% cheaper than providing machines to all the patients, all the time (154).

In the Lisbon study healthcare costs in the telehealth group were significantly lower due to reduced inpatient and transport costs (81,149). These results should be interpreted with caution given the limitations of the study. In particular, patients were assigned a study arm based on whether they lived in a rural or urban location - a factor that may independently influence hospital attendances and other health resource use.

#### *Quality of life, feasibility, acceptability and adherence*

None of the identified studies examined patient or carer burden or quality of life. The Lisbon study examined patient's attitudes to the service: 93% of patients rating the service as "good" or "very good" but only 36% of patients considered it to be a method of improving their life (152). The reasons for this are not

described, but these telehealth regimes were very intensive requiring patients to make frequent contact with the MND team. The Italian study found that the majority of contacts were routine and did not result in a change in their care (153). Similarly, only 12 of the 39 patients who took part in the cough assist study were supplied with the device, meaning that most were using the telehealth daily but gaining no benefit. Using a burdensome system without seeing any benefit to their care may be demoralising to service users. Whilst dropout in the long-term evaluations was low, the author of the Italian study suggested that it was difficult to recruit patients with MND to the trials because they had heard about the potential benefits of the telehealth system and did not wish to be randomised to the control arm (132,148).

Poor patient adherence impacted on the success of the service in which the telehealth system monitoring cough strength was used to detect respiratory exacerbations (155). The system was so complex for the patients that they did not adhere to the regime or provide sufficient readings for the system to detect a change in their condition. In another feasibility study using telehealth to support NIV use, those who adhered well to the telehealth regime experienced a reduction in hospitalisations, whereas those who failed to send data regularly experienced an increase in hospitalisations (158). However, baseline hospitalisation rates were much higher in the “good” adherence group compared to the “poor” group and this study did not explore other factors that might influence hospitalisations and adherence behaviour. Despite these problems, factors that might influence patient acceptance and adherence were not explored.

## **2.5 Technology-enabled care in other chronic diseases**

There have been numerous trials of different technology-enabled systems in other chronic diseases. For reasons described later, in the Discussion (Section 2.6), this section will focus mainly on telehealth rather than telemedicine. Systematic reviews of telehealth in the most common diseases (asthma, heart disease and chronic lung disease) have attempted to draw together evidence from the many different services in different trials. It seems that there is, at best, weak evidence from poor quality trials that there may be some positive impact on clinical outcomes and health resource use (161-164). However, interventions, diseases, populations and clinical services vary widely and therefore little can be drawn from these reviews. It was therefore more helpful to examine individual interventions that are relevant to MND services in the UK. Two services have been selected for closer inspection: the Whole System Demonstrator and Simple Telehealth (Florence). They reflect the range of technology services available in



the UK and serve as examples that demonstrate the challenges faced in development of services, evaluation and implementation. Other studies which provide evidence for the broad benefits and challenges of telehealth are described in Section 5.6.

### **2.5.1 The Whole System Demonstrator**

The Whole System Demonstrator (WSD) was the largest ever trial of telehealth. It was a UK Department of Health funded cluster-randomised controlled trial of telehealth and telecare in three areas of the south of England was launched in 2008. The aim was to determine (or “*demonstrate*”) whether large-scale telehealth was an effective and affordable model of delivering care in common chronic diseases. Patients were selected if they had either one or more common chronic diseases (e.g. heart failure, chronic lung disease, diabetes) and/or required home telecare. Call centres staffed by specialist nurses took over the monitoring and management of patients randomised to the intervention and this was compared to usual care. Outcomes included mortality, hospital admissions and health resource use and semi-structured interviews were also conducted with participants to explore the barriers and incentives to the new service models.

The study results were disappointing: it identified only a slightly reduced hospital admission rate at 12-months (odds ratio 0.82, 95% confidence interval 0.70 to 0.97,  $P=0.017$ ) and only a small difference in mortality between the two groups (4.6% 8.3%; odds ratio 0.54, 0.39 to 0.75,  $P<0.001$ ). No significant differences in quality of life were found (165). The cost associated with the intervention meant that, even when small (non-significant) differences in treatment groups were identified, the estimated cost per quality adjusted life year gained was extremely large (approximately £90 000) (166,167). These findings are similar to results of meta-analyses of telehealth in chronic diseases which find at best, weak evidence of their impact with uncertain costs (e.g. (161,162)). The study faced many challenges that highlighted the difficulties evaluating and implementing telehealth. These are discussed in section 2.6.

### **2.5.2 Simple telehealth: “Florence”**

In contrast to the WSD, “*Florence*” is a very simple and cheap telehealth system developed by Staffordshire NHS hospital trust. A text message system enables patients to report symptoms and measurements (e.g. blood pressure) and receive motivational messages and reminders to encourage behaviour such as medication adherence and healthy living. It can be adapted to be used in any simple clinical pathway and has been used in a range of diseases. It sends very

basic, pre-agreed messages to patients and returns only simple information to the clinician. It does not promote complex decision-making or manage multiple tasks.

Evaluations of the services have been limited to examining acceptability and feasibility. Interviews of patients and carers suggest it may improve a patient's ability to self-manage and reduce the impact of their disease on their day-to-day living. One published service evaluation concluded that using the system to manage hypertension was feasible and was associated with a small (11mmHg) reduction in blood pressure (168). Traditional efficacy and cost-effectiveness studies have not yet been undertaken but may be impractical given the large number of ways the system is being used and the complexity of the services within which it is being evaluated. However, given the simplicity of the system risks are likely to be low. "Florence" is currently offered to NHS trusts at no cost to local providers or patients and highlights the benefits of a simple, low cost and adaptable service which could be incorporated into current clinical care.

## 2.6 Discussion

### 2.6.1 Future use of technology in MND care

The studies described in this chapter suggest that telemedicine appears feasible and acceptable to patients and clinicians including those with MND and may strengthen networks and relationships between patients and providers who would otherwise find it difficult to access specialists. However, Chapter One identified the need to increase the frequency of contact and monitoring of patients between clinic visits rather than just make contact more convenient. Telemedicine would not, on its own, be able to increase the frequency of contact with clinicians without associated costs, clinician time and workload. On the other hand whilst evidence in this chapter supporting the use of telehealth in MND is limited, basic services appear feasible, can facilitate more frequent monitoring and contact with even severely disabled patients. Evidence identified in this chapter suggests that telehealth may allow redistribution of workload from physicians to nurses and offer the potential to reduce clinic visits and hospital admissions. This may offer cost savings and could improve the lives of patients. It also suggests that more complex telehealth services may not be feasible because of the burden on patients and costs and availability of specialist staff. The limited research suggests that remote care may be less acceptable for addressing some aspects of MND care such as psychological difficulties and may not be sufficient to replace in-person physical examination, so consideration should be given to how these needs are best met with or without technology.

Methods for future development and evaluation of these services must reflect these complexities and uncertainties surrounding telehealth: Section 2.6.4 describes how these services could be developed and evaluated in light of these uncertainties.

### **2.6.2 Challenges of evaluating telehealth**

The studies identified in this chapter highlight many of the challenges associated with evaluating and implementing technology-enabled care. Section 2.6.2 describes the challenges associated with evaluating telehealth and Section 2.6.3 describes the challenges of implementation. The main challenges that will be discussed in section 2.6.2 are: the difficulties evaluating the costs, impact, mechanisms of action and safety of the interventions within traditional trial models. The main challenges with implementation discussed are due to service user factors, clinical staff factors and service and commissioning factors.

#### **2.6.2.1 Evaluating the costs of telehealth**

The most obvious cost of telehealth is the costs associated with the technology. Both the telehealth studies in MND and the WSD were hampered by relatively high costs of the intervention associated with small clinical improvements. Technology costs are reducing making technology like “Florence” affordable meaning it could be cost-effective. Keeping up with the changing costs is challenging when clinical trials may take several years.

The additional costs associated with service delivery should not be underestimated and may be far higher than the cost of the technology. These novel services require service reconfiguration and have significant set-up and staffing costs. The WSD employed additional specialist nurses to deliver the telemonitoring and clinical care. Similarly, the Italian MND telehealth service required additional specialist nurses estimating that one specialist nurse could only manage 25 patients (153). The costs and requirement for such a large number of additional specialist staff means these systems would currently be unfeasible in the UK. For example, the Sheffield MND clinic has one respiratory specialist caring for approximately 130 patients, approximately a third of whom use NIV meaning additional trained specialists would be needed.

Assessing cost-effectiveness is challenging. Measuring health resource use is difficult, particularly in MND where patients may receive care from many different sources in both the health and social care sector. Whilst technology-enabled-care may enable more efficient use of resources (e.g. by reducing admissions or preventable complications), if unmet needs are identified there

may be a cost associated with providing this additional care. Furthermore, as the Italian telehealth study found, a small difference in the number of high cost rare events (in this case intensive care admissions) can dwarf any other differences observed in the trial (148).

#### *2.6.1.2 Evaluating the safety of telehealth*

It might be presumed that interventions that improve monitoring, communication or education would not be associated with any negative effects. This seems to mostly be the case but interventions which increase the medicalisation of a patient's life may also increase patient/carer burden and could have a negative effect on quality of life (65,169). This has not been explored extensively in previous research.

Two large studies have also reported increased mortality associated with telehealth (170,171). One study using telehealth to manage patients with congestive cardiac failure found excess mortality in the telehealth arm. It suggested the telehealth triggered extra healthcare interventions that could have resulted in increased mortality (171). This highlights a wider uncertainty around the risk-benefit balance of more active management of chronic diseases. For example aggressive treatment to lower blood sugar is actually associated with more side effects without offering any benefit (172). A second study of a self-management program for chronic lung disease was stopped early due to excessive mortality. The authors suggest that the intervention could have had a detrimental change in patients' behaviour, for example by making patients less likely to seek help during exacerbations (170). Conversely, the WSD trial saw an increase in hospital admissions during the first few months of the trial in the control patients, perhaps because the trial processes had identified problems with which staff were not confident or experienced in managing without the additional telehealth systems with which they had been trained to use (173).

These unexpected outcomes highlights the limitations of using traditional randomised controlled trials to evaluate complex telehealth interventions (115). These trials did not provide the opportunity to explore these unexpected outcomes or understand why an intervention did not work as expected. It highlights the importance of developing a good understanding of the intervention, how it might be used and how it brings about change before embarking on a definitive clinical trial. It is also important not to assume that telehealth services will automatically have only positive outcomes and design trials that can identify problems that might be difficult to qualify using traditional methods, such as changes in behaviour or rare events.

### *2.6.2.3 Evaluating the mechanisms and outcomes of telehealth using traditional clinical trials*

To justify the cost, the impact on service redesign and burden on service users, it remains important to demonstrate that telehealth offers some clinical benefit. Many of the numerous trials of telehealth have failed to demonstrate clinically significant benefits. Most failed to gain an understanding of the potential mechanisms that could bring about change or how these findings apply to “real life” services in which these technologies would be used. They also failed to explain why the observed outcomes have occurred. This is, in part, due to the evaluation methods adopted and the challenges of using traditional evaluation methods to evaluate such complex services involving patient engagement and self-management where the mechanisms of action and the context in which these occur may not yet be fully understood (174).

The majority of telehealth trials used the randomised controlled trial (RCT) methods. Traditional RCTs are reductionist: their aim is to determine whether, when keeping all other factors the same, a single factor can bring about an impact. They fail to take into account the real-world circumstances in which the intervention is embedded and cannot take into account the other complex and changing factors that can influence outcomes. This means their results are unlikely to be applicable if the telehealth service were changed or used in a different setting.

The studies identified in this chapter highlight many of problems encountered when using traditional models to evaluate telehealth in a “real-life” environment. For example, whilst the WSD did include patients in different settings, the three services in which the telehealth was embedded were unlikely to reflect all the varied and changing service environments in the NHS. In addition, even if all other variables were similar, it’s not clear which component parts of this service were vital to bring about change and how these could be reliably reproduced. Given the complexities of the interventions and the services they delivered, it is hardly surprising that the common outcome measures used in traditional RCTs (such as survival, hospital admission rates) were not sufficiently comprehensive to capture the full impact of the interventions. For example, telehealth may improve patient confidence, self-efficacy and ability to self manage or reduce carer stress. Reduction in hospital attendances or home visits may increase the productiveness of patients and carers or improve the quality of family life. These outcomes are rarely captured in traditional trials.

It is also difficult for trials to reflect the rapid developments in technology and clinical services. The WSD started in 2008 and outcomes were finally published in 2012/2013. In 2008 the WSD technology was very basic with only limited functions, meaning staff and patient experience and engagement was poor (175). This had a negative effect on recruitment and the use of the intervention. In the nine years since the trial commenced, the use of devices, device functionality, accessibility and affordability of devices has changed dramatically. These changes render the WSD technology (and thus the trial results) obsolete. To avoid this, future studies should ideally be shorter, use up to date technology and aim to gain an understanding of how future changes might affect their conclusions.

### **2.6.3 Developing and implementing telehealth**

Adoption of technology-enabled care has increased over the last decade in the UK. However, despite a clear need for service improvement such as extensive investment in testing and delivery the uptake of technology-enabled care is limited (176).

The studies described in this review have identified various barriers and incentives including barriers associated with the service users, clinical staff, service, commissioning and funding.

#### **2.6.3.1 Service user factors**

In order to be successful, a service must be acceptance and accessible in order for service users to engage with the technology and the service. Qualitative research of telehealth projects suggests that successful implementation of telehealth depends on whether the intervention can be well integrated into everyday life and health care routines (128). Success also requires services to promote relationships between professionals and users and engage and empower users. Ways in which this can be achieved include by delivering positive feedback, promoting interaction between users and staff, delivering improvements in knowledge and reinforcing positive behaviour change. Without these services are likely to remain unacceptable to all users. This was evident in the WSD trial. After the trial interviews with 22 patients who declined to participate or withdrew from the study were conducted to identify barriers to telehealth (175). Some patients were unwilling to change the way they self-manage and receive care. Some perceived the WSD to represent a potential threat to their identity as they saw their experience of ageing and self-reliance as positive experiences and worried that interventions could undermine their ability to self-care and cope. They also highly valued their existing service and were reluctant to risk changing to a new team (175). In addition, a major barrier

was the perceived technical competence required to use the equipment. Patients were concerned that special skills were needed to operate equipment and were worried about installing unfamiliar equipment in their homes. The staff tasked with recruiting to the trial did not correct these misperceptions. These staff also knew little about the technology and in some cases they were only able to provide pictures of the equipment. Even though public skills and confidence has improved over the last few years, this barrier is still posing problems to recruitment in telehealth trials (177).

Along with these barriers faced by patients with all conditions, patients with MND may find technology particularly difficult given many are elderly, severely disabled or have language or cognition problems. However, evidence suggests that some patients with MND and their carers already use the technology for self-management through self-diagnosis, education and social networking within the MND community (178-181). Some monitor their own progress and compare their disease and treatment to others using websites like PatientsLikeMe (180,182). In the wider population there also seems support for digital healthcare technology: a recent survey of 2,004 adults suggested that 47% are already willing to be diagnosed digitally instead of face-to-face with their GP (183). Exposure to computers and training for those who are less likely to use technology (such as older adults and those with disabilities) is improving attitudes towards technology (184-186) and internet and computer use in the over 65s in the UK is rapidly increasing from 6% in 2006 to 42% in 2014 (186). It is not clear however, whether patients with MND who mainly use technology for leisure will be willing to use it to access healthcare services where physical barriers, security and confidentiality may pose concerns. These potential barriers aspects merit further evaluation as part of any process evaluation of telehealth.

### ***2.6.3.2 Clinical staff factors***

Technology-enabled care involves a dramatic shift in the way in which staff interact with service users, how they develop relationships, obtain information and how they make assessments and decisions (176). The success of telehealth will therefore also depend on the clinical staff acceptance and engagement (128). Since the WSD was published other studies have explored these factors. A pilot trial of telehealth also identified many important barriers in both evaluation and implementation (187). Like the WSD, this trial was also hampered by slow recruitment rates and this also mainly due to factors related to staffing. Staff “buy-in” was felt to be a problem but the reasons for this included an unanticipated reduction in these staff, high staff turnover and poor funding of the



research. The study relied on existing clinical staff for most aspects of the trial meaning there was not adequate time for staff to recruit, deliver the intervention or collect data. Another study explored staff experiences finding that attitudes could range from resistance to enthusiasm, with varied opinions about the motives for investing in telehealth and the potential impact on professionals roles (188). Staff identified issues such as difficulties with the set-up, reliability and flexibility of the technology and services into which they were embedded leading to demoralisation. Conversely, success was seen when early positive experiences and achievements were shared with its staff. This was felt to be a key enabler to staff acceptance and encouraged further recruitment of patients to the service. As telehealth services often involve multiple healthcare professionals, “local champions” were also identified as having a positive influence on staff engagement and service adoption (189). Their roles helped increase awareness, highlight success and tackle problems as well as to help secure future funding for the services. These studies highlight the need for reliable and flexible technology, dedicated resources for telehealth and work to overcome early barriers to acceptance, along with appropriately trained and engaged staff working within a partnership approach in order to successfully develop and implement new services.

#### ***2.6.3.3 Service and commissioning factors***

As these studies have demonstrated, the success of telehealth will, in part depend on the technology and how it is implemented and used within the service. Leadership will be required to address the barriers highlighted in this chapter to ensure both top-down and bottom-up stakeholder buy-in. There must be financial investment in infrastructure, training and service redesign. Although it is now recommended that technology “*should be routinely considered in the design and commissioning of any care pathway*” it is unclear how many patients are current using the services or what the costs are (124). Learning from 3 Million Lives and the WSD suggested the need for further development and testing whilst other schemes such as the NHS Digital Technology scheme and Technology Enabled Care Services aim to promote the commissioning of telehealth, telemedicine and wider digital services (such as electronic communications or health record) (190). Case studies, resources and toolkits have been developed (e.g. (191)) to help services plan and implement technology-enabled care. However, despite the drive to adopt technology, a survey of acute trusts suggested that only a minority already have systems in place for telehealth. Whilst 108 out of 176 clinical commissioning groups have commissioned some technology services, spending £15.2 million in 2013/14 (192), these figures seem small given the number of patients with chronic diseases in the UK. This suggests

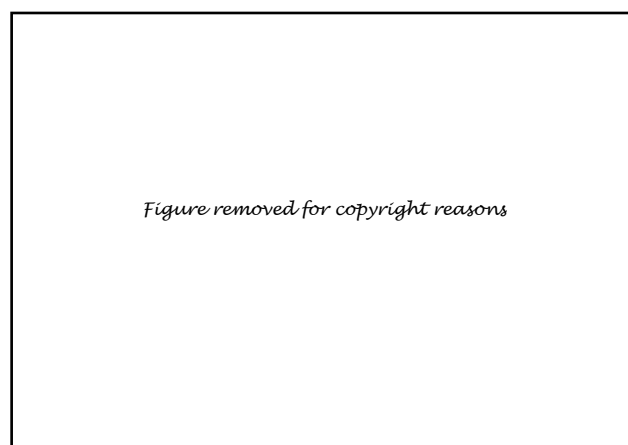


there is a way to go before these technologies are commonplace in the NHS and much work is needed to make technology-enabled care an effective part of usual medical care.

#### 2.6.4 Methods for future development and evaluation of telehealth

A telehealth service is a complex intervention because it has a number of interacting components which can act both independently and inter-dependently (for example the system itself, the existing healthcare service) (193). Success also depends on the behaviours of those delivering the intervention (for example the clinical MND team) and those receiving the intervention (e.g. the patients and carers) (193). The Medical Research Council (MRC) has developed a framework for the development and evaluation of complex interventions (193). It recommends that a development and evaluation of complex interventions should follow an iterative process rather than the traditional phased-model, better suited to trials of pharmaceutical agents (Figure 2.1). There may be several cycles of development, testing, evaluation and implementation in order to deliver success.

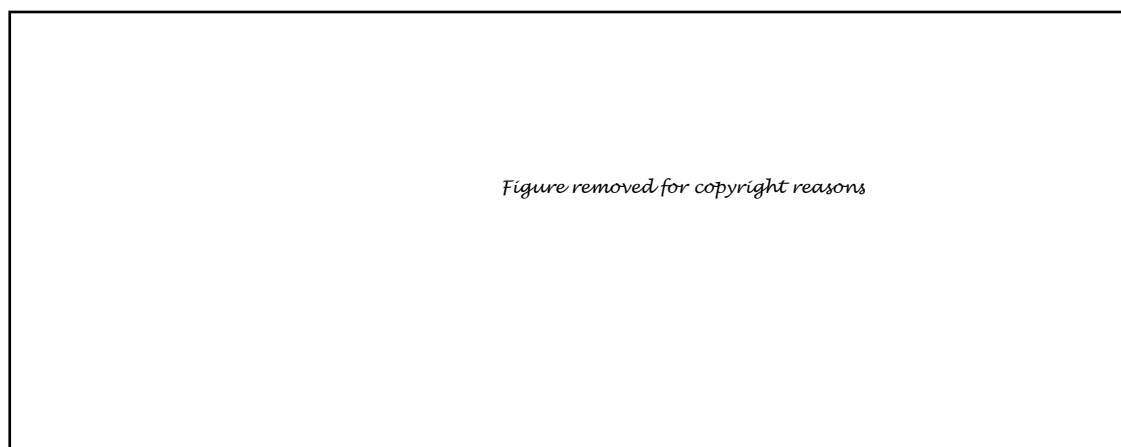
Figure 2.1 The MRC's recommended process for developing and evaluating complex interventions. Adapted with permission from BMJ Publishing group. © Craig, P. et al (2008). *BMJ (Clinical Research Ed.*



Development of telehealth should apply the recommendations of MRC framework in order to understand and address the barriers to success identified in this chapter (193). Early stages should look to explore the theory around how and why telehealth services may work in MND care as well as the value and impact of these technologies prior to any definitive trial. This may involve examining he current literature, guidelines, best and current practice (such as that described in this and the previous chapter). It may also involve research to explore the attitudes and experience of potential users of telehealth (both patients/carers and staff) in order to identify how, why and in what context these services may work. These results should feed into the development of telehealth interventions but consideration should also be given to how the service may be best evaluated in the clinical setting.

The MRC framework recognises the need to develop the theory that underpins the intervention in order to answer some of the uncertainties like those faced in WSD. It recommends time should be spent piloting and testing the feasibility of the methods of evaluation in order to identify and overcome some of the challenges in recruitment, adoption of the intervention and evaluation. Understanding how the intervention may work in “real-life” will also help predict and address the challenges of implementation. A more detailed “process evaluation” may be required to assess the *“fidelity and quality of implementation, clarify causal mechanisms and identify contextual factors associated with variation in outcomes”* (194) (Figure 2.2). Information gathered in a process evaluation would help translate the key aspects of the intervention into a clinical service.

Figure 2.2 Recommended steps in a complex intervention process evaluation.<sup>3</sup>



In order to conduct a process evaluation, alternatives to the traditional RCTs are required: these need to gain a deeper understanding of the intervention when it is used in *real life*, how it is used, the mechanisms of impact and context in which these occur. Examples of methods that may be more applicable to telehealth interventions include realist evaluation methods which aim to explore mechanisms and outcomes within the context of “real-life” in order to understand what works, for whom, under what circumstances (195). Mixed methods comparative or observational trial designs may be more useful as they can be used to both measure and explore mechanisms in detail in order to capture overall effects, and can employ realist methods in order to consider which intervention activities work, and in what context, whilst also developing and validating theory (196). Whichever methods are used, prior to a definitive trial, pilot and feasibility studies are recommended by the MRC framework to understand more

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<sup>3</sup> Reproduced with permission from BMJ Publishing group. © Moore, GF et al. (2015). *BMJ (Clinical Research Ed)*.

about the how a definitive study should be undertaken but also to understand more about how the key aspects of the intervention will be delivered and assessed (115,193). Following a successful definitive study, longer term testing may also be required to understand how the intervention is implemented in the wider health service with further evaluations planned to explore longer term impacts of the service.

## **2.7 Conclusion**

There is currently limited evidence to recommend the use of technology-enabled care in the care of patients with MND. However, current evidence suggests that these technologies could be valuable if the challenges to development, evaluation and implementation are addressed. Based on these findings, Chapter Three will describe how the TiM telehealth was developed and Chapter Four will describe the evaluation methods used in this project.

## Chapter Three

### The TiM system

#### 3.1 Introduction

The “TiM” (Telehealth In Motor neurone disease) is a software system that was developed to improve access to the specialist care the MND service offers. The TiM system consists of a piece of software used on a tablet computer or mobile device into which patients and carers enter information about their condition on weekly basis (referred to as the Patient App). This information is then sent and displayed on a secure website that is accessed by the MND team (referred to as the Clinical Portal). This chapter will describe the development of the TiM system.

#### 3.2 The aims of the TiM system

The TiM system was developed as a tool to increase the involvement of specialist clinicians in the day-to-day management of patients with MND and make care more patient-centred and make it more responsive to patients’ and carers’ needs. The need for better access to specialist MND care for both patients and carers was a research priority identified by the patient and public involvement group, the Sheffield MND Research Advisory Group (SMND RAG). This research priority also concurred with the limitations of the current service model and unmet needs of patients and carers described in previous chapters.

It was proposed that TiM system could:

- Enable frequent monitoring of patients and carers in order to identify and treat complications in a timely fashion;
- Provide a source of education and communication to promote self-management;
- Allow the MND team to use the information to prioritise clinic appointments;
- Provide access to the MND multidisciplinary team for patients and carers who are unable to attend clinic;
- Reduce health resource use, in particular, unnecessary clinic visits and avoidable emergency hospital admissions.

### **3.3 Initial development of the TiM system**

The development was based on guidelines from the Medical Research Council framework for complex interventions (115). As discussed in Chapter Two, a telehealth system is defined as a complex intervention because it has a number of interacting components and its success depends on the behaviours of those delivering and receiving the intervention. Furthermore, use of telehealth depends on the service in which it is used and in the UK, the way in which MND services deliver care does vary.

The development phase aimed to identify existing evidence, define the requirements for and develop an intervention and to perform some initial testing. Chapters Four to Six describe piloting and evaluation of the feasibility of the TiM within a clinical trial. During the trial further potential improvements were identified and further development work was undertaken. A second version of TiM system was launched 12 months after the trial started. This allowed six months where the improved system could be used and further evaluated.

#### **3.3.1 Parties involved in the development**

The content and proposed use of the TiM, the look and feel of the software and the Clinical Portal on which information about the patient is displayed was developed by Esther Hobson (EH), with advice from members of the Sheffield MND clinical and research team in collaboration with telehealth companies. Initial development was supported by Cogent Healthcare Systems but this company went into receivership so Abbott Healthcare Products Ltd took over this role in March 2014 and later this section of the business was moved to another pharmaceutical company: Mylan. Abbott/Mylan provided guidance about telehealth processes, provided the software and infrastructure to receive, store and display the information on the Clinical Portal as well as providing the Samsung Galaxy tablets and mobile data packages. However, they had no involvement in the trial methods, conduct or analysis. Advice was also received from Device for Dignity (Sheffield Teaching Hospitals NHS Trust) and the Telehealth and Care Technologies theme of Yorkshire and Humber NIHR Collaboration for Leadership in Applied Health Research and Care.

Some of the development was conducted prior to the commencement of this PhD (developing the broad aims of the TiM, the questions, many of the clinical algorithms) however further work with the software developer (including developing the final look and feel of the software, refining and testing the

algorithms, and determining how it would be used) was conducted during the PhD and further developments made during the clinical trial are also described.

### **3.3.2 Defining the intervention: Identifying the scope of the TiM system**

As outlined in the Chapter One, the important aspects of the specialist MDT, and the mechanisms by which it improves survival remain unclear. Chapter Two explained that the use of this type of telehealth in this population has not been explored and therefore the aim of the initial scoping work was to identify some of patients' and carers' needs, experiences and expectations of MND care along with their attitudes to technology and towards potential telehealth models. Therefore, initial development aimed to develop a better understanding of what the requirements were for a specialist service and how telehealth could be used to deliver them. It also aimed to understand how the intervention could vary depending on the individuals receiving or delivering the intervention. Once a basic version of the TiM system was developed, it also explored the feasibility of using the system from the perspectives of both patients and clinicians.

### **3.3.3 Stakeholder consultation**

Informal consultations were conducted with patients, carers, ex-carers and volunteers:

- User-centred co-design focus groups (see below);
- A Patient and Public Involvement Group: the Sheffield MND Research Advisory Group (three meetings were attended) where the TiM design and research methods were presented and feedback received from patients, carers, ex-carers and volunteers;
- The South Yorkshire MND Association branch meetings (two meetings were attended) where the TiM proposal was presented and feedback received from patients, carers, ex-carers and volunteers;
- One patient and carer underwent an in-depth, semi-structured interview establishing their experiences of unmet care needs;
- Five patients with upper limb weakness were observed using the Patient App and gave feedback on the accessibility and acceptability of the questions.

Healthcare professionals were consulted:

- Two specialist MND consultants and four specialist MND nurses/therapists based in SITraN reviewed the TiM questions;
- One specialist MND occupational therapist based in the community who was interviewed about her experience of the unmet needs in MND care in her area;
- One MND Association home visitor and one Motor Neurone Disease Association care coordinator who reviewed the TiM design and research proposal and provided feedback.

Literature reviews were conducted and updated throughout the PhD. These informed the aims, scope and functions of the TiM system. These were:

- The clinical features of MND, management (25), and unmet needs of patients and carers (Chapter One);
- The use of, and potential value of telehealth in MND (123) (Chapter Two);
- The attitudes towards digital technology of patients and carers (197) (Chapter Seven)
- The evidence underpinning technology enabled care (Chapter Two).

### **3.3.4 User-centred co-design**

Service design has moved from considering users as “subjects” to involving users as “partners”. The TiM project recognised understanding the needs of all those involved in MND care in order for the service to be successful. Therefore, a user-centred design approach was adopted to develop the patient and carer software. User-centred design is an approach for developing products that involves end-users throughout the development process allowing users to influence the design in order ensure that the product meets users’ needs (198). Users can offer their experience and unique perspectives and preferences to ensure the focus remains on the end-user and improve the success of the product but there is also a moral argument that those who are ultimately likely to be affected by something have the right to have a say in what that outcome will be (199). Co-design has been increasingly used in health service development to make products and services more patient-centred and user friendly (for example (200-202)). Patients, carers, volunteers and healthcare professionals have already been involved in co-design projects using their experiences of MND to develop solutions to problems they themselves identified. These include the Sheffield Support Snood (a more acceptable and effective replacement for traditional neck collars (203)) and educational websites aimed at patients and carers responding to their identified need for more information about gastrostomy and NIV(129).

Two focus groups employing user-centred design techniques were conducted in November 2012, funded by a grant from the National Institute for Health Research, Research Design Service (Yorkshire and Humber). In line with INVOLV guidelines, ethical approval was not for these patient and public involvement sessions as the participants were acting as specialist advisors to inform the priorities, planning and design of the research rather than acting as subjects themselves (204).

The two focus groups were facilitated by EH with support from a member of Cogent Healthcare and a facilitator from the Sheffield Hallam University, both of whom had experience of user-centred design. Participants were recruited via the South Yorkshire MND Association, the SMND RAG and through the MND clinic and consisted of three patients, six carers or ex-carers and an MND specialist nurse (Chair of the Sheffield Research Advisory Group).

The focus group meetings were held at SITraN. Written consent from participants was obtained. Whilst formal analysis was not conducted, the groups were audio-recorded and relevant themes were identified and fed back to the TiM development team. An introductory/ice breaker session established the group rules and allowed members of the group to become familiar with each other and understand the aim of the session. Participants introduced themselves and were provided with puzzles to complete together. Following this, an exercise exploring the experiences of a patient and carer journey to specialist MND clinic was conducted (See Figure 3.1). Participants were provided with pictures and captions describing the different stages of a clinic visit (from receiving the appointment letter to returning home after the visit). They were asked to order the pictures and captions, and this prompted them to identify their experiences, emotions and difficulties at each stage of this journey. Example patient vignettes allowed participants to consider the experiences of other patients or carers. Notes were made on Post-Its by the facilitators and placed on the table. This allowed participants to describe their experiences of MDT care, the pros and cons of specialist MND services and non-specialist community services.

The concept of telehealth was introduced to the groups and a round-robin game asked participants to describe how they would use a tablet computer in their daily life. This allowed participants to discuss their attitudes towards technology and how MND affected their use of technology. Following this, the participants took a hands-on trial of the first version of the TiM patient/carer software using a click dummy (a partly interactive prototype of the application), loaded onto a



Samsung Galaxy tablet computer. This was created by the software developers in Hypertext Mark-up Language (HTML). Observing participants using the click dummy allowed the facilitators to assess the ease of use of the tablet, participants' reactions to the system and the questions and the way in which they were presented. Patients with poor hand function were videoed to observe how they used the touch screen device. The acceptability of a clinical trial was also discussed. Participants described their experiences in previous trials, the acceptability of the trial methods and outcome measures.

### **3.3.5 Outcomes of the stakeholder consultation**

Participants in the focus groups felt that using technology and, in particular telehealth to access the MND service could be acceptable. They also felt it was acceptable for the MND team to monitor the wellbeing of carers as well as patients. The TiM questions were felt to offer an acceptable and thorough assessment of the impact of MND on patients and carers. It also established that those with significant upper limb weakness or fatigue could use the patient/carer software.

The consultation also identified aspects of the specialist MND services that were important to stakeholders and should therefore be considered when designing the TiM system. These included access to evidence-based treatments and trials, monitoring of progress and access to specialist information.

*"Without coming to clinic you are left in the dark" Patient, focus group*

The personal aspect of clinic was also important with patients valuing the ability to be able to talk to experts who could understand and solve their often-complex problems as well as provide empathy and reassurance.

*"It's nice to be told you're doing well" Patient, focus group*

Figure 3.1 The results of one user-centred design group activity that used pictures to explore a patients' journey to an MND clinic appointment.



The expert care received in clinic was contrasted with experiences of care provided by non-specialist community services (such as GPs or district nurses). Patients and carers felt community clinicians lacked the knowledge required to manage MND. This was particularly apparent for problems unique to neurological disease, where lack of expert knowledge resulted in difficulties such as delayed access to specialist equipment or poor management of specialist interventions such as gastrostomy tubes and NIV. Patients and carers also wanted more information and signposting to help them cope with the disease. This information was often lacking at important times, such as out of hours or when faced with an acute deterioration e.g. a chest infection. These difficulties were also identified by clinicians working in the community. They encountered problems with providing timely response to problems and highlighted the limits of their own expertise. They often identified problems with patients and needed support from the specialist MND team to resolve them.

Difficulties posed by the nature of the clinic-based service model were identified. These included the inflexible nature of clinic appointment schedules. These did not reflect the complexity and rapidly changing nature of the disease meaning delays in identification and treatment of problems occurred.

*"I waited so long for this special chair that by the time it arrived I had got worse and couldn't use it." Patient, focus group.*

Lack of rapid access to specialists meant some patients described delays identifying and treating problems such as chest infections, which often led to avoidable emergency hospital admissions. Patients and carers described difficulties travelling to clinic when they were in a frail condition. They also described anxieties around the time of their hospital appointment and worried about whether the clinic would identify milestones in their disease such as deteriorating respiratory function.

### 3.4 Developing the TiM questions and clinical algorithm

Work with clinicians established the set of questions and the clinical algorithm to identify the relevant problems and complications of MND and determine which could be assessed using telehealth.

Areas in which it was felt telehealth could be used to bring about improvements were those where self-reported measures were possible and interventions could improve the clinical condition and quality of life by more rapid access to treatment and monitoring. These included:

- Monitoring overall progression in disease using established functional rating scales and biomarkers which could identify deteriorations in the disease;
- Identification of serious complications which have an impact on patient survival and quality of life such as choking, falls, respiratory failure or chest infections;
- Identification of other MND related symptoms which have a negative impact on patient quality of life such as pain, excessive oro-pharyngeal secretions, carer strain or depression;
- Identifying problems with specialist equipment (gastrostomy and NIV);
- Identifying problems that could be resolved by signposting patients and carers to specialist services.

The scope of the TiM system was agreed by the MND clinical team with advice from the software developers. It was agreed that the TiM would not aim to assess urgent or emergency problems and would instead instruct patients to seek help through the usual channels. Instructions were added to the TiM system to reinforce this message. Patients and carers felt weekly sessions would be acceptable and clinicians felt this would provide sufficient information. Methods to promote adherence were considered. These included alarms on the app or clinician alerts should patients fail to adhere to the weekly sessions. Additional features were considered such as using different question sets depending on the patient's condition, or systems that allowed patients to request a call back from their nurse or to send messages. These additional features were felt to be outside the capabilities of the system in this iteration.

Telehealth systems commonly use physiological measures such as blood pressure and oxygen saturations. The only physiological measures recommended to monitor MND were a patient's weight and measures of respiratory function (such as forced vital capacity) (40,59). Early diagnosis and treatment of respiratory failure is associated with improved survival and National Institute for Health Research Guidelines

recommend that weight and respiratory function are monitored regularly (25,39). There is no one single measure of respiratory function that is used to identify respiratory failure. Instead, respiratory monitoring should involve a combination of assessment for symptoms of respiratory failure (such as sleep disturbance and orthopnoea) and the use of objective measures of respiratory function (39). Whilst daytime pulse oximetry is recommended as a screening tool, clinicians felt that this measure was insensitive to early neuromuscular respiratory failure and therefore it was felt it would be an unhelpful addition to a telehealth system. Forced or slow vital capacity and sniff nasal inspiratory pressures are recommended to measure respiratory muscle strength but these require specialist devices and use by experienced clinicians and an affordable home monitoring device was not available in 2014 (59). Therefore, it was decided that weight would be recorded where possible and patients would be asked about symptoms of respiratory failure in every session. As the weight scales used also provided a measure of balance (by recording the length of time it took for patients to become stable on the scales) this was also included.

The way in which the questions would be presented to patients was discussed extensively during stakeholder consultations. One concern was that patients would be distressed by seeing options describing the later stages of MND (such as being unable to swallow). One option explored showing patients only a limited number of options or allowing patients to skip through questions if they had not changed. Feedback from patients indicated that this was not such a problem as they were already aware of the implications of MND having seen other patients in e.g. clinic. Furthermore, presenting only a limited number of options to patients was thought to increase the likelihood of incorrect answers and also increased the number of questions in the TiM session significantly. Therefore, all the disease state options were presented and patients' reactions to these questions were explored during the trial.

### **3.5 Software development**

The iterative development allowed SITraN to produce a list of specifications and requirements which enabled Cogent Healthcare Systems, and later, Carematix, to develop the software. The initial informal consultations formed the basis of the initial questionnaire and structure of the TiM patient /carer software. This software was made in the form of an "app": a piece of software designed to be used on an Android tablet computer (referred to as the Patient App). The Patient App allowed patients and carers to enter data about themselves. SITraN developed the look-and-feel of the Patient App in collaboration with Cogent. Other telehealth systems were examined



which allowed the development of the Patient App, Clinical Portal and question design. Modifications to the Patient App were made following feedback from focus groups and other stakeholders. Further modifications to the Patient App were made by the second telehealth company (Carematix), based on the initial wireframe. The Patient App was then coded by Carematix and later beta tested (the second phase of software testing in which a sample of the intended audience tries the product out) by EH and a small number of patients. An online secure website (referred to as the Clinical Portal) was designed to be used by the clinicians to view the patient/carer answers. It was developed using an example of a pre-existing portal used by Cogent Healthcare Systems and adapted to meet the required specifications. These specifications were then used to develop a portal designed by Carematix in collaboration with Abbott. This was then beta tested by EH.

Minor amendments were made during the initial few months of the trial. Later, following feedback from those using the system, further work in collaboration between SITraN, Abbott (and later Mylan) and Carematix produced a second iteration of the Patient App (adding some additional questions), and an updated Clinical Portal. The details of these changes are found later in this chapter (3.7 Development of the TiM during the trial).

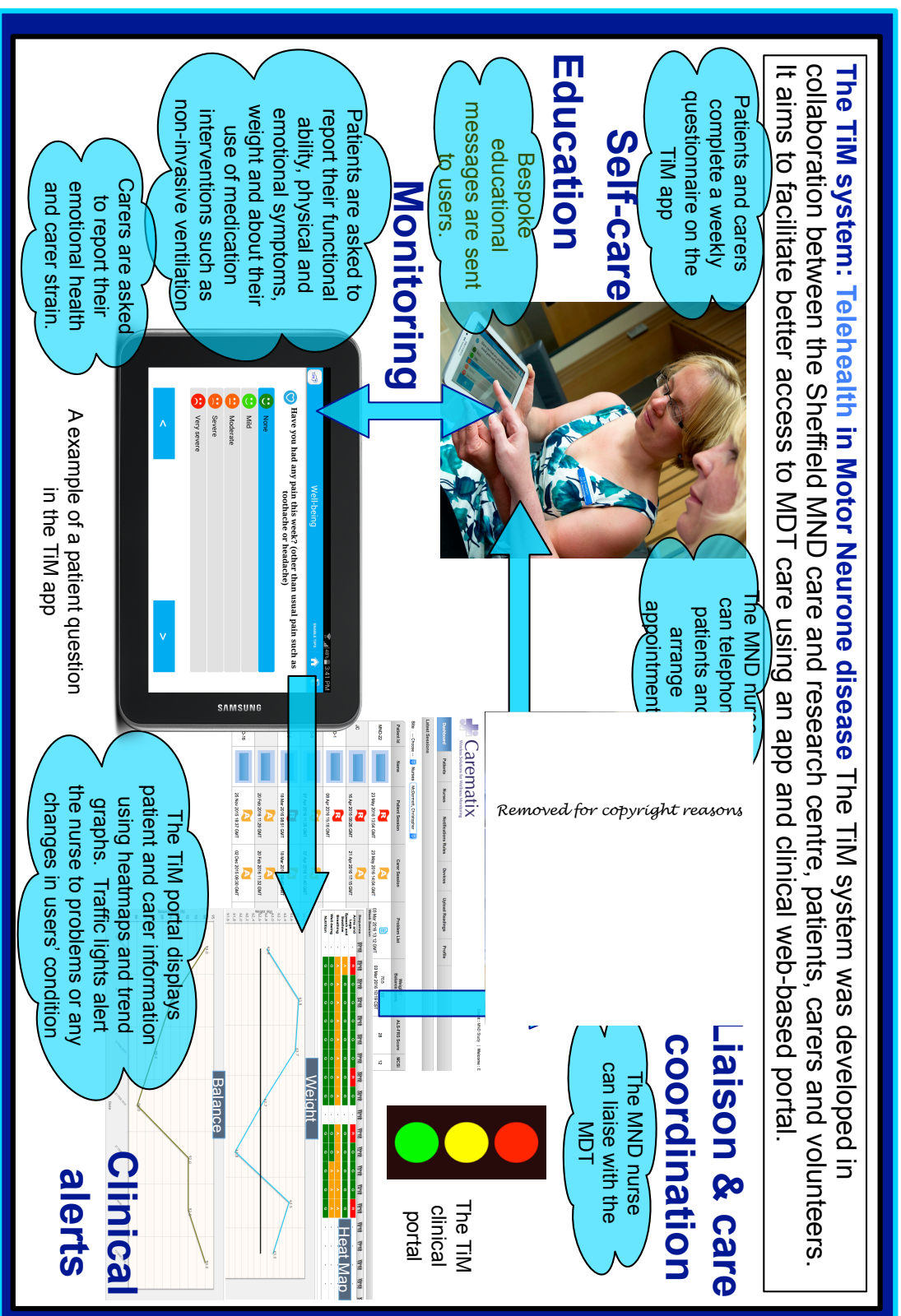
Abbott provided Samsung Galaxy Tab 3 tablets and the tablets were set up and tested by EH. This involved registering the tablet with the Clinical Portal, loading the Patient App, the additional patient information and adjusting the functions of the tablet to make it accessible and to discourage use of the tablet for activities unrelated to the trial e.g. browsing the internet.

## **3.6 The TiM system**

### **3.6.1 Overview of the TiM system**

The TiM system enabled patients and carers to complete a series of questions every week (Figure 3.2). The answers were sent to the Clinical Portal where they were automatically analysed using a pre-specified clinical algorithm in order to detect problems with the patient or carer. If problems are detected alerts are generated and displayed using a red-amber-green traffic light system. The Telehealth Nurse can review the answers and can contact the patient/carer if there is any concern or liaise with other members of the specialist MDT. The Telehealth Nurse was an experienced specialist nurse who worked in the Sheffield care and research centre.

Figure 3.2 An overview of the TiM system.



### 3.6.2 TiM Patient App

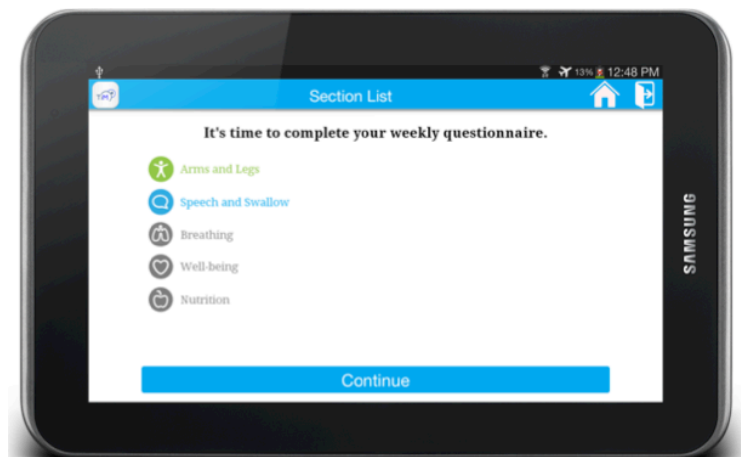
The TiM system consisted of an Android software application, installed on a 7 inch Samsung Galaxy Tab 3 (although it can be used on any Android device). The Patient App enabled patients and carers to login separately and complete a sequence of weekly questions. The TiM system also used Blipcare Wi-Fi-enabled weight scales to record the patient's weight. These scales also provided a measure of balance from 0-100 (no reference values are available). The answers were transmitted by 3G mobile internet or broadband to a web-based server, undergo automatic computational analysis and the results are displayed on a Clinical Portal (Figure 3.2). A pre-defined clinical algorithm assigned each answer an alert level (green, amber, red). Some of the questions closely match validated scoring scales (e.g. the ALS Revised Functional Rating Score: ALS-FRS-R (205) and the depression and anxiety short screening tool: PHQ-4 (206,207)). The Clinical Portal displayed the scores for these questions.

The questions aimed to cover all aspects of MND (Figure 3.3). A number of the ALS-FRS-R questions had to be slightly shortened to fit onto the Patient App screen but were as close a possible to the validated self-administered version of the scale (208). Additional questions using the ALS-FRS-EX were added in response to patient feedback. These assess functional ability in patients who have severe disability where the ALS-FRS-R may not adequately measure change (for example the ability to control switches or the ability to direct one's own care) (209). Others have been designed for the TiM system and based on clinical questions such symptom scales (Figure 3.5) or multiple option answers to identify specific problems such as potential symptoms of respiratory failure (Figure 3.6). Carers were provided with their own log-in details. This presented them with different questions. These were a carer strain score (Modified Carer Strain Index (210)) which was licensed and modified with permission from the copyright owners and the PHQ-4 depression and anxiety screen.

The Patient App was designed to be used weekly but could be completed at any point in the week if issues arose. The questions were the same each week but differed depending on the patient's answer: for example, additional questions were added if patients used NIV or a gastrostomy or reported experiencing complications (Figure 3.6).



Figure 3.3 The TiM Patient App home page. The patient questions are split into five sections: “Arms and Legs”; “Speech and Swallow”; “Breathing”; “Well being” and “Nutrition”.



After answering all of the questions, patients were prompted to weigh themselves using Blipcare weighing scales. These scales were separately connected to the internet using Wi-Fi or Bluetooth. Patients and carers were given automatic feedback based on the alert flag generated by their answers (a Final Message). If their answers produced a green flag, the Final Message reassured the patient that the answers had generated no alert. If an amber flag was generated, the message stated that the MND team would review the answers and contact them within two weeks. If a red flag was generated the message stated that the MND team would contact them within three working days. However, during early testing it became clear that amber and red flags were generated much more frequently than was anticipated. Consultation with the Telehealth Nurse who would be using the system established that she would prefer to use her clinical judgment to determine her actions to an alert and this may not involve contacting the patient, for example, if she was not concerned or had made alternative arrangements (e.g. reviewing the patient in clinic). Therefore, this was explained to patients during training and they were advised to ignore the Final Message on the Patient App.

Figure 3.4 An example of a single-choice question from the TiM Patient App. This assessed the patient's walking. This is based on the questions adapted from the ALS-FRS-R. The answers graduate from top to bottom from normal to severe disability.

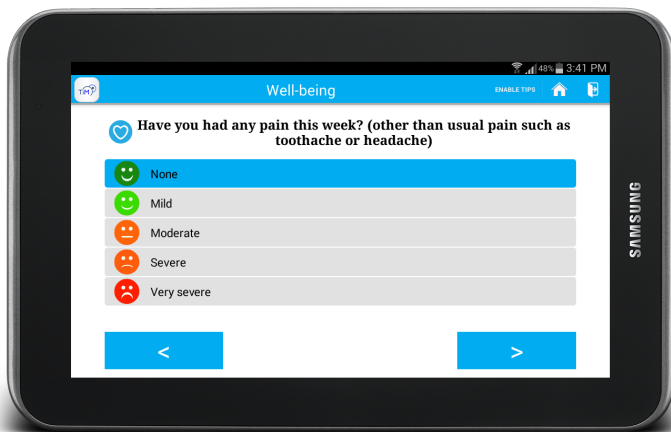
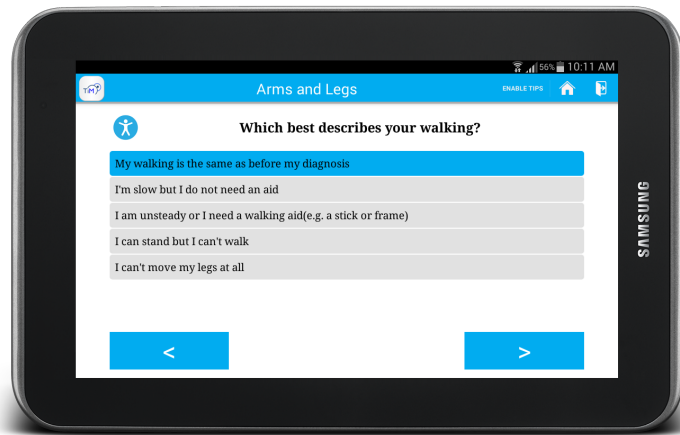
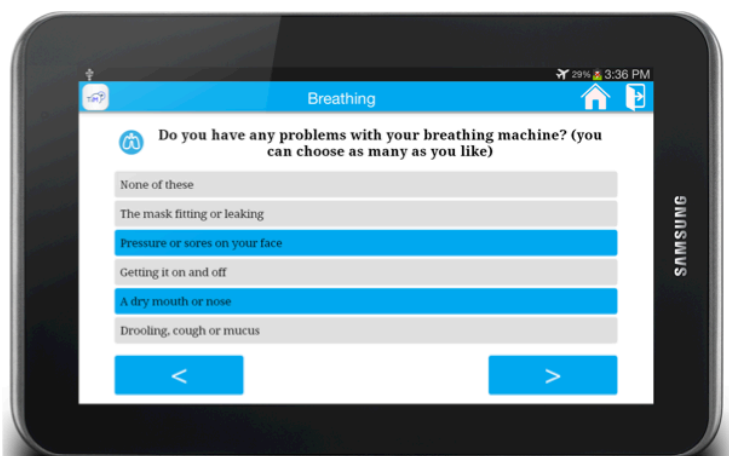


Figure 3.5 An example of a symptom severity question from the TiM Patient App. This assessed the severity of the patient's pain.

Figure 3.6 An example of a Patient App question where multiple answers were allowed.



### 3.6.3 The TiM Clinical Portal

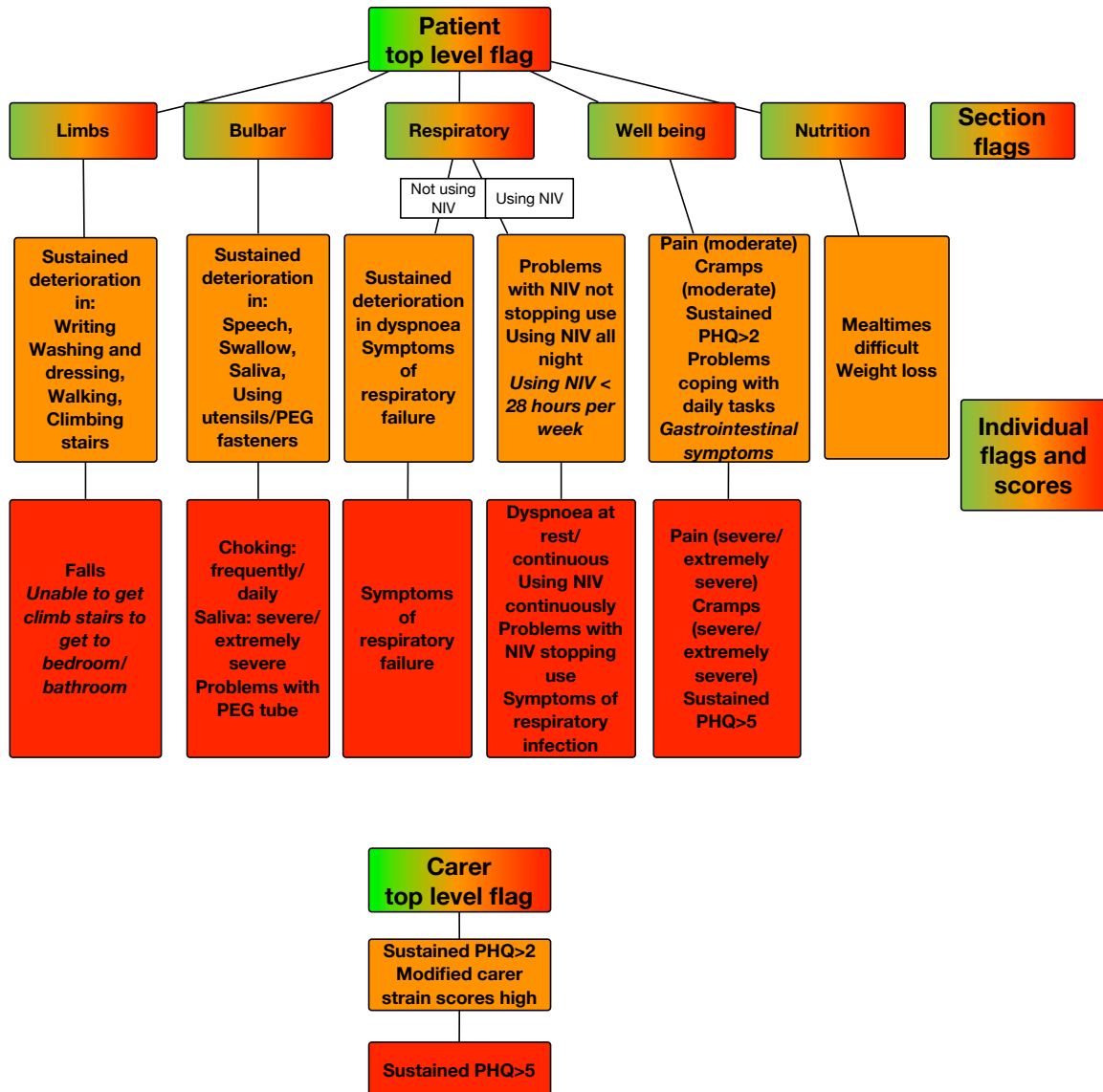
The Clinical Portal was a website which displays the answers and trends generated by the Patient App and was accessible to the MDT clinicians using a username and password. The answers undergo analysis and both individual answer and any alerts and scores were presented. The clinical alerts were determined during development based on the likely seriousness associated with an answer or the speed at which action would be expected to occur. Alerts were either red: serious, requiring action within three working days, amber: less serious, requiring action within two weeks, and green: no alert. Each patient session was assigned the following flags (see Figure 3.7):

- “Individual flags” for each question;
- “Section flags” indicating the most serious alert raised by individual flags in the section (“sections” were limbs, bulbar, respiratory, nutrition and wellbeing);
- “Top level” flag based on the most serious alert generated during the session.

Red alerts were raised for severe symptoms and serious complications whereas the amber alerts identified more minor problems or sustained progression in the disease. To avoid unnecessary alerts, minor problems would only be highlighted if they persisted for more than one session. Some answers were not associated with a flag because they were designed for information only (e.g. Do you use NIV?).

There were limits to the capabilities of the system because of the cost and time required for coding and development associated with any improvements. Negotiations with Mylan (who were funding the software development) and Carematix (who were developing the system) meant some changes could be made but it was accepted that not all would not be possible. This meant that some improvements were not incorporated (such as flags which alerted the team to a patient who had lost more than 25% of their baseline weight) and none of the questions added in the second version of the Patient App were associated with flags.

Figure 3.7 TiM system scoring algorithm. © Sheffield Institute for Translational Neurosciences, 2013. Items in italics were added in the second version of the system. Each question could generate a red, amber or green flag. Answers in the red shaded boxes indicate those answers that generated a red flag and answers in the amber shaded boxes indicate answers that generated an amber flag. A “Section flag” (the most serious flag of all the answers in that section) was generated for the patient then a patient or carer “top level flag” was generated which reports the most serious flag generated for the patient/carer’s whole session.



The Clinical Portal displayed each patient and carer answers. The front page (Figure 3.8) displayed a summary of every patient and carer assigned to that clinician. This included:

- The date of the most recent questionnaire;
- The patient and carer “Top level flag”
- The last Problem List completed (see Additional Features, below)
- Weight;
- Balance score;
- ALS-FRS score;
- Modified Carer Strain Index (MCSI) score;
- Action column (displays the number of alerts that have not been actioned by the clinician (not included in picture Figure 3.8)).

Following feedback during the trial, the second page (Figure 3.9) was added to allow the Telehealth Nurse to assess how the condition of each patient and carer had changed over time. This displays a Heatmap (a graphical representation of data where the individual section flags over the last six months are represented as colours) and graphs of ALS-FRS-R, weight (compared to baseline), balance score and modified carer strain index.

The individual patient page (Figure 3.10) displays:


- Each individual answer;
- The level of alert associated with each answer;
- Notes made by clinicians.

The “*Action*” column on the front page aimed to record a count of all alerts that were awaiting response by a clinician. Clinicians could save free text notes about each patient and carer. If a note was saved this cancelled this “*Action*” was cancelled. However an “*Action*” was generated each time any alert was generated. A patient or carer might generate several alerts in the same session (for example one in the bulbar section and one in the wellbeing section). If a clinician made a note it would not cancel every “*Action*” generated which meant many patients had a large number of un-cancelled actions. As a result, the clinicians using the TiM tended to ignore this column.

A further addition allowed the Telehealth Nurse to review the last five answers for individual questions and “pause” alerts for a number of weeks (Figure 3.11). This meant the answer would still be displayed but that flag would not contribute to the overall section or top-level flag.

Figure 3.8 The TiM Clinical Portal front page. The initial page for clinicians displaying the entire caseload and top level flags.






















Client : MND Study | Welcome : E


Wireless Solutions for Wellness Monitoring

Dashboard
Patients
Nurses
Notifications Rules
Devices
Upload Readings
Profile

Latest Sessions

Site
--- Choose ---
↓ Nurses
McDemott, Christopher
↓

Patient Id	Name	Patient Session	Carer Session	Problem List	Weight / Balance Score	ALS-FRS Score	MCSI
MND-22		 23 May 2016 13:54 GMT	 23 May 2016 14:04 GMT	 03 Mar 2016 13:12 GMT	70.5   92 03 Mar 2016 10:19 CST	28	12
JC		 16 Apr 2016 08:26 GMT	 21 Apr 2016 17:15 GMT	 13 Mar 2016 10:10 GMT	63   94 13 Mar 2016 10:14 CST	45	4
MND-1		 08 Apr 2016 15:18 GMT				20	-
MND-6		 07 Apr 2016 11:35 GMT	 07 Apr 2016 11:40 GMT		65.5	37	4
MND-5		 18 Mar 2016 08:51 GMT	 18 Mar 2016 09:40 GMT		116.7   44 02 May 2016 04:52 CST	32	6
26		 20 Feb 2016 11:29 GMT	 20 Feb 2016 11:32 GMT		61.1   52 01 Oct 2015 05:17 CST	20	20
MND-16		 25 Nov 2015 18:37 GMT	 02 Dec 2015 09:30 GMT	 19 Jan 2015 09:33 GMT	71.9   78 06 Apr 2016 02:18 CST	33	10

1 2 3 4 5 6 7 8 9 10

Telehealth in Motor Neurone Disease

Figure 3.9 The TiM Clinical Portal Heatmap.

Week Session																		
Sequence	Week 01'16	Week 02'16	Week 03'16	Week 04'16	Week 05'16	Week 06'16	Week 07'16	Week 08'16	Week 09'16	Week 10'16	Week 11'16	Week 12'16	Week 13'16	Week 14'16	Week 15'16	Week 16'16	Week 17'16	Week 18'16
Arms and Legs	-	R	G	G	G	G	G	R	G	-	R	G	G	G	R	-	-	-
Speech and Swallow	-	A	G	G	G	G	G	G	G	-	G	G	G	G	G	-	-	-
Breathing	-	A	A	A	A	A	A	A	A	-	A	A	A	A	A	-	-	-
Well-being	-	G	G	G	G	G	G	G	G	-	G	G	A	A	A	-	-	-
Nutrition	-	G	G	G	G	G	G	G	G	-	G	G	G	G	G	-	-	-

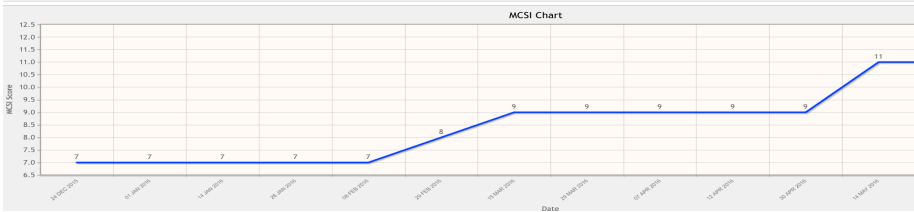
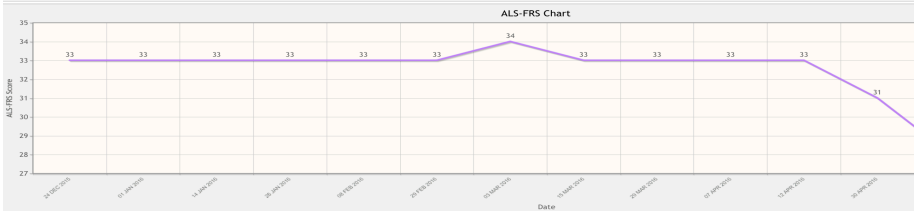
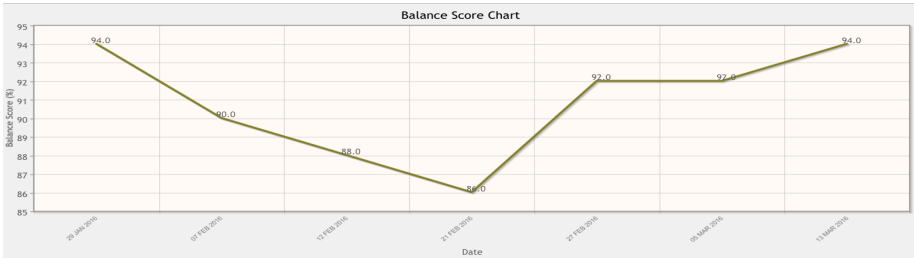
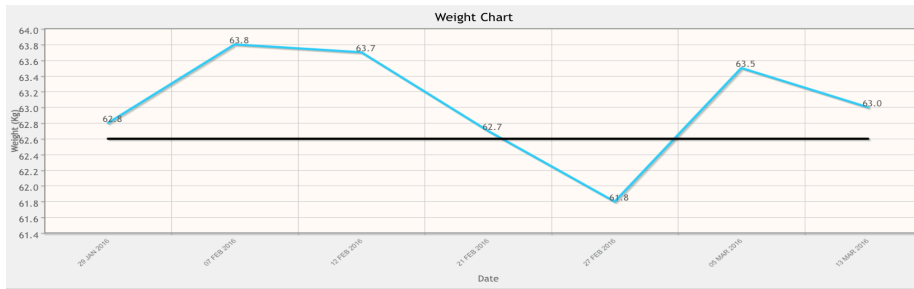


Figure 3.10 The TiM Clinical Portal individual patient page displaying one patient's answers to all the "Arms and Legs" questions. Circled are the top level flag (amber), the section flag (green) and individual answer flags (green).

The screenshot shows a web browser window with the URL `wellness.carematix.com`. The page is titled "Arms and Legs" and displays session details and a list of questions with their respective answers and flags.

**Session Details:**

- Session Id: 1000
- Flag: Top level flag (amber)
- Duration (Hr:Min): 0:2
- Week: December 2015, Week 3
- Submit Date: 16 Dec 2015 10:15 GMT
- ALS-FRS: 36
- Is PEG: No
- Is NIV: No

**Section Flag:** A green flag labeled "Section flag" is circled in red, pointing to the "Arms and Legs" section header.

**Arms and Legs Questions and Answers:**

Content	Response Text	Flag
Which best describes your walking?	I'm slow but I do not need an aid	Green
Which best describes how you get about in your home?	I have no problems	Green
Which best describes how you climb the stairs?	I can climb stairs or steps slowly	Green
Do you need to climb the stairs to get to the bedroom or bathroom?	No	Green
Have you tripped, fallen or come close to falling in the last week?	No	Green
Which best describes how you get around outside the house?	I have slight problems driving or getting in and out of the car	Green
Which best describes your writing?	My writing is the same as before my diagnosis	Green
Which best describes your ability to use your fingers on a computer, speech device, remote control, or environmental control?	I can press buttons or type, but at a reduced rate	Green
Do you currently use a computer?	I have no problems using a mouse or keyboard	Green
Which best describes your ability to move your head?	I have no problems. I can move my head in all directions without head support	Green
Which best describes your face expressions?	I, or others have noticed a change in my normal facial expression	Green
Which best describes your washing and dressing?	I wash and dress myself but it's harder than it used to be	Green
Which best describes how you transfer in and out of bed?	I have no problems	Green
Which best describes how you get comfortable in bed?	I'm a little clumsy but I do not need any help	Green

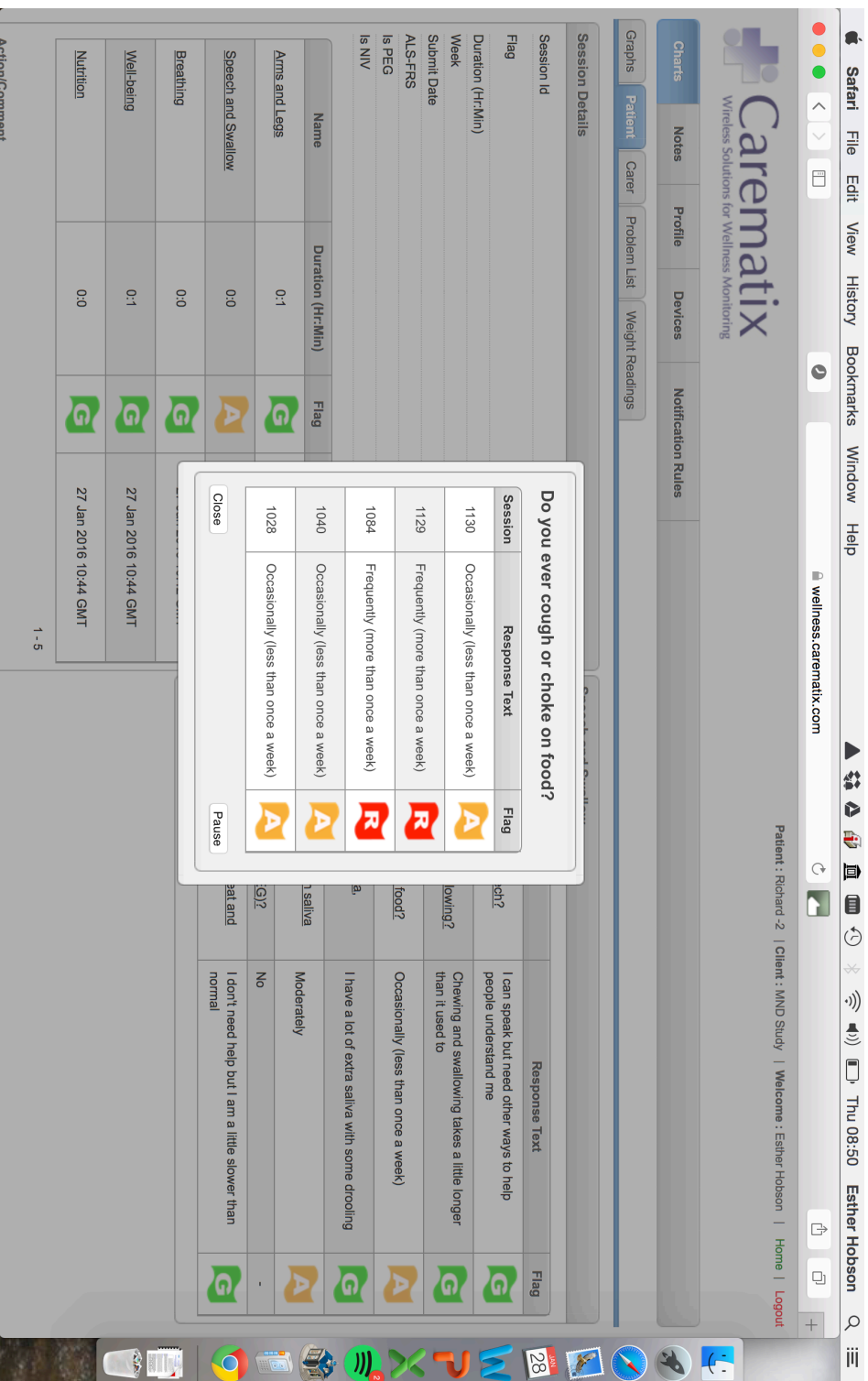
**Individual Answer Flag:** A green flag labeled "Individual answer flag" is circled in red, pointing to the green flag for the question "Have you tripped, fallen or come close to falling in the last week?".

**Top Level Flag:** An amber flag labeled "Top level flag" is circled in red, pointing to the amber flag in the session details.

**Action/Comment:** A text input field with a "Save" button is located at the bottom of the page.



Figure 3.11 The TiM Clinical Portal “pause” option. Alerts associated with individual answers can be paused by the MND team using the Clinical Portal.



#### **3.6.4 TiM system clinical team**

The Telehealth Nurse was responsible for logging into the Clinical Portal daily during the working week. She has over a decade of experience in MND and is the first point of call for the MND specialist care centre and runs a daytime telephone helpline. It is usual in an MND care centre to have at least one MND coordinator available by telephone who is commonly a nurse, but may be another professional such as a physiotherapist.

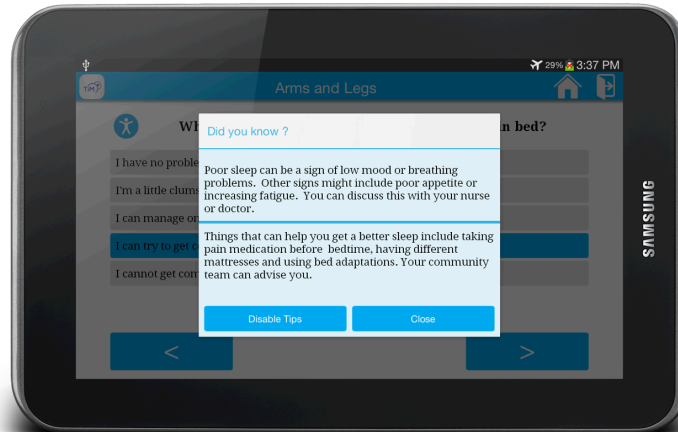
Should the Telehealth Nurse be alerted to problems, she could contact members of the hospital and community multidisciplinary teams including the consultant neurologist in charge of the patient. The majority of her work is not governed by specific protocols and other than regularly logging in and making notes on the system it was agreed that she would decide herself how to respond to alerts. It was agreed that she would respond to red alerts within two days and amber alerts within two weeks. This would involve contacting the patient or carer to gain more information, acknowledge the problem and take any necessary action. She could also liaise with other members of the MDT or arrange hospital appointments but could not prescribe medication or visit patients at home. No hospital appointments could be delayed and no clinical decisions could be made automatically using the TiM without contacting the patient or clinical team.

EH was responsible for setting up the TiM, training patients and staff and resolving technical problems with the TiM system. She also provided clinical care to a number of the participants, under the supervision of the consultant neurologist but the initial responsibility to react to alerts was with the Telehealth Nurse. When the Telehealth Nurse was on holiday she opted not to delegate this role to another member of the team so the TiM system was not monitored. The technology does allow patients to be assigned to different clinicians meaning more than one clinician could share a caseload.

#### **3.6.5 Addition features of the TiM system**

Interspersed between questions are information messages (Figure 3.12). The education was generic and focused mainly on explaining how symptoms could be managed and signposting patients to sources of support. These changed depending on which answer was selected. The messages appear when an answer was first selected but do not appear again until the answer changes. Patients could turn these messages off.

Figure 3.12 An example of an information message that appears between questions.



A “Problem list” was also part of the Patient App and enabled patients to make a list of issues they would like to discuss with their clinicians. This feature was suggested by the focus groups as an important way for patients to lead their consultations. The tablet also provide a link to the [www.myMND.org.uk](http://www.myMND.org.uk) website (which contains information about using NIV) and number of information booklets designed by EH and the MND Association (UK) loaded into an eBook reader application (Pocketbook) referred to as the “Knowledge Centre”.

### 3.6.7 Training and installation

The TiM was designed to be used with minimal training and the Patient App could be used on any Android device (including smart phones). Patients were provided with a tablet computer and face-to-face instructions were given to patients and carers along with written instructions explaining how to troubleshoot simple problems and access to a telephone helpline for further technical support. The tablet was connected to the internet using the tablet’s 3G mobile data service or using the patient’s own Wi-Fi broadband. Initially, the scales were connected to the internet using Bluetooth. However, this was found to be unreliable and instead the scales were connected to the patient’s Wi-Fi: this involved changing the settings on the scales. In order to do this, the scales needed to be connected to a computer. For those without broadband, an EE “Mifi” 3G wireless hotspot was provided which enabled both the tablet and the scales could connect to the internet.

EH installed the Patient App on each device and registered them with the Clinical Portal and also tested the Patient App and the tablet, which meant she was familiar with the device and software and could identify and resolve problems prior to the study starting.

EH attended the patient’s home to train the both patients and carers to use the Patient App. This allowed patients to be observed using the Patient App to identify potential difficulties with the software. The prevalence of cognitive impairment and difficulties with acceptance of the disease and

patients unconsciously or unconsciously minimising their problems means it was possible that the answers given may not be accurate. Patients, carers and EH could discuss the question and possible answers and EH could give guidance if the patient was not sure how to answer the questions. It also gave the opportunity for both EH and the carers to identify answers that they thought were inaccurate and resolve them. Patients were encouraged to make the final decisions and chose the answer that they thought most reflected their feelings but were also encouraged to take advice from their carers.

### **3.6.8 Security**

The Clinical Portal was stored on a secure web-based server hosted by Carematix (a US based telehealth company with medical device FDA510K approval for the software). Carematix have CE marks for all their software applications and clinical software and ISO27001 data security certification. Patient/carer answers were transferred to the server anonymously. The Clinical Portal recognises the individual number of tablet computer (IMEI) and serial numbers of the weight scales. During set-up these details were registered on the Clinical Portal and patients were identified using first name and initial and tablet number only. This meant no patient identifiable information was stored, in compliance with the Data Protection Act 1998. Access required two-factor identification and individual passwords ensure clinicians could only view their own patients' data and any notes made by clinicians are logged under their name. Carematix provided IT support, including user access and password services by email or telephone.

### **3.6.9 Intellectual property**

The research team developed approximately half the questions and the validated questionnaires were available to use without charge with the exception of the Modified Carer Strain Index for which a license was obtained to modify the questionnaire and use in the Patient App during the trial. Intellectual property was shared between SITraN and Mylan with SITraN holding the rights to the questions and clinical algorithm and Mylan holding the rights to the Patient App and Clinical Portal.

### 3.7 Development of the TiM during the trial

Following experience in the trial and feedback from users important improvements to the TiM was identified. It was agreed that changes to the Patient App and Clinical Portal could be made only once during the trial and only limited software changes were possible. Changes to the flag or score algorithms were not made. A second iteration of the TiM Patient App was developed and updates to the Clinical Portal were also developed. These were launched in October 2015 allowing the majority of patients to use the new Patient App for the final 4-5 months of the trial. As discussed early, developments were limited due to the time and cost associated with changing the system as well as the limitations of the platform on which the TiM system was run.

The Patient App was changed by:

- Adding additional questions:
  - Gastrointestinal symptoms;
  - Additional information about mobility;
  - Questions adapted from the ALS-FRS-EX scale which adds additional question to the ALS-FRS to capture changes in patients with severe disabilities (209);
- Free-text boxes to enable patients to type in additional information;
- The login screen was also changed following difficulties experienced by two participants.

More extensive amendments were made to the Clinical Portal. These included:

- The addition of a basic Heatmap front page for each patient (see Figure 3.9);
- A facility that allowed the Telehealth Nurse to “ pause” alerts which meant they no longer contributed to the top level flag (see Figure 3.11);
- Displaying balance scores and the modified carer strain score (see Figure 3.8).

Other improvements were felt to be outside the scope of this phase of the developments. These included ways to allow messages to be sent back to the patient/carers from the Telehealth Nurse or for patients to receive feedback about their scores.

### 3.8 Conclusion

This development phase produced a Patient App and Clinical Portal that could assess the important aspect of MND care that, if delivered successfully, could result in an improved MND service. The next step was to conduct an exploratory trial to understand whether and how the intervention would work within a real life setting.

## Chapter Four

### Methods. A randomised controlled pilot, feasibility study of the TiM system in clinical practice.

#### 4.1 Introduction

Chapter Four outlines the aims, objectives and rationale for the randomised control trial. It describes the methods and any changes to the protocol during the trial. Esther Hobson (EH) conducted all procedures unless otherwise stated.

The trial protocol, statistical analysis plan and an example patient information sheet, interview topic guides and patient questionnaire booklet are included in the Appendix D.

#### 4.2 Trial aims and objectives

The aims of the study were:

- To conduct a process evaluation of the TiM system;
- To conduct a pilot, feasibility randomised controlled trial of the TiM telehealth in patients with MND and their carers;

The process evaluation aimed to develop an understanding of:

- The key problems and benefits of the MND service and the mechanisms by which technology may bring about change;
- The acceptability of the TiM system to patients, carers and clinicians;
- The use and potential impacts of the telehealth on patients, carers, clinical staff and the MND services;
- Potential factors that may influence the success of the intervention.

The pilot trial aimed to determine the feasibility and acceptability of a larger, definite, multi-centre trial by examining factors such as:

- The potential recruitment and retention rates and factors that may influence these outcomes;
- Potential factors that may influence participation in a definitive study;
- A estimate of the variations in outcomes in order to provide a more accurate predictor of sample size;
- The feasibility and acceptability of outcome measurements;
- Whether the outcome measures reflect important aspects of life with MND and the impact of the TiM;
- The research and clinical staff requirements to conduct a trial.

#### 4.2.1 Justification of the pilot, mixed methods trial and process evaluation

As described in Chapter Two, many telehealth randomised controlled trials failed to detect any positive impacts or explain what happened during the trial or why the observed events occurred. One reason for this is because the TiM system is a complex intervention with multiple interacting components and multiple potential outcomes (115). A traditional RCT is usually seen as the “gold standard” way of measuring the important impacts of an intervention on outcomes such as survival cost and quality of life. However, for something as complex as telehealth, a traditional RCT will not, on its own, establish how, why and in what circumstances these outcomes occur. It would also fail to provide a deeper understanding on the intervention required to determine how the results of the clinical trial could be translated into wider practice (such as in different centres or for different patients) or what resources would be required and factors would influence its adoption and success.

Chapter Two identified uncertainties that warrant evaluation and these are best explored in a “real-life” situation by examining the processes occurring during use of the intervention. A process evaluation can be used to assess important aspects of an intervention that will influence its success and begin to develop a deeper understanding of what works and whether an intervention will work (194). A process evaluation examines how the intervention is implemented, identifies the potential mechanisms of the impact of the intervention and how context affects these two components (Figure 2.1, Section 2.6.4). In the case of the TiM system, it needs to understand what was delivered when using the TiM service, how and whether the TiM system was used as intended and why it was used in that way. This would also allow a clearer understanding of how the TiM service might work in real life/outside of a clinical trial. It aimed to capture aspects relating to both intervention fidelity (whether the TiM was used as intended) and dose (the quantity of intervention implemented). It used data collected automatically by the TiM (for example, adherence to the TiM weekly sessions, the activities of the Telehealth Nurse) along with user interviews and field notes describing the experiences, training and adaptations that were required during the trial. The trial did not aim to measure the impact of the TiM on clinical outcomes or compare the results to control participants but it did try to identify potential mechanisms of impact to identify how, and in what way the TiM might bring about change by exploring users’ response and experiences using the TiM system along with identifying any unexpected consequences of the TiM. It also aimed to identify contextual factors which might affect implementation, impact and outcomes and identify barriers and incentives to use and implementation such as user acceptability and accessibility of the TiM technology, the way in which care is delivered to both patients, carers and the healthcare team.

Whilst a process evaluation is an important part of developing the TiM, as discussed in Chapter Two, it was felt important to try to objectively measure the important impacts of an intervention such as survival, quality of life, cost



and healthcare resources in order to determine whether an intervention should be adopted into clinical practice. At the time the study started, an RCT was still felt to be the best way to determine this. As recommended by the MRC framework, a pilot and feasibility study was necessary prior to commencement of a definitive trial (193). A feasibility study asks whether and how a study could be done by collecting data which could determine factors such as sample size, the number of potentially eligible patients and the resources required to carry out the study (211). A pilot study provides the opportunity for aspects of a definitive study to be tried and optimised at small scale, prior to moving to a larger study (such as the procedures for recruitment, retention and randomisation) (211). In the case of the TiM, both of these were felt to be necessary and it was felt that the mixed methods adopted for a process evaluation could also be used to answer these questions by examining both quantitative outcomes (such as recruitment rates, outcome measure standard deviation etc.) but also explore in more detail participants' attitudes towards the research and identify barriers and incentives to a successful larger scale trial. These questions were particularly important in MND where barriers such as the small available pool of patients in the UK and the frailty of patients have historically made clinical trials challenging.

### **4.3 Trial funding and development of the trial protocol**

The trial protocol was developed in collaboration with the thesis supervisors as part of an Academic Clinical Fellowship in preparation for an NIHR doctoral research fellowship application (Appendix D). Ethical approval was gained from Leeds Bradford Research Ethics Committee (REC reference 14/YH/1068) and the sponsor (Sheffield Teaching Hospitals NHS Foundation Trust Clinical Research Office). The research was undertaken according to the CONSORT principles and Guidance on Good Clinical Practice based upon the rules and regulations by the International Conference on Harmonization (212,213). The trial was funded by the National Institute for Health Research doctoral research fellowship. A research collaboration with Abbott Healthcare (later transferred to Mylan) was developed (described in Chapter Three). A small research grant from the MND Association UK provided funding for Wi-Fi-enabled weighing scales and the software development to integrate the scales into the Clinical Portal. The funders did not influence the protocol, methods or results, with the exception of a requirement for the study team to report anonymised adverse events associated with Abbott pharmaceuticals to the company. Interim results were shared with funders during the study. Reports to Abbott/Mylan did enable their team to contribute to the development of the software, as described in Chapter Three.

#### **4.3.1 Patient and public involvement**

Patient and public involvement (PPI) was sought prior to and during the trial through the Sheffield Motor Neurone Disease Research Advisory Group (SMND RAG). The proposal was discussed at SMND RAG meetings and members reviewed the patient and carer information sheets, lay summary and self-completed questionnaires. Feedback was also gained during the



development work described in Chapter Three. One member of the SMND RAG also attended the Trial Management Group (TMG) and one member attended the Trial Steering Group.

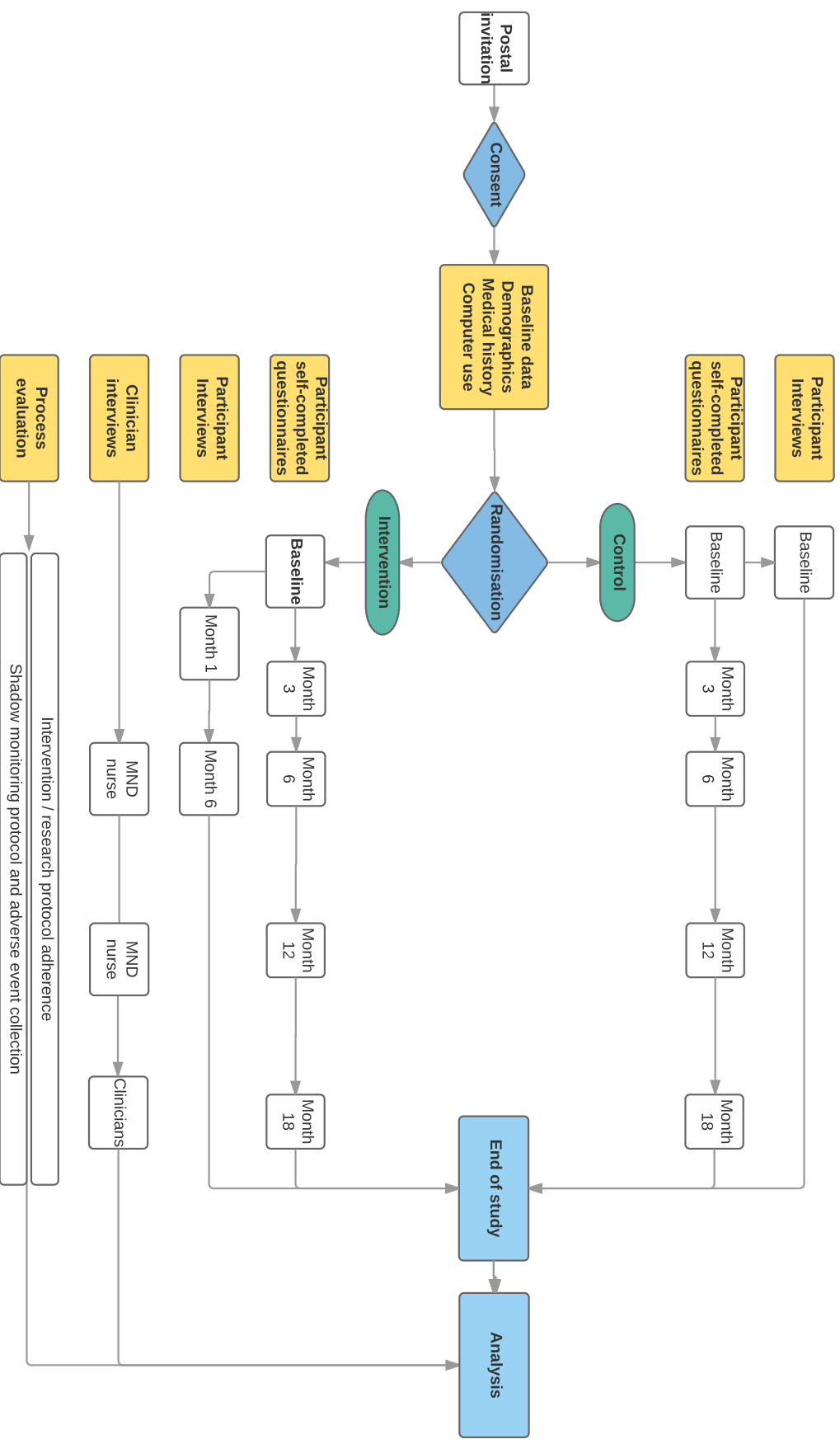
PPI feedback suggested that TiM system questions and the study methods were thorough and acceptable. One patient described the questionnaires as *“thorough, nice and quick and easy to use”*. Improvements to the wording on the lay summary, information sheets and questionnaire introduction booklets were suggested, for example, patients identified some questions that covered sensitive aspects of MND (such as swallowing problems) but patients felt it was important to include these questions. One carer felt that they may be unable to participate in the research at a time when the burden of their caring responsibilities was high but would have entered into the study and considered dropping out at a later stage.

As a result of this feedback, where possible, the participant information was improved. Participants were also given the opportunity to look at the TiM and self-completed questionnaires prior to consent to ensure they felt comfortable with participating. They were offered the opportunity to complete the initial questionnaire booklet at the recruitment visit in order to address any queries or concerns. The acceptability and burden of the TiM and the questionnaires became one focus of the qualitative sub-study.

#### **4.4 Trial procedures**

Figure 4.1 presents an overview of the trial.

Figure 4.1: The TiM trial flow chart



#### **4.4.1 Screening**

A list of patients with MND under the care of the Sheffield MND care and research clinic was created using the “ARC” database. This database collects data on all patients attending the Sheffield MND care centres as part of usual clinical care. A randomly generated sequence of numbers was produced using Microsoft Excel to determine the order in which patients were screened. A screening log was kept (212). Eventually all the eligible patients were exhausted so all new patients were invited.

#### **4.4.2 Recruitment**

Patients likely to meet the inclusion criteria were sent an invitation, including the Patient Information Sheet (Appendix D). The letter invited the patient to identify their main, informal carer, for whom a Carer Information Sheet was provided. A reply slip and return freepost envelope were provided. Postal invitations were selected to avoid overburdening patients in busy MND clinics and also in order to invite patients who could not attend clinic. If patients indicated that they were interested they were visited at home by EH to complete screening and recruitment.

##### **4.4.2.1 Inclusion criteria**

The initial inclusion criteria were:

- Patients aged 18 years or older;
- Receiving care from the Sheffield Motor Neurone Disorders Care and Research Centre;
- Living within 120 minutes of Sheffield;
- Patients with diagnosis of clinically definite or probable amyotrophic lateral sclerosis according to the El Escorial criteria.

Analysis of 200 patients in the ARC database (Table 4.1) was conducted. Patients were categorised at diagnosis and in some circumstances these categories were refined later in the condition. The database records the clinical diagnosis (ALS, PMA, PLS) based on the clinician’s impression at diagnosis. In those recorded to have ALS, an MND research nurse uses the Revised El Escorial Criteria (36) to categorise the patient using a standard operating procedure (214). There is some overlap in these categories and the clinician’s diagnosis is that recorded. For example, clinically suspected patients might refer those with only lower motor neurone signs where the clinician does not feel a diagnosis of PMA can be made. Categorising patients in this way suggests that the diagnostic criteria alone would exclude 58% of the patients, including all those with PMA and PLS, many of whom could benefit from more intensive MDT care (37). It also highlights the difficulties using a complex diagnostic system where a patient’s diagnosis may change over time meaning records may not be accurate without repeated and time consuming examinations by specialists.

p

Table 4.1: The most recent diagnosis in a selection of 200 patients.

Diagnosis	Number of patients (%)
ALS	
Clinically definite	27 (14%)
Clinically probable	56 (28%)
Clinically laboratory supported	38 (19%)
Clinically possible	27 (14%)
Clinically suspected	10 (5%)
Other diagnosis	
Primary Lateral Sclerosis	24 (12%)
Progressive Muscular Atrophy	12 (6%)
No data available	6 (3%)

In order to include all patients who may benefit from telehealth, an amendment was made to the protocol to extend the diagnosis to:

- Patients with amyotrophic lateral sclerosis with symptom onset within the last three years;

OR

- Any variant of MND (amyotrophic lateral sclerosis, progressive muscular atrophy or primary lateral sclerosis) with a progression in the condition as evidenced by a deterioration in the ALS functional rating score (ALSFRRS-R) by at least two points during the previous 18 months.

All those with ALS within three years of symptom onset were included as it was expected that the majority of these patients will experience progression of their disease during the study and therefore might benefit from more intensive MDT care. Patients with characteristics suggestive of a slower disease course (i.e. ALS with a longer disease course, or those with PLS or PMA) were also included if they demonstrated signs of progressive disease in the last two years. This was determined using the ALS-functional rating scale (ALS-FRRS-R (205)) where deterioration of two points in the ALS-FRRS-R represents a clinically significant progression. For example, progression of at least two points is noted when walking declines from normal to using an aid or when a patient commences non-invasive ventilation. This could be assessed using the ARC database, which collects ALS-FRRS-R scores as part of usual care. It would also be assessed by taking a brief history or by examining clinic letters. This may be more practical in centres where the ALS-FRRS-R is not commonly collected.

#### **4.4.2.2 Exclusion criteria:**

The exclusion criteria were:

- Patients attending another MND care centre in the UK;
- Patients unable to use the TiM system and were unwilling to permit their carer operating it on their behalf;
- Patients with any other major impairment that may affect their ability to consent or participate in the study;

- Patients with no form of telephone and/or internet communication.

The TiM system requires internet access and the tablets use 3G mobile internet. Initially, the study planned to exclude those without 3G mobile reception at home, however, initial visits established that participants in this situation were willing to use their own broadband internet to use the system and this change was adopted in the protocol.

#### **4.4.2.3 Carer inclusion criteria**

The patients were asked to identify an informal carer, defined as an adult who was the major provider of unpaid, informal care providing more than one hour per week of care. Carers were required to consent to allow information they provide during the trial to be shared with their own doctor in the event of serious clinical need.

Initially, to be eligible for the trial, patients were required to participate with a carer in order to maximise the data acquired during the study. The study protocol was later amended and submitted to the ethics committee as a major amendment in April 2015 to allow patients to participate without a carer (Appendix D). The first patient was recruited without a carer in May 2015.

#### **4.4.2.4 Carer exclusion criteria**

Carers were excluded if they had any major impairment that may affect their ability to consent, use the TiM system or participate in the study. Changing the inclusion criteria allowed patients to participate even if a carer was excluded.

#### **4.4.3 Consent**

Written consent (or witnessed verbal consent) was taken from both patient and carer. Those who declined participation were invited to give their reasons in order to identify common factors. Basic anonymised details of those invited were collected to inform the CONSORT flow chart.

#### **4.4.4 Randomisation**

Randomisation was performed using the website [www.sealedenvelope.com](http://www.sealedenvelope.com). This uses variable block (block size unknown) randomisation. Patients (and their carers) were allocated either to receive the TiM plus usual care (intervention) or to receive usual care (control) using 1:1 randomisation. Given the small sample size, minimisation was not employed.

#### **4.4.5 Sample size**

The study aimed to recruit a total of 40 patients plus up to 40 carers. Since the trial's aims were primarily to assess the acceptability of the intervention and the feasibility of a full trial, the sample size was not based on standard statistical parameters such as a clinically relevant difference between groups. Instead, the sample size was justified on the grounds of quantifying patient variance in the proposed outcome measures (in particular, quality of life measures) and on feasibility of a definitive trial. A sample size of 40 patients allows a standard deviation to be estimated to within a precision of  $\pm 20\%$  of its true underlying value with 90% confidence. This estimate could

then be synthesised with standard deviations observed in other published studies (e.g. (51,60,62,215,216)). This, combined with estimates of recruitment and retention figures, could provide a robust estimate of sample size for use in the sample size calculation for the full trial.

Given the rarity of MND, any definitive study would be infeasible if the required sample size is substantial. It was assumed that the upper limit for a feasible UK study is around 200-300 patients in total and a full study would need to be powered to detect a standardised effect size of at least 0.4 standard deviations. This trial would provide a preliminary assessment of whether the intervention might feasibly achieve this and inform the choice of outcome measures for the proposed full study.

Finally, the sample size is also in keeping with the suggestion that 12 evaluable patients per trial arm would provide sufficient data in a pilot study (after allowing for withdrawal or drop-out) (88,217).

## **4.6 Intervention**

The TiM telehealth was provided to all patients allocated to receive the intervention. The intervention is described in Chapter Three. All patients and carers were visited at home, shown the TiM system and completed the questions once prior to recruitment. Those randomised to the intervention arm were then trained how to use the Patient App. A written information leaflet about the TiM technology and an email and telephone support line were provided. If no sessions were received after two weeks, patients were contacted to ensure they were not having difficulties using the system.

## **4.7 Quantitative data collection**

### **4.7.1 Clinical outcomes**

Tables 4.2 and 4.3 describe the participant measures collected at each stage of the trial.

Baseline measures were completed at the recruitment visit. Follow-up data were collected at three and six months, 12 and 18 months using self-administered questionnaires. Appendix D provides an example of the patient questionnaire booklets. At baseline, participants could either complete the questionnaires during or after the recruitment visit. Follow-up questionnaires were sent by post. A pre-paid envelope was provided to return questionnaires. If participants did not return questionnaires they were reminded by telephone, email or in person a maximum of once although this was not always possible due to time constraints. These reminders was not recorded during the trial. In order to avoid potential bias, an independent research nurse was available to help participants complete the follow-up questionnaires. The instructions were amended in February 2015 (with ethical approval) to include an email address for the study nurse and the writing reworded to inform participants that they could complete the questionnaires over several days to reduce burden.

Table 4.2 Patient outcome measures collected.<sup>4</sup>

	Baseline	3 months	6 months	12 months	18 months	Clinic visits
<b>Patient characteristics</b>						
Age, gender	X					
Frequency of technology use	X					
Broadband/mobile internet access	X					
Difficulties using TiM	X					
Need for help using TiM	X					
<b>Medical history</b>						
Diagnosis	X					
Disease duration	X					
Comorbidities	X					
Drug history	X					
<b>Quality of life</b>						
ALSAQ-40 (218)	X	X	X	X	X	
SF-36 v1 (219)	X	X	X	X	X	
EQ-5D+D	X	X	X	X	X	
<b>Clinical measures</b>						
ALS-FRS-R (205)	X	X	X	X	X	
Pain score (current and worst)**	X	X	X	X	X	
CSS-MND saliva scale (220)	X	X	X	X	X	
Hospital Anxiety and Depression score (221)	X	X	X	X	X	
Survival						X
<b>Adverse events</b>						
		X	X	X	X	X
<b>Health resource use</b>						
Clinician encounters**	X	X	X	X	X	X
Hospital admissions**	X	X	X	X	X	X
Informal care use**	X	X	X	X	X	
Formal care use**	X	X	X	X	X	
<b>Satisfaction</b>						
MND care satisfaction**	X	X	X	X	X	
TiM satisfaction**		X*	X*	X*	X*	

<sup>4</sup> \*intervention arm only \*\* questionnaires designed for the trial

Table 4.3 Carer outcome measures collected.

	<b>Baseline</b>	<b>3 months</b>	<b>6 months</b>	<b>12 months</b>	<b>18 months</b>	<b>Clinic visits</b>
<b>Carer characteristics</b>						
Age, gender	X					
Relationship to patient	X					
Frequency of technology use	X					
Difficulties using TiM	X					
<b>Quality of life</b>						
SF-36 v1 (219)	X	X	X	X	X	
<b>Clinical measures</b>						
Hospital Anxiety and Depression score (221)	X	X	X	X	X	
Zarit Burden Interview (222)	X	X	X	X	X	
<b>Adverse events</b>		X	X	X	X	X
<b>Satisfaction</b>						
MND care satisfaction**	X	X	X	X	X	
TiM satisfaction**		X*	X*	X*	X*	

\*intervention arm only, \*\* questionnaires designed for the trial



#### **4.7.1.1 Safety and Shadow Monitoring Protocol**

As this was the first time the TiM had been used, it was agreed that no changes would be made to a patient's usual clinic visits and no decisions would be made without contacting the patient or carer. Patients were encouraged to continue to attend their usual appointments (between two and six monthly) and adverse events were collected at each appointment using the "Shadow Monitoring" case report form. Database reconciliation ensured that all admissions recorded on any case report form or patient questionnaire were entered as serious adverse events. Where possible, hospital admission and discharge dates and reason for admission were confirmed using discharge summaries.

Clinicians were asked to review the TiM answers prior to the patient's appointment and give their impression of the system using a Shadow Monitoring form. It was planned that clinicians would review the answers prior to the appointment and state whether, based on the TiM information, they would postpone or change the appointment schedule.

As this was a pilot study, no interim analysis was planned so whilst the intervention and trial were felt to be low risk, the Trial Steering Group requested that some monitoring of participant wellbeing would be appropriate. Patients' wellbeing would be monitored in clinic but carers did not receive such monitoring. Instead, the clinical team was alerted to any Hospital Anxiety and Depression scores provided by the carer that exceeded the normal range. These were recorded as adverse events and fed back to the clinical team and/or carer to take action if required.

#### **4.7.2 Outcome measure selection**

One of the aims of the research was to determine which outcome measures would best assess the impact of the TiM system. Prior to the study starting it was unclear which aspects of a participants' wellbeing would be affected by the TiM. Therefore, a number of different clinical outcome measures were selected to enable comparisons to be made during the study. The following properties were considered when selecting suitable outcome measures to examine in this trial. These included the validity, reliability, responsiveness to change and any floor/ceiling effects in the MND population (223). In the development phase of the TiM (Chapter Three), some of the participants explained that they found some research questionnaires unacceptable (in particular, carer burden scales). Therefore, questionnaire acceptability and ease of completion was also considered prior to selecting outcome measures and also evaluated during this trial. Finally, outcome measures used in the TiM system (the PHQ depression questionnaire, the Modified Carer Strain Index, ALS-FRS-R) were not used as outcome measures in the trial except for the ALS-FRS-R, for which there is no alternative measure.

#### 4.7.2.1 Quality of life

It was anticipated that the primary impact of the TiM would be by improving patient quality of life (QoL). QoL has been used as a primary outcome in many trials in MND (51). QoL is influenced by many physical, psychological and social factors and the TiM could potentially influence some or all of these domains. Therefore, it was important to explore how MND influences QoL, how the TiM system could influence QoL and how this could best be measured. Two outcome measures specifically focused on QoL were selected for comparison: a generic measure (SF-36 v1 (219)) and an MND-specific measure (ALSAQ-40) (218). In definitive trials it would be important to assess the cost-effectiveness of the TiM system so the short standard measure of health utility was also used (EQ-5D-3L) along with the EQ-5D self-reported state of health “thermometer”. An additional question which incorporates a measure of dignity was also used: this questionnaire and scoring system is unpublished (224).

The SF-36 v1 is a self-completed patient reported outcome measure with 36 questions, from which can be expressed two summary scores, Physical Component Score PCS and Mental Component Score MCS. It is the most extensively used and validated QoL questionnaire in clinical trials (225). It has been used to demonstrate that both NIV and MDT care can have a positive impact on QoL (51,106). However, it has a floor effect for those with severe disability and scores may not be sensitive to change over time (223). A second version of the SF-36 may reduce this floor effect but version 1 was selected because more population data is available in MND (226).

The ALSAQ-40 is a 40-question, ALS-specific QoL questionnaire. It examines five components: physical mobility; activities of daily living; communication; eating and drinking; and emotional components. As a disease specific questionnaire, it was expected to capture more of the impacts of MND. Furthermore, the questionnaire design is more uniform than the SF-36 as each question is posed in the same way. This may influence its acceptability in this patient group. It has been extensively used and validated in MND, with data available for large populations and is felt to be responsive to change without a floor or ceiling effect (223). It appears to correlate well with disease severity (227) and demonstrates good concurrent validity with the SF-36 (215) and EQ-5D visual analogue scale (227).

Other QoL measures were considered but discounted. These included:

- SEIQoL: it was not possible to use a self-administered questionnaire.
- Whilst designed for patients with terminal illnesses the McGill Quality of Life Questionnaire as no studies had examined the reliability or validity in MND (223).
- The Sickness Impact Profile (SIP): this had been amended to include MND specific questions (SIP-ALS-19) but the evidence for its validity when compared to other MND measures or QoL measures was not as strong as the ALSAQ-40 and no reliability or sensitivity data was available (223).

#### **4.7.2.2 Clinical characteristics and symptoms**

Patients' functional ability was measured using the ALS-FRS-R which is the most commonly used and well validated functional rating scale in MND (205) which assesses limb, bulbar and respiratory function. It is also a valid measure of clinical progression. The King's staging system was used to describe the clinical stage of patients (26). The stages are based on the loss of functional ability: the ALS-FRS-R was used as an indicator of disability.

As the TiM system aims to improve the identification and treatment of distressing complications of MND, measures assessing these symptoms were included with preference for those which had been previously used in MND (e.g. the Hospital Anxiety and Depression Score and the Zarit Burden Interview). Pain was measured using a modified Likert scale as other pain inventories used in MND (for example, the Brief Pain Inventory) were too complex to be used without supervision (228).

Measures were also included to capture any potential negative impact of the TiM system. Given previous telehealth trials have been associated with increased mortality (170,229) and increased hospital admissions (which was suggested could be due to identification of unmet need early in the trial) (173), survival, adverse events and health resource use data was collected. Health resource use and hospital admission data were collected in questionnaires. Patient-completed diaries had been used in the DiPALS trial (Diaphragmatic pacing in ALS) (56). These collected data more frequently but were often returned incomplete and therefore felt to be unsuitable in this population.

There are no disease specific tools to measure carer QoL in MND so the generic SF-36 v1 was selected. There is no single, uniform definition of carer burden or strain and its distinction from QoL is unclear (230) but given that the TiM could increase the responsibilities of the carer, it was felt important to assess this separately from QoL. Only generic tools that measure carer burden are available. The 12-item Zarit Burden Interview was selected because it has been shown to accurately reflected burden in carers of those with advanced diseases and was not excessively lengthy (222,231).

### **4.8 Evaluating the feasibility of a definitive trial**

Data was collected to evaluate feasibility of the trial methods. No specific feasibility criteria were pre-specified because a range of activities needed to be tested such as:

- Screening, recruitment and withdrawal rates;
- Rates of completion of outcome measures;
- Participant attitudes towards clinical trials.

## 4.9 TiM system process evaluation

Process evaluation measures examined the use, impact of and potential mechanisms and explanations for these findings. This was done in several ways. This was done through the collection of the following information:

- Patient and carer experience:
  - Patient and carer interviews;
  - MND care satisfaction questionnaire (patient and carer);
  - TiM satisfaction questionnaire (patient and carer);
- Clinician experience:
  - Telehealth Nurse interviews (early and late in trial);
  - Community MND nurse interview (late in trial);
  - Physician satisfaction with TiM in clinic using Shadow Monitoring;
- Adverse events including any associated with the TiM system;
  - Shadow monitoring protocol (see 4.7.1.1);
  - Patient/carer questionnaires (e.g. hospital admissions);
  - TiM system reports;
  - Interviews;
  - Field notes;
- Usage of the TiM system:
  - Date of each TiM session;
  - All patient and carers answers and alerts generated;
  - Notes made by the clinicians;
- Technical problems with the TiM system:
  - Field notes;
  - Shadow monitoring protocol;
  - TiM system notes.

It was not possible to use the TiM technology to automatically determine how long clinicians spent using the TiM system or how much additional time was taken responding to alerts. A diary was provided to the Telehealth Nurse at intervals during the trial but this diary was returned incomplete. Instead, the time burden and impact on daily work of health professionals was explored in interviews.

## 4.10 Qualitative interviews

Semi-structured interviews were conducted with participants and clinicians-the MND hospital nurse using the TiM (the Telehealth Nurse) and an MND community nurse (Community Nurse) who cared for some of the participants in the study.

Semi-structured qualitative interviews were selected because they could explore, in more depth, the processes occurring when participants and staff were using the TiM system. They also provided a more detailed understanding of the study methods, in particular focusing on what was occurring during recruitment and initial data collection. Semi-structured interviews were used because they could be conducted in a patient's home meaning the study remained low in burden. Interviews could be adapted to involve even the most disabled patient. Furthermore, they aimed to explore issues relating to participants' medical condition and care, topics that many participants may not feel comfortable discussing with strangers, for example, in focus groups. Similarly, interviews were used to capture staff experiences for reasons both of convenience but also because staff may not feel comfortable discussing their practice or experiences with individual patients in front of other staff members.

### 4.10.1 Interview conduct

Participants in the intervention arm underwent semi-structured interviews at one and six months. Participants in the control arm were interviewed only at baseline. Patients and carers were usually interviewed together as experience in previous studies suggested that this was preferred (102) and allowed carers to help with communication and attend to the patients' needs during the interviews. It also enabled discussions between patients and carers. Prior to the interview the aim of the interview and the "ground rules" of qualitative interviews were explained and consent was reconfirmed. Some interviews were paused or shortened if a lengthy interview was felt to be tiring and communication aids were used. Three participants whose speech was poor were sent additional questions by email and two were provided with an outline of the questions prior to the interview to help them prepare their answers.

Interviews were audio recorded and transcribed verbatim. Reflective notes were made immediately after the interviews, after review of the transcript, and during the trial to record new events e.g. patient contact with the research team. Some interviews were transcribed by EH: initial interviews to improve interview technique and familiarity with the data, and interviews where dysarthria meant transcription would be difficult. Professional transcription was used for the other interviews but all were checked with the audio recording for accuracy. Wendy Baird, an experienced qualitative researcher, reviewed initial interviews. She provided feedback on the topic guide, interview technique and potential

themes, as well as providing an independent assessment of data interpretation.

#### 4.10.2 Interview structure

Semi-structured interviews using predefined topic guides (Appendix D). The topic guides were developed to include questions reflecting the objectives of the trial and research questions and were influenced by a literature review of telehealth in MND and other diseases (described in Chapter One). The topic guide developed throughout the trial to further explore emerging themes and the events of the study (for example, problems with the TiM system). It also aimed to explore the impact on the TiM on clinical events that occurred in individual patients (e.g. after NIV initiation).

Topics guides were used at each time point (Appendix D). Where possible, all patients and carers were asked about the following subjects (although some interviews were shortened due to time limits or patient fatigue):

- The experiences of hospital and community MND care;
- The impact of MND on participants' quality of life;
- The unmet needs in MND care;
- Participants' attitudes towards technology;
- Participants' attitudes towards research and experience of research during the study (all patients and carers).

Control participants were also asked about:

- Participants' attitudes towards the baseline questionnaires and how they reflect the quality of life of those with MND (control patients and carers only).

Participants in the intervention arm were asked, at one and six months about:

- Participants' expectations of and experiences of using the TiM system;
- The potential impact of TiM system on participants' care, and their wellbeing.

The nurses were asked about

- The experiences of hospital and community MND care;
- The impact of MND on participants' quality of life;
- The unmet needs in MND care;
- The nurses' attitudes towards and use of the TiM system
- The impact and future use of telehealth on clinical services.

The topic guides evolved throughout the trial to explore emerging themes and the events of the study (for example, problems with the TiM system). It also aimed to explore the impact on the TiM on clinical events that occurred in individual patients (e.g. after NIV initiation).

### **4.10.3 MND clinical team interviews**

Interviews with the MND clinical team were conducted. Staff were provided with a Staff Information Leaflet and gave written consent. Topic guides were used (Appendix D).

Two interviews were conducted with the MND Telehealth Nurse. An interview was conducted at four months and explored the role of the MND nurse, the challenges faced by patients and carers, and her initial experiences using the TiM system. Wendy Baird conducted a further interview at 14 months. The interview was conducted independently of the clinical team using topic guide prepared by both WB and EH. This aimed to explore her experiences of using the TiM and the challenges posed by the TiM. These included: the MND nurses' reaction to any problems or flags identified by the TiM, the potential impact it could have on participant outcomes and the challenges that would be faced implementing the system into the NHS service.

At the end of the study an interview was conducted with a community MND nurse who had had the most patients using the TiM. This explored her experience as a community nurse, the interaction she had with the hospital team and the unmet needs of her patients. She reviewed the TiM system and provided feedback on the system and on the patients using the TiM.

## **4.11 Analysis**

### **4.11.1 Quantitative data management**

Data collection forms were generated in collaboration with data managers at the University of Sheffield Clinical Trials Unit who then developed a Clinical Trials Research Unit Epigenesis database. Data was entered into the database by EH with the exception of follow-up participant questionnaires. These were entered by an independent study nurse. Early in the trial database managers compared three participants' paper case report forms with the data entered on the database. Irregularities were identified and corrected. The database was also amended to address common errors, in particular allowing annotations to be made to the answers where participants had written comments on their questionnaires rather than completing the questions. Discrepancies identified by the database were highlighted and corrected throughout the trial. These included unexpected entries and reconciliation of errors. Any hospital admissions were identified and, where discrepancies occurred, data was confirmed using hospital records. Following database freeze, the trial statistician reviewed the data and further discrepancies were highlighted and resolved prior to release for analysis.



#### 4.11.2 Blinding

Due to the nature of the intervention, it is impossible for participants or the clinical team to be blinded. As the analysis would be performed by EH who knew the patients well, it was felt unlikely that blinding would be possible even if measures were taken to conceal the two allocated groups. The following measures were therefore put in place to reduce bias due to lack of blinding:

- Participant follow-up questionnaires were completed at home, independent of the study team;
- Follow-up data was entered by an independent research nurse who was also available to help the participants complete the questionnaires, either by telephone, email or in person in the Clinical Research Facility;
- Analysis was conducted according to a pre-specified statistics analysis plan and supervised by the trial statistician and the TMG.

#### 4.11.3 Statistical analysis

A Statistical Analysis Plan was prepared prior to release of the data (Appendix D). Data collected in the database was reviewed by the trial statistician and released for analysis in Microsoft Excel and GraphPad Prism. All analysis was conducted by EH except the scores for the SF-36 and EQ-5D, which were generated by the trial statistician using the statistical software Stata and, in the case of SF-36, compared to US population norms. The EQ-5D was calculated in two ways: firstly using all data collected whilst the patient was alive, and secondly calculated including scores of 0 where the patient had died (which corresponds to the state of death for this inventory) for all time-points between death and scheduled end of follow-up. Incomplete data was handled for the RAND-36, ALSAQ-40 and HADS scores according to methods described in the Statistics Analysis Plan (Appendix D). Where imputation was not possible, the data was excluded from analysis.

Descriptive statistics were used to describe the participant characteristics in both treatment groups and in the population as a whole. These could be compared to those in the general MND population. To explore the sensitivity of the outcome measures to capture relevant changes in participants' condition, individual scores at each follow-up time point were compared to baseline and the mean change and 95% confidence intervals were calculated. For categorical outcomes, the number and percentages falling into different categories and potential differences between groups in terms of the percentages in each category will be presented, together with their confidence intervals. Whilst normal hypothesis testing was not planned in this small sample, any noteworthy differences between groups or changes during the trial were identified.

Details of every individual TiM session were downloaded by Carematix and analysed using Excel and GraphPad Prism. This included the dates and times of each session, answers provided by participants, flag and scores generated and staff notes.



#### 4.11.4 Qualitative data management and interview analysis

Thematic analysis of the data was conducted (232). Thematic analysis is a structured method for identifying, analysing and reporting patterns (themes) within data in order to organise and describe the dataset in detail (232). This approach was chosen for a number of reasons. It can be used to compare themes across an entire data set including different participant types (patients, carers and clinicians). It can be used to examine the variety of different research questions posed in this project (such as both participants' experiences, views and perceptions) (213). It can explore participants' experiences of MND care, TiM and research but can also explore more specific questions posed during the trial such as why events or behaviours occurred in context (232). Whilst analysis is sequential, it allows movement back and forth between each stage which allows analysis to commence early in the trial which can inform development of the TiM system and the trial methods. This also allows triangulation with other data which may be available later in the trial (e.g. problems with recruitment, or later, adherence to the TiM system). As it does not require the detailed theoretical and technological knowledge of other approaches to analysis it is also felt to be accessible to a researcher early in their qualitative career (213)

A stepwise approach to analysis was taken. Familiarisation with the data involved rereading transcripts and field notes whilst listening to the audio-recordings. This allowed initial ideas (codes) and early broader themes to be generated. Discussion of the emerging themes occurred at trial management meetings and during supervisions. Data was organised using NVivo (233). Themes and codes were refined and initial results reviewed by Wendy Baird before overarching themes were identified, the coding structure refined and the data reviewed to ensure the results were consistent with the data. No rigid definition of a theme was made (e.g. how many times it occurred in the data set). Instead it was considered whether the theme captured something important in relation to the overall research questions or whether it was relevant to other observations during the trial. Eventually subthemes were arranged in tables with supporting quotes.

Analysis began following the first three interviews. These were transcribed and coded to ensure that emerging themes were explored in subsequent interviews. Early results provided some insight into how the TiM system was being used and informed medication of the TiM system. It was possible to identify which participants using the TiM system regularly or infrequently and the reasons for this were explored during the six-month interviews. However, as interviews were planned only at six months it was not possible to explore the experiences and reasons for poor adherence later in the trial although this was explored during the interview with the Telehealth Nurse and Community Nurse who were interviewed at month 14 and month 18 respectively.

#### **4.11.5 Triangulation of the results**

Following completion of the trial, a triangulation process examined the quantitative and qualitative data which aimed to answer questions relating to the process evaluation. Quantitative data included participant adherence, participant satisfaction questionnaires, the alerts generated by the TiM, the nurse's use of and reaction to the TiM system and the physician shadow monitoring data. The qualitative data was then reviewed with these results in mind and the two combined to answer each research question. Where unexpected results occurred, the data was reviewed to try to explore what happened. For example, to try to explain the patterns of adherence by participants or to explain whether and how participants' expectations of the TiM differed from the nurses' experiences. Important, incongruent or unexpected results obtained from the quantitative data were discussed at trial meetings and the qualitative data was then reviewed again in order to provide explanations for these results. This data was presented to the TMG before the final results were produced.

#### **4.12 Conclusion**

Chapter Five describes the results of the process evaluation examining how the TiM system was used in the trial. Chapter Six describes the results that determine whether a definitive trial would be feasible

## Chapter Five

### Results: A process evaluation of the TiM system

#### 5.1 Introduction

Chapter Five describes the process evaluation of the TiM system. It will describe how the TiM system functioned by examining how it was implemented, the experiences of and the potential mechanisms of impact on those who used it, and the contextual factors that may explain how/why these impacts occurred. Qualitative and quantitative data has been presented together to inform answers to the research questions. Chapter Six describes the results that examine the feasibility of the study and also describes the participant characteristics and outcome measures in more detail. It is recognised that the two research questions overlap at times and it is usual to report the quantitative results first. In this case the process evaluation has been reported first because it describes in detail, what occurred within study and whether/how the TiM impacted on the clinical outcomes recording during the trial as it was felt important to explain what occurred during the trial in order to explain the observed clinical outcomes of the trial described in Chapter Six.

This chapter will report in the results three sections and summarise the findings after each section and together in the later discussion section. Each section will draw together the data from interviews, TiM data, patient reported outcomes and field notes to answer the research questions and will summarise the results at the end of each section. Section 5.2 will outline and summarise the characteristics of the participants recruited and the interviews conducted. Section 5.3 will then describe participants' experiences of and satisfaction with their current hospital and community MND care and their unmet needs associated with difficulties accessing specialist care.

Section 5.4-5.9 reports the processes occurring in the trial related to the use of the TiM system:

- Setting up and delivery of the TiM system;
- Participant use and adherence to the TiM system;
- Participants' expectations of, satisfaction with, and experiences of using the TiM technology;
- Clinicians' use of the TiM system and reaction to the data collected by the TiM system;
- Clinicians' impressions of the acceptability, safety and impact of the TiM system in clinical practice.

Whilst the aim of the trial was not to assess the efficacy of the TiM system, Section 5.8 and 5.9 describe circumstances in which the participants and clinicians felt the TiM system might have impacted on them and their MND care. It focuses on the mechanisms for these potential impacts, why and in what context they occurred by examining:

- Participants' and nurses' perceptions on the potential impact of the TiM on their condition and their MND care;
- Participants and nurses' interactions with the TiM and reasons why participants did not feel the TiM made any impact;
- Participants' and nurses' attitudes towards the future of the TiM.

Finally, Section 5.10 discusses whether these results indicate that the TiM system is feasible and acceptable and whether and what value the TiM system may have. It also describes ways in which the TiM system needs to be improved, and makes recommendations how these developments should be implemented and further evaluated.

Figures and quotes have been used to summarise the relevant themes and subthemes in each section. Additional quotes to support these findings are available in tables in Appendix A.

## **5.2 Participant characteristics**

40 patients and 37 carers were recruited. The characteristics of the patients and carers are described in Tables 5.1 and 5.2. Patients' mean age (60.2 years, range 30-78 years) and gender (28, 70% male) broadly reflected the population of patients who have attended the Sheffield MND clinic (111). Carers were mainly female (28, 76%) and were mostly the patient's partner (34, 92%).

### **5.2.1 Baseline patient disease characteristics**

Table 5.3 reports the baseline disease characteristics. The baseline characteristics of each group appear similar. Most patients (35, 88%) had ALS but only 18 (45%) met the criteria for clinically definite or clinically probable ALS. Patients were recruited at all stages of disease with 13 (33%) patients using NIV and/or gastrostomy (26). Median duration of disease was 41 months. 17 (42.5%) patients had symptoms for more than four years, the longest was 203 months. Four patients (10%) were recently diagnosed, including one patient diagnosed in the previous two months.

### **5.2.2 Participants' experience of technology**

Most participants (32, 80% of patients, 28, 76% of carers) already used some form of technology device (computer, tablet or smart phone) daily (Table 5.4). However, four patients (10%) and nine carers (24%) used technology once a week or less. Two (5%) patients had no computer technology or internet broadband. Seven (18%) had no 3G mobile phone reception in their homes. All of these had broadband and were willing to use it for the trial. 27 patients (68%) reported upper limb disability affecting their use of a tablet computer. 34 (85%) could use the TiM independently.

Table 5.1 Patient characteristics.

	<b>Telehealth (n=20)</b>	<b>Control (n=20)</b>	<b>Total (n=40)</b>
<b>Age</b>			
Years (SD)	60.4 (11.7)	60 (10.0)	60.2 (10.7)
Range	30-78	39-73	30-78
<b>Sex</b>			
Male	14 (70%)	14 (70%)	28 (70%)
Female	6 (30%)	6 (30%)	12 (30%)
<b>Potential problems using TiM device</b>			
Hand/arm weakness/arthritis	14 (70%)	13 (65%)	27 (68%)
Vision difficulties	1 (5%)	0 (0%)	1 (3%)
Language or reading difficulties	0 (0%)	0 (0%)	0 (0%)
<b>Use of the TiM device</b>			
Independently	17 (85%)	17 (85%)	34 (85%)
Help from carer	1 (5%)	1 (5%)	2 (5%)
Patient instructs carer	2 (10%)	2 (15%)	4 (10%)
Carer answers on patient's behalf	0 (0%)	0 (0%)	0 (0%)

Table 5.2 Carer characteristics.

	<b>Telehealth (n=18)</b>	<b>Control (n=19)</b>	<b>Total (n=37)</b>
<b>Age</b>			
Mean (SD)	59 (11.6)	60.8 (10.9)	60.1 (11.1)
Range	42-84	38-73	38-84
<b>Sex</b>			
Male	4 (21%)	5 (28%)	9 (24%)
Female	15 (79%)	13 (72%)	28 (76%)
<b>Relationship to patient</b>			
Partner	18 (95%)	16 (89%)	34 (92%)
Child	0 (0%)	1 (6%)	1 (3%)
Parent	1 (5%)	1 (6%)	2 (5%)
<b>Potential problems using TiM device</b>			
Hand/arm weakness/arthritis	0 (0%)	0 (0%)	0 (0%)
Vision difficulties	0 (0%)	0 (0%)	0 (0%)
Language or reading difficulties	0 (0%)	0 (0%)	0 (0%)

Table 5.3 Patient disease characteristics.

	<b>Telehealth (n=20)</b>	<b>Control (n=20)</b>	<b>Total (n=40)</b>
<b>Diagnosis</b>			
ALS	17 (85%)	18 (90%)	35 (88%)
Total			
ALS clinically definite or clinically probable	8 (40%)	10 (50%)	18 (45%)
ALS clinically probable - laboratory-supported	9 (45%)	8 (40%)	17 (43%)
ALS clinically possible	0 (0%)	0 (0%)	0 (0%)
Primary lateral sclerosis	2 (10%)	2 (10%)	4 (10%)
Progressive muscular atrophy	1 (5%)	0 (0%)	1 (3%)
<b>Duration of disease (months)*</b>			
Mean (SD)	56 (51)	47 (35)	50 (43)
Median (IQR)	41 (18, 61)	39 (16.5, 71)	41 (17, 62)
Range	11-203	7-129	7-203
<12 months	2 (10%)	2 (10%)	4 (10%)
12-24 months	4 (20%)	6 (30%)	10 (25%)
24.1-48 months	5 (25%)	4 (20%)	9 (22.5%)
48.1-72 months	5 (25%)	3 (15%)	8 (20%)
>72.1 months	4 (20%)	5 (25%)	9 (23%)
<b>Duration since diagnosis (months)</b>			
Mean (SD)	32 (36)	21 (20)	27 (30)
Range	2-143	1-63	1-143
<b>Site of onset</b>			
Upper limb	4 (20%)	7 (35%)	11 (23%)
Lower limb	11 (55%)	10 (50%)	21 (53%)
Bulbar	4 (20%)	3 (15%)	7 (18%)
Respiratory	1 (5%)	1 (5%)	2 (5%)
<b>Treatments</b>			
Using non-invasive ventilation	6 (30%)	3 (15%)	9 (23%)
Gastrostomy	3 (15%)	6 (30%)	9 (23%)
Taking Riluzole	16 (80%)	15 (75%)	31 (78%)
<b>King's ALS clinical stage<sup>5</sup></b>			
	n=20	n=20	n=40
1	3 (15%)	2 (10%)	5 (13%)
2	4 (20%)	5 (25%)	9 (23%)
3	5 (25%)	8 (40%)	13 (33%)
4	8 (40%)	5 (40%)	13 (33%)

<sup>5</sup> King's stage 1 refers to patients with functional deficit in 1 domain, stage 2 refers to disability in 2 domains, stage 3 refers to disability in 3 domains and stage 4 refers to patients requiring NIV and/or gastrostomy. King's stage was calculated using the ALS-FRS-R scale at baseline.

Table 5.4 Participants' use of computers and availability of home broadband and 3G mobile phone reception.

	<b>Telehealth</b>	<b>Control</b>	<b>Total</b>
<b>Patient computer use</b>			
	n=20	n=20	n=40
Daily	14 (70%)	18 (90%)	32 (80%)
A few times per week	3 (15%)	1 (5%)	4 (10%)
Once a week	1 (5%)	1 (5%)	2 (5%)
Every few weeks	0 (0%)	0 (0%)	0 (0%)
Never	2 (10%)	0 (0%)	2 (5%)
<b>Home technology</b>			
Broadband	18 (100%)	20 (100%)	38 (95%)
3G mobile reception	18 (90%)	15 (75%)	33 (83%)
<b>Carer computer use</b>			
	n=18	n=19	n=37
Daily	12 (67%)	16 (84%)	28 (76%)
A few times per week	0 (0%)	0 (0%)	0 (0%)
Once a week	1 (6%)	2 (11%)	3 (8%)
Every few weeks	1 (6%)	1 (5%)	2 (5%)
Never	4 (22%)	0 (0%)	4 (11%)

### 5.2.3 Interview conduct

Semi-structured participant interviews were conducted at baseline (control participants) and after one and six months of starting using the TiM (intervention) (Figure 5.1). Interviews aimed to continue until data saturation was reached but new themes were identified later in the trial (for example, the experiences of using the TiM system by patients who were recently diagnosed, reactions to the second version of the TiM app) and so interviews continued until the end of the trial.

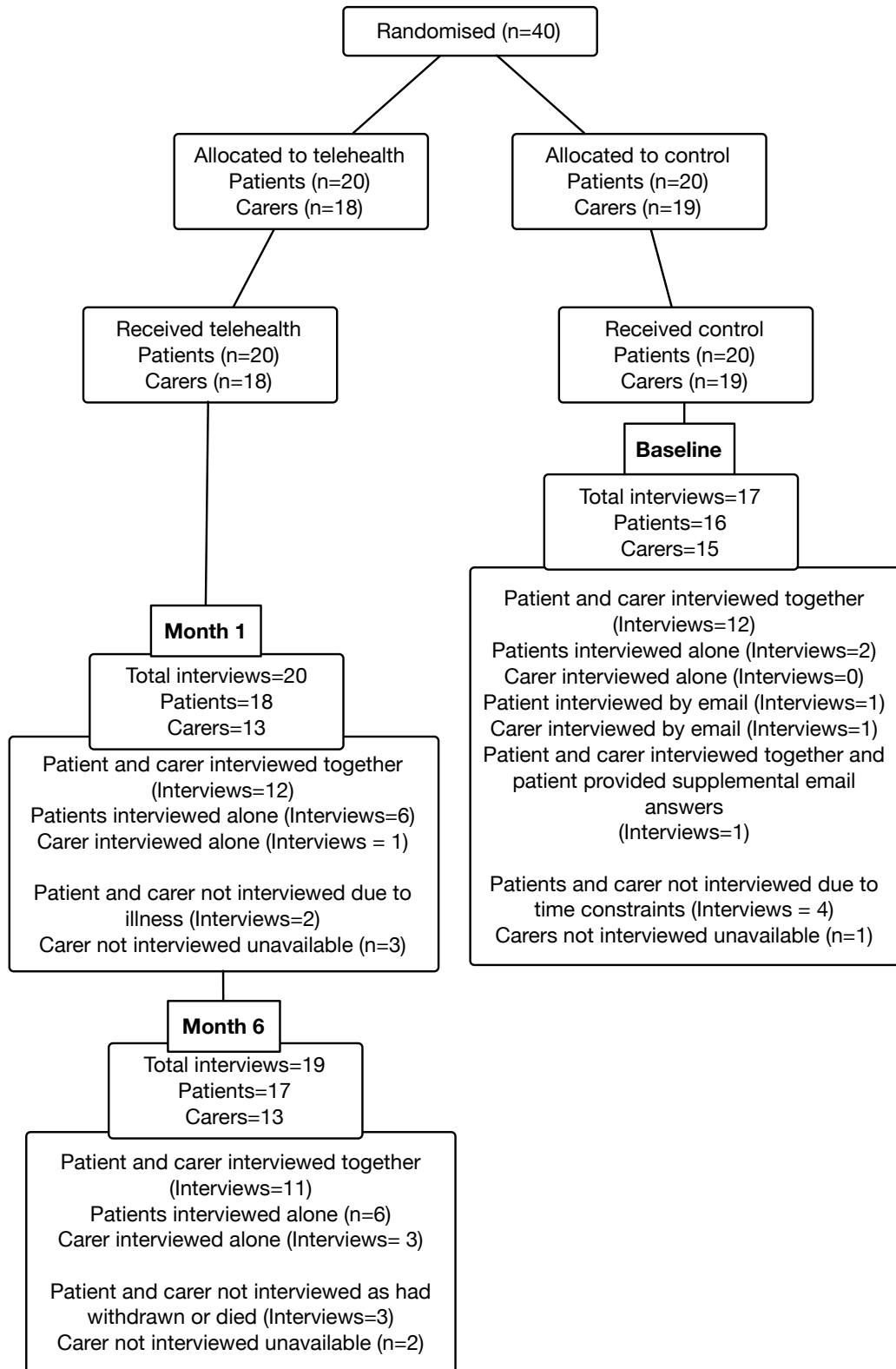
54 participant interviews were conducted. 36 patients and 32 carers were interviewed at least once. Patients preferred to be interviewed with their carer but 14 patients and five carers were interviewed alone. Interviews were conducted at home apart from one conducted in a café (at the participants' request). It was possible to involve all patients in the interviews. Many used communication devices. Two patients who were severely disabled took a passive role but care was taken to check that they were in agreement with statements made by the carer on their behalf by asking yes/no questions and they were offered the opportunity to answer questions by email (which they declined). A small number of interviews were conducted by telephone (where the participants lived at a distance) or email (where participants had severe dysarthria).

Semi-structure interviews were conducted with the Telehealth Nurse (based at the Sheffield MND clinic) at month four and month 14. One community MND nurse was interviewed at month 18.

Anonymised quotes from the interviews have been included in the thesis. Patients and carers are identified by their trial number e.g. P111 (patient) or C111 (carer). A summary of individual characteristics of each participant (e.g. age, sex, diagnosis) is not reported because it was felt that reporting all these characteristics together would make it much easier for participants to be identified. Whilst participants had consented to this possibility, some of the issues identified were particularly sensitive (such as those discussing carer roles or marital relationships). Instead, only relevant participant characteristics are reported in the text to provide context to the quote. No characteristics of the Community Nurse have been presented and any reference to her place of work has been removed. It was not possible to anonymise the Telehealth Nurses' comments however this was explained to her during the consent process and stated on the consent form.



Figure 5.1 The qualitative interviews conducted with participants during the each stage of the trial.



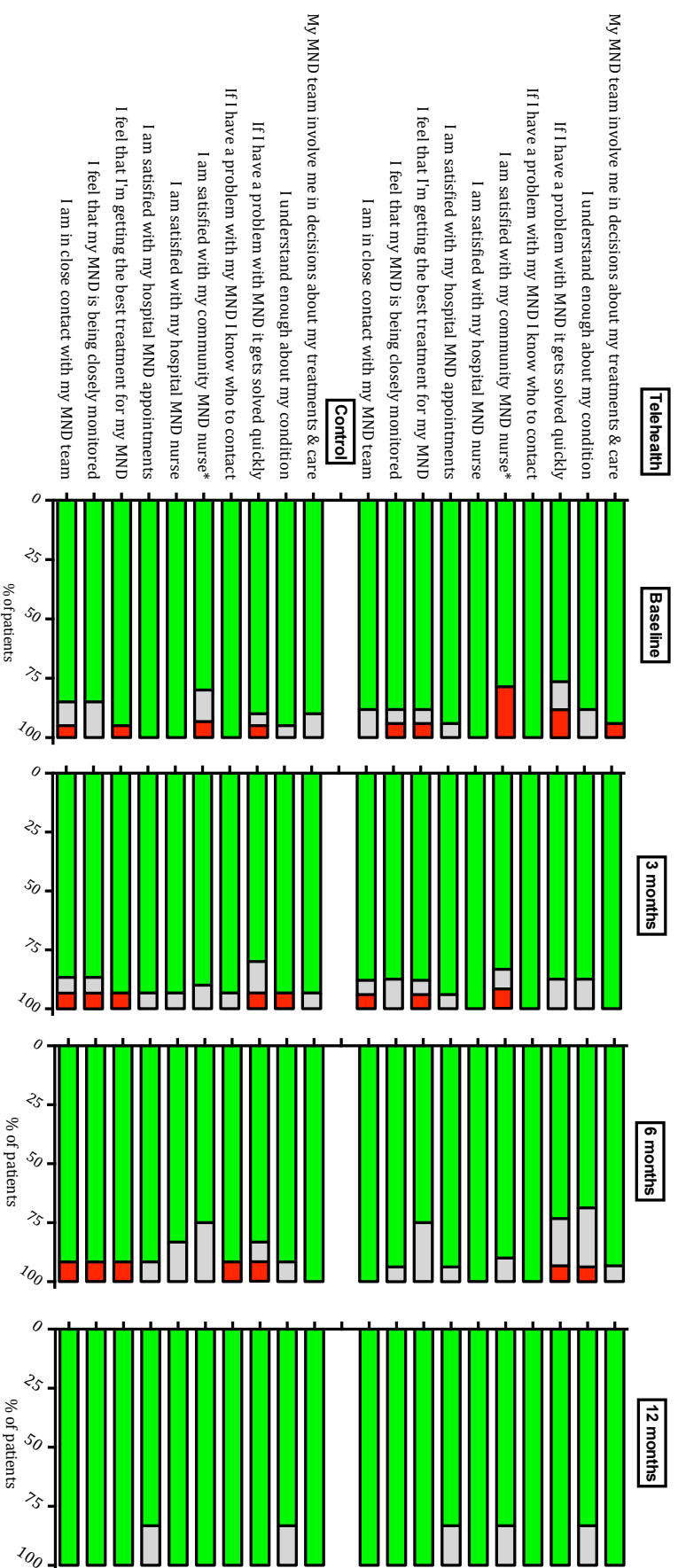
### 5.3 Participants' experiences of the current MND service

Patients' and carers' experiences of the current MND service were explored using questionnaires at baseline, three, six, 12 and 18 months and during interviews. Figure 5.2 and 5.3 display the results of the questionnaires. Most patients in both control and intervention arms were very satisfied with their MND care. The areas in which some patients indicated less satisfaction were with their community nurse, with knowing enough about MND and the speed at which problems are solved. The same pattern was seen at three and six months. Participants remaining in the trial at 12 months were very satisfied with their care. Whilst no formal comparisons were made, there appeared to be little difference between the treatment groups.

At six months, satisfaction amongst the patients using the TiM system did appear better than at baseline. However, one patient using the TiM system still felt that his/her problems were not being solved quickly and three "unsure". One patient using the TiM system felt his/she did not know enough about the condition and four were unsure.

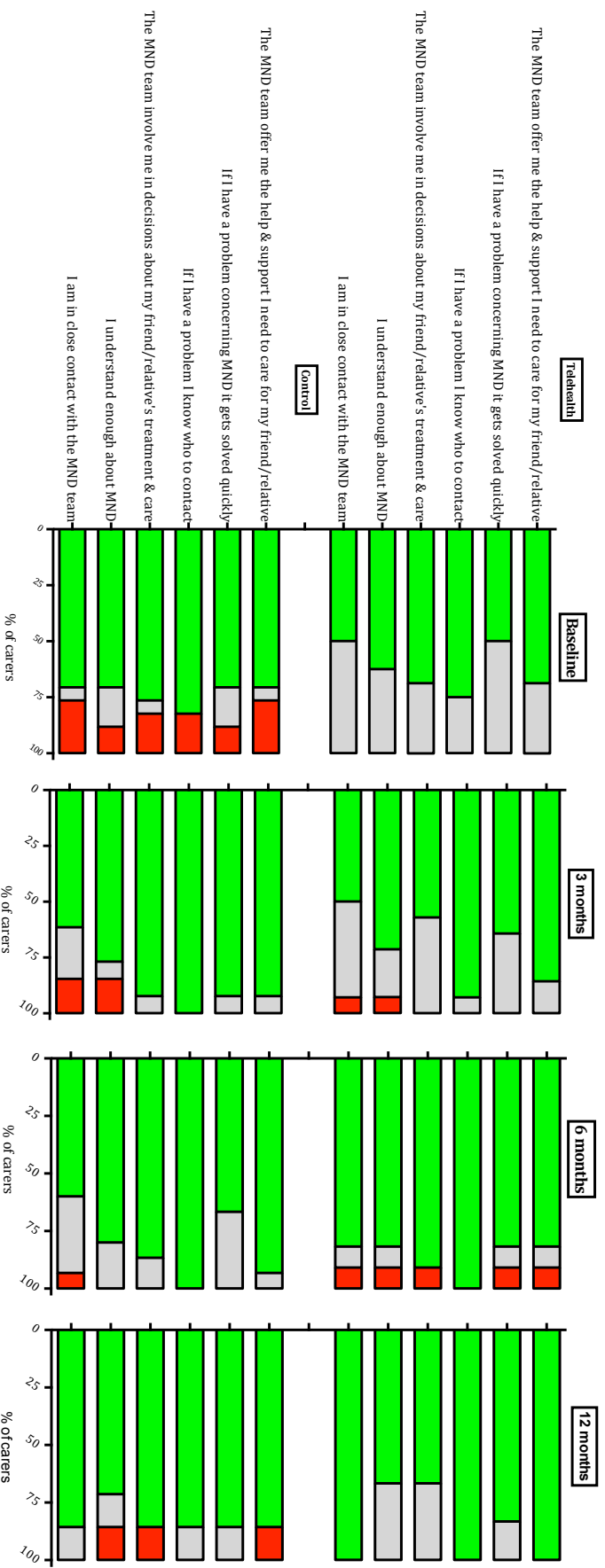
Carers were in general less satisfied with the MND service. At baseline, in total 13 (40%) did not agree that they were in close contact with the MND team or that problems with MND got solved quickly. However things had improved at six months: all carers knowing whom to contact with problems. At six months, only one (9%) carer in the telehealth treatment group felt that they did not receive help from the MND team, had their problems solved quickly or were involved in decisions about care. Whilst no formal comparisons were made, satisfaction in some areas appeared better in the telehealth arm, particularly at six months with only two (18%) carers not feeling in close contact with the MND team compared to six (40%) in the control arm.

Figure 5.2 Patient experience at baseline, three, six and 12 months (Green: agree/definitely, grey: unsure, red: disagree/definitely disagree).\*



\* Patients who indicated that they did not have a community MND nurse were excluded from analysis of this question

Figure 5.3 Carer experience at baseline, three, six and 12 months (Green: agree/definitely, grey: unsure, red: disagree/definitely disagree).

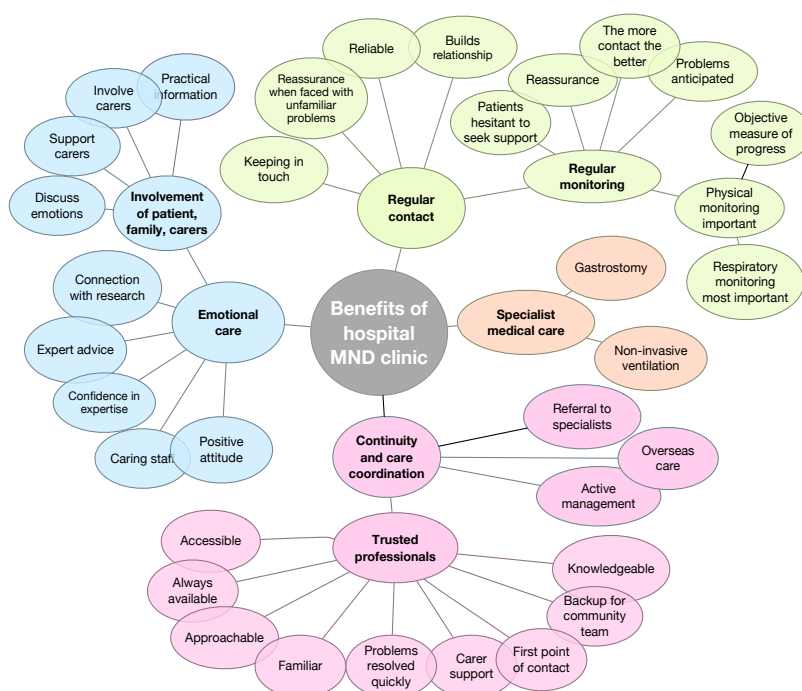


### 5.3.1 Benefits of the hospital MND clinic

Participants were also asked about their experiences of MND care during the interviews. The main identified benefits of the hospital MDT and the clinic were similar to those described in Chapter One as vital components of patient-centred care: continuity and coordination of care, regular contact with specialist and trusted professionals and the medical and emotional care and involvement of patients, family and carers (Figure 5.4, Appendix A5.1 and A5.2).

*“Everyone involved with my MND care has been first class. It is everything we could ask for and more. Royal Hallamshire Hospital Sheffield, NHS Neurological Outreach team, OT, community nurse, PEG nurse, dietician, speech therapist, local GP.” P229 baseline*

Figure 5.4 The benefits of the hospital MND clinic reported by participants.



Patients felt that the hospital multidisciplinary team (MDT) took an active and positive approach to managing their care and had a “global” role coordinating the different healthcare professionals. Patients also reported that the hospital MDT referred them without delay to the correct services meaning their needs were quickly addressed. The interaction with the MND nurse either at clinic or through the MND telephone helpline was particularly valuable:

*“Q: If you did have a problem, how would you go about sorting it?”*

*P: I think I’d ring [Hospital MND nurse].*

*Q: You’d ring [Hospital MND nurse]? What’s your experience of ringing [her]?”*

*P: Oh, I love her!*

*Q: What is it you find helpful?”*

*P: Friendly and helpful.*

*C: Yes. She’s quite informal about things.*

*P: I think I could ring her anytime.” P217*

Participants explained that the hospital MND nurse was knowledgeable, approachable, accessible and always available should they have problems and found that the nurse resolved them quickly. As they met the nurse regularly in clinic, participants developed a good relationship and she was often their first point of contact, as well as a reassuring back up to the community team. She was also an important contact point for carers who would phone her about many issues (even those unrelated to MND) and felt very reassured by her advice. The psychological benefits of attending clinic were also highlighted: participants valued being able to talk to experts who offered hope, understanding and empathy. A common theme was the importance of speaking to staff with a positive attitude towards the disease. This attitude was transferred to the patients and gave them a psychological “boost”. This was often in contrast to non-specialists, who participants felt could appear negative or unfamiliar with the disease.

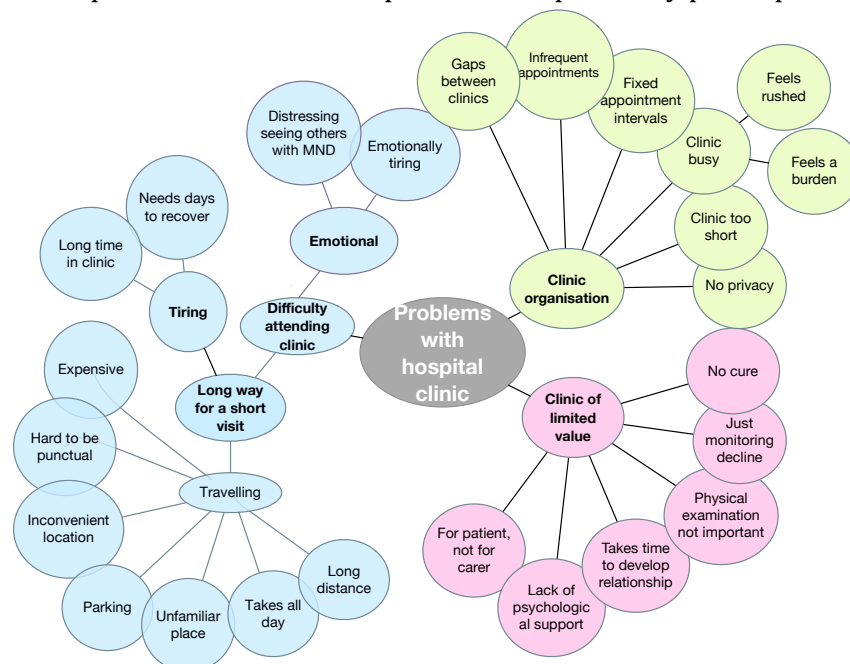
*“I didn't find them gloom merchants, they were very positive in their approach and in their opinions and their comments.” C229*

Regular monitoring of patients' progress was also an important aspect of the MND clinic. Faced with an uncertain prognosis, patients were very keen to know how they were progressing. Physical monitoring, particularly respiratory testing gave them an objective measure of their progress. If their progress was slow, patients felt positive and reassured. However, if things had changed, the patients were pleased that the monitoring would allow the team to pre-empt problems and intervene early.

### 5.3.2 Problems with hospital MND clinic

The main problem with the hospital clinic was the difficulty travelling to clinic, although the clinic organisation also posed problems (Figure 5.5, Appendix A5.3-5.5). Finally, there was a sense of frustration that, given the lack of effective treatments, the clinic made no difference to their condition.

Figure 5.5 The problems with the hospital clinic reported by participants.



Difficulty travelling to hospital was the main reason patients had stopped attending clinic.

*“Q: Was there anything you’d change?”*

*C: Move the hospital somewhere more accessible! It’s a nightmare getting in and out of Sheffield.” P172*

Attending an appointment could often involve an entire day away from home with long, expensive journeys as well as long waits in clinic. The hospital location was unfamiliar to most and parking was also a major problem. A day out at clinic could be physically tiring; one patient felt tired for days after the clinic. This became more of a problem as patients became more disabled and found activities of daily living much harder. However, along with the stress of travelling, participants found clinic was emotionally tiring due to the anxieties associated with the disease as well as impact of seeing others in the later stages of the disease.

*“We always feel a bit shattered by the time we get back trying to hold everything going.” C318*

There were also problems with the fixed appointment schedule, which could be unresponsive to the patients’ needs. The clinics were also busy and some patients felt rushed or lacked privacy, although despite this, participants did think they had the opportunity to talk to the MND team about their problems.

A number of participants felt that the MND clinic offered them few benefits. They felt frustrated that the clinic was unlikely to provide them with a “cure” and a number expressed the feeling that the clinic was simply measuring their physical decline (of which they were already acutely aware themselves without needing additional assessments).

*“All you’re doing currently is monitoring my progress, so at the minute I’ve really got nothing out of the clinic.” P318*

One patient felt strongly that the clinic offered insufficient psychological support and had to seek this elsewhere. Participants also identified other areas of need including the availability of complementary therapies (physiotherapy, hydrotherapy) and more timely access to wheelchair services. Carers did value attending the clinic, particularly to meet the MND nurse but most felt the focus of the clinic was on the patient, not on carers.

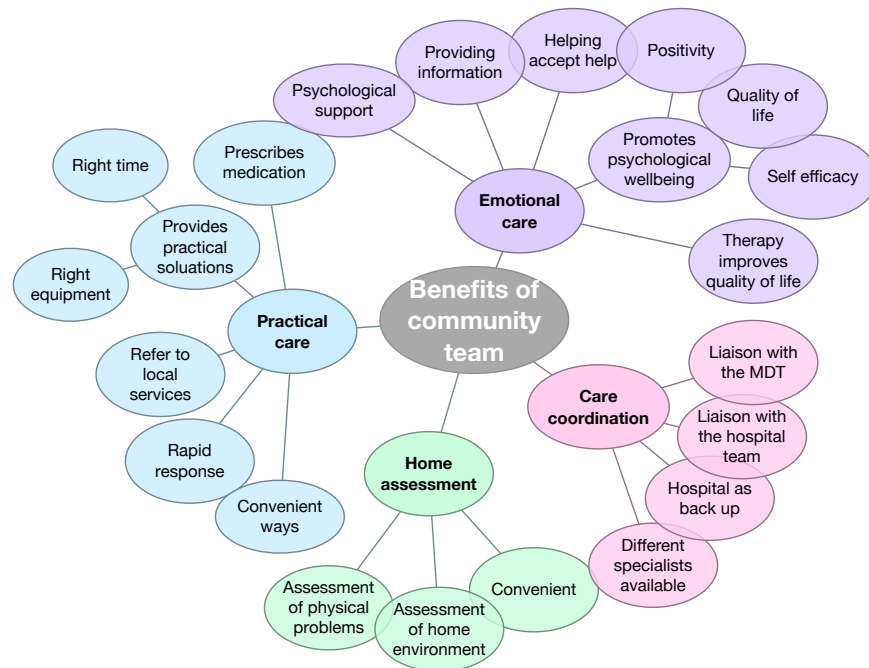
### 5.3.3 Benefits of the community team

The community teams provided both practical and emotional care to participants as well as care-coordination and liaison with other members of the MDT (Figure 5.6, Appendix A5.7 and A5.8). Participants felt satisfied when the community teams liaised with other healthcare professionals such as the hospital team and their GP, meaning the help offered by the community team was complementary to that offered by the hospital.

*“My community team visit every month. This comprises of a community nurse and a Senior OT. They have sorted me out with a wheelchair and have started the ball rolling with MNDA for funding with a wet room, a bio bidet and a rollator. They have also organised me visits to the hospice for occupational therapies.” P229*

Home visits were not just convenient, but they also provided the opportunity to assess the home environment and physical problems (such as pressure sores) in the later stages of the disease. Many participants enjoyed receiving community therapy sessions, tailored around their lifestyle which made them feel more positive, improved their quality of life but also promoted self-efficacy by providing them with information and encouragement to confidently deal with what were often challenging problems.

Figure 5.6 Benefits of community MDT.





### 5.3.4 Problems with community care

The difficulties of community care mainly occurred due to a lack of coordination of care and a lack of specialist staff (Figure 5.7, Appendix A5.9 and A5.10).

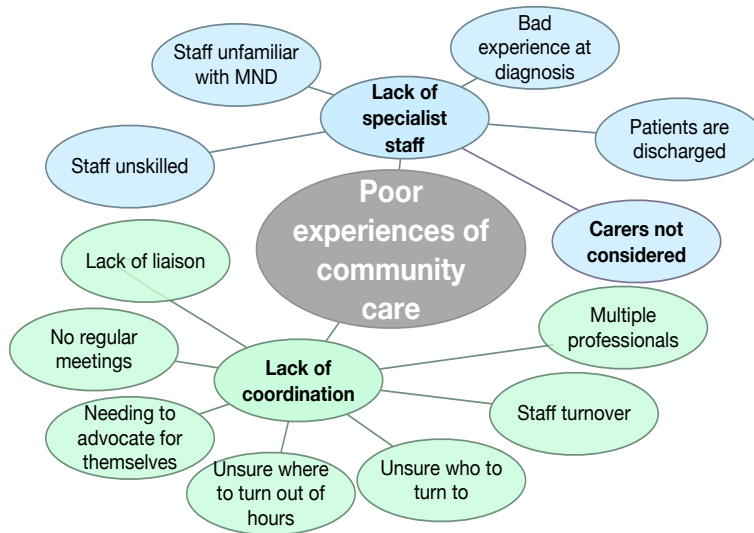


Figure 5.7 Poor experiences of community care.

Often multiple healthcare professionals were involved and participants were not always certain of their role or when they should be contacted. Some participants found that a sudden influx of professionals at the same time, who wanted to deal with sensitive issues, could be very overwhelming or upsetting.

*“When you are first diagnosed you are emotional... But once you are diagnosed everything happens: OT, physio, dietician, all at once. It’s nice because it feels like you are being looked after. But on the other side they were talking about things I wasn’t really aware of and asking me questions too early to ask.” P172*

Some patients identified a main point of contact in the community who could advocate and coordinate their care. This could be a GP, community nurse or therapist. However, others had not developed such a strong relationship with one person when multiple staff were involved, who could change as the patients’ needs changed. Some patients found that staff did not understand the condition or failed to communicate with each other: one patient (P091) had to live upstairs whilst waiting to get a stair lift fitted. He had already been assessed by four different occupational therapists.

*“Q: You told me a bit about the difficulties you’ve had getting your stair lift.  
P: Well yeah, because that’s outta your hands because it’s controlled by government bodies, it’s not controlled by you...They’ve gone through four different OTs to get the same results.  
C: Basically they should go out with a dedicated MND team...” P091*

Whilst the core community team was usually felt to be very expert, participants thoughts that some members of the extended team were unfamiliar with MND, or lacked the skills or positive attitudes towards the condition that patients and carers hoped for. Patients found contact with

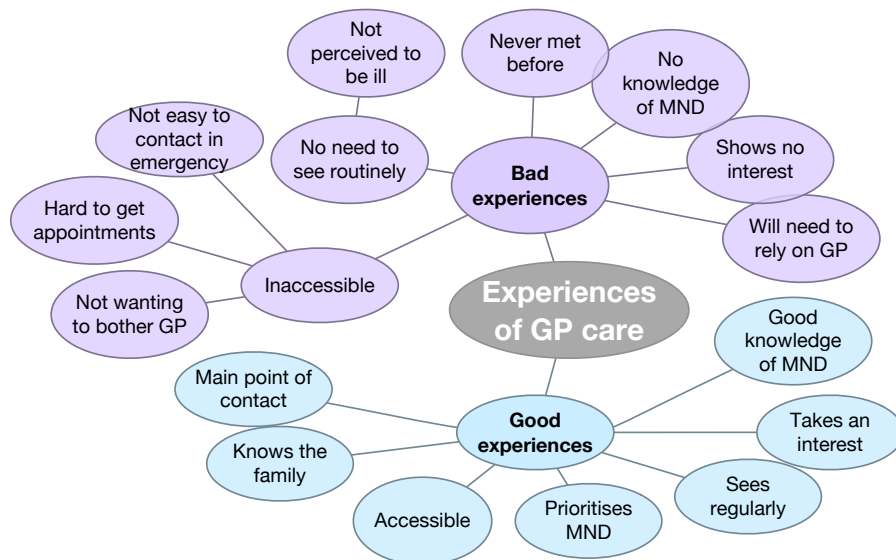
therapists and nurses helpful and reassuring but once the problem had been resolved they might be discharged from therapy. This made both the carer and patient anxious and could make it difficult or cause delays accessing the services when a new problem was encountered.

*“ Well C’s been on at me for a while to see physio again, I haven’t seen anybody since December, which is down to me ... it’s not down to them, they just said give us a ring when you need us. So I rang up ... the lady said “Well you have to be referred through your doctor.” I said “Well I’ve never had to do that before” She said “Well no, it’s changed now, you have to be referred back through your doctor.”” P145*

### 5.3.5 Experiences of general practitioners

Participants’ experiences of their GP were extremely variable (Figure 5.8 Appendix A5.11 and A5.12).

Figure 5.8 The good and poor experiences of GP care.



Some had very good experiences of their GP, who they felt took an interest in the condition and their family, might have some knowledge of MND and would arrange to see patients regularly, even when they were well. Where patients saw their GP regularly they could become the patients’ main point of contact.

*“The previous one was a fantastic GP and he had a little bit of knowledge about the disease... he kept saying I’ll see you in three months, just to keep, see how you’re doing.” P056*

Some knew they could get priority access to GP appointments, which made them feel reassured that they would be able to access help if they became unwell. In contrast, some patients thought their GP showed no interest in or knowledge of their condition. A number had never attended an appointment to discuss the diagnosis. It was common for patients to not know their GP prior to the diagnosis because they had previously been well. Now, they explained that they did not feel ill and did not have a particular

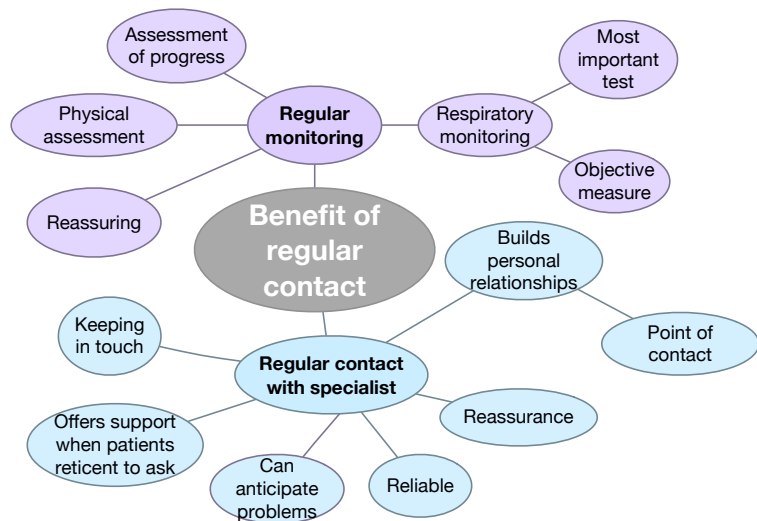
reason to book an appointment meaning they rarely saw their GP. One patient (P184) contrasted this to his diabetes, where he knew he was expected to attend regularly for check-ups. Access to appointments was a problem. Patients expected that MND would mean they would be prioritised but some did not want to book appointments for fear of not bothering GPs who they thought would be already busy. As a result of these experiences, patients and carers worried because they knew that as they became more unwell they would be relying on their GP for support.

*“Never ever had contact in all the two years he’s been diagnosed. So you’ve got no confidence. Eventually I know that we both are going to be reliant on our GP at some stage. We are going to need our GP, aren’t we? And we’ve no confidence at this moment in time” C184*

### 5.3.6 Importance of regular contact

A recurring theme was the value of regular meetings with specialist teams at the hospital and in the community. The two main benefits of this were felt to be the continuity and contact with experts, and the monitoring provided in the hospital clinic (Figure 5.9, Appendix A5.13).

Figure 5.9 The benefits of regular clinic visits.



Participants were happy that the hospital clinic scheduled regular visits, meaning they had had regular opportunities to access help. This was particularly important because many patients were reluctant to seek help and this provided an opportunity for problems to be identified or anticipated. Regular meetings also meant participants could keep in touch and develop a good relationship with trusted specialists in the MDT.

Whilst they received good care in clinic, a number of patients found that they faced difficulties between hospital appointments and were unsure how to address these problems.

*“I know when I come down to Sheffield I can get ...to know anything I want basically and, they’ve been fantastic. ...It’s just that time between...[clinics]” P056*

Whilst many patients felt happy to contact the MND team between visits, those who were recently diagnosis or who did not attend regularly had not built a strong relationship with the MND nurse meaning they were less confident in seeking telephone support from her between visits. This was particularly important when patients were not receiving frequent visits by the community teams, either because they did not have many active problems that required therapy, or because they had declined regular contact. For them, the clinic provided a reliable “*backup*”.

*“I just think when P was diagnosed that everybody came to see us and then everybody’s left us, apart from the clinic... at first I found it a bit strange that we were just left to get on with things..” C145*

In the time immediately following diagnosis, participants needed information and psychological support to deal with the diagnosis. The gaps between clinics meant they did feel unsupported, uncertain and alone. One patient explained:

*“I could have camped in [MND Consultant]’s house for the first six months, just so she was there, so I could say: but what about this? What about that? You imagine symptoms, or I did, you think: God, this is happening and that must be related to the MND... and what does this mean? I settled down, at some point...to pretty much know what’s MND related and what’s not.” P047*

Some community teams were also proactive in arranging regular visits and it seemed that these visits increased in frequency at times of need (such as immediately after diagnosis or when a patient developed new problems). In these cases it appeared the patients developed good relationships, they could easily report problems and tended to call on them for support much more than those without such regular contact. It was also common for community teams not to arrange a regular schedule, rather to suggest that the patient initiated contact if they thought they needed it. In addition, other professionals outside the core MDT (e.g. district nurses, physiotherapists) would work with a patient for a short period before discharging them meaning patients could find it difficult to get further help if they encountered a new problem. This meant that, if the patient had no current practical need (e.g. for new equipment for therapy), he/she might not have much contact with services.

*“Because it’s slow with P and he doesn’t need as much attention and care, it’s easy to feel detached from any positive interaction.” C122*

Expecting the patient to contact the team if needed was acceptable for some patients, particularly those who wanted to control their own care. Some felt empowered to contact the MDT if they had a problem. Many participants were reticent to request additional support either because of denial, for fear of admitting they were not coping or as a way to cope by trying to maintain normality. Some were not aware of whom to turn to, or what help was available. This meant that there could be a delay in identifying new

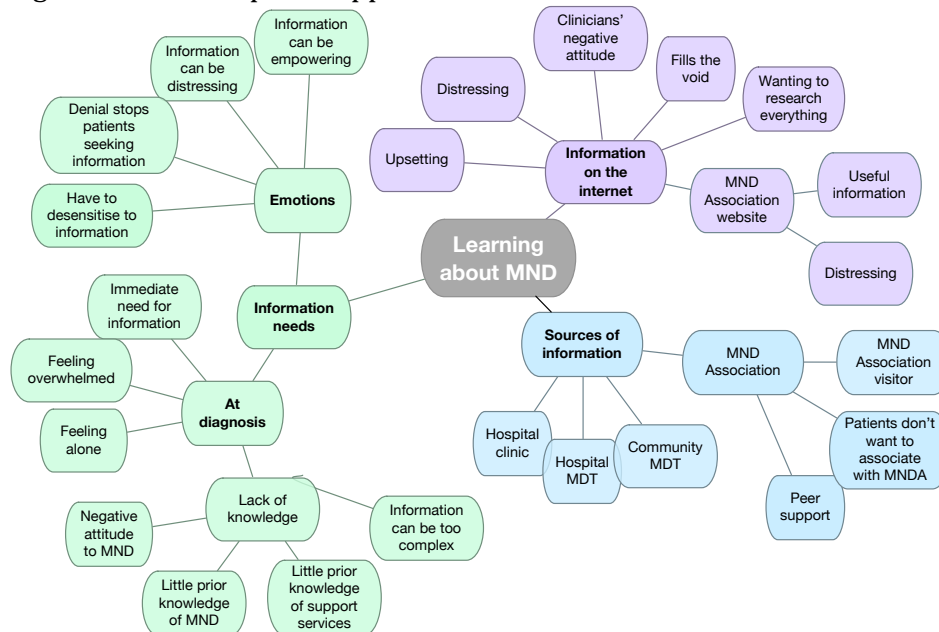
problems (particularly emotional needs). This could put additional strain on the family on whom much of the caring responsibilities fell and who often recognised the need for additional help before the patient.

### 5.3.7 Information needs

At diagnosis, most patients lacked any knowledge of MND or of the support services available (Figure 5.10, Appendix A5.14 –A5.16). If they were aware of MND it was usually framed very negatively. After diagnosis, many patients had a need for immediate information, usually about practical issues such as financial support and found the information available could be very complex. However, there was often a gap of weeks between the first clinic visit and later appointments during which these period, these needs were not met. Participants were asked about how they found out about MND. Information from healthcare professionals was the most highly valued. Some patients found it empowering and helpful to seek out information and peer support and most used the internet at some point. Most limited themselves to learning about specific questions but some aimed to seek out as much information as possible. Others found it more difficult, feeling overwhelmed, upset or in denial and explained that they had to “desensitise” themselves prior to learning more. A few patients found the information distressing, particularly regarding life expectancy whilst some patients recalled clinicians telling them to avoid using the internet but this meant they delayed accessing information when they needed it.

*“P: When we went to see ...[MND consultant] a couple of months later and she said, don't go looking on the internet any more...and that was fine but when you're on your own, in the first stages that is what you do.” P380*

Figure 5.10 Participants' approaches to information.



### 5.3.8 Summary

This data suggests that the hospital MND clinic offers regular, specialist holistic care and the opportunity for patients and carers to develop valuable relationships with trusted experts. These services are available to all patients as long as they are able to travel. Regular monitoring identifies and pre-empts problems and is also valuable for the patients' psychological wellbeing. Some patients have developed a good and trusted relationship with a healthcare professional in the community. The main contact was usually a community nurse although other healthcare professionals could play an important role making patients feel reassured that their holistic care needs would continue to be met, even if clinic becomes less accessible. This data highlights the unmet needs associated with lack of access to the right care, at the right time. Attending clinic can be a major burden meaning many patients struggle to attend and lose their relationship with the MDT, particularly with the MND nurse. Between clinics, or later in the disease, lack of access to the hospital clinic means patients and carers cannot always access the services they need and do not always have confidence that the community teams can offer the same level of expertise. Some manage to access specialists in the community or can maintain communications with the hospital team and can seek help at appropriate times. Others are not able to access this level of care. As a result, patients and carers are not receiving the physical care and emotional support they need which causes distress and potentially poorer clinical outcomes. In these patients, a more coordinated, consistent service would be welcomed by patients and carers.

## 5.4 Delivering the TiM service

The next sections described how the TiM system was set up and used during the trial. Section 5.4.1 what occurred during the set up stage of the TiM system, the problems encountered and the solutions found. Section 5.4.2 reports how frequently the TiM system was used by patients and carers and also how often they thought they should be using the TiM. Section 5.4.3 uses the interview data to describe the reasons identified which might explain the observed adherence that were identified.

### 5.4.1 Delivering the TiM service

All participants randomised to the intervention group received the TiM system and completed at least one session within two weeks of training. Training gave participants the opportunity to ask questions and queries were easily resolved.

The technical problems encountered during the trial and suggested solutions are summarised in Table 5.6 and Table 5.7. When problems with the app or tablet device were encountered, in most cases they could be resolved with telephone or face-to-face support.

The most common reasons for the TiM system failing to transmit results occurred when the patient had provided data but it had not been uploaded to the internet. It was not possible for the nurse to determine whether the patient was just not using the TiM or whether there was a technical problem and finding and resolving this problem usually required a visit to the patient's home. These problems were not due to the TiM software but due to the connection between the tablet/weighting scales and the internet. On two occasions, the patients had accidentally switched off the tablet's Wi-Fi. It also occurred when using the tablet to connect the weight scales to the internet as this quickly drained the batteries of both devices. To solve this problem, the weighing scales were connected directly to the patient's home broadband. For the two patients who did not have broadband, a separate device ("Mifi") was provided which acted as a 3G wireless router for both the tablet and scales. This worked well but for both solutions the process of connection was not straightforward and it required a home visit. Weights were often missed and it was concluded that the equipment used was not a feasible way to record weight. A more straightforward solution would involve simply using a normal set of scales and asking the patients to record their weight on the Patient App.

Table 5.6 Technology problems encountered during the trial. Some of these problems are described further in Sections 5.7 and 5.14. It also describes the solutions adopted, the impact these problems had on TiM system use and recommendations for the future TiM use.

<b>Problem</b>	<b>Solution adopted</b>	<b>Impact on the use of the TiM</b>	<b>Recommendations for future</b>
<b>TiM app</b>			
Poor finger dexterity (sections 5.7.2.3 and 5.7.2.6)	Handheld stylus provided to all patients Carer help to use device	85% could use the TiM independently. Interview data suggested that help from carers was acceptable.	Provide stylus to all patients. Encourage carer support.
Login page not intuitive	Telephone support Login page redesigned	Problem resolved with second TiM app release No further problems reported.	Provide face-to-face training. Provide telephone technical support. Make local staff familiar with the software.
Lack of confidence using the app or other features on the TiM (Section 5.5)	Face to face training Partner/family helped	None: all participants could use the app	Provide face-to-face training plus an additional contact after a few weeks to reinforce learning. Identify users with low confidence/experience and provide additional training
Patients not giving correct answers (Section 5.7.4)	Patient completing TiM with their family	Uncertain impact	A short capacity assessment at recruitment. Observe patients using TiM during training Check TiM answers in clinic.
<b>Samsung galaxy tablet</b>			
Tablet stored in place not accessible to patient	No solution available.	Interviews suggested that adherence was reduced for two patients.	Use patients' own equipment where possible.
Tablet battery drained, unable to switch on	Telephone advice: fully charge using correct equipment.	No impact.	Use patients' own equipment. Ensure local staff are familiar with hardware.
Unexpected screens/software updates	Telephone advice.	Reduced patient confidence in tablet but no impact on use,	Use patients' own equipment. Use a basic tablet that only displays the TiM app.
User fear of "breaking" the tablet	Face to face training to improve user confidence	Patients/carers reluctant to use the additional features on the tablet	Use patients' own equipment. Face to face training.



Table 5.7 Further descriptions of the problems encountered with the TIM system.

<b>Problem</b>	<b>Solution adopted</b>	<b>Impact on the use of the TIM system</b>	<b>Recommendations for future</b>
<b>Internet connection</b>			
Poor 3G phone signal	Used patients' own broadband. Check TIM connection works at patients' home.	No impact: internet connection solution found for all patients using either 3G or patients' own broadband.	Use patients' own broadband. Check internet availability prior to TIM enrolment. Staff setting up TIM need to have internet access at the patients' home to access clinical portal.
Wi-fi on tablet switched off	Home visit required.	Several TIM sessions failed to download.	Monitor adherence and alert the clinician if adherence is low. App alert if no internet connection is available.
<b>Weight/balance scales</b>			
Unreliable connection between scales and tablet	A separate 3G-Wi-Fi route provided ("MiFi").	Additional home visits required and loss of weight data for several weeks.	Manual entry for weight. Avoid using additional peripheral devices wherever possible.
Unreliable connection between scales and patients' home broadband.	This problem remained unsolved.	Additional home visits required and loss of weight data for several weeks.	Manual entry for weight. Avoid using additional peripheral devices wherever possible.
<b>Clinician portal</b>			
Password/login problems	Password support provided from Carematix team in Chicago.	Delayed access clinical portal during clinic.	Local systems access support. Integrate portal/password into systems already used in the hospital.

## 5.4.2 Participant TiM system adherence

### 5.4.2.1 Patient and carer adherence to weekly TiM sessions

Participant adherence was calculated based on the number of sessions completed over the course of the trial<sup>6</sup> and described as:

- “High” adherence:  $\geq 75\%$  of weekly sessions completed
  - 40% of patients
  - 33% of carers
- “Medium” adherence: 50-75% of weekly sessions completed
  - 30% of patients
  - 22% of carers
- “Low” adherence:  $<50\%$  of weekly sessions completed
  - 30% of patients
  - 44% of carers

Table 5.8 and 5.9 describe the level of adherence to TiM sessions at different points throughout the trial and Figures 5.11 and 5.12 displays each individual’s use of the TiM during the whole trial. Following completion of the TiM study, the Telehealth Nurse was asked how often she felt participants needed to answer the questions to provide a useful assessment of their progress. She felt that if patients completed the TiM once a fortnight this would give her sufficient information (approximately 50% of the weekly sessions completed). This means over 70% of patients who sustained “medium” or “high” adherence throughout the trial were providing sufficient data. These users continued to use the system regularly throughout the trial.

Usage tailed off later in the trial, particularly amongst the less frequent users or those nearing the end of their lives. Some patients completed less than 50% of the weekly sessions but continued to send in data regularly. For example, P317 missed sessions when she was on holiday but also, as her disease was progressive slowly chose to use the TiM less frequently. Despite this she continued to provide data regularly throughout the trial.

Adherence by carers was not as high as the patients but over half of carers continued to complete at least 50% of weekly sessions. Many of those completing sessions less frequently still continued to use the TiM system every few weeks. The nurse felt carers did not need to provide information so frequently as patients and carers providing information every few weeks was usually sufficient to keep her up-to-date with their progress. Similar to the patients, frequent users continued to use the system regularly throughout the trial. Usage tailed off later in the trial in the less frequent users.

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<sup>6</sup> The system did allow patients to complete multiple sessions per week but only two patients completed, on average, more than one session per week.

Table 5.8 Patient adherence to weekly TiM sessions overall and at different points during the trial.

<b>Adherence to TiM</b>	<b>Total</b>	<b>0-4 weeks</b>	<b>0-12 weeks</b>	<b>12-24 weeks</b>	<b>24-36 weeks</b>	<b>36-48 weeks</b>	<b>48-60 weeks</b>	<b>60-72 weeks</b>
	n=20	n=20	n=19	n=16	n=11	n=10	n=5	n=2
<b>Mean</b>	<b>65%</b>	<b>91%</b>	<b>76%</b>	<b>72%</b>	<b>72%</b>	<b>63%</b>	<b>73%</b>	<b>46%</b>
Minimum	13%	50%	33%	17%	33%	8%	25%	0%
Maximum	104%	100%	108%	108%	100%	100%	100%	92%
SD	28%	20%	24%	30%	32%	32%	28%	65%
Patients completing $\geq 75\%$ of sessions	40%	90%	50%	53%	67%	55%	80%	50%
<b>Patients completing <math>\geq 50\%</math> of sessions</b>	<b>70%</b>	<b>100%</b>	<b>75%</b>	<b>80%</b>	<b>78%</b>	<b>73%</b>	<b>80%</b>	<b>50%</b>

Table 5.9 Carer adherence to weekly TiM sessions overall and at different points during the trial.

<b>Adherence to TiM</b>	<b>Total</b>	<b>0-4 weeks</b>	<b>0-12 weeks</b>	<b>12-24 weeks</b>	<b>24-36 weeks</b>	<b>36-48 weeks</b>	<b>48-60 weeks</b>	<b>60-72 weeks</b>
	n=18	n=18	n=17	n=14	n=11	n=9	n=4	n=2
<b>Mean</b>	<b>57%</b>	<b>83%</b>	<b>67%</b>	<b>67%</b>	<b>53%</b>	<b>54%</b>	<b>46%</b>	<b>4%</b>
Minimum	12%	25%	25%	8%	17%	0%	0%	0%
Maximum	95%	125%	100%	100%	100%	100%	92%	8%
SD	29%	29%	24%	33%	33%	39%	48%	6%
Carers completing $\geq 75\%$ of sessions	39%	78%	47%	57%	67%	44%	50%	0%
<b>Carers completing <math>\geq 50\%</math> of sessions</b>	<b>56%</b>	<b>82%</b>	<b>75%</b>	<b>71%</b>	<b>55%</b>	<b>44%</b>	<b>50%</b>	<b>8%</b>
Carers completing $\geq 33\%$ of sessions	72%	94%	82%	79%	54%	67%	50%	0%

Figure 5.11 A visual representation of individual patient adherence over the duration of the trial. Each black dot on the figure represents a completed session. Each coloured dot indicates the end of follow-up.

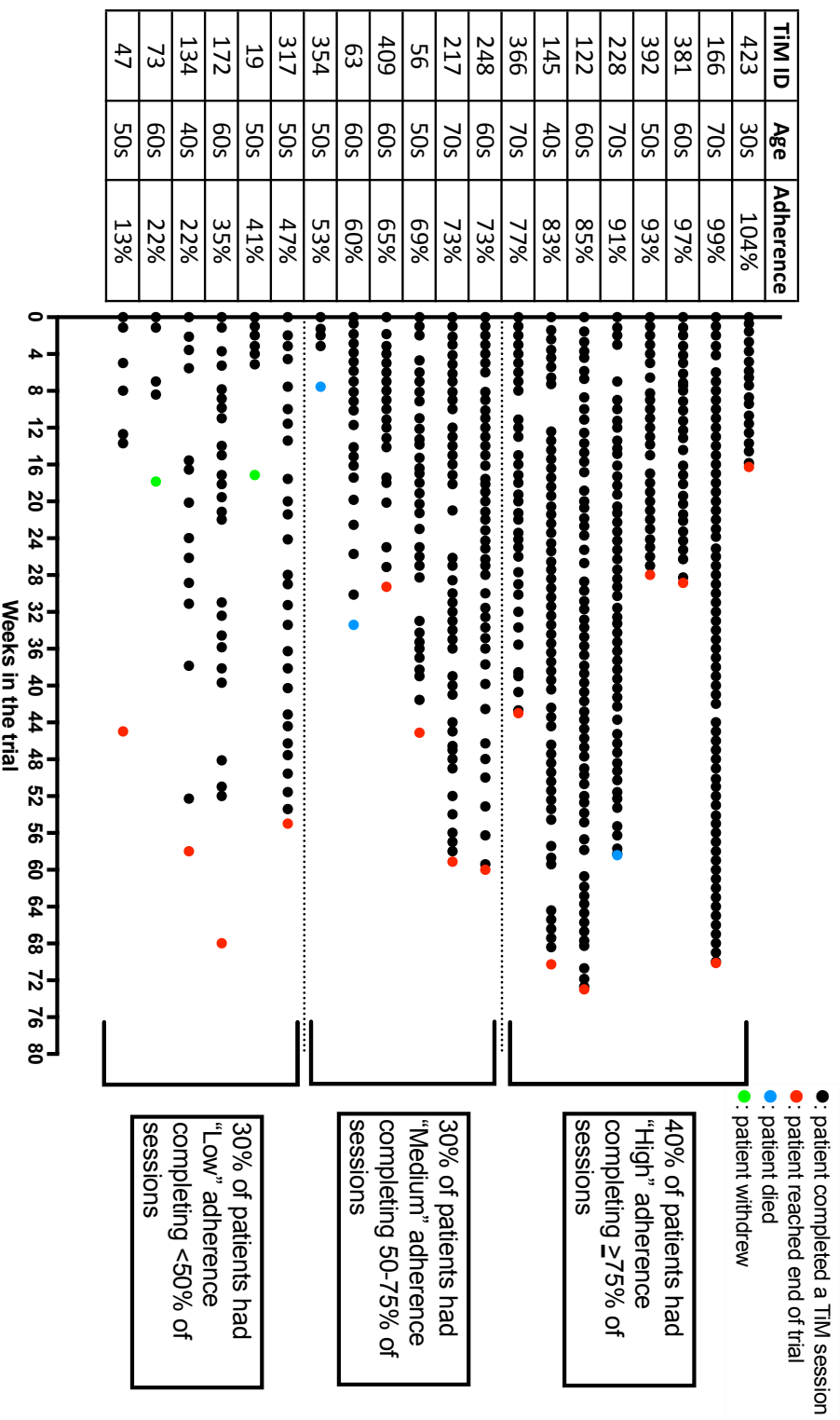
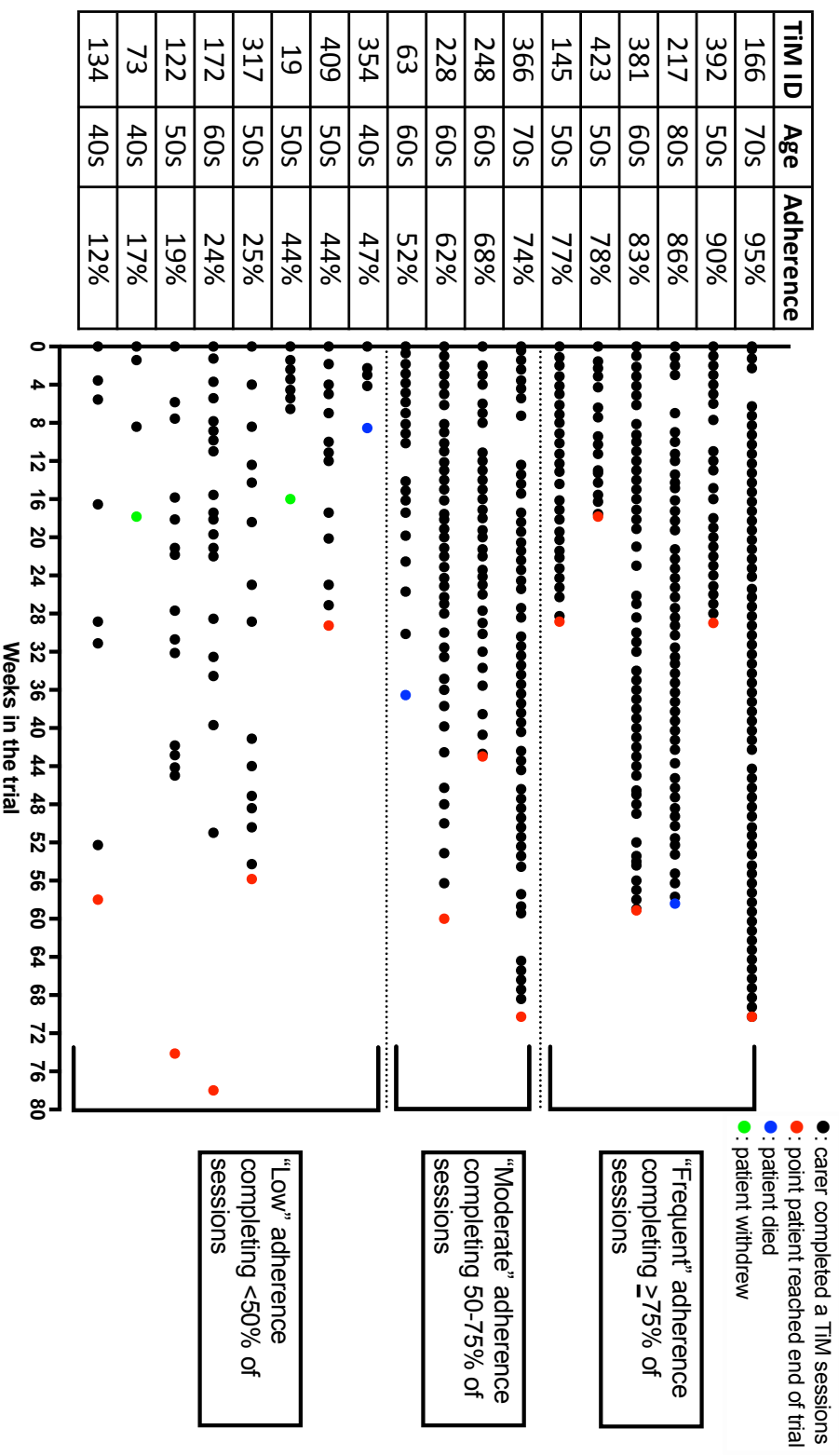


Figure 5.12 A visual representation of individual carer adherence over the duration of the trial. Each coloured dot indicates the end of follow-up.



### 5.4.2.2 Patient and carer preferences for the frequency of TiM system sessions

Figure 5.13 shows that most participants preferred to complete the TiM weekly, although some, particularly carers, preferring the complete the TiM less often. The results at three and 12 months are available in Appendix A Table 5.1. The interviews suggested that weekly sessions were acceptable to participants and presented little burden. Weekly sessions also promoted adherence by becoming part of their weekly routine (Appendix A5.17). Some participants (particularly those with slowly progressive disease) preferred to use the TiM less often and some felt they might vary the frequency depending the progress of their disease (although there was no facility to allow this on the current version of the app) such as this patient who was a high TiM user:

*“Q: How often do you think you’d need to do it to make it worthwhile...?”*

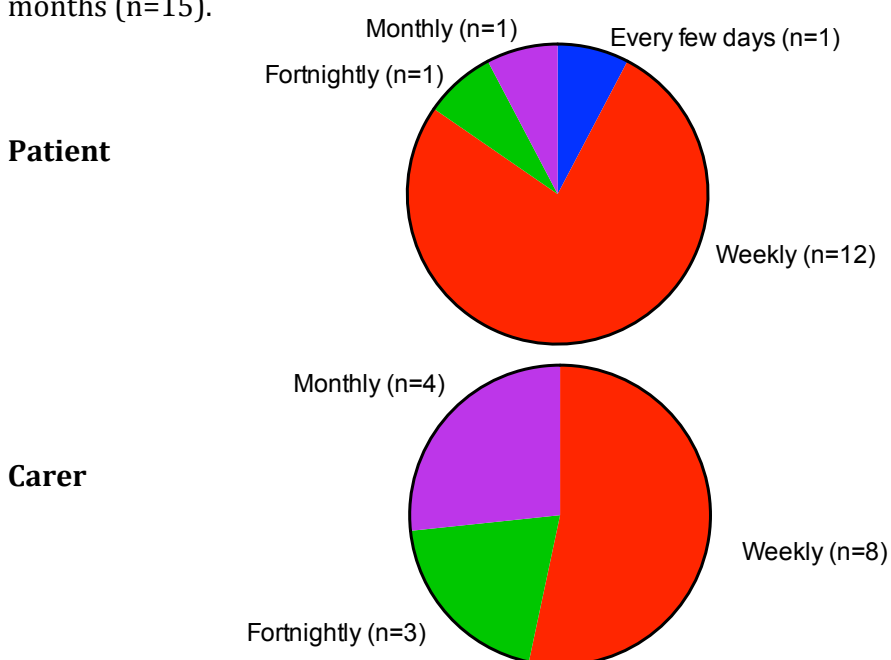
*P: Probably every month.*

*Q: ...and if things changed how would you then approach it, would you go back and do it again or would you wait for the month...?”*

*P: If things were changing quicker I’d go back in and do it again...” P423*

Carers noticed that, their answered changed more slowly compared to patients, suggesting that it may be feasible to ask carers to do it fortnightly or monthly sessions. At 12 months more carers preferred to complete the TiM monthly. However, carers also found doing the sessions weekly helped them remember and many did it together with the patient. They thought that the situation could change quickly but they also thought it should be possible for carers to do it less frequently if they felt things were stable.

Figure 5.13 Participants’ preferred frequency of use of the TIM system at six months (n=15).

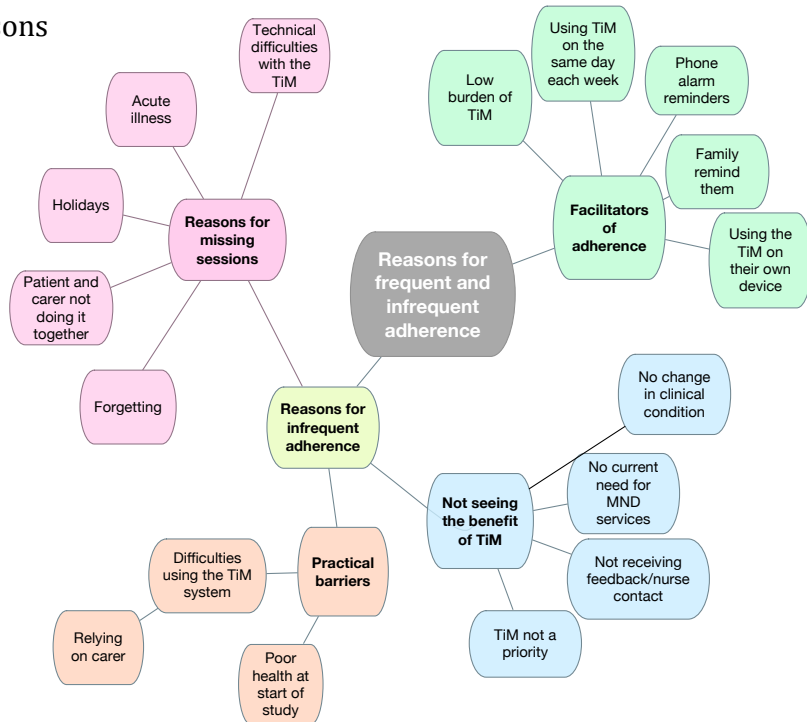


### 5.4.3 Exploring TiM system participant adherence and acceptability

#### 5.4.3.1 Barriers to and facilitators of frequent adherence to the TiM

The interviews explored the reasons for frequent and infrequent adherence. The main themes and subthemes are summarised in Figure 5.14 and Appendix A5.18.

Figure 5.14 Reasons for participants' frequent and infrequent TiM use.



Participants explained that the TiM presented little burden that it was easy to fit the TiM sessions into their weekly routine. However, they also suggested ways adherence could be promoted such as completing the sessions on the same day each week, by setting alarms, or using the TiM on their own device which they were already using every day.

Most participants missed the occasional session: forgetting, illnesses or holidays were common. Only a few sessions were missed due to technical difficulties. Some carers forgot because they did not complete it at the same time as the patient. Those patients who were “infrequent” adherers explained this was due to two main barriers. The practical barriers to TiM use (upper limb weakness and language/cognitive problems) are described in Section 5.5.2 (Barriers to the TiM app use). Some participants found the TiM did not meet their expectations and did not feel it provided them with benefit and stopped using it. This is described in Section 5.8. However, even “infrequent” adherers felt the TiM was easy to use and could be a valuable additional to their care.

*“No doubt at the end of it, [what] works is that it flags up that I need help or I don’t need help.” P134 (High technology user, Low TiM user)*

Adherence also decreased during the last few weeks of patients’ lives. Three patients died during the study and two (P354, P063) stopped using the TiM

system four to six weeks prior to their death. The reasons for this could not be explored in interviews, but participants who were interviewed did explain that they did not use the TiM system when they were ill, particularly when they were already receiving face-to-face support from local services. In the later stages of the disease, patients tend to be in frequent contact with local healthcare professionals and formal carers with the patients requiring immediate medical care, something the TiM system was not designed to provide.

#### 5.4.3.2 Carer adherence

The reasons for lower carer adherence (when compared to patients) were explored in interviews and again at the end of the trial once the full adherence data was available. Several possible reasons were identified, these were:

- Carers being too busy/forgetting;
- Carers did not think that the MDT or the TiM system was there to help carers.

Most carers reacted positively to the TiM and had intended to use the system. Some said at times they were too busy with caring duties to use the TiM. A common theme throughout the interviews was the importance of the patient being a carer's first priority and that MND care was focused on the patient, not the carer. This theme is described in more detail in Section 5.8. Because of this, some carers did not expect the TiM system to offer them benefit. A number of the carers did indicate that they were completing the study simply for the benefit of the patient, or for the benefit of other patients. Despite this, some carers (e.g. C217) continued to complete the sessions regularly.

*P: I don't mind doing it.*

*Q: What do you think?*

*C: Not a lot.*

*Q: So would you send [the TiM system] back?*

*C: I don't know, I would... no... To me, it's for P. So if she did not want to... participate on it, that's it.*

*Q: Yep. So it's about her and how she is?*

*C: ... if it's helps other people with these things then fair enough." P&C217*

#### 5.4.4 Summary

In summary, setup of the TiM system went well once initial problems had been resolved and participant adherence to the TiM system was, for most participants, sufficient to enable the Telehealth Nurse to assess their condition. The frequency of use (every one or two weeks) was acceptable to participants. Few barriers to use and adherence were experienced and these could be overcome by a short face to face training session, encouraging participants to incorporate TiM sessions into a weekly routine and using an alert to remind users to complete weekly sessions.



## **5.5 Participants' experiences using the TiM technology**

Sections 5.5 and 5.6 describe the participants' experiences of using the TiM system, drawing on information gained from field notes, the notes made on the TiM system and interviews with the MND nurses (nurses' and physicians' experiences are described in more detail in the section 5.7). Section 5.5 describes participants' initial experiences using the TiM technology along with the barriers and enablers to technology use amongst participants including the experiences of those with low confidence using technology. Section 5.6 describes participants' expectations and understanding of the TiM system, their reactions to the questions posed on the TiM system and whether they accurately capture the key problems experienced in MND.

### **5.5.1 TiM system acceptability questionnaires**

Figures 5.15 and 5.16 display patient and carer satisfaction with the TiM system at six months when most participants provided feedback. Satisfaction was similar at each follow-up time point (the results at three and twelve months are reported in Appendix A Table 5.2-5.3). Participants were also given the opportunity to write comments in the questionnaires. The key themes mirrored those identified in the interviews, which are described below.

Figure 5.15 Patient satisfaction with TIM telehealth at 6 months (n=15).

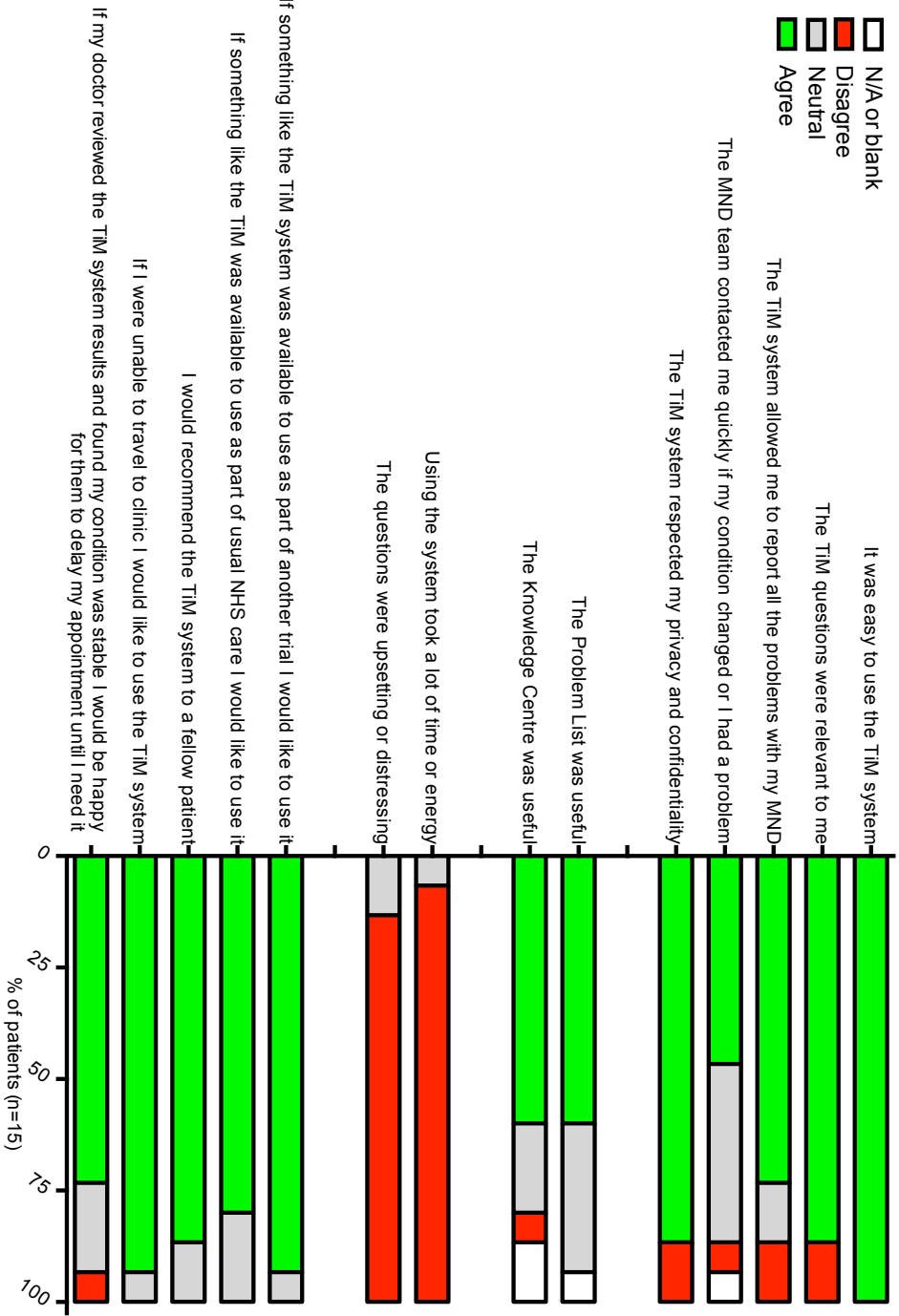
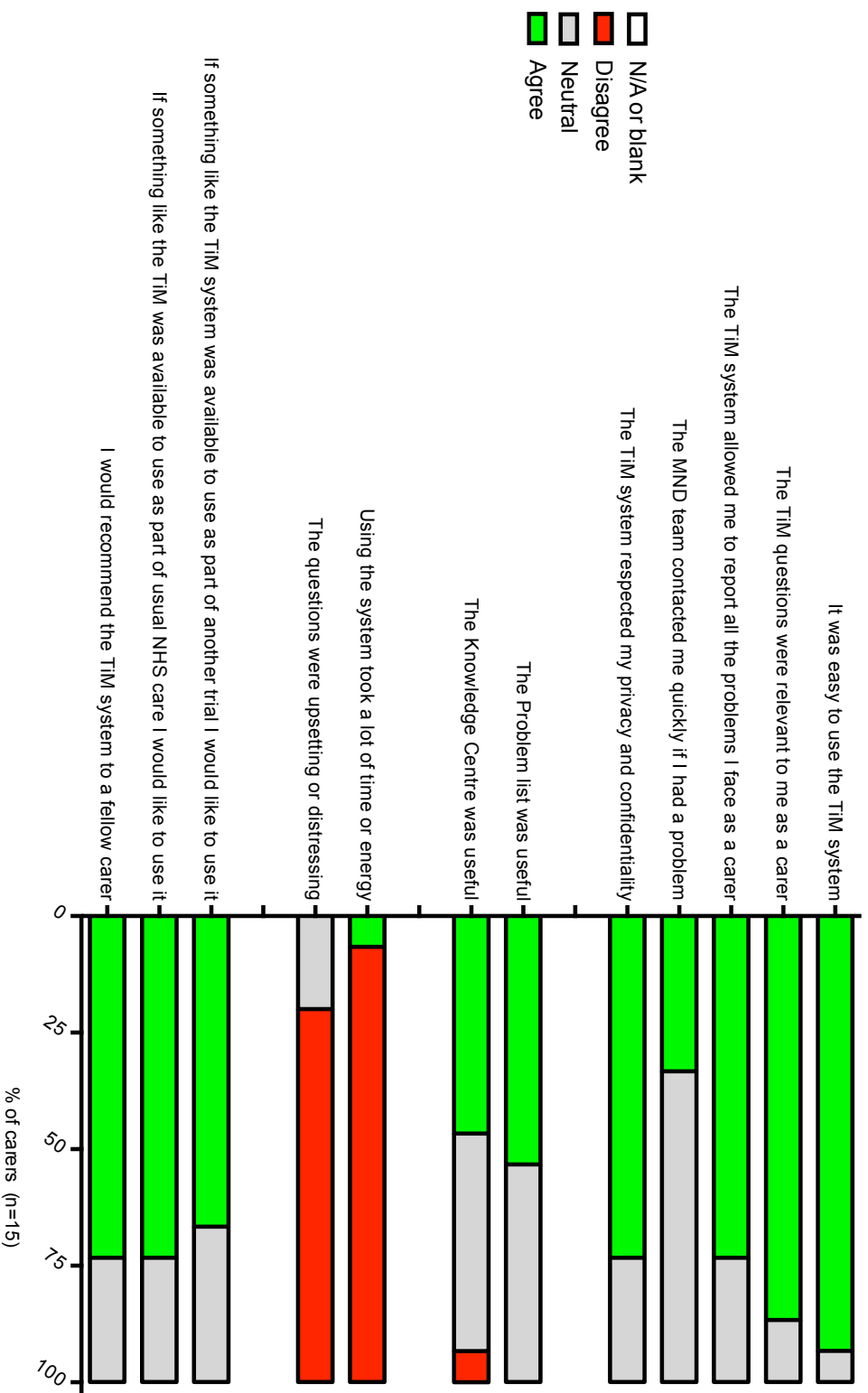


Figure 5.16 Carer satisfaction with TIM telehealth at 6 months (n=15)



### 5.5.2 Initial experiences using the TiM app

At six months, all the patients and 14 (93%) of the carers felt the TiM system was easy to use (only one carer was unsure). 14 (93%) of the patients and carers did not think the system was tiring (one patient and carer were unsure) and 13 (87%) did not think the questions were distressing (two were unsure). Participants in the interviews explained that the TiM app was extremely easy to use and of low burden (Appendix A5.19).

*"It's so easy to do; it literally takes five minutes from home." P317*

Using it weekly meant participants became confident quickly and participants did not find completing the questions weekly was an intrusion on their lives, or reminded them unduly about MND. One patient who was early in the disease explained:

*"To be honest, it doesn't bother me. When I was first diagnosed I was not keen on talking about it. I've since got better and I think that helps. So to me, I'm quite happy to, if you like, be reminded. To be honest, I think you are reminded every day. That tablet makes no difference to that." P381*

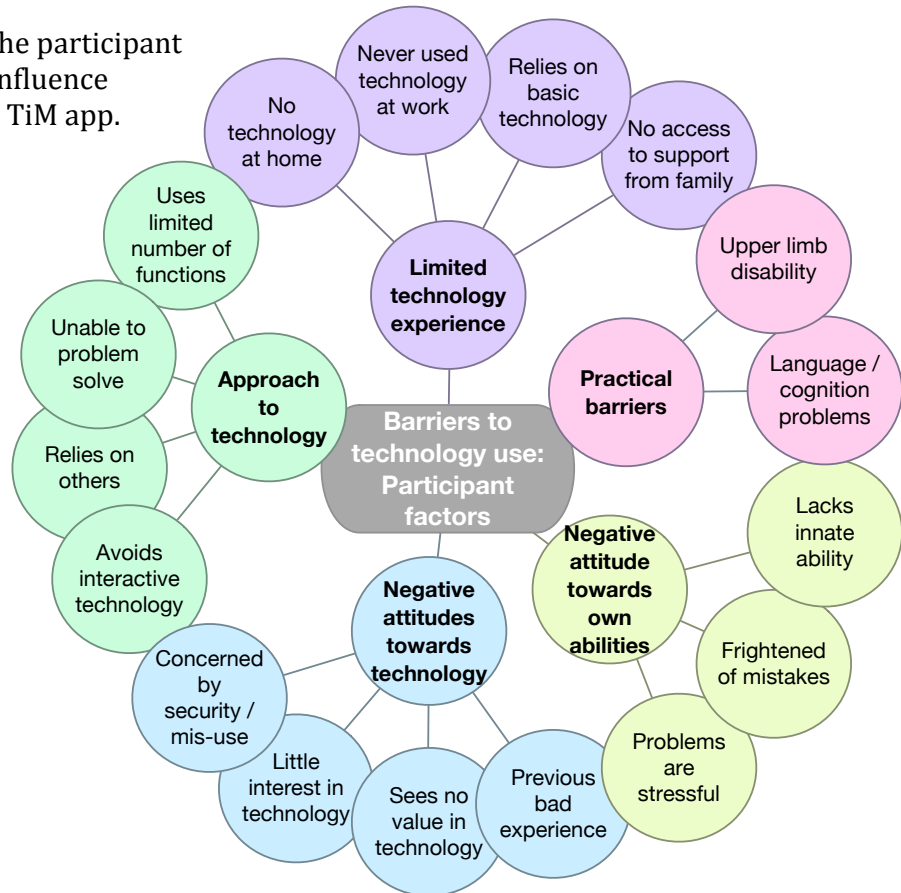
The Telehealth Nurse also felt that patients had responded positively to the TiM and found it easy to use. She initially thought some patients would be faced with barriers that would mean they would not participate in the trial or use the TiM system such as age or inexperience with technology. However, she was surprised because some patients faced by these barriers used the system regularly.

*"[There are] some patients that, I'm surprised they took it up. I'm surprised; actually that, I never thought that he would use that... and he sends his back very, very well." Telehealth Nurse*

#### 5.5.2.1 Barriers and enablers to the use of the TiM Patient App

There were two main types of barriers experienced during the trial: those relating to the technology, and those relating to the participants. Problems with TiM technology were described earlier in Section 5.4 (Setting up the TiM system). This section describes the participant characteristics that posed barriers and enablers to using the TiM (Figure 5.17 and 5.18). Practical barriers (e.g. upper limb disability or language/cognitive problems) were encountered but the most important barrier was participant attitude towards digital technology. Despite these barriers, even those who were not confident with using technology found the system easy to use and became confident to deal with any difficulties that they experienced.

Figure 5.17 The participant factors that influence the use of the TiM app.



### 5.5.2.2 The impact of upper limb disability on TiM use

27 patients (68%) reported some difficulty using technology due to upper limb disability. However, when given the opportunity to try the tablet, 34 (85%) found they could use the TiM tablet computer independently (although they may need a carer to help e.g. to plug it in).

*"My fingers are too heavy. ... I'll end up phoning somebody." P378*

Patients with upper limb weakness found the tablet touch screen helpful and several found it much easier with a stylus pen (provided with the tablet). Patients who could not operate it independently were happy to allow their carers to operate it on their behalf although they would prefer to use the TiM system on their own device which had been adapted for their disability e.g. using Eye gaze technology.

### 5.5.2.3 The characteristics of participants with low confidence in technology

The main barrier to participation identified by participants was the concern that they would not be able to use the system.

*“...we’re quite happy to deal with it, as long as it wasn’t too techy” C062*

Many participants, including those using technology daily, described themselves as lacking an intrinsic ability to use technology saying that they were “*bad*” at it, thinking others were more “*wired*” to using technology. Those with low confidence or experience using technology shared common attitudes towards their abilities, their experience and approach to technology (Figure 5.17, Appendix A5.20 and A5.21). They said they struggled to “*catch-on*” or learn to use new technology. They found technology stressful and were fearful of making a mistake or it breaking the device. They did not feel in control of technology, expressing frustration when technology did not “*obey*” them. This meant they were not confident adapting to unfamiliar technology. They tended to give up quickly if they encounter a problem as they were unwilling or lacked confidence to solve problems with technology. Instead they relied on others to set up new technology or resolve problems when technology “*went wrong*”. Some low users explained they never learnt or did not see the need to use technology, particularly if their partner used it on their behalf

*“I just haven’t used it much because I haven’t really had the need and P does all [the technology]” C380*

Those who lacked experience or confidence tended to use a limited number of basic applications but many enjoyed using leisure facilities e.g. on-demand television, Facebook, Kindle, information websites. These sites tended to require little interaction and they felt less confident using technology for more complex tasks such as internet banking, when needing to use passwords etc. Box 5.1 explores a case in more detail.

### **Box 5.1 Case vignette: negative attitudes towards technology**

Four participants did not use technology at all and three said they had little interest or need for technology and did not see it as offering value to their lives. One gentleman in his 70s (C166) explained he had a negative attitude towards technology (Appendix). The couple had no technology in the house, see no need for technology, and describe themselves as “*technophobes*”. C166 sees the continued involvement of technology into everyday life as an intrusion and feels that they were becoming isolated because they chose not to use it.

*“I’m not against it but I don’t want it and I can do without it and I don’t need it.” C166*

Both C166 and another patient P378 felt they were being increasingly pressured to use technology in every day life with a resulting loss of reliable alternatives.

*“I got pushed down that road while I were in teaching” P378*

C166 also mentioned the potential for technology to be misused, “*hacked*” or to become “*Big brother*”: intruding into their lives. The couple thought technology had negative impact on human interactions (turning people into “*zombies*”). C166 valued having the security of physical records and saw digital records as worthless and not “*real*”. Despite these concerns, the couple were willing to use the TiM system because they trusted their MND care team to provide them with a secure and safe system and had tested it out prior to agreeing to join the study. In fact, following some additional training, they were the second most frequent users of the TiM system (patient 99% of expected sessions and carer 95%). In the second interview they even mentioned that they would consider purchasing technology if they saw a reason to use it.

*“It’s unbelievable that sort of technology, but equally it’s open to anybody to get into it. So, I might be persuaded eventually, but [laughs] it’s a slow process” C166*

#### **5.5.2.4 The experience of using the TiM app by low technology users**

Only one couple had problems that stopped them using the app (P166) and their problems were resolved with some additional training (see Section 5.4). One carer in his 80s (C217) said he had difficulties with language and struggled to adapt to new things. His wife helped him to use the tablet. He had little prior experience with technology and had worked in a manual job and had a medical condition affecting his language although he did not raise these problems during training. He said by the time he returned to use the TiM a week later he had forgotten.

*“C: It’s the system that’s all. I don’t catch on very well with it, that’s ok. Like phones, I don’t bother them really.*

*P: Couldn’t read a text message.*

*C: Oh I couldn’t do anything like that.” C217*

Despite participants' concerns, following face-to-face training only C217 reported on-going difficulties using the app, the rest all felt the TiM was easy to use. Participants explained that the more they used the system, the more they developed confidence (Figure 5.18, Appendix A5.22).

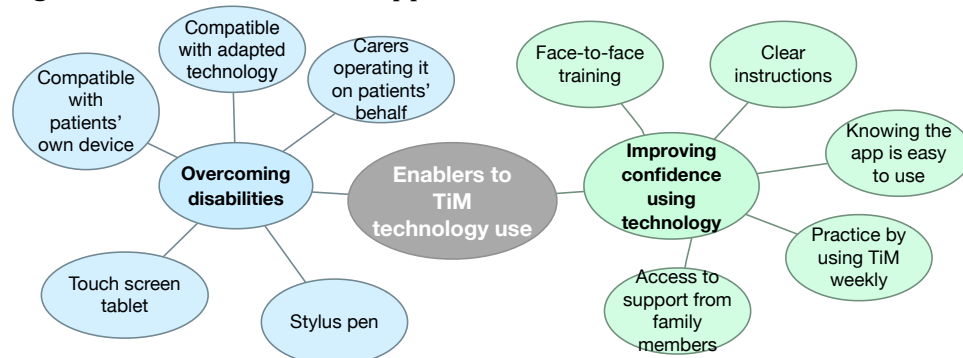
*"It is now easy to use but was hard originally"* P228 3 month questionnaire

C366 also admitted having little confidence in technology and asked her husband to "set-up" the tablet. Despite this she reported no problems once she started using the app. Having received help from his wife to use the TiM app, even C217 managed to complete sessions and was also a high TiM user, completing 87% of expected weekly TiM sessions.

Participants thought that face-to-face training was very important. They wanted clear instructions designed for those who were not experts that assumed no knowledge or experience. All the participants found the face-to-face training helped enable them to use the TiM. Some were pleasantly surprised by their achievements.

*"I thought I wouldn't be able to do it (laughter) but I can... I'm not really... I don't want computer or anything like that, so it's only that only because of that."* C228

Figure 5.18 Enablers of TiM app use.



Most patients completing the questionnaire were "unsure" whether the additional features on the TiM system (the Problem List and Knowledge Centre) were helpful. When interviewed, many commented that they hadn't used these features, some because they did not want to learn more about MND and others because they did not feel confident using other features of the tablet device. Two reported during the interviews that they had found the Knowledge Centre helpful and they had used it to find out more about MND. Others felt happy these features were available if they needed them.

The only other barrier identified was the existence of language and cognition problems: one patient could use the TiM technology but during training it was noted to be giving answers that did not appear accurate (P073). He was severely disabled, unable to communicate verbally and exhibited behaviours suggestive of mild frontotemporal deficits. He and his family agreed they would complete the questions together. Due to later illness he was unable to take part in an interview so his use of the TiM could not be fully evaluated.

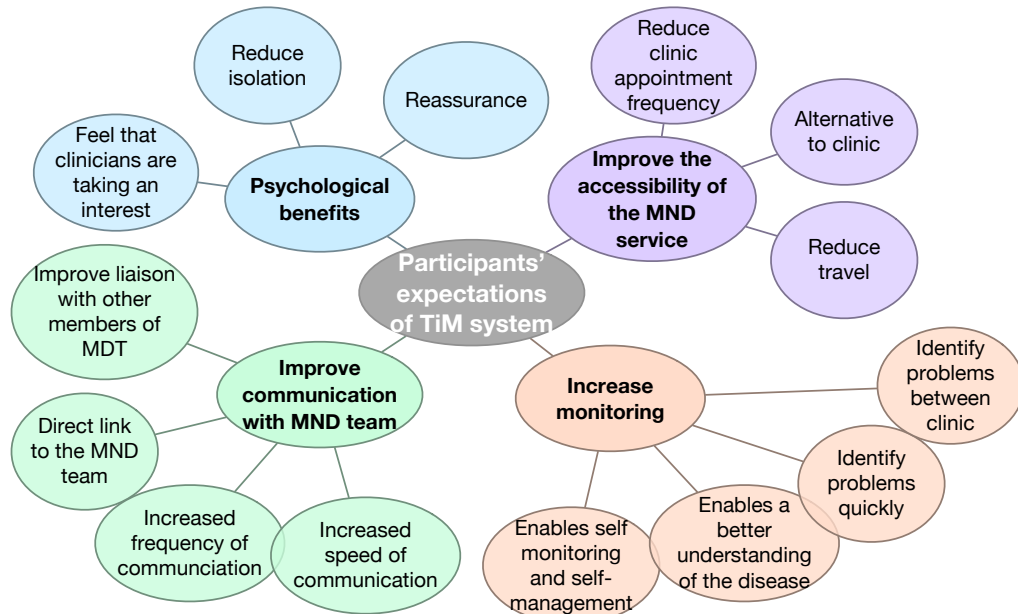


## 5.6 Participants' experiences using the TiM system

### 5.6.1 Participants' expectations of telehealth

Participants felt the TiM system could offer various benefits (Figure 5.19, Appendix A5.23 and A5.24). The main expectations were that TiM could improve communication, monitoring and accessibility of the MND care team and that this would bring psychological benefits to participants.

Figure 5.19 Participants' expectations of the potential benefits of the TiM service.



Participants thought TiM system could provide them with a “direct link” to the MND team, which would improve the speed, frequency and quality of communication between the MND team, patients, carers and their wider care team.

*“If I put it on the tablet and I send it to you, you get it there and then. So if anything ... happens to me in that period of time you know straightaway ... So the quicker you can pick up on something, it’s better for you as a doctor, as well as me as a patient.” P091*

Participants thought increased monitoring could pick up problems earlier and between hospital visits, could stimulate discussions about new problems and enable them to monitor their own progress. As a result they thought the TiM could reassure them that they were being monitored and that important problems would be identified, which would reduce the isolation they felt between clinic appointments. They felt that the TiM could help improve the accessibility of the service, reducing travel and clinic time and provide an alternative if they were too unwell to attend (Figure 5.19)

*“Sometimes it’s just the fact that, “should somebody know about this?” or “should you be telling somebody that. Wouldn’t it be nice if somebody knew this?” Just small details that you sometimes think, “Does it make a difference if somebody knew about it?” And that teled made that difference.” C184*

### **5.6.2 Participants’ attitudes towards the TiM questions**

The participant satisfaction questionnaires examined participants’ attitudes towards the TiM questions (Section 5.5, Figure 5.15 and 5.16). 13 (87%) patients felt the TiM questions were relevant to them although two (13%) disagreed. 11 (73%) patients felt they were able to report all the problems they experienced using the TiM, although two (13%) disagreed and two (13%) were unsure. 13 (87%) of carers felt the questions were relevant to them and 11 (73%) felt the TiM enabled them to report all the problems they were faced as a carer.

When interviewed, participants were satisfied that the TiM questions provided a good coverage all aspects of MND and they were not distressed by the questions (Appendix A5.25 and A5.26). Reporting deterioration in their condition using the TiM was not upsetting because patients would already know themselves if they had changed. Instead, they welcomed being able to report and discuss their current and future problems as they felt this might present an opportunity for them to receive support from the MND team. Furthermore, those that had not changed found completing the questions reassuring as they could see their answers had not changed.

*“It’s good that you can change [the answers]...keep everybody up-to-date. Cos you don’t know when things are going to change, it’s...a grey area isn’t it?...as long as people who need to know see that information...not waiting till your next visit at the clinic.” P122*

Participants felt it was very important that the information they provided was accurate and that the MND team received the right information. Participants often wanted to give more information in their answers, either by using the TiM app or by calling the MND team directly. A number of the participants thought the questions were repetitive, particularly the carer questions. Some were reporting the same problems (e.g. falls) every week. Participants thought some variation would be helpful. Some felt some answers (particularly the PHQ4 anxiety/depression score) were insufficiently sensitive to reflect the day-to-day fluctuation in their condition.

The interviews did provide an opportunity to identify changes that could be made to the TiM app. A number of important symptoms that were not included in the original TiM app were identified. These were diarrhoea, constipation and incontinence. Diarrhoea and constipation were added to the second version of the app. One patient explained that, now she had become severely disabled, many of the questions no longer changed. To reflect this, the ALS-FRS-EX scale was added which includes questions designed to identify changes in patients with severe disability (209).

One carer suggested that the questions should use other ways to assess carers' lives more critically, for example by assessing whether they were able to have free time or to take part in other activities unrelated to caring. She suggested that this could be a trigger to encourage carers to consider their own wellbeing and encourage them to adopt coping strategies.

*"...whereas the carers [questions] have really been "are you ok?" "Are you struggling a bit?" but by the nature of being a fulltime carer you are going to be struggling a little bit. And it's about, have you managed to have any time on your own this week or have you done a social activity? Maybe that type of questionnaire? How many times have you been out in the last two weeks with a group of friends? As apposed to "have you had to change arrangements?" well yes but we have to change arrangements all the time...maybe if they say, "No, I've not been out for a fortnight", that it makes them think, well actually why haven't I. And it would highlight, well that persons not getting out of the house and not doing something themselves and they are continually there. Is that... do they need a bit more support?" C122*

### **5.6.3 Participants' understanding of the TiM system**

Most participants understood that the purpose of the TiM was to monitor their condition and that the information recorded on the TiM was being relayed to the MND centre to promote clinical care (Appendix A5.27). Participants had not been shown the Telehealth Nurses' clinical portal but thought that the answers would be collected and someone would be looking for trends, be alerted to problems out of the ordinary and be able to compare their results to other patients.

*"I could see the reason why you were doing it; I realised that all the data was going to be collated and you can see then at a glance... you can see the statistics and everything, and it would highlight to you... if I had a dramatic change." P317*

However, there were some participants who did not fully understand the role of the TiM system, particularly early in the trial. Some thought it would be used for research or be used to create a database of patients for trials, rather than direct clinical care. They were often not clear who was looking at the information. Some, having never met the Telehealth Nurse, thought that EH would be looking at the system. The Telehealth Nurse also noticed this. She said they were surprised when she called them. However, when they did get a call they were pleased and reassured that the TiM worked. By the later stages of the trial the participants were clear about the role of the TiM.

*"I didn't realise that [Telehealth Nurse] was involved and she would ring us if our answers drastically changed, cos obviously they've stayed very much the same. Then I'm quite encouraged by that, I just presume that you do it yourself...and if you'd got a problem you'd ring [Telehealth Nurse] up for a bit of help." C392*

When interviewed, all participants trusted that, because medical staff used the TiM, it would be secure and their data would be kept securely. These sentiments were also reflected in the questionnaire answers with the majority of participants confident that the TiM system respected their privacy and confidentiality. Two patients (14%) did disagree with this statement but did not explain their reasoning.

#### **5.6.4 Summary of participants' experiences using the TiM**

The TiM system was found to be easy to use and did not represent a burden to participants. The technology was accessible even to participants with limited experience and confidence using digital devices. Participants were positive about the concept of telehealth to enable better access to MND services and thought that it could offer a more timely and effective service and maintain links with the MND team, something which they welcomed. Initially, some participants did not fully understand the concept of telehealth but trusted that their data would be used appropriately and stored securely. Once they had interacted with the Telehealth Nurse they understood the system better and remained satisfied with concept of telehealth.

### **5.7 Clinicians' experiences using the TiM system**

This section uses describes how the Telehealth Nurse and physicians used the system and whether the data provided was accurate and felt to be useful. Data from the TiM portal was used which detailed all the participants' answers, alerts generated and notes made by the clinicians. Interviews with the Telehealth Nurse and the Community Nurse also help understand how the system was used and the technical problems encountered. Data collected as part of the Shadow Monitoring Protocol was used to understand physicians' impressions of the system and explores the accuracy of the system along with data from the interviews with the Telehealth Nurse. Accuracy is explored further by comparing data collected on the TiM system with data collected using the validated patient reported outcome measures.

#### **5.7.1 The Telehealth Nurses' use of the clinical portal**

When interviewed, the Telehealth Nurse felt the clinical portal was “*very, very easy*” to use following minimal, face-to-face training. (Appendix A5.28) She was able to navigate through the screens easily and was confident enough to use all features of the system without fear. The only technical difficulty she experienced was with passwords. This required contact with the IT team in Chicago whereas she would have preferred a local solution. She explained was unfamiliar with the Patient App, as she had not been given the opportunity to use it before the trial. As a result, she passed all technical problems to EH.

The Telehealth Nurse did not find using the TiM system was particularly burdensome.

*“It only takes minutes” Telehealth Nurse*

During the trial a maximum of 17 patients were using the app. She explained she was responsible for approximately 120 patients in total. The consequences of scaling up the service were not explored in the interviews.

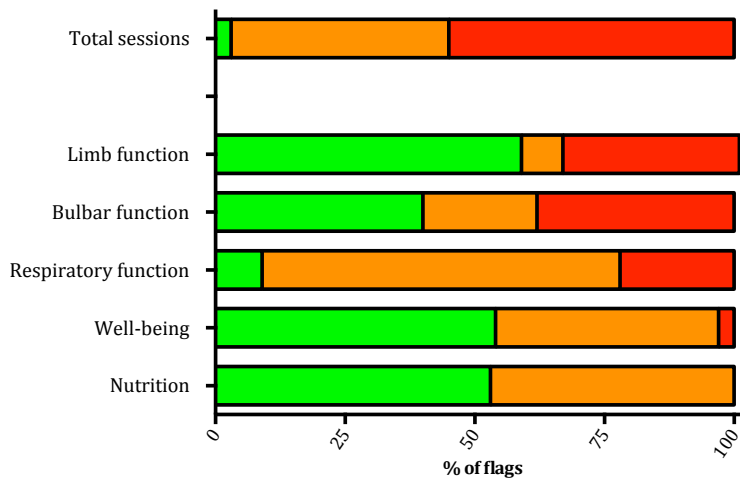
The Telehealth Nurse explained that initially she looked at the system every day but by the end of the trial she said she would look less often (weekly, and sometimes a little less often). She would look at each patient but was drawn

particularly to the alerts and to changes in the alerts since the last session. She felt that a green flag indicated everything was “ok”, orange meant “*there’s maybe some elements that might need to be looked at*” whilst a red flag indicated a problem. The additional information (e.g. whether they used NIV, what their previous answers were) helped her understand why the flags had occurred. She explained that she found the addition of the “trends” front page helpful to enable her to get an overview of things she thought were important (e.g. weight) and to see which category had changed.

### 5.7.2 TiM system alerts, notes and actions

Patients completed a total of 585 TiM sessions. Each session was divided into sub-sections assessing limb function, bulbar function, respiratory function, wellbeing and nutrition. Each session was automatically awarded a “session flag”, which was calculated as the most serious flag awarded in that session. A large number of sessions generated an alert: 322 (55%) of patient sessions alerts were red, 244 (42%) were amber and only 19 (3%) were green (Figure 5.20).

Figure 5.20 The frequency of red, amber and green flags generated by the TiM sessions. The total sessions reports the frequency of “top level” flag for all 585 sessions completed. Below this are the frequencies of “section flags” generated by 10 patients who completed a total of 334 sessions.



Each sub-section also generated an alert. It was very time consuming to use data downloaded to analysis all the alerts at individual question level so the answers for the first ten patients (T047-T217) were reviewed- a total of 334 sessions. Figure 5.20 shows the frequency of these sub-section alerts. Bulbar questions caused most red alerts (usually due to choking difficulties), followed by limb function (usually due to falls). It was also extremely common for patient to report some problem with their breathing or NIV with very few sessions generating a green breathing alert. The wellbeing and nutrition alerts were less common but they still generated a red or amber alert nearly 50% of the time.

The TiM system clinical portal provided a free text box for clinicians to enter notes. The Telehealth Nurse using the portal was asked to make notes in

response to any alerts or problems she identified. Clinicians could also made notes following clinic visits but only the Telehealth Nurse and EH did this. 99 notes documenting clinical events were identified. 46 (47%) notes were made by the Telehealth Nurse and 53 (53%) by EH (these usually described the response made by the Telehealth Nurse). The TiM system did not require clinicians to make notes in response to an alert or require that notes contained specific information. Therefore, it was not always possible to capture all the alerts that the nurse responded to or actions triggered by the TiM. It is therefore possible that this data underestimates the number of alerts and actions taken.

Each clinical note was reviewed and Figure 5.21 presents the problem identified and Figure 5.22 presents the types of action reported in the clinical notes.

Figure 5.21 The problems reported in clinical notes made on the TiM clinical portal. 99 notes were made detailing a total of 132 problems.

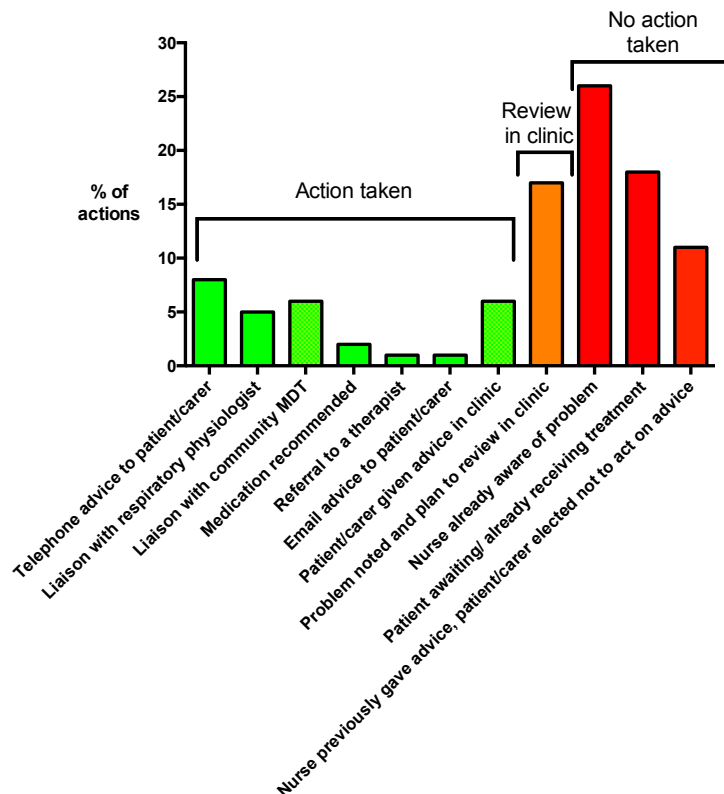
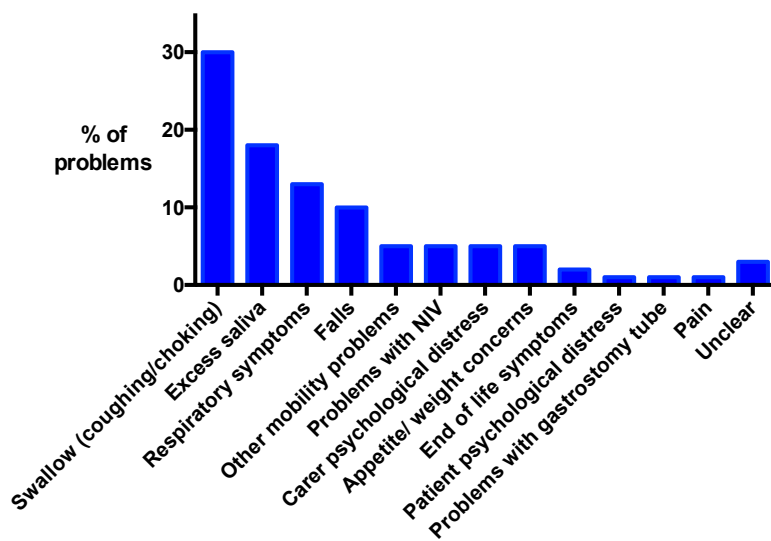


Figure 5.22 Actions reported in the 99 clinical notes made on the portal. Sometimes more than one action was reported.

Swallowing and choking were common along with various symptoms reported by the TiM system. 32% of the clinical notes made suggested that the nurse took action: the most common actions were telephone advice or liaison with other members of the MDT to share information and coordinate care. 17% of the time she planned to review the problem when the patient next came to clinic. However, on over 50% of occasions the nurse documented that she took no action and in only 18% of occasions the nurse documented that she had contacted the patient or carer. The nurse often took no action because she already was aware of the problem or that the patient/carer was awaiting treatment or had declined to accept the treatment/advice she had recommended. The most common reason for this was when the nurse was alerted to patients choking but the patient had elected to continue to eat despite the risks associated with this choice. She explained that in these circumstances she would like to temporarily “*pause*” the alert to reduce the number of alerts about known problems.

### 5.7.3 Physicians’ experiencing using the TiM system

#### 5.7.3.1 Pre-clinic shadow monitoring

Initially, plans were made for clinicians to review the TiM answers a few days/weeks prior to a patient attending the hospital clinic as well as an additional report following the consultation (the Shadow monitoring protocol). Prior to clinic, it was planned that clinicians would make an assessment of the accuracy and potential usefulness of the system and indicate whether they would change the patient’s appointment date. The approach was found to be unfeasible without additional administration support due to the following problems encountered during the trial:

- Clinic appointments were not be booked sufficiently far in advance;
- Clinic appointments would change without notice (either by the patient or the clinic booking team);
- The clinician had no regular time scheduled to review the system;
- Clinicians needed to be reminded to review the TiM at the correct time;
- Clinicians need to be provided with the paper notes to familiarise themselves with the patient (no electronic notes were available during the trial).

#### 5.7.3.2 Clinic shadow monitoring

38 shadow monitoring forms were completed when patients in the Telehealth group attended clinic. A record of all clinic visits attended by patients in the trial was not kept and the number of visits between patients so it is not possible to determine how often shadow monitoring forms were completed. Some shadow monitoring forms were not completed, either because EH was not present in the clinic or was too busy seeing other patients to provide the doctor seeing the patient with a form during clinic. The majority of forms (20, 54%) were completed by the investigator (EH) as most patients recruited to the study happened to be under the care of one consultant with whom EH worked but 18 (46%) were completed by other physicians.



Observations during training established that the clinicians were able to navigate around the different screens after very basic instructions. Figure 5.23 described the answers to a satisfaction survey completed by the treated clinic doctor for every patient and carer in the intervention arm. Responses were all positive: all clinicians agreed the TiM was useful and accurate and was a positive influence on the consultation. Clinicians were also asked to make comments. On five occasions the clinician described a benefit of TiM. On four occasions the comments suggested that the TiM identified problems, important trends or provided additional information about a patient.

*“Weight is useful as gives a more accurate track of his nutrition in last few weeks: I have asked the dietician to review his nutrition as he is losing weight.” EH r.e. P409*

Two patients using the TiM had telephone consultations. It was noted that the consultation was shorter than normal because many direct questions had already been answered.

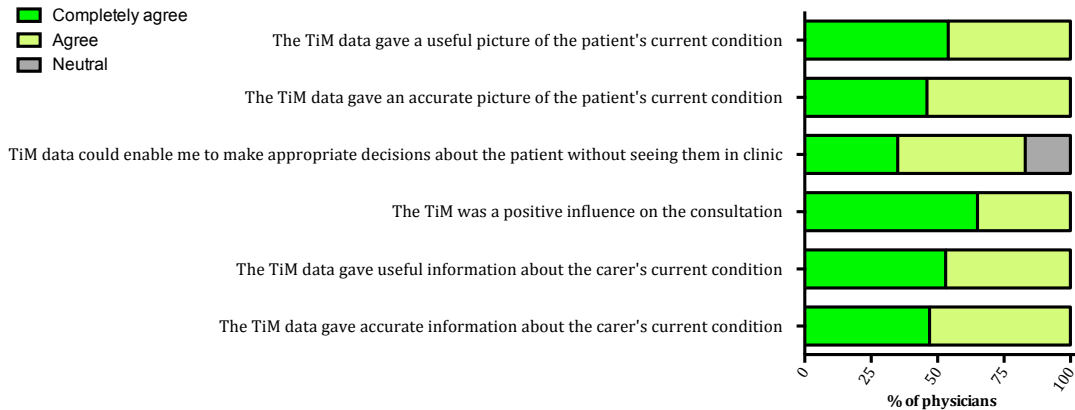
*“Quick consultation as most of the questions already being answered [using TiM].” EH r.e. P166*

Prior knowledge of one patient’s condition enabled the staff to better care patient P248. He had telephoned the secretary to cancel his appointment because he was too ill to travel. A review of the TiM answers indicated that he had deteriorated, was experiencing distressing symptoms and increasing carer strain. The Telehealth Nurse discussed this with the clinical team and, rather than cancelling the appointment, arranged a telephone appointment with a physician. The patient and carer received advice to improve his symptoms and follow-up monitoring was initiated. The patient was then able to attend clinic a few weeks later by which time he had improved.

When asked whether the TiM could be used to make remote decisions, on a number of occasions clinicians answered “*neutral*” (Figure 5.25). One clinician reported that they could manage a stable patient by telehealth plus a telephone consultation, but not by telehealth alone. In four cases, clinicians wrote that patients required a face-to-face consultation to evaluate symptoms of respiratory failure highlighted by the TiM or, in one case, where telehealth had not identified a pressure sore. In one case the physician explained that the patient communicated by pen and paper and this would not have been possible on the telephone.



Figure 5.23 Physicians' satisfaction with TiM system (n=15-28). Responses were excluded if it was not possible to review the TiM system during clinic. No clinician disagreed with any of the statements.



#### 5.7.4 Accuracy of the TiM information

The shadow monitoring results found that all clinicians agreed that the TiM answers were a useful and accurate reflection of participants' condition. Despite the complexity of the scoring and flagging system, the Telehealth Nurse trusted the information was accurate enough to use it to inform her clinical decisions making (Appendix A5.29 and A5.30). However, she often felt the limited amount of information provided meant the TiM was not sufficiently sensitive or specific on its own to enable her to identify important problems. She felt that, in order for the TiM to be useful, she often needed more information, either through discussion with the patient or carer or other members of the MDT. She also thought having a facility where patients could write comments or elaborate on their answers would add value, could save her time and would not be an additional burden.

The Telehealth Nurse and Community Nurse also suggested that patients and carers might not always give accurate answers about their condition (Box 5.2). Often the nurse needed to sensitively "*delve*" further, often looking to the carers for more information. The nurses interviewed thought that patients may minimise or lack insight into their problems, may be embarrassed or did not want to trouble their care team. This reflects the comments made by the carers (described above in Section), who found it hard to admit they were struggling and would often try to minimise problems.

**Box 5.2 Case vignette: the accuracy of the answers on the TiM system.**

The trial identified two patients who gave answers that were unexpected. One patient (P228) had severe problems with excessive saliva but did not report this on the TiM. His wife thought he chose not to report this because he did not want to think that his condition had changed whereas the Telehealth Nurse thought he did not report problems because he not want additional interventions. His wife did explain that they were a private couple and avoided involvement from healthcare professionals.

In another case, the TiM identified problems that were unknown to the Community MND nurse: P172 reported choking on food and losing weight. These problems had been discussed at her hospital appointment and the patient had been advised to use feed supplements via a gastrostomy. P172 had been reporting choking episodes on the TiM but not told her Community Nurse. Her Community Nurse had noticed that P172 had been losing weight and was not using the prescribed dietary supplements. She thought P172 might not want to admit new problems because the couple were struggling to accept that she had deteriorated. She also wondered whether P172 knew that if she admitted that she was choking she would need to stop being able to eat and drink and becoming dependent on gastrostomy feeding, something she did not want. She wondered whether patients and carers might be more honest using the TiM system if they did not see it leading directly to these unwelcome consequences. In this case, the Community Nurse thought it would have been helpful to know about the choking difficulties but the information had not been communicated to her.

No formal validation of the TiM answers was planned but it was possible to compare the ALS-FRS-R scores collected by TiM system to the scores generated by the validated self-administered questionnaire at baseline and each follow-up interval (208). Answers from the self-administered questionnaire were compared to the closest TiM session. Data was included if a TiM session was completed within +/- 14 days of the questionnaire. 51 pairs of scores were compared (in some cases up to four scores from the same patient were compared). Figure 5.24 shows the correlation between the two sets of scores. The correlation was very high with a coefficient of 0.94 ( $p < 0.0001$ ). This is comparable to the correlation found when the self-administered questionnaire was compared to the in-clinic ALS-FRS-R (208) (0.94, 0.93, 95% CI: 0.88 to 0.96).

A difference plot (Bland Altman) method was used for analysing agreement between the scores with a two-tailed value of  $p < 0.01$  considered significant (Figure 2.25). The mean difference between scores (bias) was small -0.67 (95% upper and lower limits -5.57, 4.24). On only one occasion (2%) were the differences in scores outside these limits. This suggested that, on average the total TiM scores were slightly higher (0.67 points) than the self-administered scores. The distribution of differences suggests patients with less disability tended to answer slightly more consistently than those with lower ALS-FRS-R scores.

Figure 2.26 shows how often the scores differ. On only five (10%) occasions the TiM and self-administered ALS-FRS-R were the same but most scores (34, 67%) were within +/- two points. There were some outliers: on four (8%) occasions the scores differed by five points and one patient scored five points lower on the TiM questionnaires on two occasions. Table 5.10 displays the differences in score at individual question level. There was no single question that accounted for the differences in the overall score. However, patients tended to report better function (higher scores) in the Walking and Climbing stairs questions using the TiM than the self-administered questionnaire.

Figure 5.24 Correlation between self-administered questionnaire ALSFRS-R and TiM ALSFRS-R (n=51, r<sup>2</sup> goodness of fit 0.94; p<0.0001).

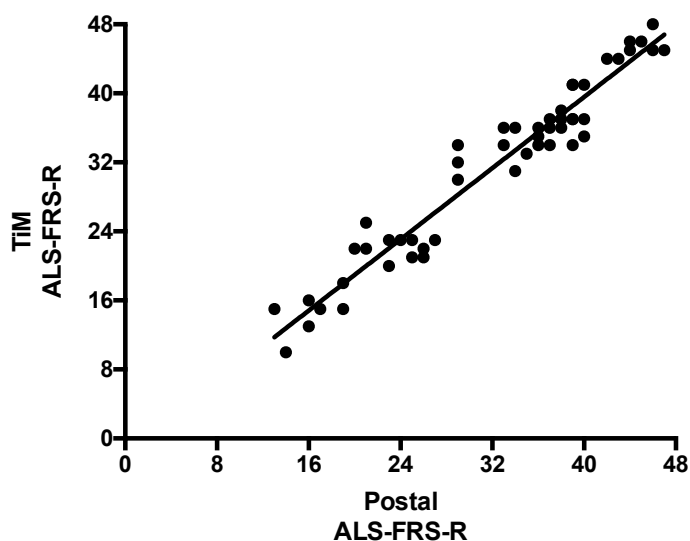
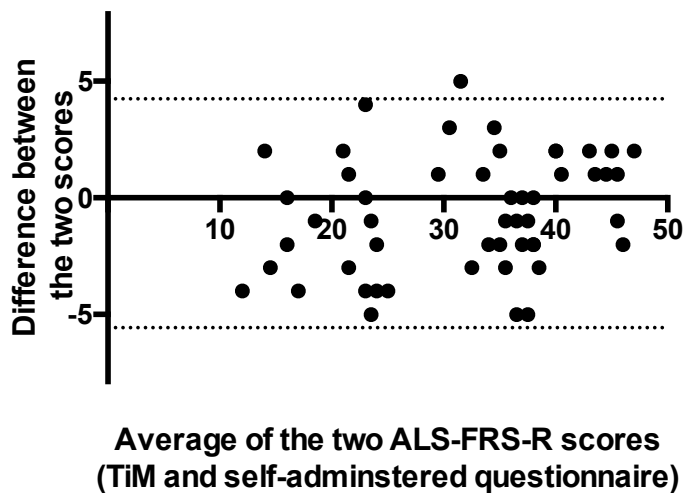


Figure 5.25 A Bland Altman plot of ALSFRS-R self-administered and TiM scores (n=51, mean difference -0.67; limits of agreement -5.57 and 4.24).



5.26 The frequency of occasions where total ALS-FRS-R calculated on the TiM differed from the paper questionnaires (n=51).

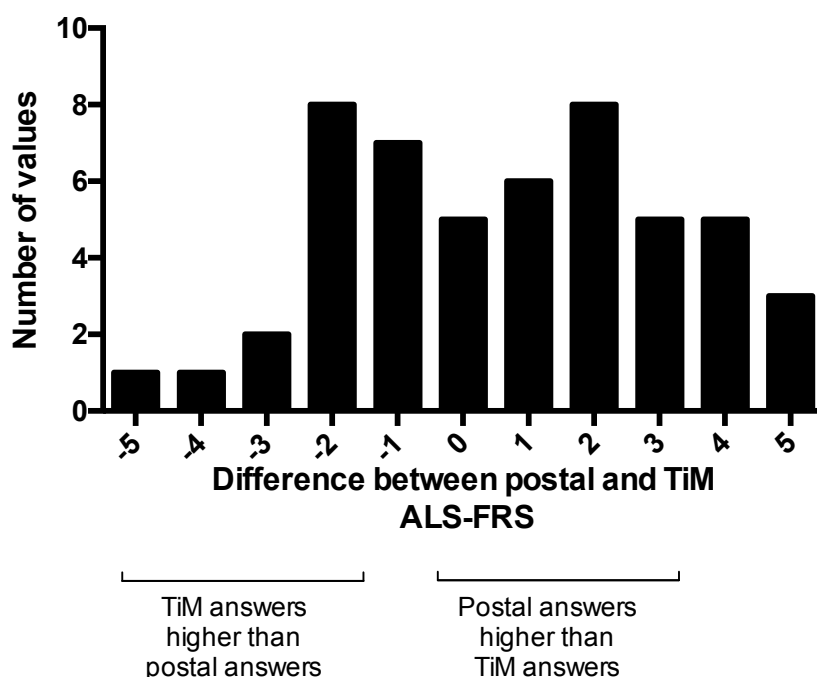
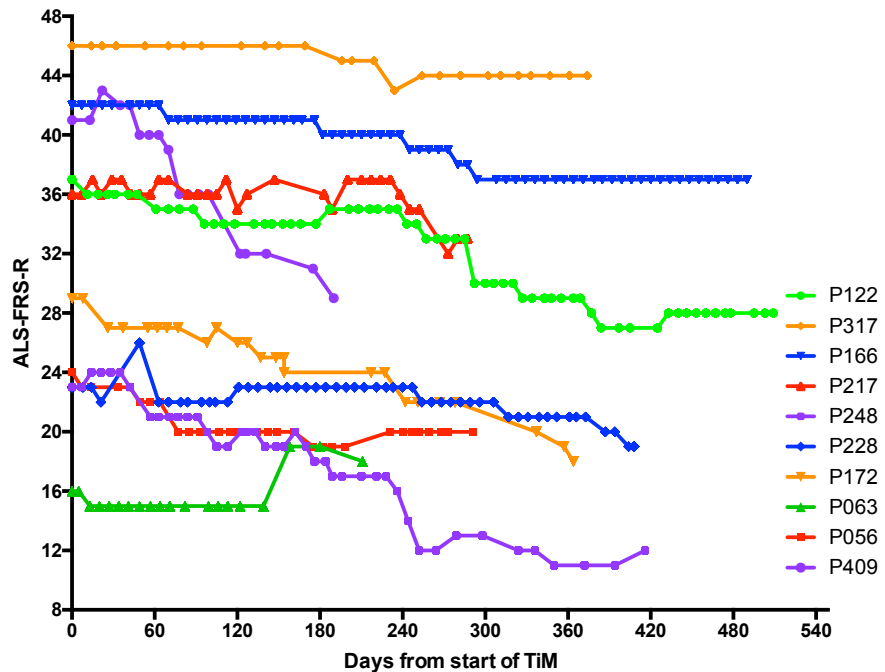


Table 5.27 The frequency of occasions where individual answers provided on the TiM ALS-FRS-R differed from the self-administered scores.

Score	TiM score higher than self-administered score		No difference	TiM score lower than self-administered score		
	2	1		1	2	3
<b>Question</b>						
Speech	0 (0%)	6 (12%)	<b>36 (71%)</b>	9 (18%)	0 (0%)	0 (0%)
Saliva	0 (0%)	2 (4%)	<b>40 (78%)</b>	7 (14%)	1 (2%)	1 (2%)
Swallow	0 (0%)	4 (8%)	<b>43 (84%)</b>	4 (8%)	0 (0%)	0 (0%)
Handwriting	0 (0%)	4 (8%)	<b>44 (86%)</b>	3 (6%)	0 (0%)	0 (0%)
Using utensils/ PEG tube	0 (0%)	8 (16%)	<b>34 (67%)</b>	8 (16%)	1 (2%)	0 (0%)
Washing and dressing	0 (0%)	7 (14%)	<b>39 (76%)</b>	4 (8%)	1 (2%)	0 (0%)
Turning in bed	0 (0%)	6 (12%)	<b>39 (76%)</b>	4 (8%)	2 (4%)	0 (0%)
Walking	3 (6%)	11 (22%)	<b>36 (71%)</b>	0 (0%)	1 (2%)	0 (0%)
Climbing stairs	1 (2%)	10 (20%)	<b>35 (69%)</b>	2 (4%)	3 (6%)	0 (0%)
Dyspnoea	0 (0%)	5 (10%)	<b>39 (76%)</b>	6 (12%)	1 (2%)	0 (0%)
Orthopnoea	6 (2%)	1 (2%)	<b>45 (88%)</b>	1 (2%)	1 (2%)	0 (0%)
NIV use	0 (0%)	2 (4%)	<b>47 (92%)</b>	2 (4%)	0 (0%)	0 (0%)
<b>Total</b>	7 (1%)	66 (11%)	<b>477 (78%)</b>	50 (8%)	11 (2%)	1 (0.2%)

These results indicate that whilst the TiM and the self-administered questionnaire results are well correlated, a difference in scores was common and on a third of occasions total ALS-FRS-R scores differed by more than two points. This suggests that the two methods of scoring should not be used interchangeably. However, it also suggests that those patients are consistently over- or under-reporting their symptoms using the TiM system. The differences could be due to inaccuracies in either the TiM or the self-completed questionnaire, or due to the natural variation in answers in patients' who are experiencing day-to-day changes in their function. When interviewed, the nurse did not feel that patients' answers varied disproportionately from week-to-week. Figure 5.27 presents the TiM ALS-FRS-R scores during the trial for ten patients and supports the nurse's assertions. Whilst the TiM ALS-FRS-R scores tended to deteriorate at different rates (as expected for this population) but week-to-week variations was minimal in most patients.

Figure 5.27 The ALS-FRS-R scores for ten patients using the TiM app during the trial.



Some improvements to the TiM questionnaire and the way patients are trained to use it may improve the accuracy and/or consistency of answers. The TiM question wording can be reviewed with a focus on those questions where the two scores differed the most. Patients' understanding of the TiM questions should be checked at baseline but also at intervals, e.g. when the patient attends clinic. Patients could be encouraged to ask questions and discuss their answers with their family. In addition, comparing the TiM scores against a same-day measure in-clinic could determine more reliably whether the TiM answers do reflect patients' true functional ability.

### 5.7.5 Summary of the clinicians' experiences using the TiM system

The TiM system was easy to use by clinicians. Reviewing the data of the small number of participants who took part did not pose a significant burden to the Telehealth Nurse or physicians. However, there were a large number of alerts generated by the system. The nurse did not always respond to the alerts. Responding to every alert would have been very time consuming and was demoralising for the Telehealth Nurse. The Telehealth Nurse wished to have the facility to pause alerts. It was not possible for clinicians to review the TiM system outside of the scheduled clinic visits without receiving additional administrative support and time. The data suggests that the TiM could provide helpful and accurate additional information to supplement a clinical consultation either in person, or by telephone as a viable alternative to clinic, particularly when the patient couldn't travel to clinic. The TiM system appeared to be reasonably accurate and a good reflection of the participants' progress and clinicians were happy to use the information to assist them making decisions as long as the option was available to telephone or see the patient in person.

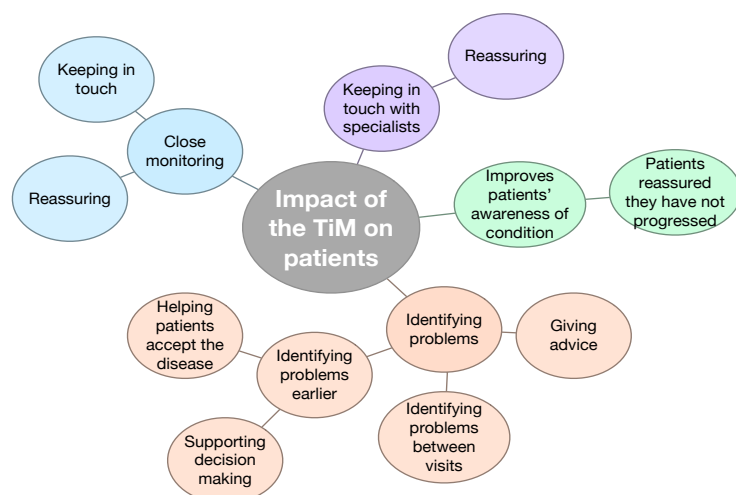
## 5.8 Exploring the potentials impacts of the TiM system

As discussed in the introduction, neither the trial nor the process evaluation aimed to establish the efficacy of the TiM. However, questionnaires and interviews did explore participants' experience of their MND care during the trial along with their interactions with the Telehealth Nurse. Section 5.8 and 5.9 describes the potential impacts the TiM may have and how the TiM might be used in the future. Section 5.8 describes ways in which participants' care and wellbeing might be affected by using the TiM and the context and mechanisms that may be underpinning them. It also explores how the Telehealth Nurse interacted with the TiM and, in particular, explores the reasons why many participants felt the TiM system had no impact on their care. Section 5.9 describes participants' and clinicians' thoughts about how the TiM system might be used in the future.

### 5.8.1 The potential impacts of the TiM system on patients

When interviewed, all participants apart from P047 expressed overall satisfaction with the TiM system (Figure 5.28, Appendix 5.30).

Figure 5.28 Potential mechanisms of impacts of the TiM on patients' care identified during the interviews



The main mechanisms by which participants thought the TiM might impact on their care were: by increasing monitoring; providing better connection with specialists; improving awareness of their own condition and enabling earlier identification of problems.

*"I think it's probably one of the best ideas to come out of the NHS for years." P122*

Weight was identified by patients and the Telehealth Nurse as a useful measure.

*"Weights have been quite interesting, cos if they can use the weighing scales ... we can monitor their weight...otherwise you wouldn't necessarily see that variation." Telehealth Nurse*

Many participants thought that the TiM improved their awareness of their own condition. Whilst they felt that they did not need to track their progress using the system (they knew themselves how they were changing), weighing themselves weekly meant patients were more aware of their weight and nutrition, something they knew they could do themselves to keep healthy. Those with slowly progressive disease also noticed that their answers did not change rapidly. Rapid progression was something all patients feared so this made them feel positive. They felt they were being carefully monitored which was reassuring, particularly for carers. It also enabled them to keep in touch with the team.

Box 5.3 below describes one case where interviews captured an event where information on the TiM did trigger earlier action by the MDT and an improved outcome for the patient and carer was observed.

In a small number of cases, participants remembered reporting a problem on the Patient App that resulted in the Telehealth Nurse contacting them and giving them advice. Often all the Telehealth Nurse did was offer reassurance or advice that the patient had heard before. Whilst the Telehealth Nurse felt that she did not do anything, the patients were very pleased that this occurred and were happy with the consultation. This reinforced the notion that specialists were monitoring them closely. In the face of a relentlessly progressing disease, these interactions were welcomed.

*"...I did the second questionnaire, and within a day [Telehealth Nurse] called saying "I've got a red flag on one of your answers." And it's the fact that I'd fallen twice while I was away on holiday and I'd put on [the TiM]... it said "have you fallen recently, how many times?" So she phoned me, and said, "Are you ok? Is there a reason why you fell?" No, just my usual clumsiness...*

*Q: Were you expecting her to call?*

*P: No, I wasn't actually. It was just a bolt out of the blue...I find that quite positive. It shows that the whole idea of it works.*

*Q: Has it changed your behaviour at all?*

*P: No. Not really." P122*

*"I think the benefit to P is real. Because ... somebody is there on hand looking at things... Because it's slow with P and he doesn't need as much attention and care, it's easy to feel detached from any positive interaction." C122*

Patient 047 did not find the system had helped her but thought that the reassurance offered by monitoring would have been very helpful for patients early in the disease. She explained her experiences when first diagnosed:

*"... for the first year no day was normal, no day looked like any other day in my life before that. ... You imagine symptoms, ... you think God, this is happening and that must be related to the MND...?" P047*

As a result, she felt that an additional contact could have been helpful to support her.

*"Q: Do you think there might have been a point in your disease where those questions ...were useful?"*

*P: Nearer the beginning, definitely...If I could have camped in [neurologist]'s house for the first six months I would have done, just so she was there, so I could say; "but what about this, what about that?"... in the first year I would have filled that in every day, just to have that touch point" P047*



**Box 5.3 Case vignette: making earlier, better-informed decisions**

The Telehealth Nurse identified one patient who she felt had gained benefit from using the TiM system. The TiM detected that the patient’s weight, swallow and mobility were declining quickly and the carer reported high levels of strain. The couple was struggling to accept his decline and the patient tried to minimise his symptoms. The nurse was able inform his community team who encouraged them to accept additional support. The patient wrote:

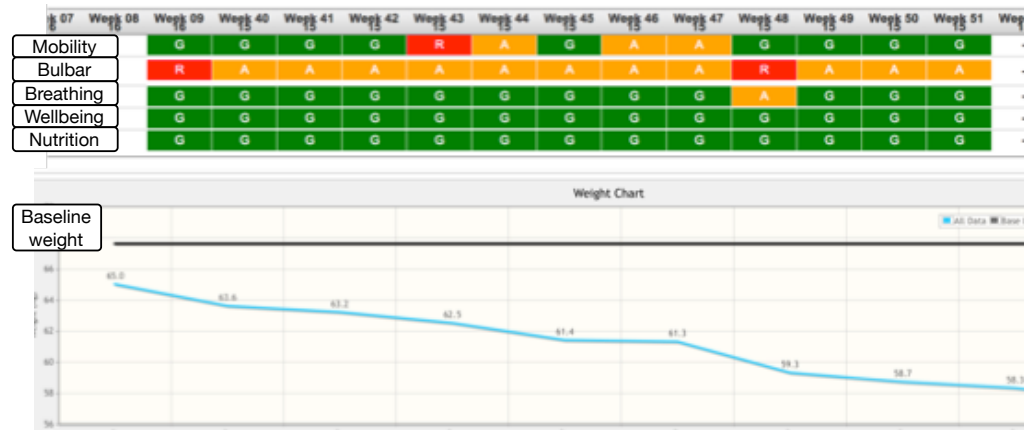
*“The questions nudged me to facing what I could do and not what I can't.” P409*

The TiM alerted the clinical team to P’s rapidly declining weight (Figure 5.29) who contacted him between clinics to highlight this information and strongly encouraged him to consider gastrostomy insertion. At the end of the trial, he did opt for a gastrostomy and was asked about whether the TiM affected this decision. He agreed:

*“Q: We kept an eye on your weight and I wonder whether you think that may have influenced your decision to have a feeding tube or not?”*

*P:I was frightened by the speed of loss of weight but was convinced how much muscle I lost.” P409*

Figure 5.29 The “heat map” showing mobility and bulbar alerts and 15% weight loss from baseline



The carer explained that she struggled to admit that she was finding things difficult and found it easier to do this using the TiM system.

*“I think for me it was the ability to be able to answer those questions without [P] knowing what I'm putting, cos ...I didn't want to upset you, I didn't want to worry you, so to be able to answer them just like that, just on the Telehealth thing... without; somebody being here asking me in front of P.” C409*

The community therapist referred the couple to the local hospice and care agency and the carer was persuaded to accept some additional support, which, in the six month interview she described as becoming a “lifeline”.

*“...she got the ball rolling there; and with the [care] Agency as well, she definitely kick-started that...Initially, you're torn because you're so grateful ...that people care and want to help, but then for me it was this is another person in the house. I remember the first time ([to P] I've not told you this), the first time B came from [the] hospice and sat with you, I think I spent the first hour sobbing in a lay-by somewhere because to my mind I'd left you with a stranger and it just felt so, so alien, it really did. But then as, as the weeks go by and ...everything's in place week after week after week, it becomes a lifeline.” C409*

### 5.8.2 The potential impacts of the TiM system on carers

The interviews identified many circumstances where the carers felt the TiM had impacted up them, either by reassuring them that their loved one was being monitored, or that problems could be identified and solved more rapidly. It also provided them with an important opportunity to highlight their own problems, separately from the patients.

Carers welcomed the additional monitoring of their loved one and additional contact provided by the TiM system and felt reassured that it could identify problems quickly. This was important because carers were often the first to recognise a problem and some found it hard to persuade their loved one to raise it with the MDT. One wife of a patient with slowly progressive disease explained:

*"I think the benefit to P is real. Because ... somebody is there on hand looking at things. I think it's a brilliant tool to be used to be able to have instant... not instant access to professionals, but...Because it's slow with P and he doesn't need as much attention and care, it's easy to feel detached from any positive interaction. Whereas with that, you know somebody's there and if there was something you'd pick up quite quickly as apposed to, you've gotta wait until your next twelve week appointment" C122*

A common theme identified in interviews was that a carer's wellbeing was directly linked to the patient's. Carers felt that improving their ability to care for their loved one would improve their own wellbeing too. However, they explained that it was hard to accept help from the MDT, either because they did not feel ready to accept or admit that they needed help (case example described in Box 5.3). They particularly found it hard to accept help from external carers. Participants were reticent to ask for extra help: the ability to remain independent was seen as a positive coping strategy whereas needing additional help was perceived as "not coping". "Not coping" was a concept associated with fear and failure and was a major negative milestone in their disease. Carers found it difficult, or even felt guilty delegating some of their duties to unfamiliar people. They would often try to remain available for the patient even when other carers were present. In addition, accepting additional help also had a negative impact on another "coping" strategy identified by participants: trying to maintain life as "normal" as possible. External carers entering the home could impact on a family's lifestyle, privacy and home environment and was often inflexible and not responsive to the carer's needs.

As a result of these barriers, carers tried to avoid accepting more help even though they recognised they needed help. Carers explained that the needs of their loved one meant they had to take priority, meaning their own needs and identify could be neglected. As a result, they were pleasantly surprised that the TiM would consider their needs as they felt the MDT's focus was also primarily on the patient. One patient's wife explained:

*"You become a bit of a non-person because the concentration is on the person who is diagnosed with MND, and rightly so, but then if affects the partner in.... it affects them as well, but they don't suffer the symptoms." C122*

This additional focus on them prompted carers to consider their own wellbeing and receive help if they were experiencing difficulties. They explained that, as the patient is usually present in meetings with the MDT, it was difficult for them to discuss their own wellbeing because they worried about the impact disclosing their concerns would have on the patient.

*Q: When people like [community OT] come to see you do they ask you about your own circumstances and how you are?*

*C: I don't think particularly. I'm aware that I could discuss it with her... but, we're always together so sometimes it's a bit difficult... to say what you think and what you feel...*

*[later] Q: If you do have a bad time, how do you tell people about that...?*

*P: Well you don't, you just grin and bear it." P&C062*

*"I find being able to have individual... meeting, as apposed to meeting as a couple: when you are at the hospital you are together, at home you are together ...should you say how are you feeling in front of the other person because you don't want them to feel bad." C122*

Carers thought that the TiM system could provide them with an opportunity for them to express their feelings in private, separately from the patient. This could be done in their own home, without having to leave the patient. They felt comfortable that the MND care team could contact them if they detected a problem to offer additional support. In fact, the impersonal nature of the TiM system was an advantage as it enabled carers to be more honest about their difficulties. One wife of a patient with rapidly progressive disease explained:

*"I think it's a really, really good way of doing it. Because whereas I probably try and flower things up a lot of the time and be upbeat about everything, I found that, because it was just me and the tablet and I was able just to be totally, totally honest about it, about how I was... feeling at that particular time... The impersonal format... of the way it was actually done; the questions weren't impersonal but the actual way you could answer them, for me, has been a real help just to be able... to do that." C409*

Box 5.3 (above) describes the experience of a carer who reported problems with carer strain and subsequently received help from the MDT. The Telehealth Nurse thought that the additional information on the TiM system meant the couple could be supported in accepting the diagnosis and the problems they were facing, and enable them to look positively towards receiving additional medical and social care.

### 5.8.3 Nurses' attitudes towards the potential value of the TiM

Despite the problems she encountered, the Telehealth Nurse felt the TiM system had potential to be of value "*As a tool to aid the patient and then aid the nurse*". (Appendix A5.31). She felt she could use the TiM to gain more information and alert her earlier to problems, on which she could intervene. She thought could facilitate sharing of information and reduce her workload. She also noted that the TiM was picking up important problems of which she was unaware, the patient and carer trying to minimise. She remarked that seeing weight trends had been useful and had enabled her to discuss problems with patients, particularly when she saw them in clinic.

The Telehealth Nurse explained that she recognised that clinics were a burden to patients and sometimes patients felt they offered little value. She thought that if TiM could reduce the burden of clinics, it would be welcomed by nurses. Whilst she felt it might be possible to use the TiM to delay appointments, she had some doubts because, like the patients interviewed, she valued the role clinic played in developing her relationship with the patient and carer and gaining information about their problems. She was also unsure whether the TiM alone provided enough information to make decisions. She felt some aspects of their care (in particular, respiratory monitoring) required face-to-face visits whereas other issues would need a combination of the TiM system and communication with the patients/carers and other members of the MDT.

### 5.8.4 Exploring why participants felt the TiM system did not have an impact on patient care

Whilst the participants did react positively to the TiM system, many felt it had not had a significant impact on their care. At six months only seven (47%) patients and five (33%) of carers agreed, "*The MND team contacted me quickly if my condition changed or I had a problem*". Some reasons for this identified in the interviews relate to the participants themselves:

- Participants felt their condition had not changed during the trial;
- Help was offered but declined.

However, the main themes identified in the trial surrounded the interaction between the participants and the Telehealth Nurse:

- Participants had not received feedback from the Telehealth Nurse;
- The TiM system had identified problems, the Telehealth Nurse did not acknowledge the problem or act in the way participants expected;
- The Telehealth Nurse took action but did not inform the patient/carers;
- The TiM system had identified problems but either no action was required or they were already receiving treatment;
- Participants did not remember the TiM system being mentioned in consultations with the hospital MDT.

Many patients explained their disease had not changed greatly during the trial and, as a result they did not think they needed help from the MDT (such as the case described in Box 5.4 and 5.5). In some cases participants reported problems but they did not think the MDT could help with the problems or that the MDT was not there to help with their problems (e.g. carer strain, discussed in 5.9.2).

## 5.8.5 The interaction between participants and the Telehealth Nurse

### 5.8.5.1 Participant experiences

The main reason participants felt the TiM system had no impact was because they had had insufficient feedback from the telehealth team (Appendix A5.32). This was the case even when their condition had changed little as participants still expected feedback in these circumstances. Participants could feel demoralised when they were expecting feedback but were not contacted. Patient 047 was particularly dissatisfied, writing:

*“I have not received any feedback/contact from the MND team while using the TiM” P047*

She had reported emotional difficulties and was expecting contact from the MDT. The Telehealth Nurse had been alerted to the problems but had not acted because she knew the patient was already receiving psychology therapy. As a result the patient was so demoralised that she stopped using the system.

*“The emotional psychological depths that I’ve been to, I was putting the stuff in Telehealth and thinking but nobody’s acknowledged this or contacted me about it, and I thought: well they’re not going to because that isn’t what the clinic’s about, and that made me stop using it.” P047*

The TiM system did not provide automatic feedback: it relied on the clinicians to inform the participants if they had reviewed the results or taken any actions. Most participants had received little or no feedback from the Telehealth Nurse and they could not recall it being mentioned during the clinic visits. Interviews with participants and the Telehealth Nurse suggested that, on many occasions, problems were being identified by the TiM system but the nurse was either taking no action or taking actions but not informing the participant. It was also noted that the nurse might talk to a patient about a problem identified by the TiM system but not mention that she had used the TiM system to identify or monitor the problem. For example, carer 409 had reported carer strain using the TiM system but was not aware that it was the information from the TiM system that had initiated the offers of help that she had received.

The interviews suggested that there was a significant difference between the attitudes and expectations of the participants towards the TiM and the problems they were reporting and the attitudes and actions of the Telehealth Nurse (Appendix A5.33). Participants described problems that they would expect to be acknowledged by the Telehealth Nurse. The most frequently reported were: chest infections; swallowing difficulties; falls (particularly first falls or continued falls) and emotional strain. Falls were a very common problem mentioned by participants. When discussing the course of their MND they saw their first fall as a significant milestone in their disease and it had a lasting impression on them. Participants were frightened of falls and a fall could knock their confidence. They identified falls as an important problem that the Telehealth Nurse should be alerted to, and they thought action could be taken.

*"...if it goes through on the TiM and it says I've had a fall then I would expect somebody would ring and say have you sorted it, are you OK... ..get some, let's get somebody in to make sure it don't happen again, because I mean I could have tripped over anything, couldn't I?" P317*

Important incidents included the first fall, frequent falls and new falls. In contrast, the Telehealth Nurse explained that falls were an expected problem in MND and she may only contact the patient if falls were a new event. Falls were also a very common alert raised by the TiM system.

*"She red flagged that she'd fallen, which is quite a common occurrence on a lot of patients, and I don't particularly worry unless they've been very, very well and then suddenly. So if it happens over a few weeks and I've spoken to them and I know the situation then I don't, I'm not always alerted by that red flag." Telehealth Nurse*

Whilst participants expected the nurse to make contact they did not have an expectation of what the Telehealth Nurse should be doing to help but they did expect their problems to be taken seriously. They expected and valued any form of contact, even if they did not want help or did not think there was anything additional that could be done.

*"Q: Would [the newly identified problem] be something that you think they'd need to call you about, or would it be something you'd expect them to deal with the next time you came to clinic?*

*P: I would probably; but because the clinic visits... there's quite a few months in-between [visits], I would expect the whole team then to come together and for you to maybe highlight it to my [community] MND nurse and say: you'd better go out and see P because her breathing's always been great and now she says that she's struggling, so see what help you can give her." P317*

Whereas the participants valued highly contact from the MDT, even if it was just to acknowledge their problems and offer advice, the Telehealth Nurse did not think she was offering anything during these calls. This was further reinforced when she did telephone and patients tried to dismiss the problem, not wanting to admit that they were experiencing difficulties. This made both the participant and the nurse feel that they were not helping and this made the nurse less inclined to contact patients again.

*"P: [OT] said last week, [Telehealth Nurse] said twice there had been a red alert because I'd fallen, I'd put that I'd fallen.*

*Q: And what did [OT] say?*

*P: [inaudible] I over balanced, I don't fall over." P217*

#### **Box 5.4 Case vignette: the importance of interaction and feedback**

P134 is middle-aged man with severe disability. He felt his disease was not progressing rapidly so did not currently require many changes to his MND care. He had high expectations of the MND care service but was motivated to comply with medical advice when he could see the benefits. He was a good user of NIV, despite struggling with the equipment. He felt this was because he experienced clear short-term benefits of NIV as well as the long-term potential survival benefit.

*“Q: And why do you think you do persevere so much with [NIV]?”*

*P: Because I think it gives me, it's useful. I wouldn't sleep on my back until I wore the mask; ...I've got pressure on my shoulder because I sleep on my left side. So being able to roll onto my back gives that a bit of ease at times as well.” P134 (High technology user, low TiM user)*

He was enthusiastic about technology and felt that the TiM system was a good idea, promoting better links with the care team, and potentially reducing clinic visits, which he often found unnecessary, given his current disease stability. However, he was an infrequent user of the TiM. He thought the main reason for low adherence was the accessibility of the tablet. However, he also explained that the TiM system was not a priority for him.

*“It was always a Monday I'd try and do it on. But... with all the [house] renovations and stuff it's sort of not become a priority at the moment.” P134*

In contrast to NIV, he found the TiM system did not offer him any benefits. He felt that his condition had changed little over the time he was in the study and did not experience any feedback. He accepted that this was, in part, because his adherence was low. His attitude was further reinforced when he developed a chest infection and was advised by the TiM system to expect contact from the MND team but he did not receive a call.

*“I had a chest infection, and they said that your [Telehealth] MND nurse will be in touch within the next; and I've never, not heard back, so. To me it feels like a... gathering exercise at the moment where you're just getting information.” P134*

Despite this, when interviewed at six months he still felt the TiM system was a potentially valuable resource if used correctly. He felt it would be a useful replacement for clinic, as long as he did not miss out on any information.

*“I'm happy to fill it in, if it gives us three months off or something, that's fine. But, you know, maybe a sort of, a way of updating it and saying, “ We've been doing this research or something”, using it...”*

*Q: So you getting messages?*

*P: ...as a two-way thing, yeah.” P134*

#### **5.8.5.2 The Telehealth Nurse behaviour towards alerts**

The interviews also explored why the Telehealth Nurse was not acting upon problems as expected. Her comments mirrored the findings in Section 5.7 that on more than 50% of occasions, the TiM system was generated an alert. The Telehealth Nurse felt that she was seeing the same problems every week, particularly falls and swallowing difficulties (Appendix A5.34-A5.35).

*“I have concerns about it, cos we have some patients that red flag every week”  
Telehealth Nurse*

This was particularly frustrating when alerts kept occurring on which she had already taken action or she felt there was no action required. Whilst she did not feel the TiM system took up a lot of her time, the requirement to deal with multiple problems for which she saw no solution added to the psychological burden of using the system. As she had wanted to be the only nurse to use the system regularly, the responsibility fell to her to manage the problems identified and/or ignore alerts that were unnecessary. Despite the number of alerts encountered, she felt she should justify why she was taking no action for each alert, particularly if the problem could be potential dangerous (such as choking). She could not control how the alerts were generated and she explained that she would stop ringing about problems that kept recurring, for which she could take no further action and would prefer to “*pause*” these alerts. She also thought that the patients could also become demoralised if they were reporting the same problems every week.

*“Maybe to them, the fact that it’s the same thing week in week out, they’ve got an insight into that problem, it’s not changing and, so they’re not looking for something to help with it really.” Telehealth Nurse*

The Telehealth Nurse explained that the information on the TiM system was often insufficient to make decisions so she might telephone the patient for more information. She would also use her experience and wider knowledge of the patient to decide how to act. In some circumstances she also delayed responding until the patient was attending clinic. In these circumstances she did not communicate these decisions to the patient. The Telehealth Nurse prioritised problems that were unexpected and placed less priority on problems she expected to occur in MND. As discussed earlier, some of the problems she said she did not prioritise were problems identified by patients as being significant: for example falls or breathing difficulties.

*“She red flagged that she’d fallen, which is quite a common occurrence on a lot of patients, and I don’t particularly worry unless they’ve been very, very well and then suddenly. So if it happens over a few weeks and I’ve spoken to them and I know the situation then I don’t, I’m not always alerted by that red flag.” Telehealth Nurse*

She also commented that she considered whether the problem identified could be solved or whether the problem required a solution. The patient interviews captured one such episode (P122). In this case, the perspective of the patient



differed: whereas the nurse felt she had not added anything to the patients' care, in contrast, the patient felt reassured that he or she was being monitored.

*"...I did the second questionnaire, and within a day [Telehealth Nurse] called saying "I've got a red flag on one of your answers." ... I'd fallen twice while I was away on holiday and I'd put on [the TiM]... it said "have you fallen recently, how many times?" So she phoned me, and said, "Are you ok? Is there a reason why you fell?" No, just my usual clumsiness...*

*Q: Were you expecting her to call?*

*P: No, I wasn't actually. It was just a bolt out of the blue...I find that quite positive. It shows that the whole idea of it works.*

*Q: Has it changed your behaviour at all?*

*P: No. Not really." P122*

The nurse found it easier to manage patients whom she already knew well, either from directly meeting them, through telephoning them, or via the community teams with whom she communicates regularly. She described developing important relationships with patients through hospital visits and via her telephone helpline. She described getting a "snapshot" of their lives. She would often liaise with the community MDT with whom she has good connections. Box 5.5 describes the difficulty the Telehealth Nurse faced when caring for those patients with whom she had less contact, or where her links with the community teams were not as good. In these cases it could be more difficult to interpret the information from the TiM and liaison with the MDT was less easy. She was even more reluctant to call carers although she also felt she had responsibility for their wellbeing too. She explained that she often did not know carers so well and sometimes felt there were less obvious solutions to carer distress. This is in contrast to the carers who were mostly extremely positive that the nurse provided vital counseling and advice. When she did not know the participants well, she said she found it easier in this case to liaise with the community MDT rather than calling the patient directly.

**Box 5.5 Case vignette: building the nurse-patient relationship**

One patient reacted positively to the idea of the TiM system but did not feel the TiM had had an impact on her during the study because she had progressed slowly and did not receive any feedback from the Telehealth Nurse. As a result she did not see the point in using it again:

*"Q: Do you think it's had an impact on your condition at all, using tablet?*

*P: No.*

*Q: OK. And do you think you'd continue to use it if it wasn't part of a study?*

*P: Well there'd be no point, would there?" P317*

When the Telehealth Nurse was asked about this patient, she explained that she had not yet developed a relationship with P317 or her carer. This was because she had only recently been diagnosed and had not attended clinic many times. She also lived at a distance from the centre and was also under the care of a community MND nurse. Her condition was slowly progressive therefore had less involvement with the hospital MDT. The nurse found telephoning patients with whom she had little relationship more difficult and she felt more reluctant to call if problems were minor.

The nurse explained that whilst she had seen the TiM questions and Patient App in development, she said she had not seen the final Patient App and did not know exactly what questions and answers it used. The Telehealth Nurse did not have the opportunity to discuss the TiM system with participants at the start of the study and during the interviews it was established that she had rarely discussed the TiM system with participants when they attended clinic. She also found that patients did not always know she was responsible for looking at the data. This meant she did not have the opportunity to understand what patients knew about or expected from the TiM system.

## 5.9 Attitudes towards future use of the TiM system

### 5.9.1 Participants' attitudes towards future use of the TiM system

Participants were asked whether they would use the TiM system again. In the questionnaires, at six months 12 (80%) patients and 11 (73%) carers would use it as part of their usual care and 14 (93%) patients and 10 (67%) carers would use the TiM as part of a research trial. 13 (87%) patients and 11 (73%) carers would recommend it to another patient. The participants who did not agree replied that they were "unsure" as none disagreed. Participants were asked whether the TiM could be used as a substitute to clinic. 14 (93%) patients would use the TiM if they were unable to travel to clinic and 11 (73%) felt that they would be happy to have their appointment delayed if the doctor felt they were stable. However, 3 (20%) were not sure and one (7%) disagreed with this statement.

Participants thought that the individual should choose how they used the TiM depending on their needs, preferences and speed of progression (Appendix A5.36). A number of patients felt they were progressing slowly and did not feel frequent clinics were valuable meaning they were happy to use the TiM instead to reduce the frequency of appointments. One was happy to reduce appointments from two to six months as long as he could communicate with the team and access the service quickly should he need help.

*"P: Well I think for me currently, if you put dialogue boxes in there, which is what I would have said you need them, I would be quite happy personally to use that and not have appointments, but be able to ask for one on that, but you would need to be able to do that at short notice rather than going to have one in two months. So to me that way is ideal."  
P381 (Early, slowly progressive disease)*

A number of participants highlighted the importance of attending clinic for respiratory monitoring and suggested that this aspect of care would need to remain an essential part of MDT care.

*"Q: How do you think this would fit in around your clinic visits and the support you would get from [hospital MND nurse]? If this was to become a part... rather than a research project, part of standard care, how do you think you would suggest using it?"*

*P: Well I think in my case I would be happy to use that and lengthen the time between visits. ... the only difference to me is the breathing test." P381*

One patient suggested that it might save time in clinic because he could complete questions and weigh himself at home before attending. Other patients were ambivalent, feeling that clinic attendance was valuable to them, particularly to benefit from the psychological support or to address problems when their disease is progressing. Some patients felt that they would not be able to be fully involved in telephone conversations, particularly when discussing sensitive matters.

*"Q: Using the tablet. Do you think you'd accept a telephone call rather than coming [to clinic] if things were too tricky for you?"*

*C: [to P] Well telephone calls aren't that practical are they for you. Because if you are tired, it's difficult to convey." C172 (Patient with severe dysarthria)*

Patients did feel that they were the centre of care when involved in discussions but one patient pointed out the importance of conversations to ensure that they could discuss all important topics, not simply those on the TiM system.

*"MND appointments allow discussion on other topics other than TiM" P248*

Patients were asked what additional features they would want in the TiM. Participants wanted the system to be more of a *"two-way thing"*, as discussed above. They were asked whether they wanted to see graphs or analysis of their answers. Many explained that they did not need this type of feedback because they can judge their progress themselves either through observing their day-to-day lives or tracking their answers on the TiM. Some thought this would be interesting but none wished this type of feedback to be automatic as they were concerned about the impact of seeing their decline plotted without any interpretation from their clinical team. Instead patients thought they wanted feedback delivered by their clinical team either in clinic or during discussions with the Telehealth Nurse.

Participants thought that various ways of communication would be acceptable and the choice depended on the patient and the problem. Face-to-face conversations were felt to be important for personal discussions.

*"I think it's not personal... I'd rather see somebody or talk to somebody than, than read about it on something on a screen." C366*

Some found using email to contact their care team helpful. Those with speech problems found it particularly helpful as they found it hard to use the phone and email also allowed patients to answer at their convenience. They could take time to answer, rather than feeling rushed in a phone call. For some, email could be seen as impersonal and telephone was more preferable for problems needing solving immediately and some felt telephone was better for sensitive or complex problems to ensure that the information exchanged was accurate. Participants had reasonable expectations of the speed at which they might receive a reply if they sent a message. They felt happy if they received an acknowledgement and were happy to wait for a definitive answer or wait until they attended clinic in order to discuss more sensitive matters.

Q: And if you put in a question, maybe something like your citalopram, like you said you had spoken to [Telehealth Nurse]. How long would you expect before you got an answer?

P: Well normally [Telehealth Nurse] gets back to me within a day or so. So I would expect two days, almost maximum.

Q: OK. So, reasonably quickly.

P: Even if, it was: "we've got your question: we're thinking about it"

Q: So, just an acknowledgement that you've email?

P: Yeah. It may be [Telehealth Nurse] can't answer me first time. Like the citalopram. What she said was: "I'll discuss it with, (I think) you" and then came back to me." P381

Participants supported the idea that their answers could be shared more widely with their clinical team. They identified their community nurse, GP and hospice and people with whom they would like information sharing.

### 5.9.2 Nurses' attitudes towards the future use of the TiM

The interviews explored how the nurses felt the TiM system could be used as part of routine clinical care or within a larger trial (Appendix A5.37 and A5.38). The Telehealth Nurse explained that she elected to use the system herself rather than delegate it to another nurse as she was oversaw the clinical care of all patients. She felt that a more formalised protocol, which outlined how she should respond to alerts, would likely increase the number of telephone calls made to patients. However, she explained that during the trial she felt it was important that she could use her knowledge and experience to independently decide how to respond to the information presented and would find it difficult working to a formalised protocol.

*"If it was written down, [that] I had to ring and I had to ring straightaway, ... I don't know whether, I would have found that quite difficult not being able to use my initiative and how I'm familiar with the patients and, don't know I might not have, I might have found that a bit more difficult." Telehealth Nurse*

Participants were happy for the TiM answers to be looked at by any member of the community team. The Telehealth Nurse thought this could be possible because liaison between members of the care team was very helpful but she also highlighted the need for the community teams to have capacity to do this. The Community MND nurse felt the TiM would be useful to enable her to learn more about her patients and would find it useful to receive information from other members of the care team. However, she explained that she would find the clinical portal difficult to access because, due to the nature of her job, which was mostly community, based, she does not use computers regularly. She also explained she was "not good with computers." and was in her 60s and about to retire and had not felt the need to adopt technology in her work. However, she would be happy receiving alerts and information from someone else. Discussions with other community teams establish that they do use electronic records and, may have better access to, and confidence with computer systems. Their opinions were not explored in this thesis.

The Telehealth Nurse was asked whether she thought other MND centres would use it. She explained that other centres have responded positively to the TiM

and she thought they are be motivated to improve the care for patients and would be willing to change as long as they thought the TiM was useful.

### 5.9.3 Summary

The potential positive impacts identified in this study included increased monitoring to pick up problems earlier and between clinic visits. This is particularly valuable to patients who are changing rapidly or for patients who cannot or would prefer not to attend clinic. In addition it could offer reassurance, particularly in the context of early or slowly progressive disease. It could also promote contact between participants and trusted specialists which would be particularly valuable in those without established links in the community. In some cases, identification of problems meant support could be put in place earlier to act upon problems and help the patient come to terms with, and cope with the change in their disease.

The TiM system provides the opportunity to monitor carers' wellbeing separately from patients in a way that fits in around their caring duties. The clinicians using the TiM felt it could be a useful addition to the current service and could be used to triage or reschedule appointments according to need if the problems with alerts were improved.

Whilst on some occasions the TiM did appear to impact positively on participants' care this was not occurring as much as was expected. The reasons for this included that the Telehealth Nurse was not responding to the high number of alerts, or was not communicating her actions to the participants. The results also highlight the difficulty of capturing the impact of complex interventions during a clinical trial, especially when relying on participant interviews to recall what happened.

In the future, the study suggested that an ideal service would be flexible enough to meet the needs of participants who may differ in their disease course as well as the way in which they need to interact with the specialist team. This service should include opportunities for face-to-face, telephone and email contact to maintain links with the specialist MDT. These results suggested that the TiM system could play a part in this service and help the teams care for patients according to the NICE best practice guidelines.

## **5.10 Discussion: The feasibility and potential value of the TiM system**

This section will discuss the feasibility and acceptability of the TiM technology, its use as a remote monitoring tool and as a patient alternative to hospital visits. It discusses how the TiM system might be used to improve patient and carer care. Given the findings of the trial, it also discusses how it should be improved.

### **5.10.1 Feasibility and acceptability of the TiM system**

#### ***5.10.1.1 Feasibility and acceptability of TiM technology***

This study has demonstrated that the TiM technology can collect information on patient and carer progress in MND requiring only minimal training and support. Participant adherence to the TiM system was good and better than many telehealth studies where adherence ranged from 40% to 90% (234). The keys to success were the simple technology, user-centred design and providing face-to-face training and support. It also involved patients and carers who were motivated to be involved in research to improve the way in which they engage with the MND team. However, as discussed in Chapter One, these results suggest that patients and carers do want better access to MND specialists and therefore it is likely that other patients and carers will also engage in the TiM system, as long as they thought the TiM system did provide this additional benefit.

Other telehealth projects found adherence tends to drop off with time (234), but in this study many participants maintained good adherence throughout. Some did reduce adherence, usually because participants became too unwell at which point they were often receiving domiciliary care, something the TiM system did not aim to offer. A number of patients stopped using the TiM because they had become demoralised because they were not receiving any feedback from the MND team and therefore the TiM was not felt to be valuable. This highlights the need for the TiM to be more interactive, even at times when patients require little more than monitoring. This is supported by the literature which found that studies involving a patient education programme had much better compliance than those without (234) and whilst participants in this study did not tend to use the additional education services on the TiM system, many patients thought that the ability to monitor their own disease and the opportunity to learn more offered them benefit.

Further improvements would make the TiM technology work better. It is recommended that, where possible, patients' own equipment is used. This is likely to be more successful as they are more familiar with their own devices and would be better able to resolve problems without relying on the clinical team. Avoiding the use of different and complex devices that were found to be unreliable in this trial (for example, the Wi-Fi-enabled weight scales) would reduce the chances of system failure. Whilst these conclusions appear reasonably obvious, our findings are in contrast with the problems identified in Chapter Two where telehealth services often use bespoke, outdated technology with which staff are unfamiliar. The clinical portal was also successful with few

technical problems but will require adequate training and on-going technical support to ensure user engagement to ensure smooth running of the service, particularly if the system would be used alongside “normal” practice (235).

#### ***5.10.1.2 Feasibility and acceptability of the TiM system as a remote monitoring tool***

Using TiM to monitor the condition of patients and carers appeared to be feasible as well as appearing broadly acceptable to patients and carers and clinical staff. TiM provided the clinical staff with information that appeared relevant and reliable and, in some patients, enabled problems to be identified and monitored earlier than would have otherwise been the case. It could also help patients be reassured that their condition is progressing more slowly than they feared, or conversely, provide patients with information to help them come to terms with their deterioration. However, in order for the TiM to be a feasible addition to the clinical service, changes to the TiM system are required to improve the way in which the clinicians (in particular the Telehealth Nurse) responds to the information provided by the TiM system and interact with patients and carers.

The main problems with the TiM encounter in this trial were the high number of alerts and a lack of interaction between the MND team and the patients/carers. In this trial, more than 50% of sessions generated an alert, to which the Telehealth Nurse was expected to respond. The large number of alerts (many of which were not felt to be appropriate) made the nurse frustrated and demotivated. “*Alert fatigue*” was an important reason why she felt disinclined to act upon alerts. These findings reflect those of other studies where alerts are often clinically irrelevant but increase work for the clinician by requiring the alert to be “over-ridden” (236). Furthermore, excessive alerts do not just cause clinicians to be frustrated and fail to respond to alerts, it also makes them anxious that they were missing important alerts amongst the multitude of other, less important alerts (237). As services adapt to new systems users may not use the system as originally intended meaning safety systems can be inadvertently bypassed (237).

The TiM was designed to facilitate a flow of information only from the patient/carer to the clinical team. The TiM system did not provide opportunities for the Telehealth Nurse to understand the expectations of participants using the TiM and *vice versa*. Without this interaction patient-centred care is not promoted and users remained unsatisfied. This study found that there was a mismatch between participant expectations of the TiM and the nurses’ attitudes and actions towards the problems the TiM identified. Lack of interaction between the participants and the clinicians using the TiM contributed to the mismatch in expectations. This disconnect was particularly evident when the Telehealth Nurse believed that the problems reported were, in her experience, a reflection of the natural history of the disease, or were problems she felt she was unable to solve. In contrast, participants expected acknowledgement even if no action were taken whereas the nurse tended not to acknowledge these problems. The Telehealth Nurse found interactions in these circumstances unsatisfactory as she felt she had nothing to contribute. She



undervalued her role and felt she was adding nothing. In fact, she was often taking actions such as liaising with the MDT and offered valuable advice, support and reassurance to patients and carers. These calls also provided opportunities to discuss other concerns or ideas and review their treatments. For a patient, any new or changing problem is unfamiliar for them and these milestones in their disease are experienced as a series of losses, with reactions similar to a grief process (31,238). Patients in our study explained that they wanted these milestones to be acknowledged, even if they thought that nothing specific could be done about the problem. Future services should ensure their staff understand the value they offer patients and carers as well as providing opportunities for the expectations of users to be better understood to enable better patient-centred care and that the patient and carer participation in decision-making.

Use of the TiM system also disrupted the traditional way in which the nurse would gather information and respond to patient difficulties (176). New routines that change in the way nurses usually work can pose a barrier to staff acceptance. Unlike some studies it did not appear that the Telehealth Nurse felt her own expertise were undermined by the system but should the system have been more prescriptive it is likely that this would have represented a significant barrier to her acceptance. She did highlight the difficulties interacting with participants with whom she did not have a good relationship. Participants in this study highlighted the great importance of their relationship with their MND nurse and this study suggests that good relationships are still required in order to maintain effective communication and acceptance.

#### ***5.10.1.3 Feasibility of the TiM system as an alternative to face-to-face appointments***

This study did not evaluate the TiM service as an alternative to clinic. However, it did identify a number of challenges to this, mainly due to the organisation of the hospital clinic. This study found that outpatient appointment schedules were unpredictable: Sheffield does not have a dedicated service to arrange appointments at regular intervals. This means clinicians are unable to review patients' results and reschedule appointments easily. An analysis of the appointments made in the three Sheffield neuromuscular clinics during the year 2015/2016 supports this assertion. Of the 908 follow-up appointments booked, 110 (12%) appointments were not conducted because the patient did not attend appointments. 761 (84%) were rescheduled: 459 were rescheduled by the hospital and 317 by patients. The service would be more feasible if the MND team could book and change appointments and schedule TiM clinician reviews. More administrative support and the use of electronic records and scheduling would also help facilitate a more flexible service.

A flexible service, using TiM rather than face-to-face appointments would need to consider the needs and preferences of patients but some patients did feel that this would be an acceptable way to access MND care, particularly at the later stages of the disease and some would be happy to delay their appointments as



long as they could be seen at short notice if required. If this change is instigated, it is recommended that impact of changing the model of care on safety and on the service as a whole is evaluated further.

## **5.10.2 The potential impact of TiM system**

### ***5.10.2.1 The potential impact of the TiM on patients***

The interviews and satisfaction questionnaires suggest that there remain many unmet needs in MND that could be met by improving access to specialist care. This study suggests that the TiM has the potential overcome some of the barriers to accessing specialist care and could complement the existing service by facilitating communication and care coordination. The TiM system could also be used to provide information and promote self-management and self-efficacy. There were a number of incidences during the trial where the TiM system appeared to helping the clinical team to manage patients and carers more proactively, particularly where patients were progressing rapidly. There were times when participants and nurses felt it identified new problems and the nurse used it to monitor patients' progress or treatment (such as NIV). The TiM system was a low-burden way of collecting information and whilst it may seem impersonal, this appeared to be an advantage to some users. It is possible that those who may try to minimise problems or feel frightened to admit they are not coping may be more likely to report problems on the TiM system. This was particularly important for carers who were clear that providing a facility for them to be easily monitored away from the patient was very important and that the TiM could be part of this service. The Telehealth Nurse felt a number of carers were offered additional support as a result of using the TiM system.

However, whilst the current TiM system appears feasible, many participants interviewed felt the TiM had not made a difference to their clinical care. Chapter Six will report that there was little difference between the treatment groups and describes reasons for these observations. This trial did not aim to measure efficacy and results drawn entirely from the participants' perspective should be interpreted with caution. Interviews may not capture all the interactions between the patients and their MND team and participants were not always aware of actions taking place "behind the scenes". The value of the TiM in these patients may be reassurance, education and the option to reduce clinic frequency rather than in changing their medical management and it may be difficult to record these changes.

### ***5.10.2.2 The potential impact of the TiM system on carers***

This study found that the carer derived benefits from the MDT service, both by improving patient care and offering carer support. Research supports the findings of this study that attention to the patients' needs may alleviate caregiver distress (239). It suggests that the TiM system could be valuable if it were used to promote patient wellbeing and make them confident that, should they need it, support would be provided in a timely and expert fashion.

Chapter One argued that carers suffer from anxiety and carer strain. These findings are reflected in the interview data and objective measures described later in Chapter Six. Carers welcomed the monitoring of their wellbeing. A

system such as the TiM system, which monitored carers in a convenient and low burden way, separate from patients may offer a solution to this need. This has wider relevance as it also highlights the need to provide support to carers in ways that fit into their lives and preferences. Carers described the need to deprioritise their own needs and a constant need to be available for their loved ones, a fear of admitting they were “*not coping*” and feelings of guilt if they prioritised their own needs. Carers did not feel traditional forms of psychological support they were offered which requires the carer to leave the patient (such as counseling or respite) were acceptable. They found that completing the TiM system was easy and fitted into their lives as they did not need to leave the patient to use it. Furthermore, it suggested that future digital services could be useful as they might better fit in around carers’ needs by providing online support accessed at times convenient to the carer, or through telemedicine which would avoid the carer needing to leave the home.

## **5.11 Improving the TiM system**

The findings from this study suggest that the current TiM system is acceptable and feasible to patients but many participants felt that the TiM system did not impact on their care and many aspects of the service require improvements in order to make it a system which is likely to have a significant impact on the MND population. The next stage of development, evaluation and implementation of the TiM system should be an iterative process to develop and test the system in more services and improve it to meet the requirements of different MND centres in which the TiM could be used. This concurs with the MRC guidelines for developing and evaluating complex interventions. The TiM system needs to do more to meet the expectations of both patients/carers and clinicians and the technology needs to work better within the existing clinical service. In particular, improvements need to focus the alert system and the way in which users interact with the clinical team.

### **5.11.1 Improving the TiM clinical algorithms and alerts**

Over 50% of sessions generated an alert in this trial. This problem will need to be addressed in future versions. The TiM study has collected data from 20 patients and carers. With a better understanding of the significance of the information provided by the TiM (e.g. which answers represent a serious problem and which could be ignored), improved clinical algorithms can be developed. This has already been explored for the carer algorithms: the scores at which the Telehealth Nurse is alerted can be raised to only alert the nurse to scores that are much higher than the other carers, or have increased significantly over time. Early analysis has suggested that this would significantly reduce the number of carer alerts generated.

Developing a protocol, which describes how Telehealth Nurses are expected to react to alerts, is one way to increase the number of actions taken/documented. This may be appropriate for problems where protocols already exist and targets are clearly defined such as medication prescribing or hypertension management. Many of the telehealth systems described in Chapter Two used clinical protocols, but it was unclear how rigidly nurses adhered to these. This approach is less appropriate in MND where care must reflect the patients’

individual goals and wishes and the limitations rather than specific targets. The Telehealth Nurse wanted to use her judgment, experience and knowledge of the patient to determine the best way to respond to problems and she felt this was likely to be the approach adopted in other MND care centres. However, the recent publication of assessment and management guidelines in the UK (39) means there are now clear standards to which MDTs should be aiming. Further consultations with MND care centres (using approaches such as a Delphi consensus (237)) could influence the development of better clinical algorithms. A framework could also be developed which, along with the NICE guidelines, could guide nurses and help them understand what is expected of them, how they could get the most out of the TiM system and how they should be interacting with patients. An iterative process could use this data to model and test the alerts and new facilities (such as the “*pause*” feature), in clinical settings to identify feasible and acceptable procedures.

#### **5.11.2 Improving patient/carer-clinical team interactions using TiM**

It is clear that participants wanted much more interaction with the MND team. A number of levels of interaction could be integrated into the TiM system. The most basic interaction could be automated. This could include information about adherence or informing participants about the alerts generated and the action taken by the nurse. Feedback could be bespoke, that is, generated by the Telehealth Nurse in response to problems. This could use technologies such as instant messaging, email, phone or video calls. The TiM could enable clinicians to provide educational materials relating to the alerts generated e.g. providing a booklet or website detailing information about falls prevention. A system to monitor and request telephone/video calls or hospital visits could also be included. All of these methods of interaction are technically feasible using simple technology, although any non-automated interaction could increase clinician burden. The Telehealth Nurse felt receiving additional information may actually reduce her burden.

#### **5.11.3 Using the TiM to promote self-efficacy**

Improving the opportunities for interaction could also enable a more tailored approach to user education. Participants in this study suggested that the TiM could be used in a more positive way to promote coping strategies. This might improve self-efficacy, a major factor influencing quality of life in MND (240). Self-efficacy is defined as a held belief about one’s own capabilities to produce and influence events that affect one’s life (25). Those with a strong sense of self-efficacy approach tasks with the assurance that they can control them and see difficult tasks as challenges to be mastered rather than as threats to be avoided. They are resilient to failure and can sustain themselves in the face of setbacks. Those who doubt their capabilities have lower aspirations, less commitment to goals and see failure as a personal deficit. Faced with failure, they will quickly lose faith in their abilities that can result in stress and depression.

Many aspects of life with MND can negatively influence perceived self-efficacy. Faced with a relentlessly progressive disease outside of their control and a series of losses of function, patients constantly have to reappraise their own abilities, experiencing feelings of frustration and failure. Patients may perceive few opportunities in which they can influence the disease, particularly those lacking knowledge about the disease or those with severe disability. They describe restricted access to tools designed to help them cope and are frustrated that services are not patient-centred or do not promote positive approaches to coping. Perceived lack of control and fear of the future is reinforced by seeing others with MND (for example when attending hospital clinic) in situations where they too are unable to manage their disease. This chapter highlighted the common but potentially harmful approaches to “*coping*” such as avoidance of the diagnosis or trying to maintain normality (both of which will inevitably fail). This further reduces their capacity to cope with future problems. This may explain why good psychological wellbeing is associated with survival, even after adjustment for confounding factors (241).

Self-efficacy can be gained by *mastery of experience* (i.e. experiencing one’s own success) (26). It is possible to strengthen self-belief by persuading people that they have the capabilities to succeed, giving them situations in which they can succeed, avoiding unrealistic expectations and by changing the way events are perceived and interpreted. Participants in this trial (along with those that are later reported in Chapter Seven), described other positive but achievable strategies to maintain control over their disease, such as seeking out information or taking an active part in their management. Participants highly valued the positive “*can-do*” attitude of some members of the MDT and felt they improved with outlook and quality of life. Carer coping strategies identified in the literature are also associated with self-efficacy. This include taking pride in and finding positive meaning in caring (239,242). The interviews suggest that perceived self-efficacy and desire and ability to self-manage varied amongst participants in this study. Even the most prepared and motivated patient will be faced with unfamiliar problems outside their control and the balance of responsibility may shift between patient, carer and the healthcare professional as the patient progresses.

Participant interviews suggest that the TiM system could be used to improve self-efficacy. The TiM already provides information about self-management but a more interactive telehealth service could further promote self-efficacy by enabling patients and carers to play an active role in aspects of their care. For example, TiM could be used to set and monitor achievable short-term goals and expectations, for example when initiating NIV or during a period of physiotherapy. Conversely, it could also support patients who experience difficulties with self-management or reduce the stress associated with perceived failure, such as when the patient needs to adapt to a new loss of function. There is evidence that telehealth programmes can improve patient

and carer self-efficacy and ability to self manage although the evidence is far from conclusive and, as discussed earlier, success will depend heavily on the service and how it is used by individual (243-246).

#### **5.11.4 Changing staff behaviour**

A recent systematic review of health care providers' attitudes towards telehealth (247) also supports these results, suggesting that the way a clinician interacts with telehealth and adapts to their role depends on their attitude towards the system and its potential benefits for patients. The willingness and ease in which the clinician adapted to their role using the telehealth is related to clinicians' perception of the benefit of telehealth to patients and the belief that they can be part of a system which brings about positive change (247,248). Clinicians who held more positive views about telehealth were more willing to consider changing their roles to incorporate telehealth (247). When clinicians could see the positive impacts, they were less concerned about technical glitches. Individual staff characteristics related to successful telehealth use included willingness to change, creative attitudes to cross discipline working, open-mindedness, adaptability and flexibility (247). This review also highlighted the importance of the knowledge of the patient and the establishment of a good clinician-patient relationship which resulted in more frequent and effective interactions (247). Telehealth systems do change the way in which staff work, their roles and responsibilities and the way in which the overall service works. Whilst a framework might guide clinicians to use the TiM more effectively, clinicians' "readiness to change" should also be promoted. This study suggests that clinicians using the TiM need to have good understanding of the technology, the value of the services they offer and expectations of their patients and carers and the importance of interaction, feedback and the promotion of self-management and self-efficacy. This could be achieved through training for clinicians to understand the aims and the potential benefits of the TiM system in their service, how it can be best used and the expectations of patients and carers prior to, and during use of the service.

#### **5.11.5 The future development of the TiM**

This study suggests that TiM system has potential to add value to MND care centres both in the UK and internationally. However, the interviews with the MND nurses and discussions with other clinicians during this study have established that care centre, community service, staff and the patients differ widely. For example, some centres already use telephone or telemedicine consultations, others use of a network of home visiting nurses (55). If care centres do try to use technology-enabled care such as the TiM, it would need to be adaptable to meet their needs. Things that work well in one centre may not be effective in others. It will therefore be important that further development and evaluation of the TiM system is conducted within a range of target services that reflect these differences.

### **5.12 Limitations of the process evaluation**

There were a number of limitations to this process evaluation. This evaluation was conducted in a single centre by the developers of the TiM. There is a risk of bias in the way the data was collected and interpreted. The different roles of EH

as TiM developer, researcher and doctor may have influenced the findings. Some patients had already met EH in a clinical capacity and it was explained to participants about EH's role of the research. However, as expected, a number of problems were raised at study visits, usually triggered by completing the questionnaires or TiM system. These were passed to the Telehealth Nurse wherever possible and attempts were made to avoid clinical discussions during the interviews or data collection visits. However, it is possible that contact with EH influenced participants' satisfaction or clinical outcomes. In a definitive trial, staff independent of the clinical team and the TiM should conduct research visits.

It is also possible that participants may have been more willing to participate and engage with the trial and the TiM system because it was provided by a doctor. They may also report their experiences more favourably, for the same reason. The interview data suggests that participants actually took part because they wanted to be part of research or because they wanted to use the TiM. Participants were critical of the existing MND care system and of many of aspects of the TiM system. The experiences described in interviews mirrored those provided by the self-administered questionnaires that were collected independently of the researchers.

The professional background of a doctor may actually have aided the building of a research relationship, allowing participants to be more open and comfortable with discussing their health with someone who is in a trusted role (249). Participants explained that they thought the research would be conducted correctly because they trusted their clinicians would act in their best interests. They also explained that they were motivated to participate because they wanted to help improve the care for people with MND and believed that, by taking part in research in the Sheffield MND care centre, their involvement in this research could make a positive impact.

At the start of the study it was expected that participants' use of technology would be the main barrier to the TiM service so the interviews with patients and carers were scheduled to occur early in the trial. Early interviews provided the opportunity to change the TiM system during the trial but did not explore some of the issues that occurred later in the trial, that is, after six months. This was the point where adherence did decline in some participants and when participants were experiencing more difficulties and/or were not able to attend clinic. Interviews were also carried out at predefined times and may not have captured important events in the patient's disease where the TiM could potentially be particularly valuable such during the initiation of NIV. In addition, using interviews to capture events that led to a change in patient/carer management was limited because it relied on the patient/carer knowing an action had occurred and that it had occurred as a result of the TiM system. As the Telehealth Nurse did not always feed back her actions to the patient they were unaware of the impact of the TiM meaning it was not captured in interviewed. These interviews did manage to capture some of the possible ways in which patients' care could change using the TiM (e.g. earlier

awareness of a new problem) but these impacts maybe better captured more systematically by using the TiM clinician portal itself.

It was also not possible to interview the two patients who dropped out of the study due to ill health or participants who declined to participate although participants with severe disabilities did participate in interviews. It is also possible that the trial captured the views of a limited selection of patients, those who were highly motivated to participate in research or those who liked using technology. As a result, a further study was conducted to capture the views of patients who may not have wished to participate in the TiM study. This is described in Chapter Seven. Reassuringly, these results align with the TiM trial results.

The study found that the main barrier to TiM success appears to be how the TiM is used by the clinical team. Whilst feedback from clinicians was captured, this was mainly from the one Telehealth Nurse using the system so did not capture the range of experiences that might have been seen had different staff used the system and in different services. Whilst it identified a number of barriers and facilitators to staff behaviour change, future studies should focus on these areas of uncertainty. It should be acknowledged that the Telehealth Nurse was also a member of the research team that developed the TiM and this may have led her to respond favourably in interviews. An independent interviewer was used in the second interview to allow her to express her views openly but she remained aware that the research team would be able to identify her views and could potentially be critical of her actions. Despite this, she was critical of the TiM system and identified various barriers to its success. Relying on one nurse to deliver the TiM system was also a limitation. The Telehealth Nurse was an experienced member of staff who was involved in the development of the MND service and therefore her current role has likely been shaped to reflect her needs and preferences. Whilst she was consulted informally during the development of the TiM and reported that she was willing and had time in her job plan to use the TiM system, she explained in the interviews that she preferred working in a particular way. She admitted other nurses may have different attitudes, may be more “*ready to change*” and might use the system in different ways. Future evaluations should aim to include a more diverse range of services and staff in order to reflect these uncertainties.

### **5.13 Conclusion**

The TiM system is accessible and acceptable to patients and carers but a number of problems were identified that meant that, at present, the value of the TiM is uncertain. Further improvements are required to tackle issues such as the excessive alerts generated by the TiM and the way in which the clinical team and patients and carers interact. Chapter Six describes whether a larger, definitive randomised controlled trial of the TiM would be feasible. However, it is clear that prior to any definitive trial, the TiM system would need significant development. This would be best done as an iterative process, within the target clinical setting and should allow individual care centres to adapt the TiM system to fit in with their existing models of care.



## Chapter Six

### Results: Evaluation of the feasibility of the study

#### 6.1 Introduction

Chapter Six describes how and whether conducting a definitive, randomised controlled trial of the TiM system would be feasible. It will explore whether a larger study could recruit and retain sufficient participants and whether a larger trial could determine whether the TiM system is effective.

Chapter Five reported the characteristics of the participants at baseline. Chapter Six reports the results of screening, recruitment rates, patient and carer clinical outcomes and health resource use during the trial. It reports any changes in the outcomes during the trial and whilst it does not aim to compare the outcomes in the two treatment groups it does report any notable differences. Where possible, it also compares the characteristics of participants to published population data in order to understand whether the participants are representative of those attending an MND clinic.

Chapter Six then uses both qualitative and quantitative data collected to discuss whether a definitive randomised controlled trial would be feasible considering whether the outcome measures collected were acceptable to participants, valid and accurate and whether the data collection methods are feasible and are a valid reflection of participants' experiences of life with MND.

Finally, it discusses the strengths and weaknesses of the study design and makes recommendations for ways in which TiM may be better evaluated.

Not all data collected during the trial is presented in this chapter. Additional data is contained in Appendix B where stated. Quotes from interviews have been used to illustrate relevant points and supporting quotes are reported in tables in Appendix B.



## 6.2 Screening, recruitment and participant characteristics

### 6.2.1 Screening and recruitment

Screening commenced in September 2014. Recruitment of the target 40 patients took 14 months (approximately 3 patients per month) (Figure 6.1).

Figure 6.1 Recruitment in the TiM trial.

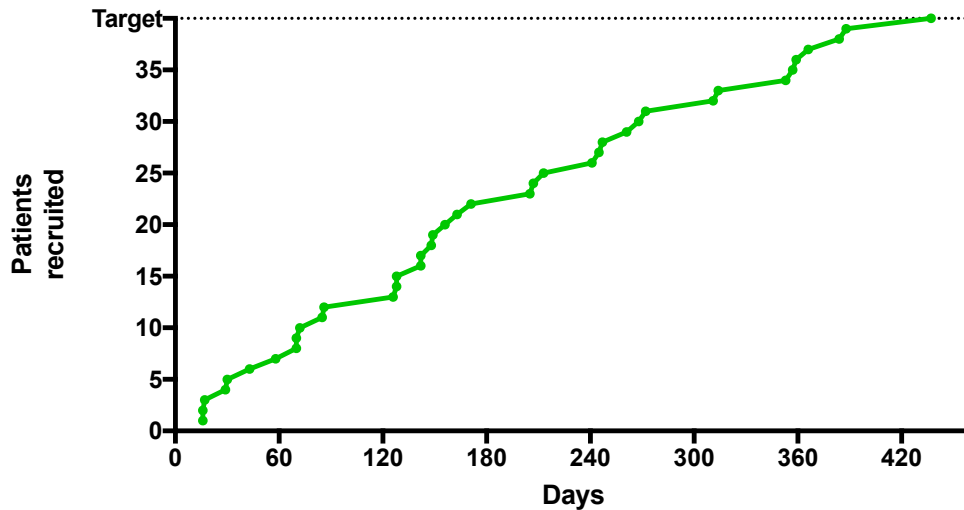


Figure 6.2 displays the CONSORT flow diagram describing the processes of screening, recruitment, follow-up and data analysis. 306 patients were pre-screened using the ARC MND clinical database. Two patients were followed up for the entire 18 months. To maximise the use of the TiM system, all participants remained in the study and those in the intervention group continued to use the TiM until the study finished in April 2016. This meant 15 patients completed between 12 and 17 months in the trial and 20 completed between six and 11 months. Participants whose follow-up finished before each time-point are included in the CONSORT diagram and referred to as “Patients/carers follow-up finished”.

Figure 6.2 CONSORT flow diagram. All participants were followed up for six months unless they withdrew or died. Participants recruited later in the trial were not followed up for the entire 18 months. These are included in the CONSORT diagram and referred to as “Patients/carers follow-up finished”.

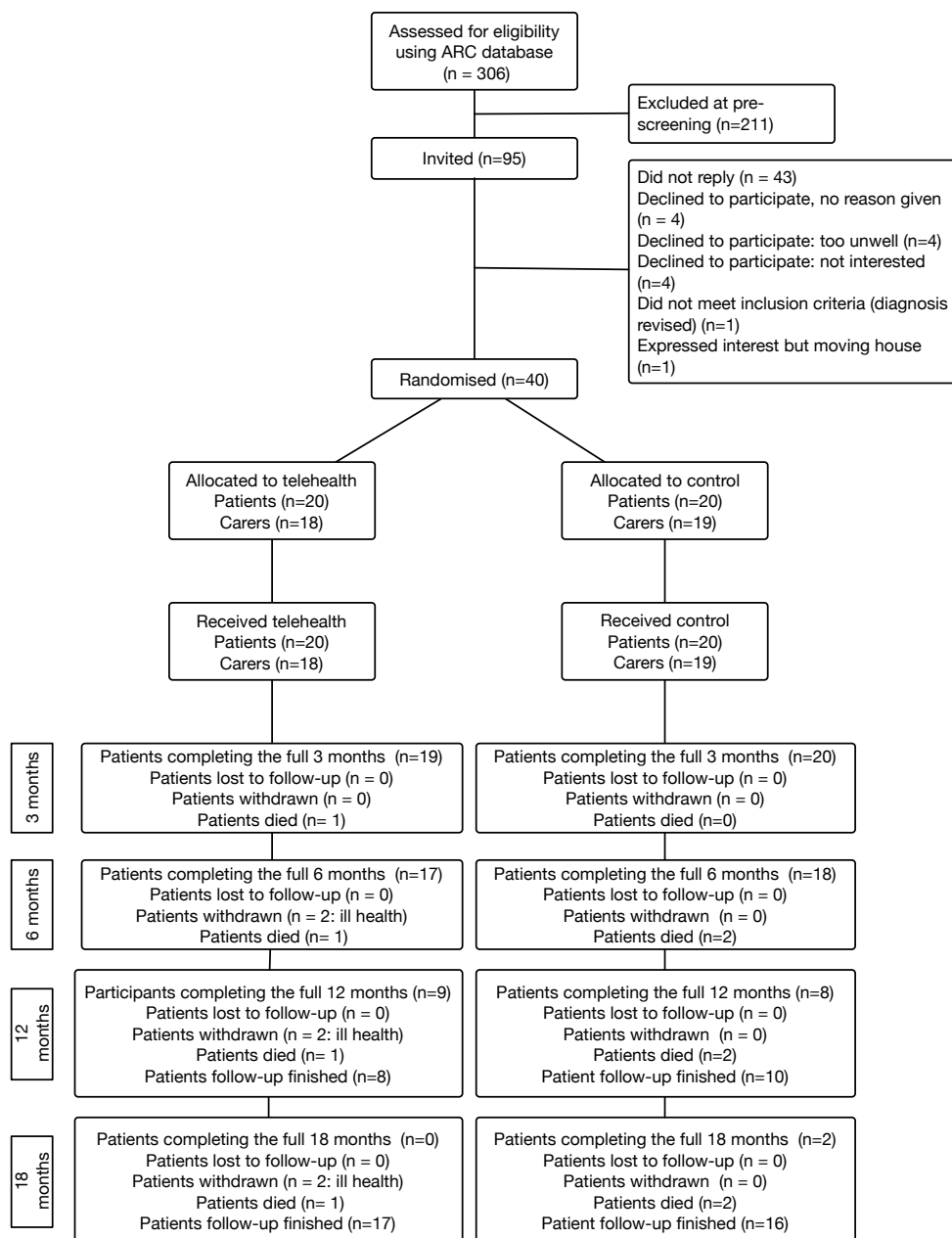


Table 6.1 describes the reasons for excluding 211 patients at pre-screening. 88 patients were excluded on clinical grounds and 123 patients were excluded because the Sheffield MND clinic was not currently their main MND care centre. This included 69 patients who lived within two hours drive of Sheffield but no data was available within the last two years on ARC. Although information on patient deaths are automatically updated by the NHS Spine system, this can be incomplete. These patients may have died or moved to another centre or may have stopped attending clinic.

All 95 patients identified as potentially eligible were invited to participate. 42 (44%) patients expressed an interest in participating and 40 (42%) were recruited. Figure 5.1 describes the reasons why patients declined. 28 patients were recruited from the population of patients already diagnosed (the prevalent population). During the trial, a further 12 newly diagnosed patients were recruited. Recruitment of all 40 patients took 14 months. The 40 eligible patients who expressed an interest in participating received a visit at home. All these patients were recruited, randomised and received the correct allocated intervention. 37 carers were recruited. Three patients who were recruited did not have an eligible carer.

Three patients died (15%) and two patients (5%) withdrew from the study: both were severely disabled at recruitment (requiring both NIV and gastrostomy feeding) and shortly after recruitment felt too ill to continue to participate. All participants continued to remain in contact with the MND centre and therefore no patients were lost to follow-up. No carers withdrew except those who were automatically withdrawn when the patients withdrew or died.

Table 6.1 Reasons for patient exclusion at pre-screening using ARC database. 309 patients were screened and a total of 211 patients (68%) excluded.

<b>Reason for exclusion</b>	<b>Number of participants</b>
<b>Sheffield not currently the main MND care centre</b>	
Live > 2 hours' drive from Sheffield	32 (10%)
Attend another care centre	22 (7%)
No data on ARC in last two years <sup>7</sup>	69 (22%)
<b>Total</b>	<b>123 (40%)</b>
<b>Attending the Sheffield MND care centre, excluded on clinical grounds</b>	
No evidence of symptom progression	36 (12%)
Severe cognitive impairment	12 (4%)
Terminal stage of the disease	11 (4%)
Symptom onset unclear	1 (0.3%)
Patient unable to read English	1 (0.3%)
Previously declined all research	2 (0.7%)
Recent diagnosis: insufficient data	16 (5%)
No eligible carer <sup>8</sup>	1 (0.3%)
Residing in a nursing home/hospital	8 (3%)
<b>Total</b>	<b>88 (28%)</b>

<sup>7</sup> This was because the patient had not attended the MND service in Sheffield. It is possible that many of these patients had died.

<sup>8</sup> Patient died before the eligibility criteria changed to allow patients to participate without a carer.

## 6.3 Patient clinical outcomes

This section summarises the patient reported outcomes at baseline, three, six and 12 months. Participant 18-month follow-up outcomes are not reported as only one questionnaire was returned. Patient quality of life (QoL) is reported in most detail as it was proposed to be the most likely primary outcome measure in a definitive trial with other clinical and economic outcomes used as secondary outcome measures. The aim of the study was not to determine whether the TiM was superior to usual care, therefore no formal hypothesis testing is performed. Instead, in the tables the mean and standard deviation at each time-point is reported. As discussed in Section 4.11.3, in order to explore whether the outcome measures were sensitive to changes in participants' condition, the mean change from baseline is also reported along with the 95% confidence interval to estimate the precision of the mean change. In the figure, mean score and standard error of the mean are reported. When the mean difference between baseline and follow-up values is observed to be significantly different from zero ( $p < 0.05$ ), the follow-up score is highlighted in bold in tables and with an asterisk (\*) in figures.

### 6.2.1 Patient quality of life

Figures 6.3-4 and Table 6.2 displays the SF-36, ALSAQ-40 scores at baseline, three, six and 12 months. Appendix B A6.1 displays the SF-36 scores in detail. Table 6.3 summarises the baseline QoL data, and compares the TiM results to population norms from adults aged 55-64 years and other studies of MND (250-252).

The average ALSAQ-40 emotional subdomain scores remained stable throughout the trial. Physical QoL scores deteriorated. By six months, average ALSAQ-40 sub-scores in all physical domains worsened and changes in the Activities of Daily Living (ADLs), Eating and Drinking domains reached significance (indicated in bold in Table 6.2 and with an asterisk in Figure 6.3). Physical Mobility, Eating and Drinking and Communication sub-scores also showed a trend towards deterioration. At 12 months, these trends persisted but the Activities of Daily Living sub-score was the only difference that reached significance. Similarly to the ALSAQ-40, the average SF-36 Mental Component Score (MCS) remained stable throughout the trial whilst the SF-36 Physical Component Score (PCS) deteriorated and was significantly different from baseline at twelve months. A similar pattern of deterioration in physical QoL scores and stable emotional scores is seen in larger MND populations (253,254).

There was little difference between the intervention and the control arms either in the baseline or follow-up QoL scores but the samples were small and confidence intervals wide.

On average, participants reported a poorer physical QoL (SF-36) than population norms for adults aged 55-64 years whereas emotional SF-36 scores were similar to those of the general population (252) (Table 6.2). However, participants' ALSAQ-40 and SF-36 were better in all domains than those in larger samples of MND patients (250,251) (Table 6.3).

Figure 6.3: Mean ALSAQ-40 sub-scores and standard errors at baseline, three, six, and twelve months. Scores range from 0 (best possible QoL) to 100 (worse possible QoL). An \* indicates scores where the mean change from baseline differs significantly from baseline ( $p < 0.05$ ).

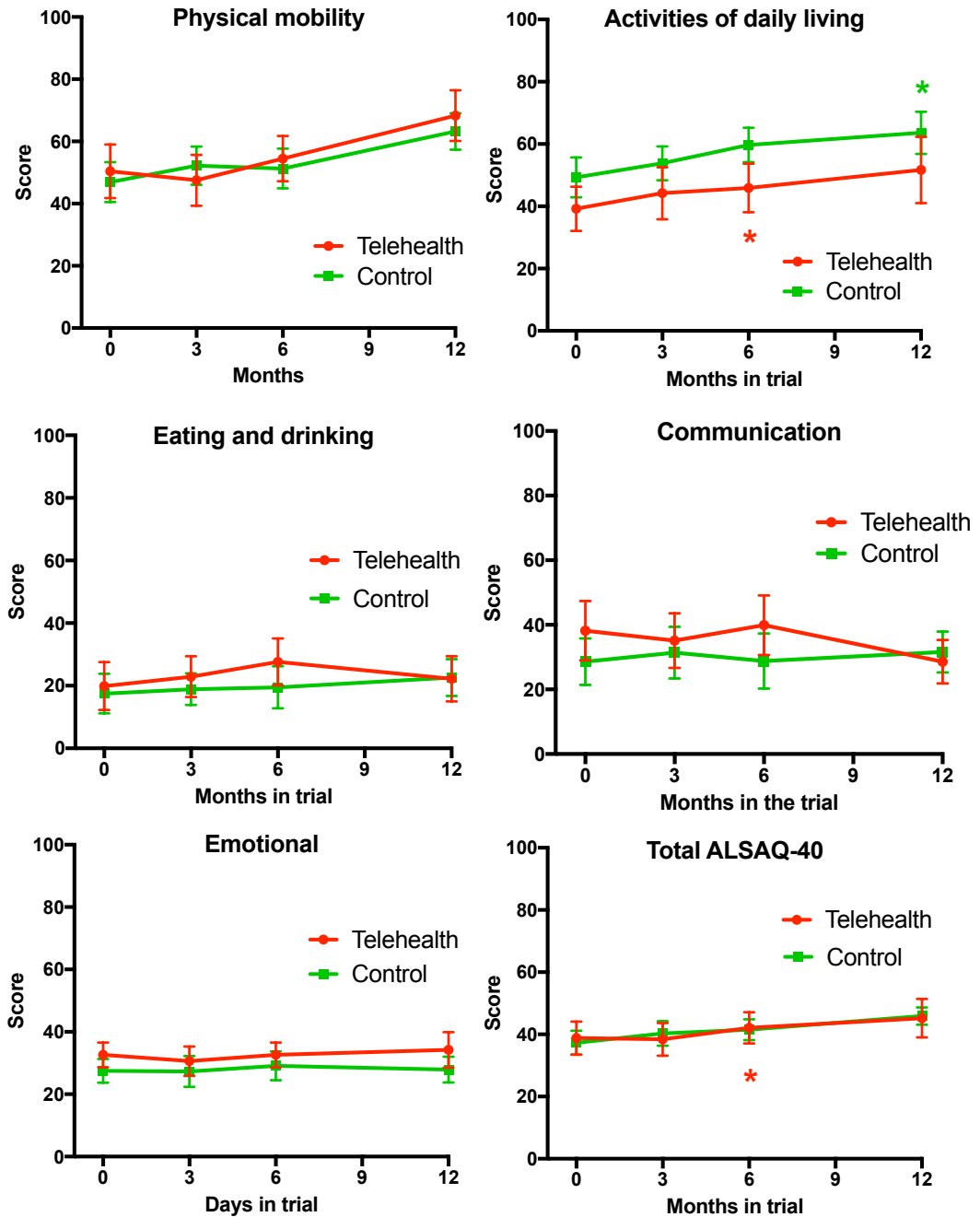


Table 6.2 Patient ALSAQ-40 index scores: mean, standard deviation (SD), mean change from the baseline and 95% confidence intervals. Scores range from 0 (best possible QoL) to 100 (worse possible QoL). Cells highlighted in bold indicate where scores are significantly different to baseline.

Patient ALSAQ-40	Base- line	3 months		6 months		12 months	
	ALSAQ -40 Mean (SD)	ALSAQ -40 Mean (SD)	Mean change from baseline (CI)	ALSAQ -40 Mean (SD)	Mean change from baseline (CI)	ALSAQ- 40 Mean (SD)	Mean change from baseline (CI)
<b>Telehealth</b>	n=18	n=16	n=15	n=16	n=16	n=6	n=6
Physical mobility	50.4 (36.6)	47.5 (34.6)	-4.7 (-15.4, 6.1)	54.5 (30.9)	5.8 (-3.8, 15.4)	68.3 (26.8)	10.4 (-3.6, 24.4)
Activities of daily living	39.2 (30.2)	44.2 (35.6)	5.8 (-0.1, 11.8)	45.9 (33.1)	<b>8.4</b> <b>(1.6, 15.3)</b>	51.7 (45.2)	15.8 (-1.5, 33.1)
Eating and drinking	19.9 (32.5)	22.9 (27.6)	6.1 (-1.4, 13.6)	27.6 (31.7)	<b>11.5</b> <b>(2.6, 20.3)</b>	22.2 (30.6)	13.9 (-16.7, 44.5)
Communication	38.3 (39.0)	35.1 (35.9)	0.5 (-5.0, 5.9)	39.9 (39.1)	3.6 (-2.1, 9.3)	28.6 (45.2)	13.1 (-12.1, 38.3)
Emotional	32.6 (16.8)	30.6 (20.0)	0 (-6.4, 6.4)	32.6 (16.9)	1.4 (-4.6, 7.5)	34.2 (24.3)	3.8 (-13.0, 20.5)
Total	38.8 (22.5)	38.4 (22.2)	0.83 (-2.6, 4.3)	42.1 (21.2)	<b>5.4</b> <b>(0.2, 10.6)</b>	45.2 (26.3)	10.8 (-1.5, 23.2)
<b>Control</b>	n=20	n=15	n=15	n=12	n=12	n=7	n=6
Physical mobility	46.9 (28.7)	52.2 (27.6)	1.6 (-12.9, 16.1)	51.3 (28.6)	8.3 (-8.2, 24.9)	63.2 (26.1)	15.0 (-17.6, 47.6)
Activities of daily living	49.3 (28.7)	53.8 (24.2)	2.3 (-7.0, 11.6)	59.7 (24.6)	9.0 (-9.6, 18.9)	63.6 (30.4)	<b>15.8</b> <b>(1.9, 30.0)</b>
Eating and drinking	17.5 (28.2)	18.9 (22.6)	0.6 (-7.1, 8.3)	19.5 (30.1)	8.3 (-10.7, 27.4)	22.6 (26.2)	2.8 (-6.3, 11.8)
Communication	28.6 (32.2)	31.4 (35.8)	1.5 (-5.9, 8.9)	28.8 (38.1)	8.0 (-20.5, 36.6)	31.6 (28.2)	9.5 (-9.8, 28.9)
Emotional	27.5 (17.0)	27.3 (22.0)	-1.4 (-9.2, 6.3)	29.1 (20.5)	-2.3 (-16.4, 11.8)	27.9 (18.6)	-3.8 (-23.6, 16.1)
Total	37.3 (17.2)	40.3 (17.7)	0.8 (-2.6, 4.3)	41.5 (14.9)	5.8 (-3.7, 15.3)	45.9 (12.5)	10.8 (-1.5, 23.2)
<b>Total</b>	n=38	n=31	n=30	n=28	n=28	n=13	n=12
Physical mobility	48.6 (32.3)	49.8 (31.0)	0.9 (-6.7, 8.6)	53.1 (29.4)	6.9 (-1.4, 15.2)	65.6 (25.5)	12.7 (-1.8, 27.3)
Activities of daily living	44.5 (29.5)	48.9 (30.5)	1.6 (-12.9, 16.1)	51.8 (30.0)	<b>8.7</b> <b>(3.3, 14.0)</b>	58.1 (29.0)	<b>15.8</b> <b>(6.8, 24.9)</b>
Eating and drinking	18.6 (28.4)	21.0 (25.0)	2.3 (-7.0, 8.3)	24.1 (30.8)	<b>10.1</b> <b>(1.3, 19.0)</b>	22.4 (27.1)	8.3 (-5.2, 21.9)
Communication	33.3 (35.4)	33.3 (35.3)	0.5 (-5.9, 8.9)	35.2 (38.3)	5.5 (-6.1, 17.1)	30.2 (35.3)	11.3 (-1.7, 24.3)
Emotional	29.9 (16.9)	29.0 (20.7)	-1.4 (-9.2, 6.3)	31.1 (18.2)	-0.2 (-6.6, 6.3)	30.8 (20.8)	0 (-10.9, 10.9)
Total	38.0 (19.6)	39.3 (19.9)	0.88 (-2.9, 4.7)	41.8 (18.5)	<b>5.6</b> <b>(0.9, 10.2)</b>	45.6 (19.1)	8.6 (-0.4, 17.6)

Figure 6.4 Mean SF-36 physical component scores (PCS) and mental component scores (MCS) and standard errors. SF-36 scores are standardised to a normative reference population (mean is 50 and SD is 10.) Telehealth and controls arms are displayed separately (left) and together (right). An \* indicates scores where the mean change from baseline differs significantly different from baseline ( $p < 0.05$ ).

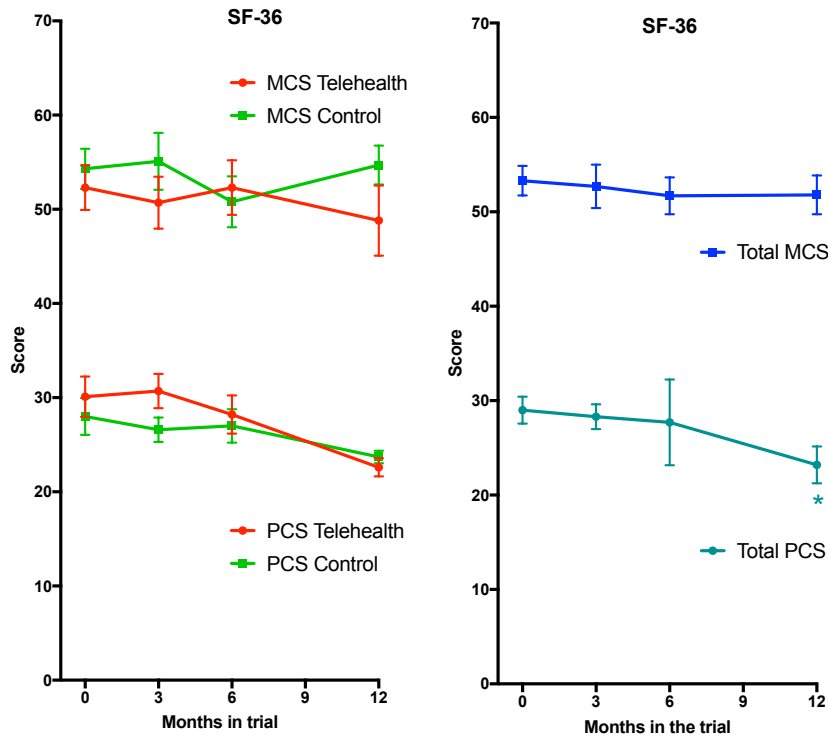


Table 6.3 The TiM population ALSAQ-40 and SF-36 means and standard deviations at baseline compared to larger population studies (250-252).

	<b>TiM study Mean (SD)</b>	<b>ALSAQ-40 population Mean<sup>9</sup></b>	
<b>ALSAQ-40</b>	n=38	n=144	
Physical mobility	48.6 (32.3)	69.9	
Activities of daily living	44.5(29.5)	69.4	
Eating and drinking	18.6 (28.4)	37.9	
Communication	33.3 (35.4)	50.3	
Emotional	29.9 (16.9)	50.6	
	<b>TiM study Mean (SD)</b>	<b>ALS-HPS study Mean (SD)</b>	<b>Population norms Mean (SD)</b>
<b>SF-36</b>	n=38	n=337	
Physical component score	29.0 (8.8)	26.45 (11.62)	45.1 (12.2)
Mental component score	53.3 (9.7)	43.69 (13.50)	52.2 (9.8)

<sup>9</sup> Standard deviation not reported. n varied from 142 and 144 due to missing data in some subscores.



### 6.3.2 Additional patient clinical outcomes

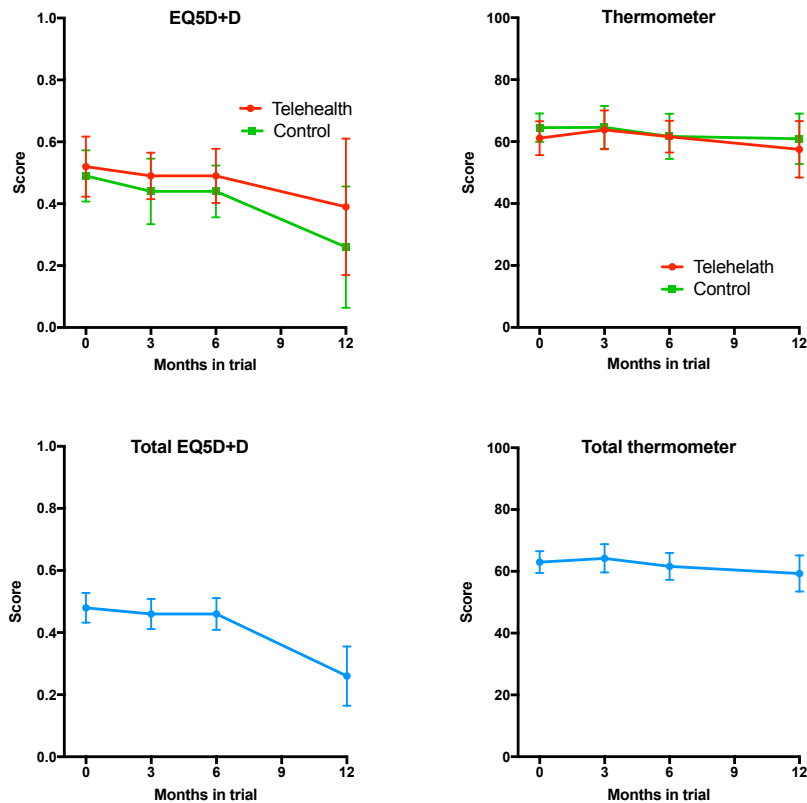
#### 6.3.2.1 Health utility: patient EQ-5D

Figure 6.4 displays the EQ-5D-3L scores. Tables of EQ-5D-3L scores with and without the additional dignity “bolt on” question are available in Appendix B A6.2 and A6.3. The calculations displayed in Figure 6.4 excluded patients who died from subsequent analysis. A further analysis assigned patients who had died a score of 0 at all future time points. This additional calculation had no substantial impact on the scores.

There were no notable differences in EQ-5D or self-rated thermometer between the two treatment groups at any time point.

EQ-5D-3L TiM scores were worse than the population norms for adults aged 55-64 years (TiM mean 0.53, SD 0.29 SD vs. general population 0.8, SD 0.26) (255). Self-rated thermometer scores were also lower (TiM 63.1, SD 21.3, vs. 79.7 SD 18.2) (255). EQ-5D-3L and thermometer scores did worsen during the trial but only the total EQ-5D-3L score changed significantly from baseline at six months (Appendix A6.2 B, indicated in bold). Health utility data for MND patients is very limited with only two studies identified but in these studies health utility scores were also worse in patients with MND compared to the general population with scores worsening over time (56,227).

Figure 6.4 EQ-5D-3L plus dignity bolt-on scores (EQ-5D+D) and the EQ5D thermometer. EQ-5D+D scores range from 1 (best QoL) to -0.59 (worst QoL). Thermometer scores range from 100 (best QoL) to 0 (worst QoL).

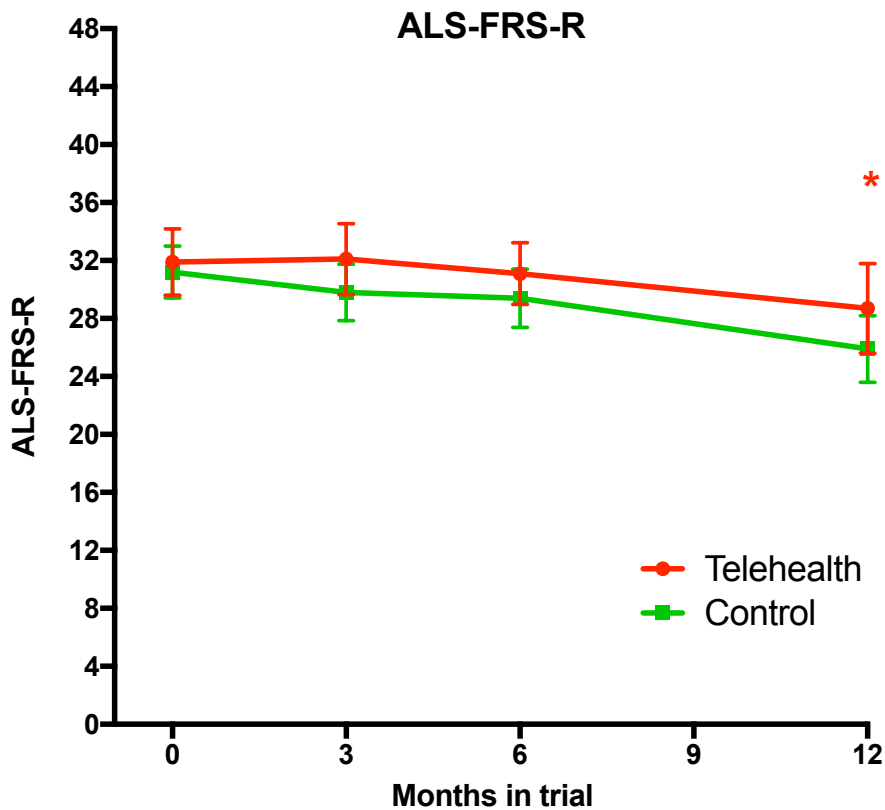


### 6.3.2.2 ALS-FRS-R

Figure 6.5 and Appendix B A6.4 displays the average ALSFRS-R scores. Scores declined (indicating worsening function) during the study by, on average 0.27 points per month at six months and 0.39 points per month at 12 months. The rate of functional decline is comparable to the monthly rate of decline of ALSALS-R in a historical study of patients attending the Sheffield MND clinic (0.34 in the second year) but much slower than many clinical trials (decline of between 0.76 and 1.60 per month) where patients with slowly progressive disease are often excluded (256,257). By 12 months the decline from baseline reached significance in the telehealth arm and when both arms were combined.

Again, there did not appear to be any notable differences between the two arms.

Figure 6.5 Mean ALS-FRS-R and standard error during the trial. Scores range from 0 (severe disability) to 48 (no disability). An \* indicates scores where the mean change from baseline differs significantly from baseline ( $p < 0.05$ ).



#### ***6.3.2.3 Patient Anxiety and depression***

The baseline and follow-up data is displayed in Appendix B A6.5-A6.7 which includes a comparison with the UK population norms broken down into gender as the incidence of depression and anxiety differs between men and women (258). Average patient HADS depression scores were low and the average scores were similar to the UK population (study mean score 4.8 females, 4.2 males vs. UK population 4.1 females, 3.9 males) (258). Seven patients (19%) had scores indicating mild symptoms (score 8-10), and one patient (3%) had scores indicating moderate to severe symptoms of depression (score  $\geq 11$ ). The incidence of higher scores was similar to the general population.

Average patient HADS anxiety scores were low, and also similar to the UK population (study mean score 6.9 females, 4.8 males vs. UK population 6.3 females, 4.9 males). 8 patients (22%) had scores indicating mild symptoms (score 8-10), and three (8%) had moderate to severe symptoms (score  $\geq 11$ ). However, these rates of higher anxiety scores were also similar to the general population. There are no large population studies of the HADS score in MND with which to compare.

During the trial, average anxiety and depression sub-scores and the incidence of abnormal scores did not change appreciably. There were no notable differences between the two treatment groups.

#### ***6.3.2.4 Pain scores***

Pain scores are available in Appendix B A6.8. Baseline pain scores were low (current pain mean 1.5 out of 10, SD 1.7, worst pain this week mean 3.0, SD 2.7) and did not change significantly during the study. There was no notable difference between the two arms of the trial.

#### ***6.3.2.5 Saliva severity scores***

A summary of the Saliva Severity Scores (CSS-MND) is available in Appendix B A6.9. At the time of writing, this version of the CSS-MND had not been formally validated and no published population norms were available making interpretation limited. Mean scores were low indicating low levels of excessive saliva (4.1, SD 5.5, scores range from 0 to 36) but individual scores varied greatly during follow up. For example, one patient's score worsened by 15 points in six months whilst another improved by 13 points. However, mean scores did not change significantly during the study and did not appear to differ between the two treatment groups.

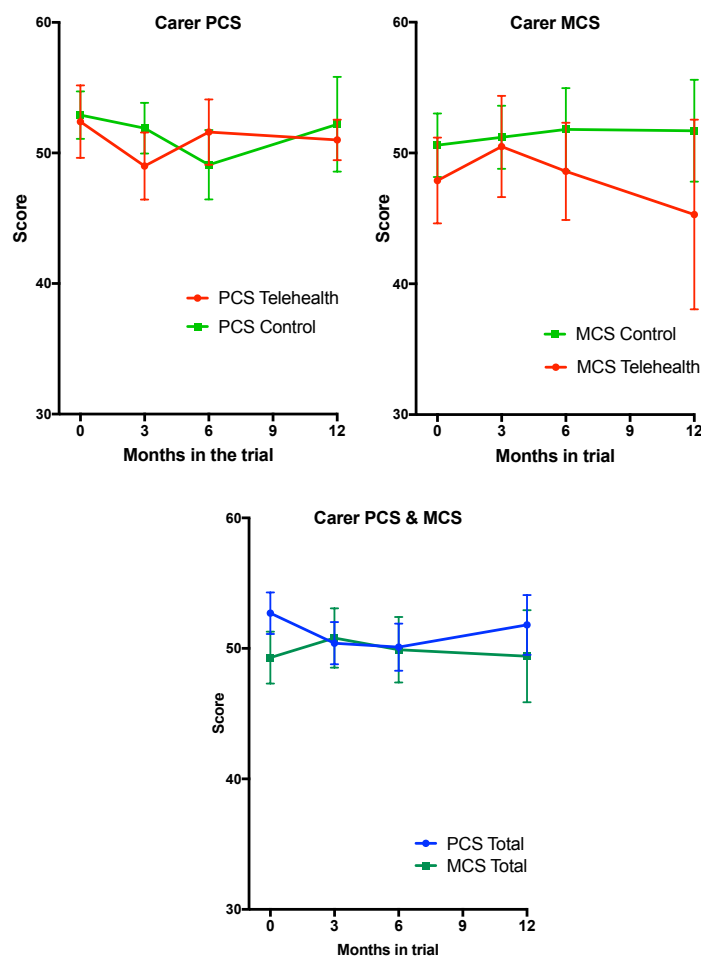
## 6.4 Carer outcomes

### 6.4.1 Carer quality of life

Figure 6.6 and Appendix B A6.10 reports the carer SF-36 scores. Physical and mental component scores were similar to population norms and were slightly better than a larger population of carers of those with MND (PCS TiM 52.7, SD 9.3 vs. ALS-HPS 46.5, SD 12.3, MCS TiM 49.3, SD 11.6 vs. ALS-HPS 41.5, no SD reported) (251).

The mean MCS remained stable through the trial but the PCS did show a trend to worsen but this change only reached significance in the control group at six months. The intervention group appeared to have slightly worse MCS at the start of the study than the control group. The intervention group MCS average deteriorated by, on average 2.9 points (95% CI -9.6, 3.8) whereas the control group scores improved by, on average, 2.4 points (95% CI -4.5, 9.3). However, the differences were small and confidence intervals wide so no firm conclusions should be drawn from these findings.

Figure 6.6 Mean SF-36 physical component scores (PCS) and mental component scores (MCS). Treatment groups are displayed separately (above) and together (Total, below).



### 6.4.2 Carer anxiety and depression

Tables 6.4 and 6.5 reports the carer HADS scores and Appendix B A6.5 compares carer baseline scores to those of patients and the UK population (258).

Average carer HADS depression scores were low and similar to both patients and the UK population (carer mean score 5.6 females, 3.8 males vs. population 4.1 females, 3.9 males) (See Table 5.14) (258). One carer (3%) had scores indicating mild symptoms and two carers (5%) had scores indicating moderate to severe symptoms. The incidence of higher scores was also similar to the general population.

Average patient HADS anxiety scores were low and also similar to the UK population and to patients (carer mean score 6.1 females, 5.6 males vs. population 6.3 females, 4.9 males). More carers had mild or severe symptoms of anxiety than depression: 9 (24%) had scores indicating mild symptoms and four (11%) had moderate to severe symptoms. However, these rates of higher anxiety scores were also similar to patients and the general population. As with patients, there are no large population studies of carer HADS score in MND with which to compare.

The average score remained similar throughout the trial. However, the number of carers with moderate/severe symptoms of anxiety increased (11% at baseline, 21% at 6 months and 31% at 12 months, highlighted in bold in Table). This trend was seen in both the telehealth and control groups.

### 6.4.3 Carer burden

Carer strain scores using the Zarit Burden Inventory (ZBI) are reported in Table 6.6. The mean baseline score was 12.3 (SD 8.8). Nine (27%) carers scored  $\geq 17$  at baseline indicating they were experiencing high burden. Average scores remained similar throughout the trial although there was a small, non-significant increase in the Telehealth scores at 12 months. Unlike the HADS anxiety scores, the number of carers reporting high burden scores remained similar throughout the trial: at twelve months four carers (33%) had scores  $\geq 17$ . The incident of high scores was lower than a larger sample of carers of those with MND (27% TiM vs. 48% population) (84) but these findings do show that high burden is a problem for many carers and requires attention.

Table 6.4 Carer HADS depression sub scores and the number (%) of patients with borderline scores or abnormal scores. Scores 0-7 are normal, 8-10 borderline/mild symptoms, 11-21 abnormal: moderate/severe).

	Baseline	3 months		6 months		12 months	
	Mean (SD)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)
<b>Telehealth Depression</b>							
Mean	n=16	n=14	n=13	n=15	n=14	n=6	n=6
(SD/CI)	4.0 (3.2)	4.6 (4.1)	0.1 (-1.0, 1.2)	4.3 (3.9)	0.1 (-0.9, 1.0)	4.8 (3.5)	1.3 (-1.5, 4.1)
Score ≥8	1 (6%)	3 (21%)	-	3 (20%)	-	1 (14%)	-
Score >11	1 (6%)	1 (7%)	-	1 (7%)	-	0 (0%)	-
<b>Control Depression</b>							
Mean	n=18	n=14	n=14	n=11	n=11	n=7	n=7
(SD/CI)	3.3 (2.8)	4.8 (4.2)	1.4 (0.0, 2.8)	4.3 (4.5)	2.1 (0.4, 4.6)	3.4 (3.4)	1.3 (-0.8, 3.4)
Score ≥8	2 (11%)	3 (21%)	-	3 (27%)	-	1 (14%)	-
Score ≥11	1 (6%)	1 (7%)	-	1 (9%)	-	0 (0%)	-
<b>Total Depression</b>							
Mean	n=34	n=28	n=27	n=26	n=25	n=13	n=13
(SD/CI)	3.6 (3.0)	4.7 (4.0)	0.8 (-0.1, 1.7)	4.3 (4.0)	1.0 (-0.2, 2.1)	4.1 (3.4)	1.3 (-0.2, 2.7)
Score ≥8	2 (6%)	6 (21%)	-	6 (21%)	-	2 (15%)	-
Score ≥11	1 (3%)	2 (7%)	-	2 (7%)	-	0 (0%)	-

Table 6.5 Carer HADS anxiety sub scores and the number (%) of patients with borderline scores or abnormal scores. Scores 0-7 are normal, 8-10 borderline/mild symptoms, 11-21 abnormal: moderate/severe).

	Baseline	3 months			6 months			12 months	
	Mean (SD)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)
<b>Telehealth Anxiety</b>									
	n=16	n=14	n=13	n=15	n=14	n=6	n=6		
Mean	6.3	7.1	0.0	6.0	-0.8	7.3	0.3		
(SD/CI)	(4.6)	(4.6)	(-1.8, 1.7)	(5.1)	(-2.9, 1.3)	(5.0)	(-1.4, 1.9)		
Score ≥8	7 (44%)	3 (21%)	-	5 (33%)	-	3 (43%)	-		
Score ≥11	2 (13%)	1 (7%)	-	3 (20%)	-	3 (43%)	-		
<b>Control Anxiety</b>									
	n=18	n=14	n=14	n=11	n=11	n=7	n=7		
Mean	5.9	6.2	-0.2	6.4	0.3	5.6	-0.6		
(SD/CI)	(3.5)	(4.4)	(-1.8, 1.4)	(4.8)	(-2.1, 2.7)	(4.0)	(-1.6, 0.5)		
Score ≥8	6 (33%)	6 (43%)	-	4 (36%)	-	2 (29%)	-		
Score ≥11	2 (11%)	2 (14%)	-	3 (27%)	-	1 (14%)	-		
<b>Total Anxiety</b>									
	n=34	n=28	n=27	n=26	n=25	n=13	n=13		
Mean	6.1	7.1	-0.1	6.2	-0.3	6.4	-0.2		
(SD/CI)	(4.0)	(4.6)	(-1.2, 1.0)	(4.8)	(-1.8, 1.1)	(4.4)	(-1.4, 1.9)		
Score ≥8	13 (35%)	3 (11%)	-	9 (31%)	-	5 (38%)	-		
Score ≥11	4 (11%)	5 (18%)	-	6 (21%)	-	4 (31%)	-		

Table 6.6 The 12-item Zarit Burden Interview scores. Scores range from 0 (no burden) to 48 (severe burden). A cut-off of scores  $\geq 17$  suggests high burden (222).

	Base-line	3 months		6 months		12 months	
	Mean (SD)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)
<b>Telehealth</b>							
	n=18	n=14	n=14	n=15	n=15	n=6	n=6
Mean (SD/CI)	11.5 (9.9)	12.7 (11.2)	1.6 (-1.6, 4.8)	13.7 (10.7)	2.4 (-1.3, 6.1)	13.8 (12.6)	4.3 (-1.2, 9.9)
Score $\geq 17$	3 (19%)	4 (29%)		4 (27%)		2 (33%)	
<b>Control</b>							
	n=16	n=13	n=13	n=10	n=10	n=6	n=6
Mean (SD/CI)	12.9 (7.9)	15.9 (8.9)	3.0 (-0.6, 6.6)	12.4 (9.5)	2.6 (-0.5, 5.7)	13.5 (9.6)	-0.3 (-7.9, 6.2)
Score $\geq 17$	6 (33%)	4 (31%)	-	2 (20%)		2 (33%)	
<b>Total</b>							
	n=34	n=27	n=27	n=25	n=25	n=12	n=12
Mean (SD/CI)	12.3 (8.8)	14.2 (10.1)	2.6 (0.0-4.5)	13.2 (9.0)	2.5 (0.1, 4.8)	13.7 (10.7)	1.8 (-2.3, 5.8)
Score $\geq 17$	9 (27%)	8 (30%)		6 (24%)		4 (33%)	



## 6.5 Adverse events

Adverse events were all expected complications of MND, e.g. pneumonia, gastrostomy site infection (Appendix B A6.11). No adverse events were reported to be caused by telehealth but four adverse events were reported to be connected to telehealth. TiM had identified two problems recorded as adverse events: acid reflux causing swallowing difficulties and excessive carer strain. On two occasions the TiM alerted the Telehealth Nurse to worsening dysphagia and weight loss that prompted staff to discuss gastrostomy with the patients. In both cases the patient went on to have a gastrostomy inserted and this was reported as an adverse event. More adverse events were recorded in the telehealth arm. It is likely that this was due to reporting bias because these patients had more contact with the study team. A true comparison of adverse event rates would have required regular research visits to capture every event. It would be feasible to arrange regular (e.g. three monthly visits) but the TiM provides weekly contact. It would be both unfeasible and far different from usual care to offer this level of contact. Therefore, observing more adverse events in the intervention group would be an inevitable and acceptable price to pay when evaluating a monitoring system.

Participants reported that the TiM did not appear to change their behaviour when unwell (something which Chapter Two suggested could be a problem with telehealth). Patients did not delay seeking help and felt able to initiate contact if they had a problem with which they thought the Telehealth Nurse could help. Chapter Five reports that on a number of occasions, participants encounter acute problems that the patient or carer thought they had recorded on the TiM, such as chest infections and falls. On many of those occasions the patient/carers had not been contacted by the Telehealth Nurse. However, the interviews and adverse event log identified no situations where participants suffered any adverse events as a result of the Telehealth Nurse not making contact.

## 6.6 Health resource use

### 6.6.1 Health encounters.

Figure 6.7 summarises the mean number of encounters with healthcare professionals per patient in the three months prior to starting the study. Figure 6.8 breaks this down with each individual health professional in the three months prior to the study. In total the average number of encounters was 9.1 in the three months with, on average, 2.2 encounters with a physician (usually a neurologist), 3.0 encounters with a nurse and 3.7 encounters with a therapist (such as a dietician, speech or physiotherapist). Encounters with a GP were uncommon (mean 0.7 in three months).

The mean number of encounters with healthcare professionals in both treatment groups increased during the study but the number of encounters reported by individual patients was extremely variable: a quarter of patients reported less than four encounters whilst one patient had 30 encounters over the previous three months. Later in the study one patient recorded 121 encounters in three months. Most encounters were the specialists in neurology/palliative care who

were either part of the MND MDT or related therapists (see Appendix B A6.12-A6.16 for additional data). However, many patients were not sure of the background of all the professionals they met and it was not possible to determine whether some (particularly therapists) were part of the specialist MDT or from a non-specialist background.

Figure 6.7 The number of patient-reported MND related healthcare encounters in the three months prior to the study (baseline) and during the study (mean and range).

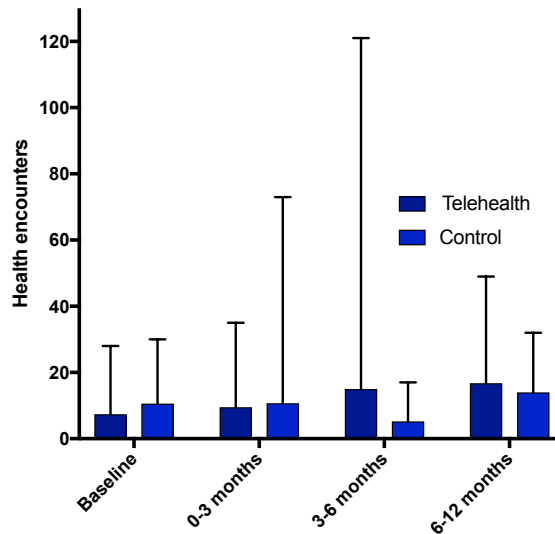
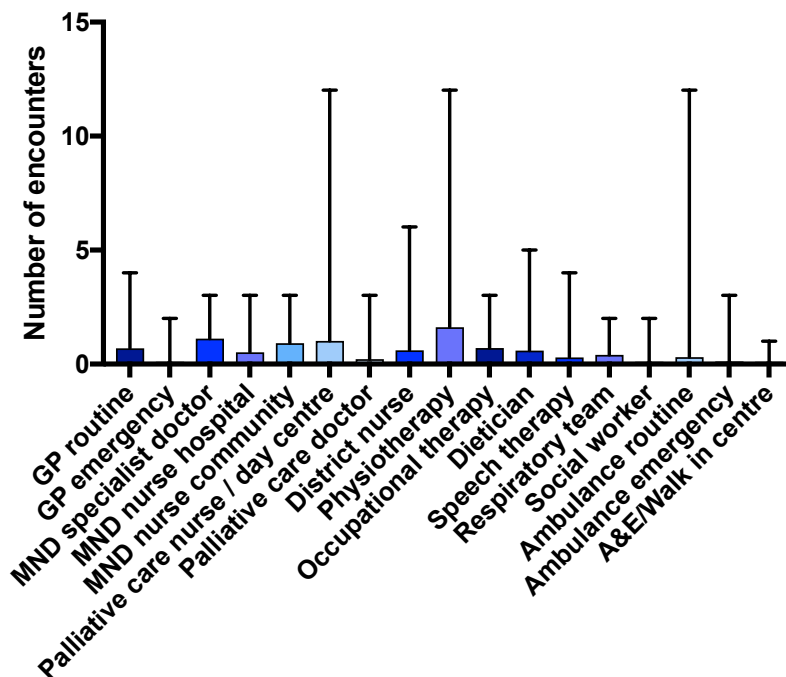


Figure 6.8 Patient encounters with healthcare professionals due to MND in the three months prior to the study commencement (mean and range, n=38).



### 6.6.2 Hospital admissions

In the three months prior to the study starting, patients reported a total of ten hospital admissions (34 overnight stays) (Appendix B A6.16). Five emergency hospital admissions were reported (27 days, 0.52 admissions per patient, per year).

During the trial, admission rates were low: nine MND-related admissions were reported (64 nights in total were recorded not including one hospice admission for which the duration of stay was not collected) (Appendix B A6.16). No patients required admission to high dependency unit or intensive care. The most common reason for admission was for gastrostomy insertion. MND related emergency admissions were uncommon: four emergency admissions due to MND occurred during the trial (23 days). The number of admissions was too small to make a meaningful comparing between the two treatment groups.

### 6.6.3 Personal care requirements

Figures 6.9 and 6.10 display the informal (unpaid) and formal (paid) carer hour requirements estimated by patients per week (Appendix B A6.17). Both formal and informal carer requirements were extremely variable. Formal carer hours ranged from 0 to 168 hours per week with most patients still not requiring formal care at 12 months. Individual patients did report a significant increase in formal care early during the study, these were mostly in the telehealth group. The results from this small number of patients meant the means are skewed with the mean formal care hours in the telehealth group increasing much more than the control group whereas the median carer hours remained less than five hours throughout in both arms.

Informal carer hours also ranged from 0 to 168. The median number of hours of informal care received at baseline was 14.5 hours. A group of patients reported they received more than 160 hours per week of informal care throughout the study whilst a number also reported fewer than five hours per week. The median number of carer hours received did not show a particular trend in either group, in fact, in the Telehealth group it reduced over time. Again, the small number of patients reporting over 160 hours of care per week means the means are skewed and this large variability makes drawing any conclusions from the results impossible.

Figure 6.9 Mean patient estimated hours of informal (unpaid) and formal (paid) care received per week and the interquartile range.

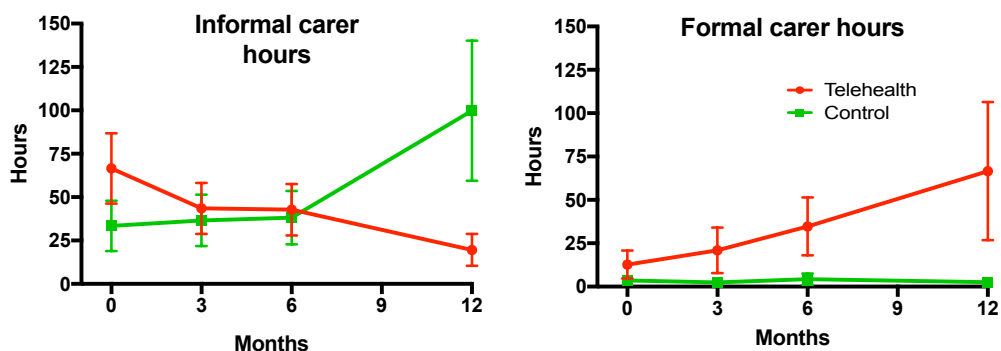
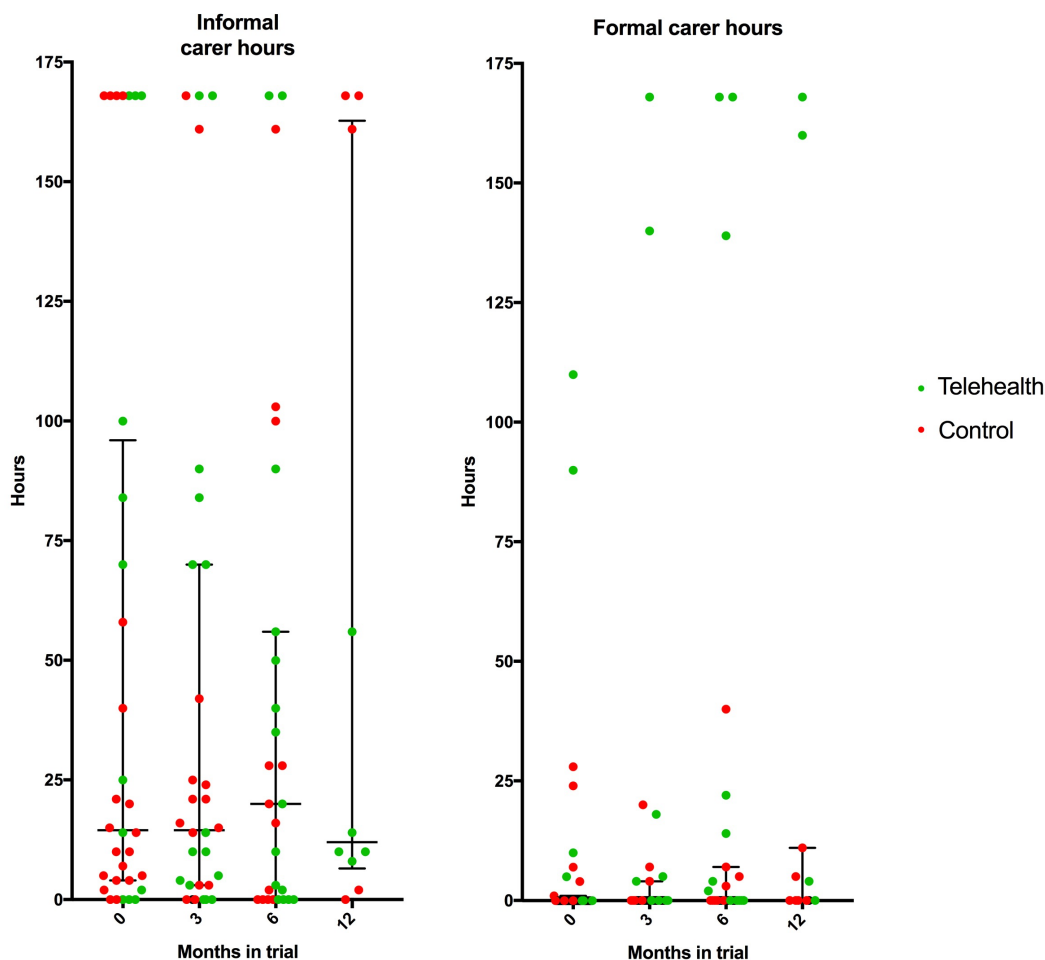


Figure 6.10 Individual patient estimated median hours of informal (unpaid) and formal (paid) care received per week and the interquartile range.



## 6.7 Summary of outcomes

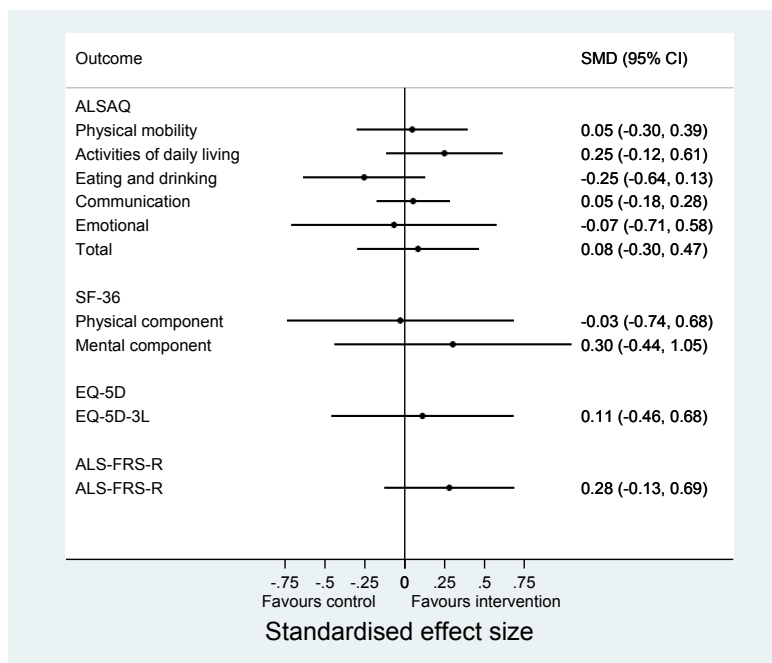
In summary, where it was possible to compare, participants in this study appear to have better outcomes at baseline and during the study than those in the general MND population. During the trial, some outcome measures appeared to be sensitive to change, detecting deterioration in participants' condition as they progressed. These tended to be the outcome measures recording physical wellbeing, health encounters in patients and the incidence of severe anxiety in carers. In most cases, these changes from baseline did not reach significance but the sample sizes were too small to draw firm conclusions. In contrast, emotional QoL scores in both patients and carers were comparable with the general population and remained stable throughout the trial.

For most measures, there were no clear differences between the two arms in any measure but the sample size was too small to draw firm conclusions. The estimated treatment effects at six months (n=28) were calculated for the most likely outcome measures thought to reflect the impact of the TiM: QoL (ALSAQ40, SF-36), the EQ5D and ALSFRS. To aid comparability, the differences are reported using the standardised effect sizes at six months (the point at which

most patients had completed outcome measures). The standardized effect size is defined as the difference between the treatment groups as a ratio of the baseline standard deviation. These were calculated by the trial statistician, based on a regression model in which the estimated difference is TiM-control (the coefficient for treatment effect from the model) (Figure 6.11 and Appendix B A6.18). Whilst the confidence intervals are wide, the standardised effect sizes do favour the intervention in most cases, suggesting a larger trial might reveal some significant treatment benefit. In this trial, estimated standardised effect sizes of around 0.2-0.3 were observed in many of the outcome measures. These results should be interpreted with extreme caution, given the aim of this study was not to detect a difference in effect. However, it does support the results from the qualitative data that suggest that the TiM might be of benefit in some ways, to some patients, but that the current impact is not sizeable. What this graph may also suggest is that, whilst the sample sizes are small, there was no evidence from either the quantitative or qualitative data that TiM led to worse outcomes.

Given MDT care is known to improve survival, this would be another potential outcome measure. Dates of death were also collected and participant status checked at the end of the trial. There were 10 deaths (25%, six intervention group, four control group) but comparing Kaplan-Meier survival curves did not add any additional information (Appendix B A6.19).

Figure 6.11 The estimated treatment effect for the quality of life and health utility measures and ALS-FRS-R.



## 6.8 Evaluating the feasibility of the study

This section examines whether the results of this study suggest that a larger TIM trial would be feasible by examining, recruitment, retention, data collection and acceptability and perceived sensitivity of the outcome measures.

### 6.8.1.1 Study retention and outcome measure collection

Table 6.7 summarises the number of participants in the study at each time-point and the number of participants who completed the follow-up questionnaires. Appendix B A6.20 and A6.21 report the results in detail. Return and completion of the follow-up questionnaires was excellent: 80% of eligible patients and 82% of carers returning questionnaires at 6 months. Compliance fell at 12 months but remained high at 71% (patients) and 67% (carers).

No participant sought help from the independent research nurse when completing the questionnaires and, as shown in Table 6.8, the majority of the questionnaires were sufficiently complete to analyse. It was possible to analyse all the ALSAQ-40 answers whereas SF-36 was incomplete in 2% of questionnaires. The most common questions left incomplete were those that asked patients how many hours per week of informal and formal care they received. 9% of these questions were left blank, several stated “24x7” (which was imputed at 168 hours per week). The interviews (reported below) suggested these were left blank because patients thought it was difficult to quantify the amount of additional time their carer spent helping them. Section 6.9.1.3 describes possible reasons for these observations and may explain why, when these questions were analysed the results differed much more greatly between patients than expected.

Table 6.7 Patient and carer compliance with questionnaires.

	<b>Base- line</b>	<b>3 months</b>	<b>6 months</b>	<b>12 months</b>	<b>18 months</b>
<b>Total patients</b>					
Patients available for follow up	n=40	n=39	n=35	n=17	n=2
<b>% Eligible questionnaires completed</b>	<b>98%</b>	<b>87%</b>	<b>80%</b>	<b>71%</b>	<b>50%</b>
<b>Total carers</b>					
Carers available for follow-up	n=37	n=35	n=33	n=18	n=2
<b>% Eligible questionnaires completed</b>	<b>97%</b>	<b>80%</b>	<b>82%</b>	<b>67%</b>	<b>50%</b>

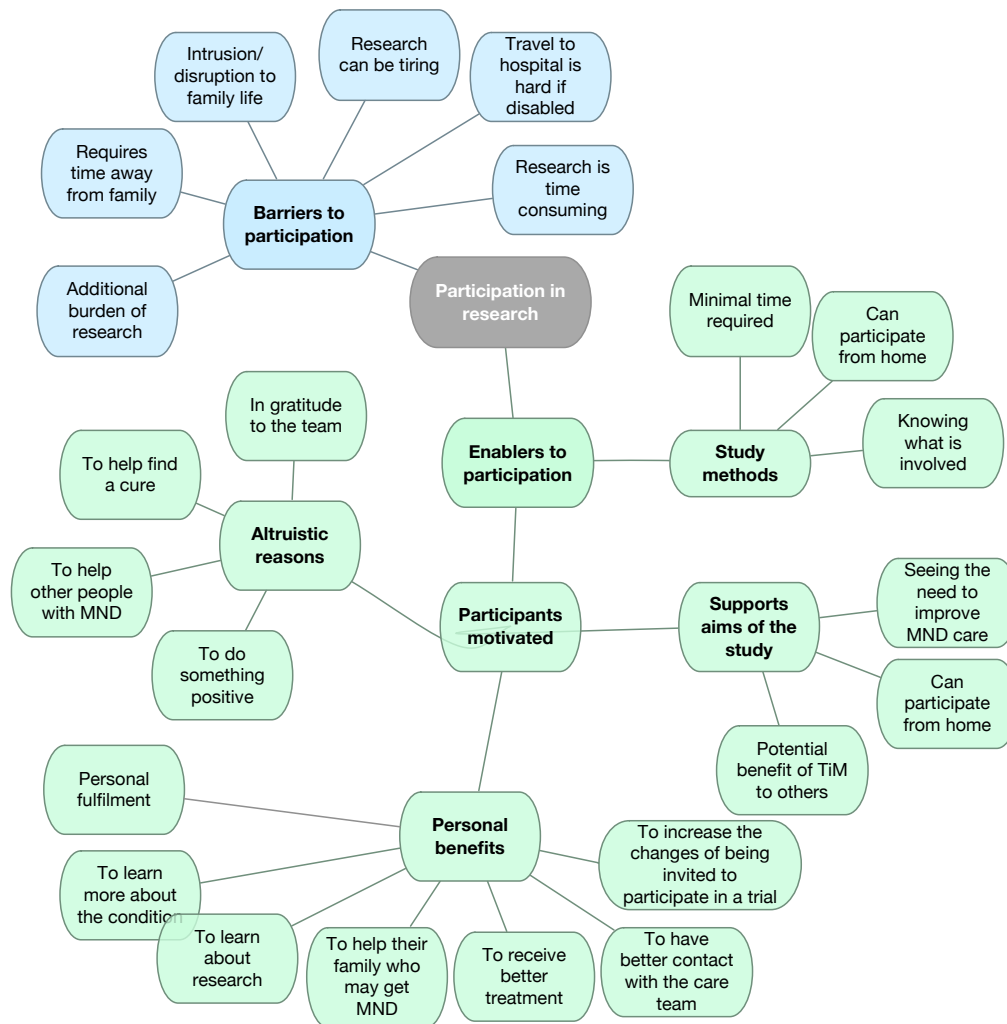
Table 6.8 The number of questionnaires returned by participants which could not be analysed because they were either blank, or had insufficient data from which to calculate a score/total (where possible standard imputations were performed for SF-36, ALSAQ-40 and HADS to account for missing data).

<b>Patient questionnaire</b>	<b>% incomplete questionnaires</b>	<b>Carer questionnaire</b>	<b>% incomplete questionnaires</b>
ALS-FRS-R	0%	SF-36	2%
SF-36	2%	HADS	0%
ALSAQ-40	0%	ZBI	0%
EQ-5D	1%	Carer satisfaction	0%
HADS	0%		
CSS-MND	0%	TiM satisfaction	0%
Pain scores	0%		
Health encounters	1%		
Hospital admissions	1%		
Formal and informal carer needs	9%		
Patient satisfaction	0%		
TiM satisfaction	0%		

### 6.8.1.2 Barriers and enablers to participation in research

As mentioned earlier, nearly half of all patients invited to participate expressed an interest in being involved in this study and all of those who were eligible went on to take part. Patients said they took part for two main reasons: because they liked the concept of the TiM system (this was described in Chapter Five) or because they wanted to take part in as much research as they could. During interviews, participants identified barriers and enablers to participating in the TiM research, these are shown in Figure 6.12 (additional quotes in Appendix B Q6.1-6.4).

Figure 6.12 Participants' motivations for participating in the TiM trial.



The main reasons why participants felt able to take part was because they were highly motivated to participate in any research but also because they study was low in burden (completed at home, minimal visits and a clear understanding of what would be expected of them). Participants also had a strong altruistic desire to be involved in research, to help others and in gratitude to the clinical team. They also thought that they might gain benefit from being involved in research: by learning more about research, MND and their own condition or prognosis, to improve their chances of taking part in a treatment trial and to have increased



contact with the MND team. Being part of something positive made patients feel they still had a valuable contribution to make, even when severely disabled:

*"I love being part of something worthwhile." P229*

Participants did identify some barriers to research (Figure 6.12) but the nature of the TiM study (low burden, outcomes collected at home) meant they found it easy to participate and taking part was worth the burden. Participants felt that they had been provided with sufficient information to take part. Some admitted that they had not read the information leaflet and most identified the recruitment visit as the main source of information about the trial. Whilst some participants expressed a preference for the intervention arm, they were happy to be randomised and those in the control arm were content with their allocation.

Most participants had some understanding of research, most having been involved in other research. Participants felt frustrated about the speed of research to find a treatment and felt time was running out for them to be cured. They all wanted to see treatments that had tangible benefits i.e. a reversal of their disability. Participants wanted to learn about research from various sources as this gave them hope although they recognised that some information could be unreliable and could be giving "false hope". A small number were willing to use unproven therapies or take part in trials even if they had to potential to harm them in return for an opportunity for a cure. They trusted the trials would be "safe" if it involved a doctor whom they trusted.

### **6.8.1.3 Participants' attitudes towards the outcome measures: acceptability and validity**

In interviews at baseline, participants in the control arm described their attitudes towards the self-administered questionnaires. Detailed themes and supportive quotes are displayed in Appendix B Tables Q6.5 and Q6.6. The most common themes were:

- The importance of assessing all aspects of life with MND;
- The questionnaires were acceptable;
- Most questionnaires provided an accurate, fair and thorough assessment of life with MND;
- Questions examining emotional health and strain were the best assessment of their experiences of MND;
- The SF-36 questions were too subjective and did not reflect the experiences of life with MND or as a carer;
- Estimating the number of hours of care patients receive is difficult.

Participants felt that the questionnaires provided a "fair assessment" of their experience living with MND and felt it was important for the questionnaires to cover all aspects of the disease including those that might be perceived as distressing e.g. breathlessness, dysphagia. They were already aware of the future problems they may face: this did not distress them.

*"To be quite frank, doctor, I wouldn't care a monkey's what you ask ...I have no hang-ups about any questions, however personal, the team think it's necessary to ask; I've seen it all, done it all and got the t-shirt." C229*

All participants felt that completing the questionnaires was an acceptable task and most were easy to complete accurately. They were content, as they knew the answers would be of benefit to the research and felt comfortable answering personal questions. Carers also thought it was important to ask them questions about their physical and mental wellbeing and burden of caring. They remarked that both carer and patient wellbeing did suffer when they experienced carer strain. Carers felt the questions examining their burden reflected the experiences of being a carer.

*"It was a strange one cos [the Zarit Burden Interview] was asking you what I feel about spending the time with him, that I don't have time for meself... Yeah, it is quite a thing cos you're always thinking... "Has he got enough drinks? ... then, anything to eat?"... I don't like to be too far away from him, even though I'm in the house ... in case summat happened and he needs me." C091*

The ALSAQ-40 was felt to be the most straightforward QoL questionnaire to complete. Patients found the questions detailed, relevant to their disabilities and easy to answer because the questions were clear and the multiple choice options used similar to the way patients described their difficulties (e.g. having walking difficulties "sometimes" or "often"). Participants found the SF-36 and the health utility measure EQ-5D difficult to complete. The language was felt to be too subjective, for example the generic term "health" used in the SF-36 and EQ-5D was confusing and meant it difficult to describe their own health state. Some felt they were entirely healthy and did not see MND to be a "health" problem and some carers did not feel they had any health problems. Others were not sure whether to take into account MND or age-related problems when answering the questions. SF-36 asked about the impact of their health on their "daily activities". As their lives had changed so significantly, both patients and carers found it difficult to assess the impact of MND. Most no longer worked and those with moderate or severe disabilities no longer completed many of the activities assessed in the SF-36 meaning the questions were insensitive to changes in their condition. Three patients (five questionnaires in total) left the EQ-5D mobility sub-question blank because the answers were too broad to capture their disease state. The patient explained:

*"Well I'm not confined to bed, so has it got to be I have some problems with walking about?" P137*

Patients found reporting the number of hours of care they received to be the most difficult to answer. This was the most common question left blank (9% of occasions, see Section 6.9.1.1). Couples explained that their roles had gradually changed as carers took over many of the domestic jobs that were usually shared making it difficult to quantify how much of their role was "caring" and how much was part of what they expected of a partnership. Some carers explained that even if they weren't directly providing care they always had to be alert to the needs of their loved one and so many patients wrote that they required care "all the time". The questionnaire did not capture patients who had multiple carers or where professional carers took over the role of an informal carer.

#### 6.8.1.4 Validity of the outcome measures

Participant interviews suggest that the questionnaires were easy to complete without guidance from the research team. There were no opportunities in the trial to verify the accuracy of the data collected in the self-reported questionnaires. However, the database did automatically identify responses that were outlying or unexpected. They were then verified using the original participant questionnaires. There appeared to be no particular individual or questionnaire that provided unexpected answers. Examination of the individual ALS-FRS-R scores did identify six patients whose functional scores improved by three points or more between baseline and three months. Three of these patients continued to report this sustained function at six months. It is not clear why this occurred. It is unusual for a patient's disease to spontaneously reverse but it has been observed in clinical trials (259,260). Patients reported day-to-day variations in their function but it is also possible for treatment to improve function (for example, using medication that treats excessive secretions or therapy which improves mobility). It is also possible that the way patients answered the baseline questionnaires could have been influenced by the investigator or the trial procedures. It would therefore be advisable to ensure that the method of completion remained consistent throughout the trial.

The only outcome where there appeared to a clear difference between controls and the telehealth group was the number of informal and formal hours of care reported. The telehealth group reported an increase in the mean number of formal hours of care received whilst the control group reported an increase in informal hours of care. It has already been discussed that the individual results were so variable and skewed by a small number of participants reporting very high numbers of hours. The participants themselves also highlighted the difficulty reported these figures. Whilst these results were not known when the interviews were conducted, the interview data was reviewed to consider whether these results are important. Participants interviewed did identify a potential link between formal and informal care: that formal carers took over duties from the main informal carer (although most carers who received additional support felt the difference this made to their own duties was marginal). An alternative explanation is that the TiM could bring about an increase in formal carer hours. It is possible that, by identifying problems earlier and initiating medical interventions (which require additional carer support) or encouraging carers under strain to accept additional help, the TiM could actually increase the number of formal care hours received. However, a direct link between the TiM and carer arrangements was not identified. These findings support the notion that future evaluation of the TiM should also use some formal measure of both carer strain and hours of care received. A better questionnaire might ask carers to record their details in more detail, quantifying hours where they provide direct care and hours carers have to be available for their loved one.

## 6.9 Discussion: study strengths and weaknesses

The TiM study design had many strengths and weakness. The main challenges and suggested solutions that were either used in this trial or could be adopted in future trials are described in Table 6.9.

Table 6.9: Challenges related to study methods encountered in the TiM trial and potential solutions.

<b>Challenges</b>	<b>Solution</b>
<b>Sample size</b>	
Improving patient response to invitation to participate in trials	Improve information in the patient invitation processes and patient information leaflets.
	Keep participant burden low and highlight the benefits and accessibility of trials to potential participants.
	Involve the control arm participants in qualitative aspects of the study to avoid resentful demoralisation.
Small pool of eligible patients	Keep a broad and pragmatic inclusion/exclusion criteria that reflects the research question.
	All participants use the intervention: use historical controls/before/after evaluations.
	National registries to allow mass screening and identification of potentially eligible patients in other centres.
<b>Collecting outcome measures</b>	
Compliance with questionnaires	Telephone contact to remind participants to complete the questionnaires.
	Provide low burden and alternative ways of participating e.g. telephone visits, postal, online questionnaires.
Participants inaccurately completing questionnaires	Schedule opportunities to help participants complete questionnaires early in the trial (e.g. at baseline visit).
	Provide participant information and training in accessible forms e.g. videos.
	Use alternative/additional methods of data collection e.g. interviews, observations.
	Use alternative ways to collect safety/adverse event data e.g. regular telephone calls/diaries/electronic records
<b>Assessing the impact of the TiM</b>	
Outcome measures not accurately assessing participant experience or impact of the TiM	Use measures that better reflect the likely mechanisms of TiM impact e.g. Generalised self-efficacy scale.
	Use disease specific and intervention specific questionnaires.
	Improve participant selection to recruit patients likely to benefit from improved MDT care (e.g. including those with more rapidly progressive MND).
Measuring impact of the TiM on service users	Measure impacts relevant to stakeholders e.g. self-efficacy, carer strain, emotional quality of life.
	Use mixed/qualitative methods at different stages of the process to capture the range of experiences.
Measuring the impact of TiM of staff and healthcare resources	Automated collection of staff time using the TiM system.
	Evaluate the TiM in centres that use billing or appointments software to collect healthcare resources use.

### 6.9.1 Strengths of the study design

This study achieved good levels of recruitment, retention and compliance. Figures are comparable with more intensive MND clinical trials (e.g. (56). It also enabled a wider range of patients than is usually seen in clinical trials of MND, including those with severe disability and longer disease duration. This meant the population was a better reflection of the patients attending a typical MND service. This was helped by the broad inclusion criteria, the low burden of the intervention and the study methods, which were developed consultation with patients ensured the study was acceptable. Having dedicated research staff embedded within the clinical team with time to support the participants during the study is also key to the success of telehealth trials (187).

Similarly to other studies in terminal diseases, patients in this trial were highly motivated to participate in research, not simply because of feelings of altruism and gratitude, but also because they believed they may also gain benefit from participation (261). It should be recognised that many patients want to participate in research and efforts should be made to reduce barriers to involvement, even for those patients who may be severely disabled or nearing the end of their lives.

As described in Chapters Two and Four, recruitment into telehealth trials is often limited by negative attitudes towards technology (234). This study did not appear to face this problem as patients participated who faced various barriers such as a lack of experience of technology or severe disability. Adopting a user-centred approach to the design of the TiM, introducing the TiM in a positive way and providing support and training to participants meant all participants who tried the TiM system, were willing to participate in the study and most would use the system again. Furthermore, the study interviews (described in Chapter Five) provided an opportunity to capture participants' experiences of the study and the TiM meaning the intervention and the trial procedures could be adapted to further improve the way in which participants were recruited.

Future studies could build on the success and lessons from this study: publicising the trial and adapting the trial literature to highlight the acceptability of the TiM may increase uptake. Many participants felt that face-to-meetings delivered more useful information than information leaflets. Alternative ways of delivering the key messages in research (such as how the TiM works and its ease of use) could be used. These might include pictures, videos, cartoons or patient stories. Postal invitations were used in this study to reduce the burden on clinic but an additional face-to-face invite by staff that are confident using the equipment and feel invested in the TiM service may also address these barriers.

### 6.9.2 Limitations of the study design

Table 6.11 describes some of the challenges identified in this trial that would be faced in a larger evaluation of the TiM and some of the ways in which these could be addressed. This pilot study did not aim to detect differences between the two treatment groups and the sample size was too small to make it likely that a meaningful difference between groups would be statistically significant. The

observed magnitude of differences between the two groups is small, more specifically; the point estimates of the differences between the groups were at best modest. This could be due to one or a number of potential factors:

- The study methods:
  - The sample size was too small to estimate changes in participants' outcomes with sufficient accuracy;
  - The outcome measures were not sensitive enough to capture the impact of MND, or of the TiM on participants.
- The TiM system:
  - The TiM system did not make a meaningful impact on participant care or wellbeing;
  - The TiM did not have a demonstrable impact on the specific patients who participated in the study;
  - The TiM system was not used to its full potential.

Chapter Five described reasons why the TiM system may be ineffective or was not used to its full potential. It also described the characteristics and experiences of participants who may not benefit from MND care or who already receive good care. This chapter explores the other explanations for this lack of observed difference and the implications they have for future evaluations.

### **6.9.3 Capturing the effectiveness of the TiM in a trial**

One of the aims of the study was to better understand which outcome measures would be most suitable to use in a future trial and the sample size this would require. This last section of Chapter Six discusses which outcome measures, sample size and MND population would be best likely to capture the impact of the TiM in a definitive study and whether a trial using these recommendations could be feasible.

#### **6.9.3.1 Selecting the best patient outcome measures**

Whilst this thesis has argued that using traditional RCT methods to evaluate complex interventions like telehealth has many flaws, it will still be important to capture the important impacts of the TiM in order to determine whether it should be implemented and commissioned. Whilst it appears that the TiM system is likely to be safe, it would also need to be seen to deliver either an improvement or reduce any deterioration associated with progression of the disease or provide a service at the same standard but with reduced cost. Ideally, This will require the use of outcome measures that are sufficiently sensitive to the consequences of MND upon which the TiM is thought to impact.

As one of the main goals of MDT care (and therefore the TiM) is to improve or sustain QoL, this was felt to be an appropriate primary outcome measure. The trial explored which QoL outcome measure would best capture the impact of the TiM in this population. Participants felt that the ALSAQ-40 was a better tool to capture their experiences living with MND, compared to the SF-36. In this small trial, the ALSAQ-40 did capture deterioration in some aspects of QoL at both six and 12 months. It is suggested that a deterioration of six points over three months is a meaningful change (262) and changes in scores at 12 months ranged from eight to 16 which suggests it did capture meaningful change. The modeled

standardised effect sizes (described earlier in Section 6.8, Figure 6.10) suggest that TiM may have some impact on ALSAQ-40 physical domains. These observations suggest that the ALSAQ-40 is both an acceptable and sensitive measure that could be used to capture meaningful change in this population in a future trial. Whilst SF-36 was felt to be less reflective of patients' experiences of life with MND, the physical component score also detected a change during the trial and Figure 6.10 also suggested there might be a treatment effect associated with the TiM. The SF-36, along with the EQ-5D, also offer valuable ways of comparing interventions in different disease and could be used as secondary outcome measures and would provide important evidence if the TiM was considered for commissioning.

Given MDT care is also associated with improved survival, it may be expected that, by increasing access to the MDT, the TiM system would also be associated with better survival. Therefore, survival this should also be measured as the TiM system, by increasing access to MDT care may also improve survival. However, given 75% of participants in this trial were alive at 12 months and the average patient survives two to four years, detecting a survival gain would require follow-up far greater than 12-18 months. Extending the trial follow-up would not only make the trial less feasible to conduct, as discussed in Chapter Two, lengthy trials are likely to be hindered by changes in technology and the services in which they are embedded. Therefore survival would also be most useful as a secondary outcome measure.

The TiM would also require an assessment of cost-effectiveness and the impact on factors such as hospital admission and health resource use. Funders of future research and eventually commissioning bodies would expect an assessment of cost-effectiveness in order to make funding decisions. Whilst the focus should be on the clinical outcomes that can be more reliably estimated, an assessment of cost-effectiveness should still be planned and should take into account the challenges encountered in this trial. The problems encountered in this trial were also seen in the studies reported in Chapter Two and are faced by many trials of complex interventions. Emergency hospital admission rates were low in all participants in the trial meaning a large sample size would be required to determine whether TiM made a meaningful difference. In addition, any savings brought about by telehealth can be dwarfed by any difference in very costly hospital admission which may be entirely unrelated to TiM (81). The number of health encounters varied very widely between patients and may not necessarily bear any relation to the quality of care received or the patient wellbeing or quality of life. It is uncertain whether a higher number of encounters indicates a patient with a great morbidity or conversely may reflect better access to local services. Improving access to specialist care may increase the number of health encounters due to the identification of patients' unmet needs. This may be beneficial to the patient but may be associated with more cost and increasing staff requirements. Alternatively, earlier access to specialist services may result in earlier treatment, fewer non-specialist encounters and avoidance of costly emergency admissions. Despite these problems, this study demonstrates that collecting health resource use is not infeasible. Health encounters can be easily collected using self-reported questionnaires. Planning research contacts with



the patient during the trial along with the use of electronic records will data collection more systematic reliable.

#### **6.9.3.2 Selecting the best carer outcome measures**

Any future trials of the TiM system involving carers should adopt different outcome measures to evaluate the impact on this population. Carers highlighted many problems with the SF-36 and the scores did not differ from the general population norms, nor do they change as the patient progresses. Carers felt the Zarit Burden Index better reflected their experiences but this also did not change during the study. This could also be because carers adapt to their experiences. It is also possible that carer strain is influenced by the increasing support provided by healthcare professionals or formal carers as patients deteriorated. However, a third of carers had high Zarit Burden Index scores and the incidence of severe HADS anxiety scores increased during the study. This may indicate carers who, faced with sustained and increasing demands, may not have the coping support mechanisms required to adapt to their experiences. If the TiM could be used to identify carers in difficulty and provide ways to improve their coping strategies it could reduce or avoid an increase in carer strain compared to controls and therefore these outcome measures appear to be the most promising.

#### **6.9.3.3 Potential alternative outcome measures**

One limitation of examining participants' response to the questionnaires using interviews is that, whilst participants reported that questionnaires examining their emotional quality of life better reflected their experience of living with MND, this study, along with others, found that patient and carer emotional quality of life scores do not change as the condition progresses (224, 244). It has been suggested that this is because patients continuously change and adapt to their current situation (263) and this was reflected in the TiM interviews with patients explaining that their priorities changed as their activities become more limited but they still gained fulfillment from family relationships and lives as carers and partners. One patient explained:

*"You do adapt because you have to, but your world gets so much smaller." (P166)*

Alternatively, the experience of MND progression is described as a series of losses that were often associated with complex feelings of frustration, guilt and failure. (31). These reactions may make it difficult to quantify the impact of the disease on their QoL. These limitations suggest that whilst QoL outcome measures are acceptable, they may not be sensitive to the impact of the TiM and alternative outcome measures, which encompass the holistic aims of MDT, should be explored. A number of participants felt that outcome measures should capture more positive aspects of their day-to-day lives and how they cope and remain resilient. As described in Chapter Five, the TiM has the potential to improve users' self-efficacy, which is an important influence on QoL. As the relationship between self-efficacy and QoL has only recently been implicated in MND, measures of self-efficacy were not captured in this study and are rarely used in RCTs. Future studies of the TiM should examine patient behaviour more carefully and more objective such as the Generalised Self Efficacy Scale could be employed (264). However, even if this better reflects the impact of the TiM, a trial demonstrating improvements in self-efficacy alone is unlikely to be as



persuasive as one using commonly used outcome measures such as survival and QoL. Therefore, it is recommended that both self-efficacy and quality of life should be adopted as the most important outcome measures explored in any future trials.

In summary, these findings suggest that, of the outcome measures used in this study, the ALSAQ-40 would be most likely to capture a meaningful impact of the TiM in a definitive trial. Other measures, such as survival, SF-36, disability (such as ALS-FRS-R), and health resource use remain important measures to assess could be useful secondary outcome measures along with carer QoL. Non-clinical measures that better reflect the mechanisms of TiM such as self-efficacy should also be included. However, even with the ideal outcome measures, an RCT will be very challenging for the reasons described above and would not on its own allow future development of the TiM system. Therefore, for the next stage of development, alternative ways of evaluating the TiM should be explored; these are discussed in Chapter Eight (Section 8.4).

#### *6.9.3.4 Patient selection: capturing the impact of TiM in different patient populations*

Chapter Five described two different mechanisms whereby the TiM may bring about change. These impacts may be of a different magnitude in different participants. The TiM could improve care-coordination, provide education and reassurance and improve self-efficacy. The interviews suggest that patients at all stages of the disease may benefit from increasing knowledge of their condition but those with slowly progressive or mild disease, or early after diagnosis may gain most from this approach. The TiM could also improve the identification and treatment of complications of MND and potentially prevent hospital admissions. These problems tend to occur later in the disease when patients are more disabled. If a definitive RCT were to be conducted, evaluations could potentially use two trials, with two populations (for example, early/mild MND and later/more severe disease). Different primary endpoints that are thought to be most sensitive to changes in that subgroup could be used. This would require twice the sample size. Alternatively, one trial could use a composite endpoint that aims to capture the outcomes in both groups and could also capture a measure of carer outcome. This does have drawbacks: firstly it may be difficult to interpret the meaning of a composite measure. Secondly this measure is likely to be less sensitive than a single outcome and would therefore need a greater sample size, though perhaps not as much as if two trials were conducted.

This study also highlights the problem with having a broad patient inclusion criteria. Patients whose disease was mild or slowly progressive did not feel the TiM made an impact on their care because they did not encounter many of these problems. These patients could be excluded from future trials and this may increase the likelihood of observing a positive impact of the TiM. However, further narrowing the inclusion criteria would make it more difficult to recruit sufficient patients and excluding a considerable number of the MND population attending clinic may make the results less generalisable.

Another reason why the TiM may not have appeared to have a positive impact on this particular group of patients is because participants in the TiM study may already be experiencing good care and/or better outcomes than other patients. A number of the outcome measures recorded in this study indicated that TiM participants at baseline have better outcomes than other patients with MND. Participants in this trial had, on average a longer disease course, slower progression, fewer hospital admissions, better QoL and lower carer strain (91). It seems unlikely that the positive outcomes were due to the research processes alone because baseline data was already better than in other MND studies. Trials are likely to have a tendency to select participants who will experience more favourable outcomes: patients that volunteer for research may be better able to access specialist services or may be those with better psychological wellbeing, or already experiencing less family strain. It is also possible that the MDT care provided in Sheffield is already of a high standard. Caution is advised when comparing current outcomes to historical data, as MND care has improved over the last decade (265). However, these observations should not be a reason not to continue to develop the TiM. In fact, these differences between outcomes for TiM patients and others with MND highlight the need to ensure that all patients have access to good MDT care and this study demonstrates that even those patients and carers who attend a specialist centre experience variations in outcomes and have many unmet needs, many of which could be addressed by better access to MDT care.

#### **6.9.3.5 Sample size**

A definitive study requires an adequate sample size to make the chances of detecting a significant change in outcomes likely. Potential patient primary outcomes that encompass the holistic nature of MDT care that were explored in this trial were: quality of life; survival; and disease progression (using the ALS-FRS-R).

In order to estimate the total sample size required for a definitive study, the following assumptions were made:

- Significance testing would adopt a 90% power and 5% significance level;
- Follow up should last for 12 months which would be long enough to allow sufficient time for the TiM to have an impact but short enough to retain sufficient patients in the study. Two approaches to calculating the endpoint could then be adopted:
  - a) A single time-point at 12 months;
  - b) A longitudinal composite of end points at four follow-up time periods (for example, 3,6,9 and 12 months);
- A trial completion rate of 70% at 12 months (75% of the patients in this trial were alive at 12 months);
- A likely effect size of 0.3-0.4 standard deviations.

When determining whether an intervention has made a clinically significant difference, the standardised effect sizes (in which the difference is given in terms of standard deviation units) can be used to determine the strength of any

difference between the two treatment groups. In general, an observed treatment difference of 0.2 standard deviations is felt to be small but not trivial, with a difference of 0.5 medium and 0.8 large (266). More specifically in MND, a difference of 0.12-0.26 standard deviations in the ALSAQ-40 represented small but clinically meaningful differences in quality of life in MND (these were the average difference in ALSAQ-40 sub-domain scores observed in patients who reported that they were “slightly worse” in follow-up) (254). In addition, ALSAQ-40 scores in patients who reported that they were “much worse” differed by 0.3-0.45. Whilst the TiM system is not a disease modifying therapy (meaning the TiM is unlikely to have a very large effect on outcome) the interview data and the standardised effect sizes calculated using the modeled trial data (see Section 6.8) suggest it might have a modest effect. Whilst the system is likely to be safe and not associated with high costs, it would be unlikely that the TiM system would be commissioned if a study demonstrated that the TiM system offered only a very small benefit. Therefore, calculating the sample size based on expectation that the TiM should have a modest effect sizes (defined as a difference in standard deviations of 0.3-0.4 (standard deviations)) would be realistic.

These assumptions would suggest that, for a single time-point, with 30% dropout, a total sample size of between 377 and 669 patients would be required (Table 6.10). For a longitudinal end-point this reduces to between 143 and 251 (i.e. 71-126 patients per arm). It seems reasonable to use a longitudinal measure given the aim of MND care is to improve the patients’ lives throughout their disease, not simply to impact upon a single point in time.

Table 6.10 The calculated total sample sizes for the two approaches to calculating the endpoint at different effect sizes. These were calculated by the trial statistician and based on the parameters stated above.

	Single time point		Longitudinal <sup>10</sup>	
	Unadjusted	+30% drop-out	Unadjusted	+30% drop-out
<b>Effect size</b>				
0.2 SD	n=1052	n=1503	n=396	n=566
0.3 SD	n= 468	n= 669	n=176	n=251
0.4 SD	n= 264	n= 377	n=100	n=143
0.5 SD	n= 170	n= 243	n=64	n=91

A target sample size of 250 is realistic but not without challenge. Sheffield MND clinic being one of the largest in the UK, and even using very broad inclusion criteria, as described in Section 6.2, 68% of patients recorded on the clinical database were ineligible to participate in the TiM study. Of the 30% of patients identified in Sheffield that appeared eligible, 55% did not reply to the study invitation. This suggests a best-case scenario with between 10 and 20% of patients at any other MND care centre would be eligible and willing to participate in a future trial of the TiM. For a sample size of 250 this would therefore require the involvement of MND care centres with a total caseload of

<sup>10</sup> Assuming one baseline and four follow-ups with a common correlation of 0.5.

between 1250 and 2000 patients, involving between one quarter and half of all centres caring for patients with MND in the UK. A multi-centre study that addressed some of the barriers to recruitment identified in this trial (see Table 6.16) could improve the number of patients recruited but other factors, such as participant burden are unlikely to be improved given the study was already designed to be low in burden for patients and staff. Competing trials in different centres may also limit recruitment but links between UK MND care centres through networks such as the NIHR Dementias and Neurodegeneration (DeNDRoN) Specialty mean multi-centred trials already receive excellent support and this could enable even small centres to participate.

Problems with recruitment are not unique to MND: one review suggests that less than 31% of trials managed to meet recruitment targets and half required an extension (267). Whilst this study faced some problems with recruitment, it has also developed better understanding of the barriers and facilitators of recruitment and retention. This should improve future trials of telehealth and other complex interventions in MND. Other developments such as the new UK-wide MND registry (268) (which allows patients to register themselves for trials and provide clinical details) may also help and could even allow patients to pre-screen themselves and take part in trials even when they cannot attend a research centre.

## 6.10 Conclusion

This chapter identifies several strengths in this pragmatic, low burden clinical trial which enabled successful recruitment, retention and collection of outcome measure in a patient population who are a good representative those attending an MND clinic. It has also identified some problems that suggest that the next stage of the TiM should not involve a definitive RCT because this would be an inappropriate approach. Whilst there may have been some trends towards a treatment benefit, a lack of a clinically notable differences between the trial arms and the clear need for future cycles of development indicates that further improvements are required prior to any comparative trial.

Should an RCT be undertaken, there are some uncertainties about whether it would be possible to recruit an adequate sample size, to capture the relevant impacts of the TiM and determine the clinical effectiveness and cost-effectiveness of the TiM using the current outcome measures in the typical population attending an MND clinic. Furthermore, conducting an RCT in TiM in multiple centres would make it challenging to do this when working within the various different MDTs in the UK that will have different expectations of the TiM and would be likely to want to use it in different ways. Chapter Eight discusses alternative ways in which the TiM could be evaluated in the future.

Chapter Seven explores whether using technology within an MND service is likely to be acceptable to the wider patient population outside this small trial. Finally, Chapter Eight discusses what conclusions can be drawn from this study, the lessons learnt and recommendations for the further of the development, evaluation and implementation of the TiM.

## Chapter Seven

### Exploring the use of digital technology by people living with motor neurone disease

#### 7.1 Introduction

This chapter describes work conducted and published during the PhD to capture the views of a the broader population of people living with MND than just those in the TiM trial, and explore some of the barriers and incentives to successful use of telehealth and technology (49).

This work was conducted together with an MSc student Saima Fazal (SF). The project was conceived and designed by Esther Hobson (EH). EH trained and supervised SF who collected the questionnaire data, gained consent and conducted the interviews with participants. Analysis was conducted by EH and SF. SF prepared the initial results and report to submit for a master's degree in clinical neurology. Following this EH re-analysed the data and prepared a manuscript for publication.

#### 7.2 Background

As described in Chapter Two, the use of digital technology devices is now a prominent part of normal life and healthcare. As described in Chapter One, specialist assistive equipment also offers ways to overcome disability caused by MND. However, there has been limited evidence to help understand whether digital technology will be acceptable or accessible to people with MND and their carers. This warranted further exploration. The TiM trial provided an opportunity to explore the use of the TiM system in “real-life”. However, the patients who put themselves forward to participate in the TiM trial are unlikely to be representative of all the attitudes or experiences of all those who attend the MND clinic. For example, the TiM trial may have excluded participants who were not confident to volunteer for a study involving technology with which they were unfamiliar. This study was developed to explore the use of, and attitudes towards digital technology in a wider group of patients, their family members and friends.

## 7.3 Methods

A detailed description of the methods and link to the online supplementary data are available in the published paper (Appendix E).

Attitudes towards digital technology were examined focusing attention on:

- Everyday digital technologies (such as the internet, laptops and tablet computers);
- Everyday technologies that had been adapted for disabilities (such as communication software applications on tablet computers);
- Digital “assistive technologies”, i.e. those designed specifically for people with disabilities (such as environmental controls and switches).

A postal and an online questionnaire were used and, to explore the subject in more depth, semi-structured qualitative interviews were conducted. The research questions, questionnaires and interview topic guide were developed following a literature review and consultations with clinicians and the Sheffield Motor Neurone Disorders Research Advisory Group who reviewed the questionnaire and suggested improvements.

### 7.3.1 Questionnaire

Patients with motor neurone disease (pwMND) who were cared for by the Sheffield MND clinic in June 2015 were identified using the ARC clinical database. Patients and an informal carer, friend or family member (fMND) were also invited to complete a questionnaire. Others pwMND, their friends and family members to complete an online GoogleDocs questionnaire advertised using social media and the Motor Neurone Disease Association UK research newsletter.

### 7.3.2 Interviews

Convenience sampling was used. Patients with any type of motor neurone disease and their accompanying carer who were attending their routine MND clinic appointment were invited to participate in semi-structured interviews. Patients were excluded if they could not give consent, were too unwell to spend extra time in clinic, or who had been interviewed in the TiM study.

Interviews were recorded and transcribed verbatim and data was organised using NVivo (269). Thematic analysis was used to interpret the data (232). Transcripts were read independently by SF and EH to familiarise themselves with the data and generate initial codes. Codes and themes were reviewed and refined together. The interviews were completed before the results of the questionnaire were available. However, following initial analysis, a process of methods triangulation compared the data sets to determine whether the findings from each data set were consistent (269). Where important themes, similarities and differences were identified, the datasets was reviewed looking for explanation for these findings. Results were then discussed with the wider

research team and the qualitative data was reviewed, codes were further refined and EH recoded each interview and prepared the final manuscript.

Ethical approval was gained for the postal questionnaire and interviews (NRES Committee North West-Preston). Written or witnessed consent was obtained. Ethical approval was not required for the anonymous online questionnaire but participants were directed to a website containing a participant information sheet and were required to confirm their understanding and willingness to participate.

## **7.4 Results**

### **7.4.1 Questionnaire participants**

126 patients were invited. 49 patients (39% response rate) completed the patient postal questionnaire (Table 7.1) and 37 completed the friend/family postal questionnaire (Table 7.2). 28 of the participants were also participating in the TiM study. 36 patients and 19 family member/friends completed the online questionnaire. It was not possible to calculate a response rate for the online questionnaire.

One patient questionnaire was excluded because no written consent was returned. One online response was excluded because it was impossible to determine whether the patient had also completed a postal questionnaire. All friend and family member responses were combined and are referred to as "fMND".

### **7.4.2 Interview participants**

Eight patients were approached for interviews. Two patients rescheduled their appointments and could not be interviewed. Five patients, all female, and five carers (all family members) were interviewed in six interviews, ranging from 16 to 37 minutes (Participants are described in detail in Appendix E). One patient declined but his son was interviewed. Two patients had dysarthria and their carer helped them to communicate. One patient used communication aids but chose not to use them during the interview. One couple was participating in the TiM trial. They were in the control group and had not been interviewed during that study.

*Table 7.1 and Table 7.2 removed for copyright reasons*

The main themes identified were: the value of technology to enable patients to continue with normal life; the role of the internet in providing information; the barriers to using technology; and the role of technology in MND care.

#### **7.4.3 Technology enabling a normal life**

Most patients (82%) and fMND (87%) surveyed used at least one digital device every day. Participants used a range of technologies and adaptations (reported in Appendix E). iPads and laptops were the most frequently used everyday devices (Figure 7.2). Use of the internet, particularly for leisure, was also common (Figure 7.3). Those interviewed were very positive about using everyday technology because they found technology enabled them to continue to lead as normal a life as possible.

*“Anything that makes life’s journey, when necessary, better: she will accept it.” Husband 6*

Participants interviewed also valued technologies with which they were already familiar, could be used for multiple purposes (including leisure and assistance), and were easy to use. Internet services were described as particularly useful when MND made daily activities difficult. For example, for a patient with poor

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<sup>12</sup> \*Calculated using a 3x2 contingency table using Chi-squared comparing the types of fMND in the online and postal questionnaire



mobility, the ability to shop online independently was a “*life saver*”, (Son 3). Another found that email had helped avoid the social isolation associated with speech and language problems (Patient 6).

Figure 7.2  
Frequency of use  
of everyday  
technology by  
patients  
(pwMND) (postal  
and online  
questionnaire  
combined).<sup>13</sup>

*Figure 7.2 removed for copyright reasons*

Figure 7.3 Uses  
of the internet by  
patients and  
fMND

*t reasons*

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#### 7.4.4 Using the internet to access information and support

All those completing the online questionnaire and 60% of fMND in the postal questionnaire used the internet to seek information about MND. Fewer patients in the postal questionnaire sought information this way (40%). The most commonly visited website was the Motor Neurone Disease Association (UK) website and many revisited the site (Figure 7.4). Even in the postal questionnaire, 78% of patients had visited the site. Participants wanted to know more about all aspects of the disease (Figure 7.5). Most preferred information to be available on websites, with written information, videos or information via email also being popular (Figure 7.6). However, books and written leaflets were also popular particularly amongst fMND and low users of technology.

Of the patients who could remember, 79% thought that at diagnosis, their MND care team had recommended looking on the internet although of these, only 30% had been recommended a specific site. 21% recalled being advised not to look on the internet. The internet also provided a way of receiving support from other people living with MND: 77% of patients in the online questionnaire used the internet to talk to others with the condition although only 14% of those in the postal questionnaire did. fMND used this less commonly (online 42% and postal 11%).

Figure 7.4 Frequency of visits to MND related websites by patients and fMND.<sup>14</sup>

*Figure 7.4 removed for copyright reasons*

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Figure 7.5 pwMND's and fMND's preferred topics of information about MND<sup>6</sup>.

*Figure 7.5 removed for copyright reasons*

Figure 7.6 pwMND's and fMND's preferred methods of receiving information about MND<sup>15</sup>.

*Figure 7.6 removed for copyright reasons*

Interview participants described turning to the internet to learn how to cope with their condition and how to be prepared for the future. Researching alternative treatments offered hope and the feeling that they were doing something themselves to fight the disease.

*"I would suggest that the family go on the internet and study the illness themselves. So that they can learn of how this disease works, how it affects, because they need to be prepared. The family needs to prepare themselves so that they can be strong for the MND sufferer." Patient 1*

Interview participants found the practical and emotional support available on the forums even more valuable because of the experiences they shared with fellow "comrades" living with the disease.

*"The internet is a wonderful thing. I use it stay in touch with my fellow MND sufferers as we do support each other when one of us is feeling very scared. We'll all gather on the internet and just try and be a support, reassure them they'll get through this; we're all*

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*here for them. I'm learning so much more about the illness through other sufferers."*  
Patient 1

Not all experiences of the internet were positive, particularly around the time of diagnosis when participants naturally turned to the internet to seek information about the disease.

*"It's natural, isn't it? There's something you don't know, you go online now don't you?"*  
Husband 2

Most had little knowledge of MND and, following the shock of the diagnosis, most of what participants could recall was negative: for example, the terminal nature of the disease, the lack of treatment and poor prognosis. Information on the internet reinforced these ideas.

*"It was a shock, to be told you was going to die and especially, not having any awareness of the disease. ... I was just told to go home, get my affairs in order, tell the family. That was it really."* Patient 2

*"If you just Google 'MND'... you get all the gory bits first"* Husband 2

Many felt the information on the internet was unreliable or confusing and some stopped looking. Like those surveyed, most preferred to use official sites such as the Motor Neurone Disease Association explaining that they thought these sites were more reliable.

*"There's as much misinformation as good information but you don't know which"*  
Husband 4

Two patients did not go online at all, explaining that they were fearful of facing the future and preferred instead to approach problems as they encountered them.

*"I will never go online because I'm the kind of person that deals better with what I don't know-I can't worry about. I'm not going to change anything by reading all the bad things about it. I know what's going to happen. I'll deal with it when it comes."* Patient 2

Participants preferred to receive information from a professional because the information was felt to be more reliable, specific to their circumstances and was delivered with the correct detail and pace.

*"Online has its place, but it all needs to be talked about."* Husband 2

Whilst patients could access reliable information from their health professionals, wider family members relied on the internet for information. This could be helpful when they wished to learn more about the disease than the patients. However, this could also cause tension, with three participants describing difficulties when their extended families had developed overly negative impressions of MND following research on the internet.

*"My son went on the internet and frightened himself with the information that was on there. He thought I was immediately going to die"* Patient 3

#### 7.4.5 Barriers to using technology

Figure 7.7 describes the barriers identified in this study. Common themes were: barriers due to disability, the devices themselves and users' negative attitudes towards technology. Lack of experience or confidence using devices was a common barrier to using technology. The postal questionnaire identified 12 low users of technology: nine (19%) patients and three (9%) fMND used it less than once a month. They were older than the other participants (median 74.5 years,  $p < 0.0001$ ). Reasons given for not using technology were: having no need (four), not knowing how to use it (four), poor hand function (three), fear of breaking it (one), and having a bad experience of computers (one). However, nine of the twelve thought that they could use digital technology if they had the appropriate equipment and training. They all preferred to receive written information about MND, although some thought email (four) and books (three) would be helpful with none wishing to access information using the internet.

Figure 7.7 Barriers to technology use identified in this study <sup>16</sup>.

*Figure 7.7 removed for copyright reasons*

Three carers interviewed described their loved ones as not being “*technology people*” thinking that they lacked an innate ability to use devices. They thought they lacked confidence in problem solving and would rely on family members

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for help. One son thought his father was not interested in using technology because he had always been too busy to use it. Difficulties with cognition and language caused further problems that severely restricted one patient's use of technology (Patient 6): reading and concentration were difficult and she was unable to learn to use new devices such as a new mobile phone. Patient 6 found text-to-speech software too slow, instead relying on basic drawing software.

*"When [she] writes, even in there [note pad], it missed words out. The brain is working but the brain isn't actually interpreting it to say 'speak it properly' or even 'write it properly'. She knows what she wants to say and she knows what she wants to do, it doesn't always come in the right order." Husband 6*

Husband 6 was concerned what would happen if his wife could not use technology. She relied on it to avoid the social isolation associated with speech and language difficulties and they were unaware of any suitable alternatives.

Arm weakness was a common problem, but many patients adapted everyday technologies to overcome this with a preference expressed for devices that were light and not bulky. 33 (40%) of patients surveyed purchased additional equipment, mostly everyday technologies such as tablets and computers, but six patients had purchased specialist voice recognition or eye gaze software (Figure 1). Cost and lack of awareness was particularly a barrier to accessing unfamiliar or specialist technology. Four couples felt they did not know enough about available specialist assistive technology and wanted more guidance from experts. Two patients wished that they had accessed specialist technology earlier in the disease in order to make the most of its benefits. Some experienced delays in receiving equipment or training and in one case, by the time equipment was available, the disease had progressed making the technology unusable.

*"We should have known six months ago" Husband 2*

*"...when I could still talk properly" Patient 2 [referring to voice banking]*

Whilst technology was often recommended by health professionals and the MND Association, many learnt about adaptive and assistive technologies through word of mouth, internet research, the media or through personal recommendations on internet forums.

Everyday digital technologies, particularly those that patients were already using before the diagnosis, were perceived to be part of normal life. However, patients recognised that there would inevitably be a time when they would need to depend on more specialist assistive technology. There was more resistance to using this type of technology, even when they thought it would be valuable. Some patients had delayed thinking about, or accessing more specialist technology until they felt "ready" or until they really needed it. The need to rely on technology represented a significant milestone in the disease and fighting to remain independent helped maintain a positive outlook.

*"It takes about a year to persuade her to have them, and then when she has them then she really likes [it]... Once she stops going up and down the stairs, that's like a battle lost...."*  
Son 3

#### 7.4.6 Using technology to access MND care

Only a minority of patients surveyed already used the telephone (27%) and email (17%) to communicate with their specialist care team. Using everyday technology to communicate with the MND team was generally acceptable, particularly using email and the telephone (Figure 7.8). In the 12 low users of technology in the postal questionnaire, six supported telephone contact with their care team (answering "Yes" or "Maybe"). There was less support for using other technology, only one thinking email/computer contact was acceptable. There was less support for using technology as an alternative to clinic. In the low users of technology, five thought the telephone was, or "maybe" acceptable but only two supported email and one, video contact.

Figure 7.8  
Acceptability of  
using technology  
to communicate  
with their MND  
team and as an  
alternative to MND  
clinic  
appointments  
(online and postal  
survey results are  
combined)<sup>17</sup>.

*Figure 7.8 removed for copyright reasons*

All the patients interviewed had telephoned the MND specialist nurse at some time and one had used email. All reported positive experiences and thought technology could speed up communication. Whilst no patients had used telephone or video conferencing as an alternative to hospital appointments, one thought it could be useful as she became more unwell, as did a number of those who completed the questionnaire. Questionnaire participants were concerned about data security and the potential for loss of face-to-face contact if appointments were replaced.

*"I would rather speak to people in person not machine" fMND postal survey*

The other concern raised was that communication with the MND team could be difficult using technology and that patients who are unable to speak or type quickly may be excluded from the consultation.

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## 7.5 Discussion

This study supports the findings in Chapter Five that suggests that pwMND have a positive attitude toward technology. The increasing availability of everyday technology that is familiar, accessible and affordable enables patients to continue to participate in many aspects of normal life. There are many adaptable solutions that can help solve some of the different and changing problems posed by MND. However, mirroring a survey of pwMND living in Australia, there remains a need for greater awareness amongst clinicians and those living with MND about technology (50). Despite this, number of patients who had access to up-to-date digital devices that could access TiM is reassuring. This suggests that it would be feasible for most patients to use their own device, with which they are familiar, something the TiM participants suggested in interviews. Even most of those who did not use technology seemed happy to learn, reflecting the findings in the TiM trial.

In addition to the findings in the TiM trial, participants in study identified other barriers to telehealth such as accessibility, ease of use and concerns about security. Even high-tech solutions may not meet patients' expectations (270,271). Reassuringly, in the TiM trial, these barriers did not seem to impact on uptake of the TiM where these barriers were overcome by careful device design and face-to-face training and support. This study suggests that reducing costs, improving awareness amongst patients and clinicians of solutions that meet their changing disabilities will be important when using new technology. Finally, whilst the use of assistive technologies represents a milestone in the disease, introducing new solutions sensitively, with hope and optimism (whilst managing expectations where technology is imperfect) could overcome some of the negative perceptions of technology use.

Participants in this study also describe a need for information about MND that can, in some circumstances be met by using the internet, as long as they still have access to reliable information from their MND team. Given the importance of internet information, advising patients to avoid the internet may be counter productive (272). These studies have identified challenges not unique to MND. Information available on the internet is important to the wider public, but information from health professionals remains more valued (273,274). Clinicians should signpost patients to reliable sources of information and help patients interpret their findings. In this study participants, tended to prefer information available on websites, in written and video form meaning informative websites such as MyNIV (129) are valuable resources. It also suggests that telehealth can play a role in providing trusted and reliable, "bite-sized" amounts of information and signposting, that is relevant to the problems experienced by the patient.

There was not universal support for telehealth amongst this population but most comments suggested that participants supported the concept of technology-enabled care to improve access to the MDT, particularly as an addition to face-to-face care. The acceptability of telehealth as an alternative to clinic may depend on individual preferences and circumstances and how much



patients feel able to engage in communication through technology. Difficulties with cognition and language were also raised in this study and they pose more challenging barriers to patients and to the success of telehealth. If these barriers are not overcome, patients risk losing access to medical services that would actually further increase inequalities. It is likely that some people living with MND will remain unable or unwilling to use technology. As digital technology is becoming an increasing part of healthcare delivery, care should be taken to ensure that these patients continue to have their needs met in alternative ways; however, they should be given the option to try technology and be offered additional support and assistive devices.

### **7.5.1 Limitations**

This study involves a small sample from one care centre supplemented by a small number of online responses. There was some overlap with the participants in the TiM study. As such, the findings may not be representative of the wider MND population. There may be an over representation of the views of younger people living with MND and those who already use technology. Given the median disease duration was 41 months, our results may not reflect those with more rapidly progressive disease who may have different technology and information needs. Similar to the TiM study, spouses were the most common carers but the online questionnaire managed to capture the views of friends and wider family members using the online survey. Along with the TiM interviews, these results suggest that the wider family often have different attitudes towards the diagnosis and their access to reliable information. They also appear to have an influence on and enable patients to use technology. Their attitudes warrant further investigation. Participants identified the hospital MND centre as a major source of information. The experiences of those who attend a different MND service may be different and warrant consideration if telehealth is to be adopted in other service models.

Despite these limitations, the results are consistent with those in a smaller survey of patients in Australia (50). Furthermore, a rich range of experiences and barriers to technology has been identified. Both high and low users of technology shared many of these experiences. The additional interviews identified more sensitive and potentially more challenging barriers specific to MND such as the fear of dependence on technology. Identifying the impact of language and cognitive impairment on technology use, which may affect their ability to engage with telehealth is particularly important.

### **7.6 Conclusion**

These results support the findings of the TiM trial that suggest that the digital technologies such as the TiM are likely to be acceptable and accessible by the majority of people living with MND in the UK. There was support for some telehealth in MND care but, as already discussed in Chapter Five, it will be important to address the concerns and barriers identified and ensure that acceptability and use is monitored to ensure patients are not excluded from the services.

## Chapter Eight

### Discussion: The future of the TiM

#### 8.1 Introduction

This chapter summarises the results of the thesis and suggests what the future should hold for the TiM system. It discusses whether the results support the proposed need to improve access to specialist MDT care for people with MND and whether technology-enabled care could meet that need. It summarises the required improvements to the TiM system that have been identified. It explains whether a definitive RCT is feasible and whether it is most appropriate next step in the TiM project and makes recommendations for how future evaluations should be conducted. Finally, it describes the implications of the findings for other areas of MND research and more widely in technology-enabled care.

#### 8.2 The aims of the TiM project

The aims of this project were to develop and test a telehealth service that could improve access to specialist MND care for patients and their carers. It has argued that the complex and changing nature of MND means that specialist management from an MDT is currently the best way to care for those living with the condition. The evidence identified in the literature, along with the evidence from this project does support the need to improve access to specialist MND services. The results of this thesis also support the argument that carers of those with MND experience significant strain and require ways for their wellbeing to be monitored and promoted that fit in with their preferences and duties as a carer.

The thesis identified evidence that technology-enabled care can help patients with many diseases access clinicians. The literature suggests that telehealth appears particularly promising as it could enable additional monitoring and communication without the patient having to travel to appointments. Evidence from other research outlined in this thesis suggests that telehealth may be feasible as an addition or adjunct to in-person appointments and may be cost-effective if it reduces physician time and hospital attendance. Prior to this project commencing, it was established that no telehealth system designed to manage MND in a holistic manner had been developed or evaluated, nor was there evidence to determine how, or whether telehealth would be useful in these cases.

This study used some of the literature and previous experiences of using telehealth in chronic disease and MND to inform a user-centred design approach to develop the first version of the TiM system. Following this, user testing in “real life” as part of the TiM trial to make a wider assessment of patient and carer experiences has established that technology-enabled care

could be acceptable to patients and carers, as long as the services and technology are developed and adapted to meet their needs and preferences. The study found that the TiM system appears to be an acceptable way for patients to provide information about their condition and has the potential to be used to improve communication, education and support and provide an alternative or adjunct to routine hospital visits. If used to its full potential, the results suggest that the TiM system might be able to deliver better patient outcomes through mechanisms such as by ensuring monitoring and better access to the MDT and by promoting positive patient attitudes and behaviours such as self-efficacy.

### **8.3 Improvements to the TiM system and development of the TiM service**

This study identified a number of problems with the TiM system that impact on its effective use and acceptability. The main challenges in this study lay not with the technology, rather with the way in which it is used (particularly by the clinical team) and the way it would be integrated within the clinical service. This reflects the experiences from other telehealth trials outlined in Chapter Two, where new interventions that need to be integrated within existing services were met with many barriers. This study has identified a number of developments that will be key to overcoming these barriers. These are:

- Providing ways for patients, carers and the hospital and community health teams to interact better;
- Improving the clinical alert system to make the alerts more sensitive and specific to relevant problems;
- Improving the adaptability of the system and developing a framework within which different clinical teams can operate;
- Developing a TiM system that could be used on any device.

The results of this trial reflect the wider evidence which emphasises the importance of developing relationships and promoting interaction between staff and users, something that the current version of the TiM system does not do (176,275). Lack of interaction was not just due to the technology or the large number of alerts faced by the nurse but also due to difficulties establishing a relationship using digital technologies. One option would be to introduce other ways of communication such as messaging services or, for more complex consultations, phone calls or telemedicine. Chapter Seven suggested that these additional digital communications would be acceptable, particularly when patients were unable to attend clinic.

Telehealth and telemedicine (video consultations) appear complementary: collecting routine information about a patient at their own convenience, allowing the Telehealth Nurse to better triage patients and arrange more detailed consultations with patients at home that focussed on the patient's current needs. More recently, two small evaluations suggest that telemedicine could be a valuable adjunct to the MND service (276,277). Both services involved a nurse telephoning the patient before the clinic visits to gain

information, much of which could be collected using telehealth. Therefore it is recommended that the use of these two services together be explored.

This study found that that some aspects of MND care cannot be delivered remotely. The community team is important source of support to participants, arranging home adaptations and providing a lot of medical and psychosocial support, particularly near the end of life. However, clinicians and participants felt the hospital MDT still had a role to play, even near the end of life and the MND nurses felt that the links between the hospital and community enabled teams to share information, work together and promote good practice. The TiM system could enable information to be shared between teams and enable a smoother transition into the time when patients can no longer travel to appointment, a time that many patients in this study feared because they felt they would no longer be able to access the services they need. The way in which the teams work together using the TiM warrants further evaluation in different centres.

At the time of design of the TiM system, weight was the only useful objective measure of a patient's condition that could be collected remotely. The study found that weight was a valuable objective measure of a patient's condition and participants also valued monitoring their weight. In addition, both patients and clinicians also felt objective monitoring of respiratory function was important. Since the TiM system was developed, the Airsmart Spirometer has been launched. This can use a patient's smartphone to transmit measures of respiratory function to an online portal (278). It costs €69 which may be a reasonable price to allow patients to avoid attending hospital simply for this test. Other apps in the early stages of development can measure aspects of a patient's voice, breathing pattern and fine motor skills or can alert the physician to patients who are admitted to hospital but their feasibility and usefulness is yet to be determined (279). The Wi-Fi-enabled weight scales used in this trial also provided a measure of balance. The meaning and clinical value of the balance scores has yet to be explored but further analysis of the data collected along with validation of the weight in healthy volunteers and other patients is planned and this may be a useful tool in identifying mobility problems or risk of falls. The TiM system could use telemonitoring to measure blood oxygen and carbon dioxide to detect nocturnal respiratory insufficiency or monitor the use of non-invasive ventilation. Technology has advanced since the studies described in Chapter Two were commenced and a pilot trial of telemonitoring of NIV is already underway (159). Devices that record oxygen saturations are already available and the trials described in Chapter Two suggested this could be a feasible addition to the TiM. However, measuring arterial carbon dioxide is much more expensive and technically difficult with machines currently costing £9000 meaning at present, this facility is not feasible and needs further development (280).

Discussions with the TiM developers (Mylan, Carematix) have indicated that it would be possible to make the recommended improvements to the TiM system. It will be important to continue to use a user-centred, iterative approach to inform further developments. It is therefore recommended that after the simple

improvements recommended in this thesis have been completed, the next stage should involve testing, feedback and further redesign. It is planned to conduct this in a larger number of different MND centres. Any modification to the technology is associated with a cost so further iterations should be limited but there should be capacity for individual centres to modify the TiM system to meet their needs. Some adaptability will be built into the next version of the TiM system (for example, to modify the clinical algorithms or to integrate it into their own IT systems) and evaluations should determine whether this flexibility satisfies the requirements of different centres.

These next steps should also provide the opportunity for a framework to be developed to describe in broad terms ways in which the TiM could be used to its full potential and ensure that the service meets the expectations of users. The framework should outline the potential uses and benefits of the TiM and recommend ways in which staff could interact with patients and carers. It was clear from this trial that a framework that is too prescriptive would not be acceptable to clinical teams who like to use their own judgments when making decisions. Other telehealth studies have also highlight the risks associated with staff disenfranchisement should they feel their clinical practices are threatened or undermined (188,275). Therefore, rather than aim for a completely standardised approach to using the TiM system, a framework would allow flexibility to ensure can be integrated into the local service and remain acceptable to the clinical team. However, whilst teams may work in different ways, the introduction of evidence based clinical guidelines (e.g. NICE guidelines (39)) means that clinician teams will be taking a more consistent approach and broad framework can reflect this best practice.

#### **8.4 The future evaluation of the TiM system**

Whilst a randomised controlled trial was previously held to be the gold standard approach to demonstrate the clinical impact of an intervention, it is increasingly recognised that an RCT may not be the best approach to support the successful development and implementation of complex interventions such as the TiM system (281). This study demonstrated some of the limitations of an RCT: it allowed only limited development of the intervention during the trial and it would not be possible to carry out the further stages of development and testing recommended in this thesis within an definitive RCT. In addition the difficulties experienced in this study reflect the view of others that that an RCT would fail to clarify the complex clinical, professional and institutional factors that influence the success or failure of such a complex intervention (176,281). Therefore it should be concluded that, at this stage, a definitive RCT would not be recommended.

Instead of an RCT, it is recommended that the next steps should aim to develop the intervention further and explore how it may be integrated into different services. Initially, the basic changes recommended in Section 8.3 should be implemented before further testing in clinical practice occurs. Following this, a further, a more iterative process of evaluation and development should be adopted in order to understand of the processes involved in using the TiM in

real-life in different MND care centres and to evaluate any changes made to the system. Realist evaluation methods adopting mixed methods techniques that seek to better understand how the TiM works are likely to be better ways to meet these aims (179,180). They could be used to facilitate step-wise testing of different versions of the technology, gain feedback and test further improvements. Realist methods allow emerging theories to be tested. For example, if a particular pattern of adherence is identified, or a particular impact is observed in the context of particular subgroup of patients, the reasons of this could be explored in more depth with staff interviews (180). These methods are now more seen to be acceptable ways to produce rigorous evidence and are being adopted in the NHS (281). For example, the seven NHS England Test Bed projects are adopting these approaches to enable a more rapid and pragmatic evaluation techniques to develop and evaluate new digital interventions within clinical services (189).

It has been established in this study that patients, carers and staff can use the TiM technology and that the principle of telehealth is acceptable to most patients and carers. As discussed in Section 8.3, the main challenge for the TiM in the future (and therefore the main focus of the next stage in development) is to enable the TiM to be used to its full potential in each service by ensuring that clinicians are making use of the system, responding to alerts and interacting with participants. In addition, as already discussed earlier, staff acceptance is a key component to the success of telehealth and barriers to engagement remain. Technology-enabled care requires a fundamental shift in the way services are delivered and how clinical staff interact with patients therefore future development and evaluations must establish if and how clinical staff can adapt and use the telehealth to their satisfaction whilst continuing to deliver high quality service (176).

It is recommended that the next stages of the TiM should adopt a range of methods that reflect the complexity of the unanswered questions. More quantitative data should be collected to observe and understand the processes involved in TiM in more detail than was done in this trial. Intervention fidelity should be explored further than it was in this trial by determining whether and how the TiM was used and compare this to what is expected by observing aspects such as how staff adhere to the TiM framework and react to alerts. It should also explore more about the impacts that occur. This could be done better by capturing interactions between staff and users more closely by recording events and staff actions automatically on the TiM system and then exploring these specific events in more depth using qualitative methods. Comparing current practice to historical clinical practice (such as examining clinic visit frequency) will determine whether a service is likely to reduce overall healthcare costs or be feasible given the available resources. Proxy measures of quality such as adherence to clinical guidelines or frequency of contact with the MDT can be collected to determine whether a new service delivers the same standards of care as usual care.

In parallel, staff experiences and behaviours in different delivery settings should be explored using mainly qualitative methods (e.g. interviews, focus groups).

Theoretical frameworks such as the Normalization Process Theory could be applied to help understand how these changes occur and to promote future development of the service (282). This theory has been applied to process evaluations of other complex interventions in healthcare to study how and why some interventions but not others become embedded (normalised) in routine practice (283). Without the constraints of an RCT, continuous evaluation and reflection on ways in which individuals and teams respond and adapt to novel services can be used to determine if and how a successful service can become embedded into normal practice. This would be particularly important to understand how staff might react both as individuals, and as members of a team to using the TiM framework and how this could help deliver the important aspects of the MDT care service.

In summary, future evaluations of the TiM should examine its use in real-life, in larger numbers and in different centres. Complementary methodologies should be used in different centres to understand the various uncertainties highlighted in this study.

### **8.5 The feasibility of evaluating the TiM in a randomised controlled trial**

MND services and technology are changing and patients do not have time to wait for new developments to improve their lives. It is clear that the TiM system requires further developments, however, if the evaluations proposed in Section 8.4 indicate it to have good potential to improve care, there should be minimal delay between development and implementing the service more widely in clinical practice. In order for it to be implemented widely, the service would require commissioning for any additional technology and staff costs. Decision-makers do usually expect traditional evidence of a service's efficacy and cost-effectiveness in order to decide which interventions to fund with its limited resources. Despite the arguments outlined in this thesis, a future RCT should not be discounted as this type of evidence remains the most persuasive to support a service being approved and commissioned. This study demonstrates that a randomised controlled trial of telehealth in MND could be conducted: that is, it could recruit, retain and collect data from participants attending an MND care centre. A large sample size would be required but the numbers would not be infeasible as long as the study remained low in burden for participants and MND centres. A composite endpoint measure, using the most relevant outcome measures (such as ALSAQ-40, SF-36 and/or survival) taking into consideration the treatment group differences over a number of time points would provide a more sensitive estimate of the impact of the TiM.

However, as exemplified by the Whole System Demonstrator, an RCT faces major challenges and is at high risk of failing to demonstrate the relevant impacts of the TiM. In addition, lengthy trials will not allow the technology keep up with the rapid changes in technology or health services outlined in the 2014 NHS Five Year Forward vision. Therefore, it should be concluded that an RCT is not the correct way to produce the rigorous evidence required to further the implementation of the TiM in the NHS. The methods described in Section 8.3 will be far better placed to do this. In addition, if the TiM system does indeed



produce positive impacts for patients and carers, the proposed next stages of evaluation should demonstrate to local teams that it is something worth commissioning. These local “champions” who witness the successes of new services can deliver persuasive arguments to support commissioning of services (189). Finally, weight of support from patients and carers who also support the need improve the care of those living with MND along with positive narratives of those who have used the TiM would only help local champions strengthen the argument for adoption of the TiM system into their MND service (203).

## 8.6 Implications for future research

This study shows the value of iterative, user-centred design and focus on end-users prior to and during evaluations of telehealth in order to ensure interventions are acceptable and feasible. It also highlights the benefit of process evaluations in “*real-life*” settings prior to comparative trials in order to understand the users’ needs, expectations and goals as well as the mechanisms of change brought about by the telehealth which may need to be measured in future trials. Much of the telehealth literature examines the technology and participant experiences. There is less focus on staff and service factors and it is recommended that this be the focus of future research.

This study also has implications of other trials of interventions in MND, many of which have faced challenges that have affected their success. The recommendations contained in the MRC framework for developing and evaluating complex interventions and conducting process evaluations are relevant to many other clinical trials. The importance of careful planning and piloting of the trial design can overcome problems with recruitment, retention and outcome measure collection. Ensuring a good understanding of how interventions should be used, tested and delivered is also vital. These considerations should be made long before a definitive trial commences.

## 8.7 Conclusions

This study has demonstrated that the TiM system is an acceptable method of facilitating access to MND services and, if improvements are made, could improve the care of patients and carers with MND. Further improvements to the TiM are required and an iterative approach to development should be adopted use methodologies better able to capture the complexities of the intervention. A randomised controlled trial could be used to compare the TiM to usual care but it is unlikely to be successful in understanding all the important aspects of the TiM system. Instead, the alternative methods described in this chapter may be better placed to provide more rigorous evidence of the TiM’s impact on clinical care and cost-effectiveness and enable it to be integrated successfully within the specialist MND care service



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## Appendix A: Supporting data for Chapter 5

- A5.1 The benefits of the MND hospital multidisciplinary team.
- A5.2 The psychological benefits of the hospital MDT.
- A5.3 Reasons why participants felt the clinic was not always beneficial.
- A5.4 The problems associated with the organization of the hospital clinic.
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- A5.7 Psychological care provided by the community team.
- A5.8 The care coordination provided by the community team.
- A5.9 Participants experiences with lack of care coordination in community MDT.
- A5.10 Participants' experienced problems with community MDT due to lack of expert staff.
- A5.11 The participants' positive experiences of general practice.
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- A5.14 The information needs of those with MND.
- A5.15 Sources of information about MND.
- A5.16 Participants' experiences of information about MND available on the internet.
- A5.17 Participants attitudes towards the frequency of TiM sessions.
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- A5.19 Participants' initial impressions of using the TiM app.
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- A5.21 Negative attitudes to technology expressed by participants.
- A5.22 Facilitators for TiM use.
- A5.23 Participants' expectations of the potential communication and monitoring benefits of the TiM service.
- A5.24 Participants' expectations of the potential benefits of the TiM service.
- A5.25 The acceptability of the TiM questions.
- A5.26 The validity / accuracy of the TiM questions.
- A5.27 Participants understanding of the TiM service.
- A5.28 Nurses' experience of using the TiM clinical portal.
- A5.29 The accuracy and sensitive of the TiM information
- A5.30 Participants' experiences of how the TiM impacted on their care.
- A5.31 The Telehealth Nurse's attitudes towards the value of the TiM.
- A5.32 Participants attitudes towards clinician feedback.
- A5.33 The mismatch between the participants' and nurses' expectations of the TiM service.
- A5.34 The problems associated with excessive TiM alerts.
- A5.35 The problems associated with excessive TiM alerts.
- A5.36 Participants' attitudes towards the future of the TiM.
- A5.37 The Telehealth Nurse's attitudes towards how the TiM might be used in the future.
- A5.38 How the TiM might be used by other teams.

Table 5.1 Patient and carer preferred frequency of TiM use.

Table 5.2 Patient satisfaction with Tim system at 3 and 12 months.

Table 5.3 Carer satisfaction with Tim system at 3 and 12 months.

A5.1 The benefits of the MND hospital multidisciplinary team.

<b>Care coordination</b>	
Coordinates care	<i>"If there's any problems [MND centre's input has] been more global, rather than equipment and stuff that's wanted here." P248</i>
Referrals to specialists	<i>"...people just came out of the woodwork when I was first diagnosed." P134</i>
MDT actively manage condition	<i>"Sheffield seems to be showing a lot of interest, which is reassuring. I know when we go and see [local neurologist], there's not much she can do, to be fair. We go and she says how are you and we say, all right and we have a bit of a chat and off we go and that's it. You sort of expect a physician to heal you." C172</i>
<b>Sheffield MND helpline</b>	
Nurse first point of contact for many	<i>"Q: And if you had a problem and you thought it might be something to do with your MND what, who would you, how, what would be your sort of method of contacting or finding out about it? P: I'd always phone [MND nurse]. Q: And, and how do you find it when you, you do phone? P: Excellent. C: Yeah, she sorted the first initial things out...she made the contacts P: Well if I have a problem with the drugs I'm currently on; so I phoned [MND nurse] and she answered me there... So I think that, to me, is the best route." P&amp;C381</i>
Nurse is familiar	<i>"I know all... you over there are pretty good, every time I phone [MND nurse] up ...if I've left her a message she's usually back to me as soon as she can. So yeah, my first call... if I thought it were MND related then ring Sheffield and [MND nurse], which is reassuring." P145</i>
Nurse approachable	<i>"Q: If you did have a problem, how would you go about sorting it? P: I think I'd ring [MND nurse]. Q: You'd ring [MND nurse]? What's your experience of ringing [her]? P: Oh, I love her! Q: What is it you find helpful? P: Friendly and helpful. C: Yes. She's quite informal about things. P: I think I could ring her anytime." P217</i>
Always available	<i>"I now, within myself, would have no hesitation in picking up the phone and making a phone call if I thought that there was something that I needed [PJS]'s help or intervention" P046</i>
Problems get resolved quickly	<i>"C: ...you're on the phone and they answer; even if they're not there, they ring back immediately and the answer is there..." P137</i>
Provides carers emotional support	<i>"[MND nurse], she's so lovely, she really is. And I know there was summat once wrong, a while since, and I rang her up and she put me mind at rest. Yeah, [MND nurse] I think is lovely, yeah, yeah." C228</i>
Backup for community team	<i>"Q: And if you had a question now or a problem what do you do? C: Well I can go to...,our occupational therapist who comes out to see us, and we've got her email and we've got her phone number; so [OT] would be the first one, or, if not available [MND nurse]." P062</i>

A5.2 The psychological benefits of the hospital MDT.

<b>Psychological benefits of the hospital MDT</b>	
Positive attitude	<p><i>"Q: And, and when you come to the clinics now, what it is that you want to get out of coming?"</i></p> <p><i>P: Well what I'd like to get out of it is any information that's going on, any positives, any trials going on, any success stories. I like to, I like people to tell me that they've known somebody that's had ALS for ten years; that makes me happy." P317</i></p> <p><i>"I didn't find them gloom merchants, they were very positive in their approach and in their opinions and their comments." C229</i></p>
Staff are caring	<p><i>"No, she's a nice lady, she knows, she can empathise, which is nice and she, she's obviously caring the way she comes across." C317</i></p>
Able to speak to an expert	<p><i>"When I saw [MND neurologist], we've had a really good relationship from day one. So he tells it as it is and I ask it how it is ... upfront really, which I think is the best way. That's the way I wanted to be cos then I can, you know, I can deal with it then." P056</i></p>
MND provides practical information	<p><i>"[referring to a benefit assessment form] [MND nurse] told us how to answer the questions." C392</i></p> <p><i>"I was first introduced to the PIP on the day that, [MND nurse] told me about that..." P248</i></p>
Confidence in the expertise of a specialist centre	<p><i>"The diagnosis at [district hospital] ... was a bit lackadaisical. When I went to Sheffield the diagnosis was, well obviously Sheffield's got more experience ... haven't they? I think maybe if the first place that you go to for, you know, to research it, if they're not really experienced on the disease." P056</i></p> <p><i>"Knowing what they talk about, which is comforting." C229</i></p>
Close connection to research	<p><i>"I was looking on Facebook and I noticed that there's a [man] whose wife apparently died of MND quite recently. He's a huge fundraiser. He'd put this thing on; it was a little short film. And [consultant MND neurologist] was in it." P122</i></p>
Opportunity to discuss emotions	<p><i>"I don't talk about it awfully much, other than, you know when I come to the clinic, or discussing it with the outreach team." P122</i></p>
Opportunity to support carers	<p><i>"He talks, and if there's any concerns or if I need to talk to him about anything then obviously, you know, I can talk to him." C145</i></p> <p><i>"There were a time, I were really upset because I were really worried. But I didn't make a point. But the [nurses] were really good. They ushered me into a little room and I cried. It spring-boarded a lot of things... and they acted upon it. That's when we got the physio and the dietician and everybody came.... I needed to talk to somebody and it helped me." P184</i></p>
Opportunity to involve carer	<p><i>"They have all the knowledge, the technical knowledge and how it develops and how it's best treated. I think it's valuable to feel part of that team and you can explain things that are happening and they can explain to you what might happen and the things to look out for. And... [Pauses] as apposed to being an isolated carer, if you know what I mean, to be part of the "team"." C122</i></p>

A5.3 Reasons why participants felt the clinic was not always beneficial.

<b>Clinic offers little perceived value</b>	
Clinic is not going to provide a cure	<p><i>“Q: And what is it about clinic that you, you, you, you find you need to, you need to come for?”</i></p> <p><i>C:...I've got to admit I like to see [MND nurse] but apart from that there's nothing, they're not gonna give me a miracle cure.” C228</i></p> <p><i>“If I could go every three months and it would have a chance of making me better or improving my life, I'd go every month, no problem. It's just so frustrating that nothing's happening.” P184</i></p>
Clinic is just monitoring decline	<p><i>“... this is not necessarily my belief, [people] feel that it's all just an exercise of measuring and monitoring how the disease progresses in individual patients, and we really want to see something at the end that's a bit more than just a measurement of progress.” P232</i></p> <p><i>“All you're doing currently is monitoring my progress, so at the minute I've really got nothing out of the clinic.” P318</i></p> <p><i>“I guess that would then cut down my travel time to clinic, you know, clinic doesn't really fulfil a great deal in my life other than ticking some boxes and sort of knowing where the progression's going.” P134</i></p>
Physical exam not important	<p><i>“Q: And how do you sort of, do you, do you monitor your progression or the change in your disease?”</i></p> <p><i>P: I know myself that there's things I can't do that I used to be able to do, and that's my benchmark. Very early on in my clinic we stopped doing muscle scores cos I didn't wanna know, I knew that my finger wasn't working, I didn't need someone to tell me that I was a three or a four or a five, and that was all a bit arbitrary because you could be a five one day and a three the next depending on how you were feeling; and also who was administering the test. So it was a pointless exercise for me. I just know now that I can't walk or I can't do this or... that, but I can still hold a glass of wine and do lots of other things.” P134</i></p>
Takes time to develop relationship	<p><i>“Q: And did you use the telephone service to [MND care centre nurse], the MND nurse? Did you use that?”</i></p> <p><i>C: No I've not been in touch with her at all.” C062</i></p> <p><i>“C: You've had no real contact with [MND nurse]. C381</i></p>
No need for clinic nurse if community nurse sufficient	<p><i>“C: Do you think [MND nurse] should be playing more of a part, role? What's she gonna do differently to what [Community Nurse] does is the question...from a locality perspective I suspect it would be a bit out of her way...it's all about personal contacts..”</i></p> <p><i>P: I guess [MND nurse]'s got more hands-on cos she's more hospital-based and she's seeing people day after day after day.” P&amp;C381</i></p>
Lack of psychological support in hospital clinic	<p><i>“To me, I thought [clinic has] never been about psychological wellbeing and your mental wellness and therefore; and truthfully I thought I don't know why these questions are in here, because that clinic isn't equipped to deal with that and I know that.” P046</i></p>
Clinic focus is on patient, not carer	<p><i>“Q: Do people ask you about sort of how you are and how, what's your mood like, when you see, you know, doctors or clinic or...?”</i></p> <p><i>C: No.</i></p> <p><i>Q: What, what do you think about that?”</i></p> <p><i>C: It's not about me, it's about P</i></p> <p><i>Q: And do you think people should ask you, though, about it?”</i></p> <p><i>C: No cos it's not about, at the end of the day it's not about me, it's about P, so no.” C145</i></p>

A5.4 The problems associated with the organization of the hospital clinic.

<b>Problems with clinic organisation</b>	
Gaps between clinic	<p><i>"I know when I come down to Sheffield I can get to know anything I want basically and they've been fantastic. ...It's just that time between...[clinics]" P056</i></p> <p><i>"It's a good idea to monitor symptoms if they crop up out of the blues we're not sure whether it's anything or not..." C062</i></p> <p><i>"I did feel that I'd been told and left ...like that they give me this horrible diagnosis and it were like, go away and think about it ...I just suddenly felt like...: you've got this; go away, that's it. ." P321</i></p>
Clinic infrequent	<p><i>"So I haven't been to see [MND neurologist] since the first time that we went; so he's only been twice to see him." P166</i></p>
Fixed appointments	<p><i>"P: I think once they'd told me the diagnosis I didn't kind of hear much after that, it was kind of a strange day, it was just; and, and for a good, probably a good couple of weeks after that I was quite down and, yeah, it was like worried about the future.</i></p> <p><i>C: I suppose I, I felt like the diagnosis had been given and then that was it, see you in three months' time." P&amp;C423</i></p>
Clinic busy	<p><i>"[MND neurologist] he's always got a very, very positive attitude but you've got limited time, because he's got a full clinic, he's got a dozen patients sat there, cueing up to get in." P184</i></p>
Feeling like a burden	<p><i>"I've sometimes felt that I'm taking time up in the clinic that somebody else could use better than me." P046</i></p>
Privacy not always possible	<p><i>"If I am being honest, I remember thinking: this is all happening at the same time, there's only a curtain between us and; I can hear, I could hear, I could hear, do you know what I mean, I could hear other people and what tests they were having. I was surprised at that, ... because everything up to that point had been as you would expect with a medical consultation, you know, it's, it's you in a private room, you know, out of ears." P409</i></p>
Clinical can be emotionally and physically tiring	<p><i>"I know this is horrible, perhaps not a very nice thing to say, but when we've been we always feel as though, at the minute, we're quite lucky because there's always (laughs) somebody... that's got another side effect though because you think: that'll be us soon...that's the only thing going to the clinic ... we always feel a bit shattered by the time we get back trying to hold everything going." C318</i></p> <p><i>"Q: You mentioned it affects you afterwards? Before as well?"</i></p> <p><i>P: Two days. For two days after, mentally and physically. Because it's such an effort for everything to do for me. " P184</i></p>
Distressing to see other people in later stages of disease	<p><i>"P: It does get me down sometimes, in my more quiet moments; I might sit and think about it. You are reminded about it a lot..."</i></p> <p><i>Q: Do you compare yourself to other people with MND?"</i></p> <p><i>P: Yeah, only when I come to your clinic! That's the only time I see them! I remember the last time I was there when I met you: there was a lady in a powered wheelchair. She was in the next cubicle to me. Probably age similar to me... It's the speech side would really annoy me. If I couldn't talk. That's the thing more than anything that would worry me more.... Not being able to converse with people, and tell them how I feel... But hopefully that's a long time down the line... So it won't worry me." P122</i></p>

#### A5.5 The practical barriers to attending clinic

<b>Practical barriers to attending clinic</b>	
Long day for a very short visit	<p><i>"C: We're seeing his registrar now. He's very good.</i></p> <p><i>P: They are all good. I've got nothing but admiration for them.</i></p> <p><i>C: But you are very quickly in and out, aren't you.?</i></p> <p><i>P: Yes. I'm only there 10 minutes. That's 11 o'clock in the morning, 'til half past seven at night, my day for that."</i> P184</p>
Travelling	<p><i>"Q: ...You'd rather not come at the moment; I think that was the travelling, was that right?</i></p> <p><i>P: It was. It was about two hours to get there, about an hour consultation and then another two hours to get back."</i> P166</p>
Parking	<p><i>" We just park up... sometimes hard to find a parking space (laughs) but that's same at every hospital"</i> P145</p>
Clinic in unfamiliar place	<p><i>" ... we've been there that many times, we always get lost."</i> P145</p> <p><i>"Q: Is it the travelling the main...?</i></p> <p><i>C: Well last time we went we were there about four hours before we got in because it's always busy there isn't it. Because we left at night and it was dark and I got "done".</i></p> <p><i>Community nurse: ...You got fined for going through a bus lane.</i></p> <p><i>C: I went through a bus lane. I didn't realize and I couldn't get out of it because they had a photograph."</i> C062</p>
Travel is expensive	<p><i>"C: Train tickets are a bit expensive, so we've driven the last few times..."</i> C392</p>
Hard to be punctual for appointment	<p><i>"C: I have mixed feelings about Sheffield. It's essentially a day out. If we're going to Sheffield, it takes P quite a long time to get her sorted out in the morning..and the thoughts of setting off before 10 or 11 are out unless you really want to rush yourself. She gets upset, uptight because she always likes to be punctual. Punctuality is something we've lost recently I think...So Sheffield is a full day. And it's not a pleasant run and it's not a pleasant place."</i> C172</p>
Clinics can be lengthy	<p><i>"C: Well last time we went we were there about four hours before we got in because it's always busy there isn't it..."</i></p> <p><i>C: So I stopped [going] after that. We were there quite a long time"</i>P062</p>

### A5.6 Benefits of the community multidisciplinary team.

Benefits of the community services	
Home visits are convenient	<i>"Q: And you've been quite poorly recently and had a few things changed... how has that been? P: Not too much of a problem; you've got to accept where you are. And basically everybody comes here, they're actually coming here to help me, not for any other reason... You hear about all these problems in the NHS; to me it seemed brilliant." P354</i>
Allows assessment of home environment	<i>"There's an extremely good [local] team in the neuro physiological clinic. The OT came to see me at home very soon after I was diagnosed, and scouted round the house to see what sort of the place we lived in...and made it perfectly clear that if the stairs became too much I should get on to them straight away and they would get, either a stair lift or another handrail. You get the feeling you only have to ask and somebody will do something about it. Extremely helpful." P166</i>
Allows assessment of physical problems	<i>"Q: What, have they picked up anything else that you've found helpful? C: Well [district nurses] was the main thing, cos I mean when I used to do it meself I didn't have a clue what's going off because I don't know what's going off and (laughs) but when these people came in they soon tried to say, well this is here, that's there, and this wants seeing to or... Q: So they've noticed things like her skin and her bottom..." P063</i>
Communicating in convenient ways	<i>"Q: Does she get support from anyone? P: Well, we've got the outreach team, and [neurology community nurse] is really good and [community physio] from the outreach team. They are always sending us emails." P122</i>
Accessible	<i>"If I wanted her to come out she's only on end of a phone." P145</i>
Rapid response	<i>"P: Well the last one was the mattress... one came and was fitted but we didn't know what to expect so what came we accepted, but I then got sores in me back, asked [OT] to come and look, as soon as she saw it she rang up and ordered a different one and it came that day. C: Later that day, yeah, she rang at four o'clock, they were here at six with a different one. P: So most of the time things are met very well." P137</i>
Refer to local services	<i>"Q: You mentioned the hospice, that she goes every week and she has been for some respite. How do you find that for yourself? C: It's not too bad really. I drop her off at half ten and pick her up at three. I just do a few jobs around here." P063</i>
Prescriptions	<i>"C: They're amazing. [The] community matron; she'll call every so often, if I need anything I'll just ring her, she'll provide us with prescriptions" P378</i>
Provision of practical solutions	<i>"And the specialist nurse with the [local] practice was brilliant; I've got the blue badge, which makes a terrific difference." P166</i>
Practical equipment is important	<i>"Q: If we were to give you say £1 million that you would invest in helping people around the house with things, the problems that you face, what do you think, what would be the things that you would...? C: It'd be things like a chair and; just things generally, you know, it's, just things for P, make things a bit easier." P228</i>
Right equipment	<i>"The CASS team referred me to wheelchair services and they said, we think you need a [new] wheelchair. What I had, they said wasn't very adaptable for future usage, so they said we'll get you a more suitable wheelchair...I've got more support for me back...more support all the way round" P056</i>
Right time	<i>"In fact it's getting solved ahead of the game really, that's why I've got the wheelchair guys coming shortly." P313</i>



A5.7 Psychological care provided by the community team.

Psychological care	
Psychological support	<p><i>"P: She's very good for gently moving you to the next stage without saying, oh you're gonna be crippled-up. You're not (...) too far before it (...) so let's have a look. C</i></p> <p><i>: She's looking ahead all the time but in a, in a good...</i></p> <p><i>P: In a nice way." P248</i></p>
Providing information	<p><i>"Q: Do you get most of your information from [MND community nurse] or do you look on the internet?</i></p> <p><i>C: Most through [MND community nurse]" P063</i></p>
Helping patients accept the help required	<p><i>"P: Well, funnily enough, it was [OT] from the outreach team who talked me into a mobility scooter... she had to badger me for about two months" P122</i></p> <p><i>"Q: And what; do you, is it something that you needed a bit of sort of badgering or encouragement to do?</i></p> <p><i>C: Definitely, definitely, yeah. I tend to be a putter-offer, I just do and I say, "oh yeah, well thank you, we'll have a think about it and I'll get back to you". Say if it was [OT] who was always, you know, she's always been a real champion for us, hasn't she, and.....but, yeah, I would always put it off until there comes a point where you think: well I can't put that off any, anymore now." C409</i></p>
Promotes positive outlook	<p><i>"It's not like going to a physio and going to a hospice... you go in there, we come out, and we have a laugh and, take the Mickey out of each other ...and you come out and you almost feel lifted emotionally as well as; so it's really good." P248</i></p> <p><i>"We go to [local hospital]; I've got a really good physiotherapist, she's great, she's really positive. Every time I go she's "That's great, yeah, you know, you're doing really good, there's no changes, your legs are still strong" which is great; that gives you a bit of a buzz." P317</i></p>
Promotes quality of life	<p><i>"C: The work that they've got with P and improved his mobility and improved his quality of life. That's helped us, hasn't it? It got you through summers with the garden, when we went on holiday. It meant he could go for little walks along the beach with us. It just made so much difference." P184</i></p>
Promotes self efficacy	<p><i>"P: Well I've had both support from you, and, to be honest, the physio after my hip operation was great. She was very positive. You know: "you can do this" Q: So building your confidence and things." P381</i></p> <p><i>"C: At one time he did have a choking do that he was frightened of anyway (makes gasping sound) and couldn't get his breath.</i></p> <p><i>...Although I didn't panic but wasn't sure what to do, because the suction machine wasn't helping, wasn't moving it. So I got him on the nebuliser and the breathing machine (laughs) and got him in bed relaxing and eventually it came, came round. I did ask [community nurse] what should I do in; she says "Well you did all what you can do" she said "if you'd have sent for ambulance they would have only done what you did, cos there's nothing else they could have done".</i></p> <p><i>Q: Did that make you feel a bit more confident to do that or a bit more worried?</i></p> <p><i>C: Yeah, well a bit more confident, I think, that, you know... But he han't had one as bad because now, I suppose now that you know what to do then you do it automatically." C366</i></p>

A5.8 The care coordination provided by the community team.

Care coordination	
Community team liaises with with hospital MDT	<i>"She usually phones me, [community nurse]; anyway, she phoned last week and I think she's doing now, instead of her phoning me, if I'm worried ... I phone her, I says that's fine; she's gonna let doctors know and I think she's letting them know at hospital. I says "Yeah, that's fine, I'll phone you if I get in difficulty" C228</i>
Communication between teams is welcome	<i>"I'm quite surprised that you're all in communication really. I didn't know you spoke to [OT], [Physio], and I didn't that [GP] and you and the hospital were quite so connected, so that seemed to be a, quite a positive thing." P354</i>
Hospital can be a backup	<i>"Q: And if you had a question now or a problem what do you do? C: Well I can go to Jackie Hill, our occupational therapist that, who comes out to see us, and we've got her email and we've got her phone number; so like [OT] would be the first one, or if not available [Telehealth Nurse] at the Hallamshire." P062</i>
Develops a good relationship	<i>"But I really felt that, you know, Sheffield is there if I really need them, but on the other hand [local team] is here." P166</i>
Different individuals provide regular contact	<i>"The [community] team, she comes once a month. I've got the district nurses now coming once a month. Dietician comes probably once every three months." P056</i>

A5.9 Participants experiences with lack of care coordination in community MDT.

<b>Problems with the community MDT</b>	
Lack of care coordination	
Dealing with multiple professionals	<p><i>“Q: You told me a bit about the, the difficulties you’ve had getting your stair lift. P: Well yeah, because that’s outta your hands because it’s controlled by government bodies, it’s not controlled by you...They’ve gone through four different OTs to get the same results. C: Basically they should go out with a dedicated MND team...” P091</i></p>
Staff turnover/ unavailable	<p><i>“C: We’ve got that chair done Q: In the bathroom? Who got all of that arranged for your? C: Its [OT from the council] Q: Does she see you regularly? C: She had a baby. I think she is back in December. She finished in March. I think she’ll be back in December.” P063 “Q: How do you find having different people? P: It’s all right. You get to know one person. When they change you have to start again but it’s not a big problem.” P145</i></p>
Unsure who to turn to	<p><i>“Q: Who’s your main point of call? C: It just depends on what problem it is, if it’s a nurses problem I’ll get hold of them, if it’s something bigger I’ll...” P063 “Q: So you’ve got two people that you feel you can call...? C: That I feel that I could get in contact with. The only thing I bother about is at what stage should I ring for a doctor.” C366</i></p>
Dealing with unexpected emergencies out of hours	<p><i>“Q: It sounds like you have learnt a little bit more about these things that are quite complicated [referring to caring duties]. Do you think it would have been helpful if ...other carers and husbands like yourself were taught about this sort of thing earlier in your, the course of the illness or...? C: Yeah, I thought meself like, but. I suppose it’d be a good thing for anybody now that. But things are clearing up now. This last night it was bothering me like that... I thought, and I said to her: “You aren’t bloody dying are yah?” She were like funny [looking ill]...going grey and funny, and I thought, then I looked and her eyes were looking glazed, and I thought what the hell’s going off here? So I phoned [community nurse].” C063</i></p>
Needing to advocate for oneself	<p><i>“Q: Are there any problems that you’ve had that you struggled to get resolved? P: Not really because I’m very vocal, I have no problem going to a meeting, so if we have a problem or something then we’ll go down to our local [MP], or get onto the council or get onto MNDA. I have no problem rattling someone’s pen, and I’m not a person that takes no for an answer... But not everyone’s like that and that’s what worries me.” P134</i></p>
No regular meetings	<p><i>Q: And you mentioned that you’d seen the physio in December and then you hadn’t for a while... Do you think you should have been seen more regularly...? C: I think so... I know they’re busy, but like since the last time P was seen he was left to get on to a new set of exercises with no backup. Like P is seen sort of every three/four months at the clinic, I think it would be advisable for a physio to come out as well sort of every three, four, five months just to make sure ... everybody is up to speed with the exercises... if there is any problems they can be ironed out when they come out to check.” C145</i></p>
Not interacting with each other	<p><i>“Q: Cos they, cos they each have their own little environment of knowledge and, and ability and then, in a practical sense, and then... P: And being the patient you suddenly got; and it’s amazing how many people don’t even know other people in the system, you know; I’ve got a neuro casement manager, who’s been great, she’s helped me in so many things, but [PJS] don’t know her, you know, it (sighs) I don’t even know if [Telehealth Nurse] knows her. But to me she’s been, she’s a nurse by background, but she’s been so much help in so many things. But I find the fact that (interruption) I find that she’s not a more integral part of the MND world within the hospital fascinating.” P047</i></p>

A5.10 Participants' experienced problems with community MDT due to lack of expert staff

<b>Problems with the community MDT</b>	
Lack of expertise	
Staff's expertise may be limited	<i>"I've also got the nurse, once a month, so again I could ask her advice, cos I know that she's skilled in knowledge of MND, she just isn't up to speed with things that you can do holistically or positive things, looking at the internet, things like that." P317</i>
Staff unskilled	<i>"When the PEG nurse came; [the tube] has to be split, pulled out and moved... He has to twist it round once a day. You've got to split the actual pin, and I couldn't do that, I couldn't, cos you have to like squeeze and twist and (laughs) and I couldn't do it. So the [PEG nurse] says "Well I'll get the district nurse to come and do it". So the district nurse comes every fortnight and does it, but (laughs) but when they come they don't always know how to do it. Q: Right. You're telling them what to do? C: I'm telling them what to do, although I can't do it. If they can't do it they've sent somebody else to come and do it (laughs) which is all a bit stressful. When you send for district nurse, she had to come and do something and then they don't know how to do it." C366 "P: Oh, well that'll be it then, cos she said my name had come up at a meeting so they thought they'd come and see me and; so I said "Oh that's fine, OK, fair enough". And, and we said, I said to her "What do you know about MND?" She said "Don't know anything." P380</i>
Bad experience at diagnosis makes later care harder	<i>"I think the worst part for me and my husband was the delivery of the diagnosis, to be honest with you, it was very, it was, it was done in a very negative manner." P317</i>
Therapists discharging patients making them less accessible	<i>" Well C's been on at me for a while to see physio again, I haven't seen anybody since December, which is down to me ... it's not down to them, they just said give us a ring when you need us. So I rang up ... the lady said "Well you have to be referred through your doctor." I said "Well I've never had to do that before" She said "Well no, it's changed now, you have to be referred back through your doctor." P145</i>
Carers not considered	<i>"I think the hardest thing is that you become...[like] another piece of the person's equipment. I had a bit of a to do with the lady that came to the house from the council who came for a financial assessment or something. She sat with her back to me talking to P and I needed to provide some information... she was quite rude, and... she was being very hostile and I said; "I'm just asking a question." I understand, it's about P, but the question she was asking he wouldn't know the answer to anyway. And, it was a little bit of a situation. I said to [community MND worker] who came later on: "I just felt like a piece of P's equipment: there to fetch and carry and provide". You become a bit of a non-person because the concentration is on the person who is diagnosed with MND, and rightly so, but then if affects the partner in.... it affects them as well, but they don't suffer the symptoms." C122</i>

A5.11 Participants' positive experiences of general practice.

<b>Good experiences of GP</b>	
Good knowledge of MND	<p><i>"Dr [GP], the previous one was fantastic GP and he had a little bit of knowledge about the disease as well." P056</i></p> <p><i>"I suppose some doctors are totally clueless about the condition and others are quite, her doctors isn't that bad. She's quite a switched on lass.</i></p> <p><i>P: When I first went, she knew what was wrong with me.</i></p> <p><i>Q: You think she knew what was wrong when you first went."</i></p> <p><i>P172</i></p>
Accessible	<p><i>"I know if I need... to see her she'll just come out now." P056</i></p> <p><i>"I am lucky over here. Whenever C rings up for an appointment, they normally slot me in somewhere the same day – which is exceptionally kind." P229</i></p>
Seeing patients regularly	<p><i>"The previous one was a fantastic GP and he had a little bit of knowledge about the disease.. he kept saying I'll see you in three months, just to keep, see how you're doing." P056</i></p>
Knows the family	<p><i>"P: Sometimes I have to wait for an appointment but I always see the same doctor every time ... he knows me and he knows the family. Well my mum only died two and a half years ago and he visits and I'd only to ring up and he was there wasn't he? Knows my daughters, who looks after me, knows my background, knows what's going on." P217</i></p>
Takes an interest	<p><i>"Q: If you were going to give advice to a new nurse or a new GP who's got a patient for the first time with MND, is there any advice that you'd give them, from your experience?</i></p> <p><i>P: ...to listen more than anything, just to perhaps like my GP's done: get in touch with me a bit and say: "make an appointment every four weeks, come and see me, see how things are going." Just to be involved with that person, keep up-to-date, so you know that you kind of know that they're there in case you do need anything."</i></p> <p><i>P423</i></p>
Prioritise patients with MND	<p><i>"We got a letter from [GP] saying that because of the illness I'd got I would be put on the priority list ... and since then everything's been pretty good; if I've needed to ring the doctor then this gives you, if they want a doctor to come out to see you they will come and see you...I think the reassuring thing for me is the fact that I can ring up and know that I'm gonna see the doctor within, if not that day the next day...even with C, which is more, even more reassuring for her, that if I was taken poorly here the doctor would be here...it's reassuring for us, and hopefully we'll never need it, but it's nice to know it's there." P248</i></p>
GP can be main point of contact	<p><i>Q: Who's your first point of call if, if you can't sort something out yourself?</i></p> <p><i>P: Probably GP or me mum. (laughs)</i></p> <p><i>Q: Yeah. And you say you've got a good relationship with your GP, that's, that's right, isn't it?</i></p> <p><i>P: Yeah. I've not seen him for a while but I've not needed to, but he's generally OK, yeah, he's a good guy." P423.</i></p>

#### A5.12 Participants bad experiences of GP

<b>Bad experiences of GP</b>	
Showing no interest	<p><i>“Q: How have you found your GP through all of this? P: Useless. C: He’s never ever contacted us at all... He’s never seen him; he just goes for his blood tests and that’s it. P: But all the blood tests I arrange, in fact the first three the nurse said “Why have you come?” C: I mean you don’t expect him to be ringing every five minutes, I understand that, but if he gets a letter to say that, I mean he can’t have that many patients with that.” P381</i></p>
No meetings arranged	<p><i>“P: Can I just tell you something, interrupt about that? Since I’ve been diagnosed with motor neurone disease I have never seen my doctor about it or anything related to it. Not that I’ve requested to, to be honest.” P184</i></p>
No knowledge of MND	<p><i>“P: I don’t think GPs, I don’t think the GPs know, I, I don’t think they’re clued up as... C: No. P: ...as, as what, as what they can, what they could be. Cos again, going back again, that first doctor I saw just said it were sciatica.” P&amp;C145</i></p>
Never met before	<p><i>“P: Well it’s in, this in the fortunate position where I was never ill, then, then I’m getting it all at once now I think, but, aren’t I?” P248</i></p>
Not seen routinely as not seen to be unwell	<p><i>“Q: And since the diagnosis do you have much contact that way? P: No. I’m not poorly. I’ve been once, two or three times since 2004.” P172 “Q: So do you have a relationship with your own GP? A: Yeah, my own GP’s a, a very nice lady but I, I don’t go to see her because I’m not unwell.” P317</i></p>
No regular visits for MND needed	<p><i>“With my local GP, I tend not to visit much with MND related issues although in truth, I haven’t had many problems that couldn’t be resolved or talked through at Sheffield or with the community team. But, nonetheless, I know that you do keep her updated with my progress because she will chat about that when I see her.” P229 “P: Well I think from the GP point I would like at least once for them to contact me. I appreciate they’re busy but I think long-term probably save time if they spoke to me once. “ P381</i></p>
Appointments hard to access	<p><i>“It’s taken a week to get in to see the doctor. If it were, like you were an emergency I think you’d get one a bit sooner, but basic, basic appointment it’s took seven days, just to go in and see a doctor.” C145 “We’ve got a phone appointment on Wednesday cos we couldn’t get an appointment to get a sick note, so I’m just hoping that he will issue a sick note over the phone. I couldn’t get an appointment with [GP]. In this day and age, when somebody’s got MND you would think it would flash up on the GP’s computer: this man needs an appointment...It’s a horrendous diagnosis then not to be able to get an appointment at the bloody GPs.”C392 “C: I think we’ve just got to, you know, be quite forceful when we ring up for appointments... P: The front desk at doctors are legendary aren’t they? A big barrier.” P392</i></p>
Poor access for carers	<p><i>“C: Yes. He can ring up and speak to GP over phone, I’ve gotta make an appointment to see him, and then when I go see him it’s all in my head.” P091</i></p>
Not wanting to bother GP	<p><i>“You don’t like making an nuisance of the GP, normal people don’t make a nuisance at the GP do they?” C392</i></p>
GP not point of contact in an emergency	<p><i>“C: Well I think until there’s an emergency, you know, that we need to; but then again would we go to the doctor? I don’t think we would, I, I don’t think we would because you feel as though they haven’t, as I say, our first thing is to come to you which I suppose that you’re more, you are speciallists and everything, but I don’t think the doctors would, I don’t know.” C381</i></p>
Will need to rely on them	<p><i>“No contact with the GPs. Never ever had contact in all the two years he’s been diagnosed. So you’ve got no confidence. Eventually I know that we both are going to be reliant on our GP at some stage. We are going to need our GP, aren’t we? And we’ve no confidence at this moment in time” C184</i></p>

A5.13 The value of regular contact with specialist services.

<b>The value of regular contact with specialist services</b>	
Patients want regular contact	<i>"[referring to a drug trial] It was good because, it meant I was going to the clinic every month... there was more involvement. They took blood every month. I did the puff test... ECG... weight... Maybe it was that that made you feel better. Maybe you knew that they were hands on, that they were doing their best to see if they could sort out or resolve any issues... It was quite interesting. I quite enjoyed it, in that perverse sort of way."</i> P122
Reassurance when faced with unfamiliar problems	<i>"I could have camped in [MND Consultant]'s house for the first six months, just so she was there, so I could say: but what about this? What about that? You imagine symptoms, or I did, you think: God, this is happening and that must be related to the MND... and what does this mean? I settled down, at some point...to pretty much know what's MND related and what's not."</i> P046
Reliable regular contact	<i>"I just think when P was diagnosed that everybody came to see us and then everybody's left us, apart from the clinic... at first I found it a bit strange that we were just left to get on with things... I think a little more backup from the physio, I think that would help everybody; it'd put my mind at rest, and it would also give the person suffering a bit more backup: I am doing it right, and it probably gives them a bit more confidence in themselves."</i> C145
Builds personal relationships	<i>"Q: And you mentioned seeing patients in clinic when you came. What are you feelings about coming to clinic, in general? P: It's always beneficial. It means I can meet people like [nurse]. I've known [nurse] ever since I've started coming to clinic and, I count of her more as a friend now than a nurse... Even if it's only just to have a chat. People say, "How are you getting on? You are doing alright. We'll have a laugh."</i> P122
Offers support even if patients reticent to ask	<i>"I know P is not a one to phone up and say, can you come? I have to keep pecking his head until he's fed up ... and then he'll go "I'll do it."</i> C145 <i>"I know they're a phone call away but I'm not that sort of person... I'm happy not to do anything, I don't want to do anything. I don't want to; I think I'm just plodding on, to be honest with yah."</i> P321
Keeping in touch	<i>"Because it's slow with P and he doesn't need as much attention and care, it's easy to feel detached from any positive interaction. Whereas with [the TiM], somebody's there and if there was something you'd pick up quite quickly as apposed to, you've gotta wait until your next 12 week appointment."</i> C122
<b>Regular monitoring</b>	
Regular monitoring of progress is reassuring	<i>"Like with P's breathing tests or his muscle strength tests, and the questions that they ask, it's nice to know the scores. Yes P is getting worse but only smidgens at a time...It's nice, to be able to get that input straight away."</i> C145 <i>"They're not that great in [local hospital] because they sit back because I go to Sheffield.You do all the tests, the blowing machine...so I know[how I'm doing]."</i> P172
Physical monitoring	<i>"I used to see [MND neurologist] first, and then I used to come out and then they used to weigh me and do me breathing tests and do the physio."</i> P145
Assessment of progress	<i>"With a Sheffield neurologist, we need to give an honest evaluation about any developments/ deterioration"</i> P229
Respiratory monitoring most important	<i>Q: What are the things that you think are the most important about coming to clinic? P: For me the most important thing for me going is when they check my breathing. I like to know whether me breathing is getting any worse. "</i> P145
Respiratory monitoring is objective	<i>"The breathing. That's gone down. I can't remember what it was last time. ...62 or 59 or something. So that's dropped from; I mean the first one I ever did was 111, so that's just over half from where we were."</i> P248
MND team can anticipate problems	<i>C: Yeah. And me daughter, she rang [MND nurse] up (laughs) and said: "It's time he got this PEG in." Q:What did [MND nurse] say; had she already started planning it or..? C: Well they had, thought about it, and they were very good because she got him in quite quickly. C366</i>

A5.14 The information needs of those with MND.

<b>Information needs</b>	
Little prior knowledge of MND	<i>"To be honest I didn't know a lot about MND at the time. I'd never given it a second thought. So, I'm a very positive person, generally speaking. So, really, when she told me she said "It's bad news" and I said well... I didn't know enough, I had to come home and Google it to find out what it's all about." P122</i>
No experience of support services	<i>"Cos we're in blind here, we don't know... it's all new [to us]" C423</i>
Negative attitude to MND	<i>"Q: Had you heard anything about PLS, MND, before you'd been to that clinic? P: MND: frightening." P217</i>
Patients felt alone after diagnosis	<i>"After we were given the news, we were just really left to go home; there was no counselling... I think it took us about three weeks to actually pull ourselves together; during that time nobody had contacted us" C317</i>
Once MDT involved patients felt supported	<i>"People just came out of the woodwork when I was first diagnosed" P134</i>
The involvement of the MDT could be overwhelming	<i>" When you are first diagnosed you are emotional. . But once you are diagnosed everything happens: OT, physio, dietician, all at once. It's nice because it feels like you are being looked after. But on the other side there were talking about things I wasn't really aware of and asking me questions too early to ask." P172</i>
Patients had unmet information needs at diagnosis that needed to be addressed immediately	<i>"Q: What kind of information do you find helpful? P: Not so much now, because everything's more or less sorted out, but when, when, obviously when I was first diagnosed, just like the benefits system and everything like that" P145 "C: The immediate thing was to get the Careline set up...and get [P] up and downstairs safely." C062 "... nobody told me was you have to tell DVLA; so without reading the MND thing I wouldn't have done that." P381</i>
Information could be very complex	<i>"Q: And how, so how did you go about finding out what sort of things you might be entitled to? C: We are still not a hundred percent sure, to be honest, cos it's very, very complicated." C392</i>
Emotions around the time of diagnosis make information seeking very difficult	<i>"I came out [the] surgery in a flat spin. It was a real shock. For two weeks, I didn't sleep... lost my appetite, became really anxious. I visited the ... GP twice because I was hyper ventilating. It was all a result of the shock." P229 "I went online ... but it frightened me a bit to read about it, so...I stopped doing it, to be honest... it were upsetting. So, I've learnt about it just through hospital and things like that..." P172</i>
Denial stopped some seeking information	<i>"In the early stages of diagnosis we were in denial: [MND consultant] had it wrong for me as far as I was concerned" P134 "But at beginning ...we didn't want it." C228</i>
Learning about MND could be a positive experience	<i>"We just have it in the back of our mind that we've got a long time left together now, but we didn't think... that last June. We were thinking that was it more or less... but the more we've learnt ourselves and the progress that I'm making, I think that's given us renewed hope." C317</i>
Information can be empowering	<i>"what [MND neurologist] and her team have said, I didn't find them gloom merchants, they were very positive in their approach and in their opinions and their comments" C229 "I personally felt quite philosophical about it. I was just strangely relieved that I knew what I was dealing with. I just thought it was Gods will and I knew that, once diagnosed, the MND family would wrap its arms around me (and they have!)" C229</i>



A5.15 Sources of information about MND.

<b>Sources of information</b>	
Community MDT	<p><i>Q: Do you get most of your information from [MND community nurse] or do you look on the internet?</i></p> <p><i>C: Most through [MND community nurse] C063</i></p> <p><i>"[Community Nurse] talked to us for quite a while immediately after we got the diagnosis." P360</i></p>
Hospital MDT	<p><i>"[MND consultant] was very good on putting us in touch with [MND nurse] and so putting us in the, in the loop, I think." P134</i></p>
Hospital MND clinic	<p><i>"I've learnt about it just through, through hospital and things like that..." P145</i></p>
MND Association visitor	<p><i>"And [MNDA visitor] and through MNDA" P145</i></p>
Written information	<p><i>"P: We got a book from Waterstones. (laughs)</i></p> <p><i>Q: And, and how did you know about the book?</i></p> <p><i>P: Because the specialist nurse mentioned there was a book." P166</i></p>
Internet peer support	<p><i>"I think I was more concerned with P on, on the, on the web because I was concerned about her morale. In actual fact that, I think that was unfounded because, of course, P's gained an awful lot of comfort from talking on the web with other patients and getting their reactions." C229</i></p>
Some patients can't/don't want to access MNDA and therefore rely on statutory services	<p><i>"Q: And have you had any contact with the Motor Neurone Disease Association?</i></p> <p><i>C: No... I'm not very computer literate and ... I really don't know how to go about it, and I don't really want to be talking to other people about their illnesses, if I'm being honest, ... I feel that I know enough about it.. I don't really want to, cos I know that would be like ...your worst nightmare, wouldn't it, talking to other people about their illnesses..." C392</i></p>

A5.16 Participants' experiences of information about MND available on the internet.

<b>Experience of information about MND on the internet</b>	
Internet information could be upsetting	<i>"I don't really go online and research ...cos I find it quite upsetting." P145 "... you go on some of the sites and it's always the worst scenario, ... and you start reading it and you're thinking: oh my God, I don't want, I can't be doing with this. So I didn't." C248</i>
Patients have to desensitize themselves to the distress of reading about MND	<i>"I had to sort of desensitise myself." P172 "Oh I do now. Once it got going a bit, I know what sort of things are involved then I started to go. I read half an hour, cry, give up. But now I can read it and it doesn't really bother me. So I go on the MNDA site, on the forum, everything day and read what everybody else has put. So I think I've become interested." P172</i>
Info from MND Association could be distressing	<i>"Well it's interesting... to read about other people's reports on how they tackle it... and some [is] distressing ... and being so young is quite distressing. C062</i>
Info from MND Association could be helpful	<i>"I like the MND website because you've got the different things to look at and you can look at them when you want to, like the end of life care and end of life decisions, and they're not just there in your face after some other part of information as well" P408</i>
Clinicians had a negative attitude to the internet	<i>"I remember when ...I was first diagnosed...[MND consultant] said "...don't go home and turn the internet on because ...you'll just crumble in a heap when you've read it, so forget it." And so... I never have done, I've just looked up things that I've needed to know." P248 "And they said to me: "Don't got on the internet." So I didn't. So I had no idea, really." P172</i>
Needing to be ready to learn	<i>"I suppose if I read, "You've got an illness that might go up and down, but you might not die next year", that would have been nice, but I don't think there would have been because I wasn't ready to know." P172</i>
The internet fills the void when little knowledge given	<i>"P: When we went to see ...[MND consultant] a couple of months later and she said, don't go looking on the internet any more... P: ...and that was fine but when you're on your own in the first stages that is what you do." P380</i>
Some wanted to research everything	<i>"So I then went home and with the use of the internet researched everything I could find about the disease" P232</i>

A5.17 Participants attitudes towards the frequency of TiM sessions.

<b>TiM session frequency</b>	
Weekly sessions acceptable	<i>"Maybe once or twice a week would be enough."</i> <i>C063 (Frequent user)</i>
Weekly sessions make it part of routine	<i>"I'll keep it to Tuesday and do it every Tuesday while I'm working at home and I'll have peace and quiet."</i> P122 (Excellent user) <i>"I was quite happy using it weekly, cos things can change so quickly...I'm a terrible, I'd forget when I'd done it the last time and ... doing it maybe on the thirtieth of every month, I'd forget..."</i> C392 (excellent user)
Varying frequency according to speed of progression	<i>"Q: How often do you think you'd need to do it to make it worthwhile...?"</i> <i>P: Probably every month.</i> <i>Q: ...and if things changed how would you then approach it, would you go back and do it again or would you wait for the month...?"</i> <i>P: If things were changing quicker I'd go back in and do it again..."</i> P423 (Excellent user)
Carers may do it less often	<i>"Maybe carers don't need to do it quite as often but ... maybe you would ask people how often they wanted to do it and maybe they would start at once a month and then as things progressed they did it a bit more often"</i> C378 (control)

A5.18 Reasons for frequent and infrequent adherence to TiM identified during the interviews.

<b>Reasons for missing individual sessions</b>	
Forgetting to use the TiM	<i>"I can't stand on my own so C has to bring it in here because I don't like to do it when he's working. So then I forget." P172 (Infrequent user)</i>
Patient and carer not doing it together	<i>"I'll do it and just leave it on the arm of the chair or something and say, "You need to do it". I don't know if she has on not." P122 (Excellent user)</i>
Holidays	<i>"Oh dead easy; I know we do miss some weeks, but we've been, you know, if we, if we're away and we don't take it with us, we leave it here." P317 (Infrequent user)</i>
Acute illness	<i>"We just didn't do it, he weren't fit enough to do it." C228 (Frequent user) "...when he was not very well he just couldn't be bothered." C366 (Excellent user)</i>
Technical difficulties	See Table 6.1 & 6.2
<b>Reasons for infrequent adherence</b>	
Poor health state at the start of the study	Reported in field notes made during calls with relatives.
Being too busy / having other priorities	<i>"It's just, with, with all the renovations and stuff it's sort of not become a priority at the moment." P134 (Infrequent user)</i>
Not receiving feedback and becoming demoralized with the TiM system	<i>"I have not received any feedback / contact from the STH MND team while using the TiM" P047</i>
No current need for MND services so not seeing a benefit of TiM to their care	<i>"Well there'd be no point, would there?" P317 (Infrequent user)</i>
Unable to access the TiM tablet out without assistance	<i>"I can't stand on my own so C has to bring it in here because I don't like to do it when he's working. So then I forget." P172 (Infrequent user)</i>
<b>Facilitators of frequent adherence</b>	
Using TiM on the same day each week	<i>"We always, always remember that it's on a Thursday." P392 (Excellent user)</i>
Phone alarm reminders	<i>"Q: If it sends you an alarm reminder, would that be an annoyance...? P: No, it would probably be more of a trigger for me to do it" P134 (Infrequent user)</i>
Family members reminding them	<i>"Our grand daughter rings us at about 7 o'clock to remind us. Then we finish up doing it on a Thursday morning." P217 (Frequent user)</i>
Being able to use TiM on their own device	<i>"If it worked on my phone there would be no issue whatsoever, cos I do everything on there; I shop... I can control lights, heating, everything on the phone. I think if TiM worked on there then you would get your responses every week." P134 (Infrequent user)</i>

A5.19 Participants' initial impressions of using the TiM app.

<b>Initial use of the app</b>	
Easy to use	<i>"It's so easy to do; it literally takes five minutes from home." P317 [daily technology user]</i>
Quick to use	<i>"It's not a problem is it? It takes minutes, it's not like you have to sit there for half a day and do it, it literally, it's, it's sort of minutes." P248 [daily technology user]</i>
TiM accessible and acceptable to the elderly	<i>"So this lady [P217], she's an elderly lady who you thought wouldn't have embraced anything like this. But she has done and she, her and her husband both send it back; she's very disabled but able to use her hands quite well...they're both in their eighties; and she's a very good replier, sends it in." Telehealth nurse</i>
TiM accessible to those with significant disabilities	<i>"[There are] some are patients that, I'm surprised they took it up. I'm surprised; actually that, that, I never thought that he would use that... and he sends his back very, very well." Telehealth nurse</i>
Confidence the information would be held securely	<i>"I'm assuming that your department is one that's reasonably secure and has got reasonable standards... I can only make my judgement on the people I meet who are involved in it." C166</i>

A5.20 The characteristics of those lacking confidence in technology user and their approach to using technology.

<b>Characteristics of those with low technology confidence</b>	
Unsure if they would be able to use the TiM	<i>"...we're quite happy to deal with it, as long as it wasn't too techy" C062 [uses technology a few times a week] "...as long as I can do it" P392 [uses technology daily]</i>
Lack of experience using technology	<i>"I don't use the internet for my job and it's all still paperwork orientated" C395 [uses technology daily]</i>
Difficulties with language	<i>"C: It's the system that's all. I don't catch on very well with it, that's ok. Like phones, I don't bother them really. P: Couldn't read a text message. C: couldn't do anything like that." C217 [never uses technology]</i>
Frightened they might make the TiM go wrong	<i>"Q: Have you used any of the other things that are on the tablet, so the education things or the website? P: Oh I daren't touch all that stuff in case it goes wrong. (laughs)...I pressed that one day and I got a bit panicky (laughter) so I... left it...I just use it for the questionnaire now and that's it." P145 [uses technology daily]</i>
Frightened they might break it	<i>"...plus it doesn't belong to us and if we broke it we'd be devastated" C145 [uses technology daily]</i>
Frightened they will enter wrong information	<i>"My fingers are too heavy. ... I'll end up phoning somebody." P378 [once a week technology user]</i>
Technology use is stressful	<i>"But I can... if I'm, if I'm taught ...without aggravation." C380 [uses technology every few weeks]</i>
Problems using technology perceived as failure	<i>"I tried to order a book on it last week and I can't do it (laughs) it kept, I've lost passwords and all sorts..." C392 [uses technology daily]</i>
<b>Low user's approach to technology</b>	
Use technology for only a limited number of familiar purposes	<i>"I have used the computer for various things, and if I'm using it for something and I know what I'm doing, that's fine; I can get on for certain things now..." C380 [uses technology every few weeks]</i>
Avoids using unfamiliar technology	<i>"Q: And, and you say you were a little bit worried about the technical side? C: Well I am, I was... I can manage things... I use Kindle and a laptop. Computers are a bit more of a thinker... (laughs) and...I don't do them all the time so I'm all right with basic stuff." C062 [uses technology a few times a week] "I know basically how to navigate [his own device], whereas [the TiM] I don't." P145 [uses technology daily]</i>
Unable to problem solve: relies on others	<i>"Q: And what do you do if you get, get stuck on a problem? C: Have to wait till me daughter-in-law comes up and get her to sort it out for me." C392 [uses technology daily]</i>

A5.21 Negative attitudes to technology expressed by participants.

<b>Negative attitudes towards technology</b>	
Lacking an interest in technology	<i>"It doesn't really interest me, if I'm being honest." C392 [uses technology daily]</i>
Not seeing a need for technology	<i>"I'm not against it but I don't want it and I can do without it and I don't need it." C166 [never uses technology]</i>
Feeling pressured to use technology	<i>"All the time we're being pressured [by people] that take all this marvellous technology up; and every day it is getting worse and worse, because it's getting beyond the control of the average person how to manage it properly." C166 [never uses technology]</i>
Feeling excluded/missing out if not using technology	<i>"I do feel...a slight social outcast, but I seem to be very much in the minority." C166 [never uses technology]</i>
Worried about the consequences of technology misuse	<i>"... certain things are very useful [but] once it gets to the mass market...it of gets exploded and misused. ... You've got to the point of small businesses being blackmailed by hackers." C166 [never uses technology]</i>
Worried about online security	<i>"And as for banking online, God, it's a laugh, I would not touch it...if something goes wrong you have the devil's own job to try and put it right because there's no proof." C166 [never uses technology]</i>
Worried about intrusion into their privacy	<i>"I wouldn't have a Smartphone for a start, you know cos Big Brother's up there already." C166 [never uses technology]</i>
Previous negative experience using technology that was unreliable	<i>"...eventually these programs got more and more complicated and the time it was taking for sending information down and getting back was absolutely ludicrous; the thing would crash say at eleven o'clock on a Monday morning and you'd have to start all over again." C166 [never uses technology]</i>
Technology is an unwanted replacement for human contact	<i>"They can't pick up a phone normally anymore because they're so busy faffing about with their smart phones." C166 [never uses technology]</i>

A5.22 Facilitators for TiM use.

<b>Facilitators for TiM use</b>	
<b>Improving confidence using the TiM</b>	
Face to face training	<i>"I would take it up if I was shown that the program was spot on" C166</i>
Clear instructions	<i>"...That the instructions were aimed at an idiot like me... and not on the assumption that I would know what to do, cos half the instructions are based on the person knowing what they're gonna do, so it seems to me." C166</i>
Participants realising it's easy to use	<i>"I thought I wouldn't be able to do it (laughter) but I can... I'm not really... I don't want computer or anything like that, you know, so it's only that only because of that." C228</i>
Using it weekly to develop skills	<i>"I was quite happy using it weekly, cos things can change so quickly...I'm a terrible, I'd forget when I'd done it the last time," C392</i>
Enabling others to help them use it	<i>"He's got used to it as long as I set it up." P217</i>
Seeing a purpose to use technology	<i>"It's unbelievable that sort of technology, but equally it's open to anybody to get into it. So, I might be persuaded eventually, but [laughs] it's a slow process" C166</i>
<b>Facilitators to use by those with disabilities</b>	
Stylus pen helped patients with upper limb disabled	<i>"Q: You mention you've got some problems with your hands. How do you find using your iPad? P: It's a lot better since you gave me this [stylus] So I don't hold it like a button. Other than that it's great. Q: Have you got any other gadgets like that? P: No. [to C] You ordered some more because you liked it didn't you?" P172 [daily technology user]</i>
Touch screen is accessible	<i>"It's fine. I mean it's getting more awkward to me, for me cos obviously my hands are [weak], but, it's quite easy. Yeah, the touch screen, it's better than if you had to press this keyboard sort of thing." P056 [daily technology user]</i>
Use patients' own device	<i>"I think it'll probably have more of a take-up with people using their own device, because ... I'm comfortable with my phone." P134 [daily technology user]</i>
Family/carers enter information on patients' behalf	<i>"Q: ... is it something that you'd ask your carers to do or your family...? P: Yeah, yeah, definitely. Q: ... would you have any concerns in them seeing your answers and that sort of thing? P: No, I'd rather have the family do it rather than the carer do it, but I wouldn't have any problem, the family seeing it at all." P056 [daily technology user]</i>



A5.23 Participants' expectations of the potential communication and monitoring benefits of the TiM service.

<b>Potential benefits of the TiM identified by participants</b>	
<b>Improved communication with MND team</b>	
Increase speed of communication	<i>"If I put it on the tablet and I send it to you, you get it there and then. So if anything ... happens to me in that period of time you know straightaway ... So the quicker you can pick up on so, something it's better for you as a doctor as well as me as a patient." P091</i>
Increase frequency of communication	<i>"And you know somebody within the team is going to look at that information. So you are connected, once a week. So it's not every three months." C184</i>
Provides a direct connection with specialists	<i>"Well I'd read up about the telemed and I thought, well it gives you a direct connection with Sheffield and the team. I know it's an IT link but it's a definite link because once a week you are communicating with a team." C184</i>
Improve communication and liaison with other members of the MDT	<i>"Well I can't see there's a different way to what we're doing now; I'm quite surprised that you're all in communication really....I didn't know you spoke to [community MND team], and I didn't that [GP] and you and the hospital were quite so connected, so that seemed to be quite a positive thing." P354</i>
<b>Increased monitoring</b>	
To identify problems quickly	<i>"It just seemed a way of being able to communicate with, with my care team and letting them know on a regular basis how you're doing; and no doubt at the end of it (...) it flags up that I need help or I don't need help." P134</i>
To identify problems between clinic appointments	<i>"I thought it'd be a good idea for both of us, but mainly for P and, because it is a long time between the hospital appointments, and I thought well it's a good idea to monitor symptoms if they crop up out of the blue and we're not sure whether it's anything..." C062</i>
Enables a better understanding of the disease	<i>"When, when P started off with the home journey we, it was obviously dizzy spells.... So I said well we'll just keep a diary of what's happening so you yourself know what's happening, so that's what he's doing, and in effect, this is what, your telehealth could do eventually is sort of monitor people..." C091</i>
Enable self monitoring	<i>"So we can monitor ourselves as well at the same time. So it's helping you in the long run as well...I think you've gotta monitor yourself so you know how, what you can do and what you can't do. It's, you can't just rely on everybody on the end of a phone, pick up and say, you know, I've got this, that and the other. You've gotta look at health and safety for yourself as well, for whether you can walk or whether you can run or whether you can open a door or open a lid or carry a glass or whatever, you know, at the end of the day that's monitoring yourself, so you've gotta do it." P091</i>

A5.24 Participants' expectations of the potential benefits of the TiM service.

<b>Potential benefits of the TiM identified by participants</b>	
<b>Psychological benefits</b>	
Clinicians take an interest	<i>"Somebody's taking an interest, somebody's wanting to know" C184</i>
Reducing isolation	<i>"You're not going to feel isolated." C184</i>
Reassurance	<i>"Sometimes it's just the fact that, "should somebody know about this?" or "should you be telling somebody that." Wouldn't it be nice if somebody knew this. Just small details that you sometimes think, "Does it make a difference if somebody knew about it?" And that telemed makes that difference." C184</i>
<b>Improve accessibility of the MND service</b>	
Reduce clinic appointments	<i>"If you can glean enough information of what I send through so I don't have to come to the hospital, I think that's a positive" P354</i>
Provide access to MDT when unable to travel to clinic	<i>" We just thought it would be quite good cos not everybody can get into clinic and thinking about the later stages, but it's still important to monitor how things are going" P480</i>
Reduce travel time	<i>"that would then cut down my travel time to clinic, you know, clinic doesn't really fulfil a great deal in my life other than ticking some boxes and sort of knowing where the progression's going but, you know, I think most of that now can be done through this server, through TiM." P134</i>

A5.25 The acceptability of the TiM questions.

<b>Acceptability of the TiM questions</b>	
Patients wanted the TiM to include questions about all aspects of MND	<p><i>"I've found the questions, I think they're all relevant. And, ... it might be in the future when things do, if things do get worse it might be I might need those questions to highlight things and that's quite, quite comforting."</i> P423</p> <p><i>"There's one question about you use a feeding PEG. I don't at the minute so that's not relevant to me at the moment. But obviously as time goes by it, it will be. I think I just put, "no", I don't use one... But I think it should be on there because, ... in time I probably will be using one."</i> P145</p>
Emotional wellbeing questions were welcomed	<p><i>"I think it's important to find out, not just physically, how a disease affects somebody but how, emotionally, mentally it affects them. As a say, I'm quite a positive person, but, I have some off days."</i> P122</p>
Carers happy sharing their sensitive information	<p><i>"Q: The sort of questions that they're asking you, quite, they're quite personal questions, aren't they...? How you feel about sharing those?"</i></p> <p><i>C: No problem."</i> C392</p>
Questions made patients think about the consequences of their disease, but this was not a problem	<p><i>"Q: How does it feel having to sort of be faced with that question [about gastrostomy tubes]?"</i></p> <p><i>P: ... when I first did that it was dead easy cos I just put "no" ... and just moved on. But since then, since we've been to this Advance Care [planning] thing. ...And that, that sort of brought it to the fore ... it's a thought that I wouldn't really wanna think about, but you've gotta think about, so I think on that one, is that something I shall maybe ask more to get more advice on."</i> P248</p>
Reporting a deterioration on the TiM was not distressing	<p><i>"I think: am I getting worse? But, yes, am I getting worse... I don't think any of the questions are really frightening. You know it might happen."</i> P172</p> <p><i>"in a sense it's good that you can change, you know, the, keep every, everybody up-to-date. Cos you don't know when things are going to change anyway, do we, we don't, you know, it's just, it's like a bit of a, a grey area isn't it? ... as long as people who need to know see that information then it's ... not waiting till your next visit at the clinic is it...?"</i> P122</p>
Wanting questions that assessed how they were coping	<p><i>"Maybe if they say, "No, I've not been out for a fortnight", that it makes them think: well, actually why haven't I? And it would highlight that person's not getting out of the house and not doing something themselves and they are continually there. Do they need a bit more support?"</i> C122</p>
Questions were repetitive	<p><i>"It's repetitive. ... I pick it up and I think oh God, here we go again, same old, same old. [I] put a couple ...more different ones in,... but no, the questions are right..."</i> C145</p>
Questions become irrelevant if disability severe	<p><i>"As I am unable to use my arms and legs at all, many of the questions have become irrelevant to me beyond the first time of using it."</i> P047</p>

A5.26 The validity / accuracy of the TiM questions.

<b>The validity/accuracy of the TiM questions</b>	
Patients want answers to be accurate	<i>"If I've got a form I like to fill it in as accurately as possible."</i> P248
Patients were concerned that their answers would be misleading	<i>"I have lost weight [a few weeks ago] but I haven't [lost weight in the last week]. The way I'm reading it now... sounds like I'm still losing weight, well I'm not...I wouldn't like 'em to think looking at it, or you looking at it in Sheffield and thinking "God, he's still losing weight" P248</i>
The answers are insufficient to reflect small changes	<i>"Sometimes they answers to chose are too far apart so if the answer is one day a week, I answer no, or several, it's nearer several. So it's accurate but it's wide." P172</i> <i>"The questions are quite in a narrow band, and because it's a slow-burner not much changes unless there's a step change, such as ...the chest infection the other week." P354</i>
The condition varied from day to day making weekly assessments difficult	<i>"I thought: if I was doing the questionnaire on that day, "what sort of assistance do you get from your family? The answer would be off the scale somewhere. I thought: some of the questions don't quite fit the answer. So I try to put the most representative" C172</i> <i>"I think some of the questions are a bit too general and wide rather than, for instance... what can I not do with my hand that I used to do, and how am I dealing with it." P166</i>
Informal care requirement questions were difficult to answer	<i>"The margins are too wide. One of the questions is, how much time do you spend in the day looking after her? And, there's a sort of, there's 3-4 hours. But I don't even look after myself for 3-4 hours, I just potter around. That's always gonna be the same answer." C172</i>
Some questions contradicted each other	<i>There are some questions on there that are bit ambiguous for me [for example] being able to use the stairs. Well I can't use the stairs but I still have a bathroom upstairs so I still walk from the top of the stairs to our bedroom." P134</i>
Patients wanted to provide more information to clarify their answers	<i>"... if you have any more questions to ask you've got that... availability to ask [the MND team] if you have any problems..." P056</i> <i>"If you want to ask anything maybe you could type it in instead of it just being yes/no" CaT Patient 317</i> <i>"I think that, that would be a good addition. Because you, you could answer a question and at the end of the section just put in, and just expand on what, why you've answered that, if you see what I mean? I think a comments box would be a good idea." P122</i>
Same problems identified every week	<i>"It's a probably the same answer I give every week... It says; "Do you stumble or feel that you fall, or have you fallen?" And I do, every single week, I guarantee that" P122</i>
Answer affected by other health problems	<i>"So at the minute I'm slightly doctoring the answer; so I'm saying I can dress myself but I can't, but it's not the MND." P381</i>

A5.27 Participants understanding of the TiM service.

<b>Aims of the TiM service:</b>	
Monitoring	<i>"For you to be aware of it, and monitor it..." P402</i>
Relay information to the MND team	<i>"It shows how you're feeling which gets then relays to the nursing staff. If you've any questions you've got the item on it where you can ... ask that as well... I would think... it's read, isn't it, and then probably recorded somewhere." P056</i>
Look for trends	<i>"I would say they are probably going on to some sort of graph that detects a trend. I mean with me, you wont get a trend because sometimes you are up and sometimes I'm down. It'll look like a [gestured up and down]. But I would imagine the ideal situation is when you can detect a trend but that does depend on what's happening." C172</i>
Provides trends and alerts to problems	<i>"I'm guessing that it comes to someone's desk and that they're able to see a chart... from week to week, and I would imagine that there would be a series of red flags for you or some traffic light system... that red's intervention required, amber's a warning, green's get on with it.." P134</i>
Prioritise patients in need	<i>"I could see the reason why you were doing it; I realised that all the data was going to be collated and you can see then at a glance... you can see the statistics and everything, and it would highlight to you... if I had a dramatic change." P317</i>
Data would be used for research	<i>"I didn't realise that that's what was going to happen, I thought it was just being used for research." C392</i> <i>"I would assume it goes to some databank somewhere and they try and correlate the answers I've given with, perhaps somebody else ... to see if there is any common ground."P122</i> <i>"I imagine it goes onto a database ... and then if yourself and [Professor] are ever doing any research they may be able to...or if there's any trials you might be able to select from that who would be suitable for that trial." P 317</i>
Both clinical care and research	<i>"I imagine it goes on a survey of all the people you're doing to compare us with each other, and also to follow my own progress." P166</i>
<b>The role of the Telehealth Nurse</b>	
TiM Nurse looked at data	<i>"It shows how you're feeling which gets then relays to the nursing staff, doesn't it." P056</i>
EH was looking at data	<i>"I didn't realise that [Telehealth Nurse] was involved and she would ring us if our answers drastically changed, cos obviously they've stayed very much the same. Then I'm quite encouraged by that, I just presume that you do it yourself...and if you'd got a problem you'd ring [Telehealth Nurse] up for a bit of help." C392</i>
Unsure who looked at data	<i>"I'm guessing that it comes to someone's desk and that they're able to see a chart" P134</i> <i>"The ones that have spoke about it to me I don't think they realise that I'm seeing their responses." Telehealth Nurse</i>

A5.28 Nurses' experience of using the TiM clinical portal. All quotes are from the Telehealth Nurse.

<b>Using the clinical portal</b>	
Easy to use	<i>"The training that I've had from seeing it this side was brief from Esther and it's, it's never, it's not difficult so it, I find I, right from the beginning I found logging on has been the most difficult thing, so; but once you're on finding your way around it is very, very easy, very easy,"</i>
Low burden	<i>"It only takes minutes"</i>
Easy to understand the flag system	<i>"If everything's OK it's green, ... [if] there's maybe some elements that might need to be looked at, it's an orange or yellow, and then if there's an alert it's a red one."</i>
IT support for passwords required	<i>"My main problem was me accessing it to begin with, and that was very problematic. It's just asked me to change me password."</i>
Nurse didn't know how to use the patient TiM app or resolve technical problems	<i>"N: I have had a couple of phone calls, cos [the participants have] got my contact number through this, and they've rung with a problem, usually a logging on problem and... Q: Forgotten their password? N: Yeah...I've asked Esther, to be honest, because I'm not familiar with their device."</i>

A5.29 The accuracy and sensitive of the TiM information. Quotes are from the Telehealth Nurse (N) unless otherwise stated.

<b>Accuracy of the TiM information</b>	
Information accurate to help make some decisions	<p><i>"N: [EH] has led me to believe that it's quite easy to red flag on the carer. So this chap is triggering ... [reads the PHQ4 questions] So I mean ... the four that are triggering, they're all about...</i></p> <p><i>Q: Worry, stress?</i></p> <p><i>N: Yeah, thoughts: yeah. I know how poorly this lady is, I know how disabled she is, and I do know him, and when you speak to him he's very blasé about it all, which actually is more of a worry."</i></p>
Information in TiM wasn't sufficiently detailed enough to be sensitive	<p><i>"N: ...I think if they're routinely sending us an update every week I think you're more likely to pick up on problems, but I don't... I thought that would be so.</i></p> <p><i>Q: Is that, do you think that's happened?</i></p> <p><i>N: No not really. I don't know that the questions are sensitive enough, and I suppose the thing is that it might, if it triggers a contact phone call then you may well pick up on things sooner." (early interview)</i></p>
Needed more information	<p><i>"N: It's almost like you need a two-way thing (laughs) you need to ask them a question, [for example] how long have you been coughing... are you bringing anything up when you're coughing... you know, that type of thing... have you had a temperature... it's almost like [laughs] you need a two-way communication, cos this is just a snapshot, isn't it..."</i></p>
Discussions are required to fully understand a problem	<p><i>"I think some of the problems with patients using NIV, very specific problems, you only pick up from a conversation with them. I don't think you pick it up on the Tele, cos it's [the way] it's structured, it might show a problem but not a specific problem."</i></p>
An additional comment box would help gain more detailed information	<p><i>"Q: Yeah. Do you have, would you have time to read the comment boxes?</i></p> <p><i>TW: I would hope so. You'd have to make time. If it was a problem that was coming up all the time, yes, I would hope that that; in some ways that might save you time."</i></p>

### A5.30 Participants' experiences of how the TiM impacted on their care.

<b>Impact on if TiM on patient care</b>	
Improves knowledge	<i>"Because since I've done it I'm taking more notice of my weight but I didn't before so I know it very carefully. It made me aware of that." P172</i>
Close monitoring	<i>"I'm certainly not left alone for more than a month, ever...Sheffield is there if I really need them, but on the other hand [local team] is here." P166</i>
Reassurance to know being monitored	<i>"I think the benefit to P is real. Because... somebody is there on hand looking at things... Because it's slow with P and he doesn't need as much attention and care, it's easy to feel detached from any positive interaction." C122</i>
Keeping in touch with specialist	<i>"...it's knowing that somebody else is in your corner." C423</i> <i>Q: Do you think there might have been a point in your disease where those questions ...were useful?</i> <i>P: Nearer the beginning, definitely. I think, and I can only guess, that it must be the same for lots of long-term conditions; you know, I've lived with this for over five years now... you get to understand your own body and you know it's, it's normal for me now and for the first year no day was normal, no day looked like any other day in my life before that. So... if I could have camped in [MND consultant]'s house for the first six months I would have done, just so she was there, so I could say, but what about this, what about that; and you imagine symptoms, or I did, you know, you think God, this is happening and that must be related to the MND... So in the first year I would have filled that in every day, just to have that touch point," P047</i>
Nurse giving advice	<i>"When I came back on Tuesday last week and I did the second questionnaire, and within a day [Telehealth Nurse] saying "I've got a red flag on one of your answers." And it's the fact that I'd fallen twice while I was away on holiday and I'd put on it, you know: it said "have you fallen recently, how many times?" and I'd fallen twice while I was on holiday. So she phoned me, and said, "Are you ok? Is there a reason why you fell?" No, just my usual clumsiness....</i> <i>Q: Were you expecting her to call?</i> <i>P: No, I wasn't actually. It was just a bolt out of the view...I find that quite positive. It shows that the whole idea of it works.</i> <i>Q: Has it changed your behaviour at all?</i> <i>P: No. Not really." P122</i>
Nurse identifying problems	<i>"Q: [Telehealth Nurse] called, I think she spoke to you about when you fell...  P: Mm.  Q: ...what did you think about that when that happened?  P: It was useful wasn't it?  C: Well you weren't in so she spoke to me.  P: Yes, because I'd tripped over the bedroom chair...  C: that's right and, yes, that was the main thing, that's right, yeah. No, it was interesting that that, that had been picked up because we weren't, we don't know how it was picked up." P&amp;C166</i>
Identifying problems between clinic visits	<i>"When I filled it in last week, and within a day [Telehealth Nurse] was phoning me. How much better could you have that? Instead of, two months down the line and I attend the clinic and they say "how have you been, have you fallen?" and I say "oh yeah I did: two months ago". See where I'm coming from? You've got that instantaneous contact with this technology that perhaps you don't have without it. So I'm a great believer in that, I'm a great believer in technology." P122</i>
Supporting important decision making	<i>"Q: The other question I had was that we kept an eye on your weight and I wonder whether you think that may have influenced your decision to have a feeding tube or not; do you think it, do you think it had?  P: [writing] I was frightened by the speed of loss of weight but was convinced how much muscle I lost." P409</i>
Help accept the disease	<i>"The questions nudged me to facing what I could do and not what I can't." P409</i>



A5.31 The Telehealth Nurse's attitudes towards the value of the TiM. Quotes are all from the Telehealth Nurse

<b>The Telehealth Nurses' attitudes towards the value of the TiM</b>	
TiM could be valuable	<i>"As a tool to aid the patient and then aid the nurse"</i>
To identify problems between clinic visits	<i>"A number of patients with MND and their carers will wait till a clinic, instead of contacting us with, if they're, they're worried about something, or there's a change in their, you know, their condition, and I think if they're routinely sending us an update every week I think you're more likely to pick up on problems."</i>
Alerting to problems earlier	<i>"Q: So it could have a use maybe in alerting you to earlier need for intervention? N: Yeah, yeah."</i>
Help monitoring trends	<i>"I mean the weights have been quite interesting, cos if they can use the weighing scales ... that's been quite interesting, so we can monitor their weight... cos otherwise you wouldn't necessarily see that variation."</i>
TiM wouldn't have a negative impact on the service	<i>"Q: do you think a patient will be concerned this is trying to take away a part of the service, or do you think the clinical team might feel it's taking away part of the service? N: I don't think either side would. From a clinical side I think that anybody would be willing to make it as easy for the patient as possible."</i>
Clinics are a burden to patient	<i>"I think from the patient's point of view I think it becomes very burdensome, the travel into clinic, very much so...But certainly the, the travel and the amount of time and effort for them to come to clinic to sit in clinic to then go home again, it's very difficult for them."</i>
Patients do not see value in attending clinic	<i>"... [patients] sometimes say; "nothing, I don't get anything out of coming to clinic because you're reiterating the same things, I know I'm getting worse..." So there are some patients that don't see the value of coming to clinic anyway. Now whether they would use a system like this and see the value of that I don't know."</i>
TiM could allow patients to be managed remotely	<i>"I think it could. I think it's one of those difficult things that at the moment, because it's not something we systematically do. And they are attending clinic or I have connections with their community care team, so I am in touch with what's happening and things are getting monitored. I don't know."</i>
Some problems need face to face assessment	<i>"Q: How reliable this kind of technology would be in deciding when or, when to cancel an appointment for a patient? A: Oh I don't know, I don't know. Q: Would you feel secure looking at that saying that patient doesn't need to come in? A: I think, I think it depends, so when I look at, if it's a breathing problem and if I didn't know them and they were having problems with their breathing ...that would alert me and I would [think]: right we need... to contact, we need to be looking at this and monitoring it...I think it depends."</i>

A5.32 Participants attitudes towards clinician feedback.

<b>To act upon problems and provide feedback</b>	
Feedback reinforces the benefit of the TiM	<i>"I find that quite positive. It shows that the whole idea of it works." P122</i>
Not receiving feedback is demoralising	<i>"The emotional psychological depths that I've been to, I was putting the stuff in Telehealth and thinking but nobody's acknowledged this or contacted me about it, and I thought: well they're not going to because that isn't what the clinic's about, and that made me stop using it." P047</i> <i>"...it's like all forms and all surveys... they say "your opinion is important please fill in the following..." and you say something that you think is absolutely dramatic and mind blowing and nobody comes back to you on it. And you think: well how important is that survey?" C172</i>
To provide feedback even if nothing had changed	<i>"Q: And would you expect perhaps someone to tell you what's going on with the tablet or the answers? P: Yes. Because if I hadn't changed much, I would have thought I would have had some feedback."P172</i>
To acknowledge problems even if nothing can be done	<i>"[falls] ... knocks your confidence ...I probably were putting too much onus on Sheffield Hallam because (laughs) we've got this and there's not jack shit they can really do about this and we know that.. Q: But that kind of acknowledgement's quite important, do you think, of the, what happens ...? C: I do, yeah, it's a bit of support, in't it, it's knowing that somebody else is in your corner." C423</i>
MND team couldn't solve their problem	<i>"Q: If your answers changed what do you expect of the MND service? P: I don't, to be honest. Let's say if I thought I'd got a problem I wouldn't necessarily come to you because I don't think, I think, you know, I, the impression that it's medical to do with P, and if I have got a problem really; because when you flash up it does say if you, is to contact the, there is, so I would probably, I mean that's not part of your remit, is it, me really if I've got a problem?" C381</i> <i>"[emotional support] That's not what that clinic's about, that clinic's about physical wellbeing and physical health... truthfully I thought I don't know why these questions are in here, because that clinic isn't equipped to deal with that." P047</i>
Feedback thought to be pointless if nothing can be done	<i>"But then again, what's the point of coming back if you can't say anything?" C172</i>

A5.33 The mismatch between the participants' and nurses' expectations of the TiM service.

<b>Mismatch between patient and nurse expectations</b>	
Patients expected contact if they experienced important problems:	
Falls	<i>"Q: ...do you, do you think they're important things that she needs to know about?"</i>
Chest infections	<i>"Q: ...do you, do you think they're important things that she needs to know about?"</i>
Dysphagia	<i>P: I would say yeah... cos one of the questions is have you fallen or tripped? Obviously if I am falling more often, (well I am, I fell a few weeks ago, didn't I? but that, that's first time in months...). If I was falling ... over every week I would say that, yeah, she needs to know something like that, or if I'm starting to not eat me food properly, if I'm starting to cough, I think obviously she needs to know that" P145</i>
Emotional difficulties	<i>"Most of my problems at the time are emotional, and the TiM does not appear to trigger any intervention." P047</i>
Problems may not be seen as important to nurse	<i>"She red flagged that she'd fallen, which is quite a common occurrence on a lot of patients, and I don't particularly worry unless they've been very, very well and then suddenly." Telehealth Nurse</i>
Problems may not be seen as important to patients	<i>"Q: When you put that you had fallen, what were you expecting to happen? P: No. No. Q: And when you heard that [your OT] had heard about it, what did you think about that? P: Nothing really. Q: And, do you think in the future, if something were to happen to you, and you put on here, what would you expect to happen, what would you like to happen? P: I would think [Telehealth nurse] would ring. But the only thing is the over balancing, so far, isn't it." C217</i>
Problem may not be seen to be under the MND team's remit	<i>"[emotional support is] not what that clinic's about, that clinic's about physical wellbeing and physical health. To me, and in my own head, I thought it's never been about psychological wellbeing and your mental wellness and therefore; and truthfully I thought I don't know why these questions are in here, because that clinic isn't equipped to deal with that." P047</i>
Participants expecting contact when stable	<i>"It would be nice for someone to phone occasionally ... particularly if anything changes.: C172</i>
Not expecting a particular action: expect nurse to decide	<i>"Q: And what would you expect to happen if you did change your answers like that week? P: Not really, no, cos you know more than I do." P056 "I would tend to leave it to them to solve anything that needed solving." C217</i>

A5.34 The problems associated with excessive TiM alerts. All quotes are from the Telehealth Nurse unless indicated.

<b>Excessive TiM system alerts</b>	
The same alerts appear every week	<i>"We have some of our patients that do this every time... They ... cough or choke at least once a week."</i>
Alerts increase the time required to use the system and can cause frustration	<i>"Then when it was coming up every week... I knew I'd spoken to them about that [problem] and that was their choice. And I'd kept putting [a comment in the TiM notes] but you're sorta thinking; why do I have to keep putting it on every time?"</i>
Nurse can't control the alerts	<i>"If you know somebody's got a problem and they're not really trying to do anything about it, then you know that [alert is] gonna keep coming back every week; and I haven't been putting comments on all the time."</i>
Nurses may appear to not be acting on potentially dangerous problems	<sup>1</sup> <i>[reads] "Do you ever cough or choke on food?" And then he's put: "Occasionally", and that's fine."</i>
Problems flagged even though the patient has chosen not to medical advice to avoid the problem	<i>"cos I know that patient and I know that they've chosen to eat and that it is problematic. But they've got a feeding tube and they should really be using their feeding tube, but they're [also eating]. Then when it was coming up every week, I knew I'd spoken to them about that and that was that choice?"</i>
Reporting the same problems without solutions could be demoralising to patients	<i>"Maybe to them the fact that it's the same thing week in week out, they've got an insight into that problem, it's not changing and, so they're not looking for something to help with it really."</i>
Repeated problems on which no action could be taken should be paused to avoid excessive alerts	<i>"Q: Are there any other, other things that you'd change at the moment to make it, to improve the system? TW: Apart from the, the same red flags coming up every week with the same problem, having some way of either taking them off or say, or putting a comment in that, that would take it off by saying you've addressed this problem, it's, it's still gonna be there, it's not gonna change."</i>

A5.35 The problems associated with excessive TiM alerts. All quotes are from the Telehealth Nurse.

<b>Nurse reaction to alerts</b>	
Calls patient for more information	<i>"[I] ring the patient about it and ask them"</i>
Liaises with the community team to get more information	<i>"I try and get a bit more information, cos the, the community team may have been out and seen them and seen them face-to-face and have got something a little bit more useful back; so I have used it for that circumstance. And I'm in touch with the community team quite often, so sometimes if I'm ringing about something else I'll ask about one of the patients that's on here."</i>
Prefers to wait until clinic	<i>"I've seen somebody that was red flagged, cos they're coughing more..I've put a [TiM note] that we'll review in clinic next week."</i>
Will chose not respond to problems she thought were common in MND	<i>"She red flagged that she'd fallen, which is quite a common occurrence on a lot of patients. I don't particularly worry unless they've been very, very well and then suddenly. So if it happens over a few weeks and I've spoken to them and I know the situation...I'm not always alerted by that red flag."</i>
Using all the TiM information on the to make a decision	<i>"They were having problems with their breathing but I would look: are they on a breathing machine? No. That would alert me. So I think it depends."</i>
Patients and nurses prioritise different problems	<i>"I did the second questionnaire, and within a day the [Telehealth Nurse] calls saying "I've got a red flag on one of your answers." And it's the fact that I'd fallen twice while I was away on holiday... she phoned me, and said, "Are you ok? Is there a reason why you fell?" No, just my usual clumsiness.... Q: Were you expecting her to call? P: No, I wasn't...It was just a bolt out of the view... I find that quite positive. It shows that the whole idea of it works." P122</i>
Having a relationship with the patient made it easier for the nurse to call the patient	<i>"I think it helps me that I know the patients. So I know this chap very, very well, I have a relationship with him and his wife; ringing up's quite easy to do, they wouldn't, they wouldn't be fazed by that. My response would be; "oh there's been a red flag on the Telemedicine that you sent through, a message that you've sent through, and that's why I'm ringing". And that was quite an easy one."</i>
Harder to ring those who she didn't know	<i>"There are a small number of patients that I don't know, it just so happens that they've been very well through, so there hasn't really been any major alerts."</i>
Ringing carers may be difficult	<i>"If we've had a carer's response that's red flagging I don't always find that an easy phone call to make to a carer who's struggling."</i>
Patients not expecting her call	<i>"I rang a lady who I didn't know and she red flagged that she'd fallen... It was the lady's husband ... he was quite shocked that I'd rung cos I didn't know them and I just explained about it, and he just said "No, it was just a little trip, she's absolutely fine, no problem."</i>
Nurse doesn't feel her calls benefit patient	<i>"I've said "Oh you've had some problem with this?...I know because you sent a Telemedicine and I'm the one that looks at the problems and sees what's what." And they said "Oh right, oh yes, it's nothing, it's fine." I don't know..."</i>

### A5.36 Participants' attitudes towards the future of the TiM.

<b>Preferred way to communicate with MND team</b>	
Modes of communication depends on the individual	<p><i>Q: How do you think is the best way for people contact you?</i></p> <p><i>P: I think for me it'd be by phone, but again that will be depending on the carer and my speech. I mean I'm currently OK with the phone.</i></p> <p><i>Q: And how do you feel about email contact or contact through the Telehealth?</i></p> <p><i>P: Again that's fine by me, I use email, computer all the time, but again you'd have to judge that on the individual." P381</i></p>
Contact needs to be convenient	<p><i>"And phoning you up, I don't know about you but I hate phone calls: you are just settling down to have a nice cup of tea or a chocolate biscuit or whatever and the phone rings, you have someone trying to persuade you to change your heating systems" C172</i></p>
Alternative methods of communication add flexibility	<p><i>"I'm really happy ...communicating by email, because for me I can do it then in my own time, because I haven't got use of my hands and arms; so if I know that there's an email that I can read and then reply to in my own time, that's far more relaxed for me actually than the telephone... I can speak fine but the telephone, somebody has to hold it for me...if I'm not in exactly the right position it's not comfortable to take a r." P047</i></p>
Telephone may be uncomfortable for some	<p><i>"I feel a bit awkward on the phone, and you can't get across how you're really feeling on a phone anyway..I tend to get nervous when I'm on the phone and stuff and I forget what I'm saying to people." P423</i></p>
Dysarthria makes telephone hard	<p><i>C: [to P] Well telephone calls aren't that practical are they for you. Because if you are tired, I mean it's difficult to convey."C172</i></p>
Email may be impersonal	<p><i>"I think that's a bit impersonal email, you know, that, that's what I thought" C423</i></p>
Telephone useful for problems needing an immediate answer	<p><i>"If it's something that needs doing, dealing with here and now: the telephone, email is, is my favourite way of communicating, because it suits my condition.." P047</i></p>
Some subjects are better discussed face to face	<p><i>"I think it's not personal... I'd rather see somebody or talk to somebody than, than read about it on something on a screen." C366</i></p>
Happy to receive feedback in clinic	<p><i>"I realise that you are probably busy people, so I'm quite happy for someone to say, when we're down there, "oh by the way, your survey has altered and, you know, do you want to talk to you about it." C172</i></p>
Happy to wait for a reply as long as their message had been acknowledged	<p><i>Q: And if you put in a question... How long would you expect before you got an answer?</i></p> <p><i>P: Well normally [Telehealth Nurse] gets back to me within a day or so. So I would expect two days, almost maximum.</i></p> <p><i>Q: OK. So, reasonably quickly.</i></p> <p><i>P: Even if, it was: "we've got your question :we're thinking about it"</i></p> <p><i>Q: So, just an acknowledgement that you've email?</i></p> <p><i>P: Yeah. It may be [Telehealth Nurse] can't answer me first time. Like the citalopram. What she said was: "I'll discuss it with, (I think) you" and then came back to me." P381</i></p>
Importance of respiratory monitoring	<p><i>"Q: What do you think, how do you think this would fit in around your clinic visits and the support you would get from [Telehealth Nurse]? If this was to become...rather than a research project, part of standard care, how do you think you would suggest using it?</i></p> <p><i>P: Well I think in my case I would be happy to use that and lengthen the time between visits. I mean, the only difference to me is the breathing test." P381</i></p>
Happy to share the information with other members of the care team	<p><i>"Q: And is there, is there someone locally that you think would be, so that would be able to see your answers ...?</i></p> <p><i>P: Well a good one would be the GP, wouldn't they? Or even the hospice, or, even the district nurses, probably more the district nurses, cos obviously they've got a regular visit now, haven't they?" P056</i></p>

A5.37 The Telehealth Nurse's attitudes towards how the TiM might be used in the future. Quotes are all from the Telehealth Nurse

<b>How would the TiM be used?</b>	
Delegating TiM duties may not be possible	<i>"I agreed to do it originally cos I said the thing is when a red flag comes if it's somebody else doing it and looking at it they're gonna come to me."</i>
The nurse wants to use her judgement, not follow a strict protocol	<i>"The way this study is run at the moment I can respond in, in the way I think is appropriate" Telehealth Nurse "if it was written down, [that] I had to ring and I had to ring straightaway, ... I don't know whether, I would have found that quite difficult not being able to use my initiative and how I'm familiar with the patients and, don't know I might not have, I might have found that a bit more difficult."</i>
Some nurse may be more willing to follow a protocol and call more often	<i>"N: It's difficult, I think you would probably get more useful information out of the research nurses, but you would have to have a system where they'd be able to go to somebody to act upon what was [needed]" Telehealth Nurse "I think if it was a bigger study and.. it was a very ... carefully monitored study, I think maybe the person doing this, looking at this ... looking at what the replies have been, if they had to contact them that might work better."</i>

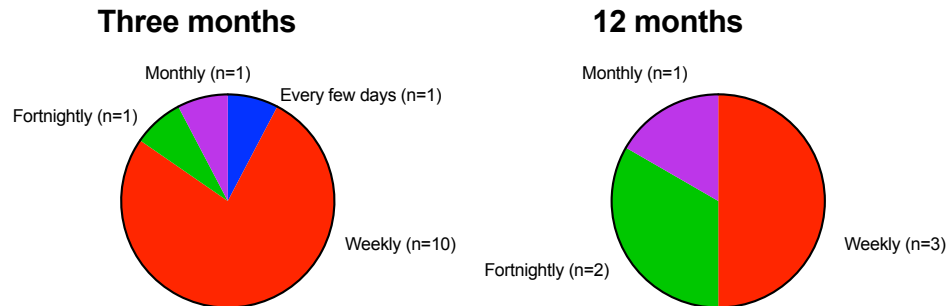
A5.38 How the TiM might be used by other teams

<b>Use by community teams</b>	
Community teams would need capacity	<i>"I think if they have the capacity it would be useful," Telehealth Nurse</i>
It would increase information available for community teams	<i>"Q: Could [you] see [the TiM] fitting into the role you play or whether you think it's not very helpful? N: I think it probably could because, like you've just said.. that [patient has] reported on here that she's ... coughing/choking so many times but she never said that to me." Community nurse</i>
Community staff may not have access to computers	<i>"I'm not very good at computers. I have to say, that is the thing I find most stressful about working here. You I'm home based. I go on NHS website...so I'm not on, well I can get onto it but I do not cos I don't spend a lot of time [in the hospital]."Community nurse</i>
Community staff happy to receive information from Telehealth Nurse	<i>"Q: If someone else was looking at this, telling you there's a problem? N: Yeah, no, that would be fine, that would be fine, yeah, yeah."Community nurse</i>
<b>Use by other MND centres</b>	
Other services would respond positively	<i>"I think their gut reaction is that that sounds something potentially helpful to us; I haven't really had any negativity" Telehealth Nurse</i>
Other services would want TiM if it saved them time	<i>"I think that if it saves them time I think that they would definitely embrace it." Telehealth Nurse</i>
Other services would want TiM if it benefited the patient	<i>"From a clinical side I think that anybody would be willing to make it as easy for the patient as possible, as long as it was useful." Telehealth Nurse</i>
Nurses would use it if it were part of their usual role	<i>"Q: But then if you were thinking about implementing this into the NHS who would you get the most useful information from? TW: I think if it was implemented and it was part of somebody's role every day they would just do it, they would do it automatically; and, yes, I could envision that it would be very useful. So I suppose I'm a bit, it's half and half." Telehealth Nurse</i>

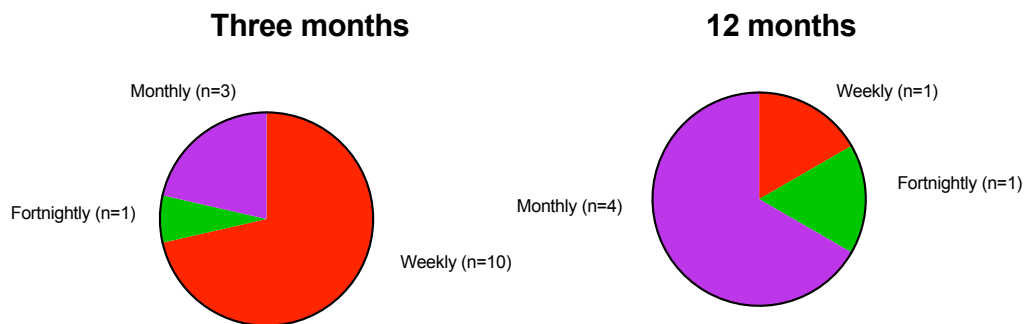


Appendix A Table 5.1 Patient and carer preferred frequency of TiM use.

## Patient preferred frequency of TiM use

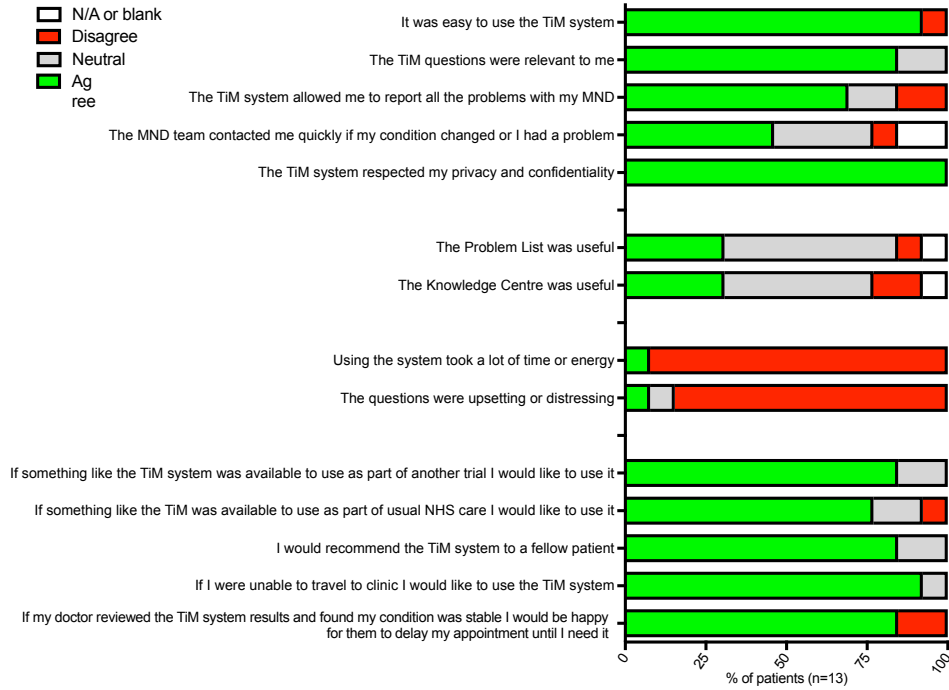


## Carer preferred frequency of TiM use

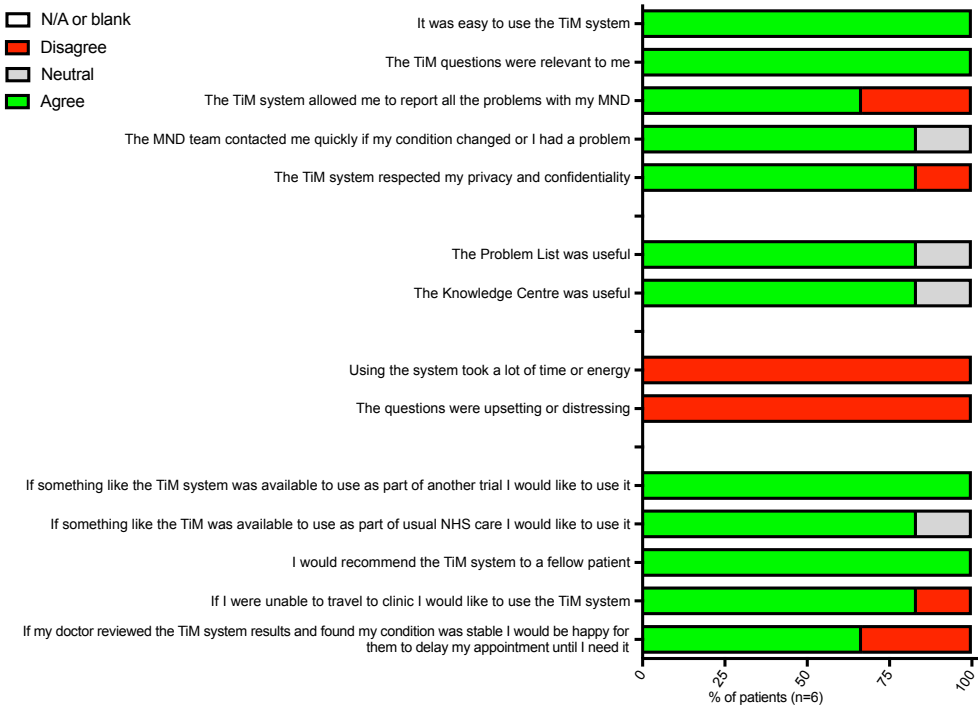


Appendix A Table 5.2 Patient satisfaction with Tim system at 3 and 12 months.

### Patient 3 months

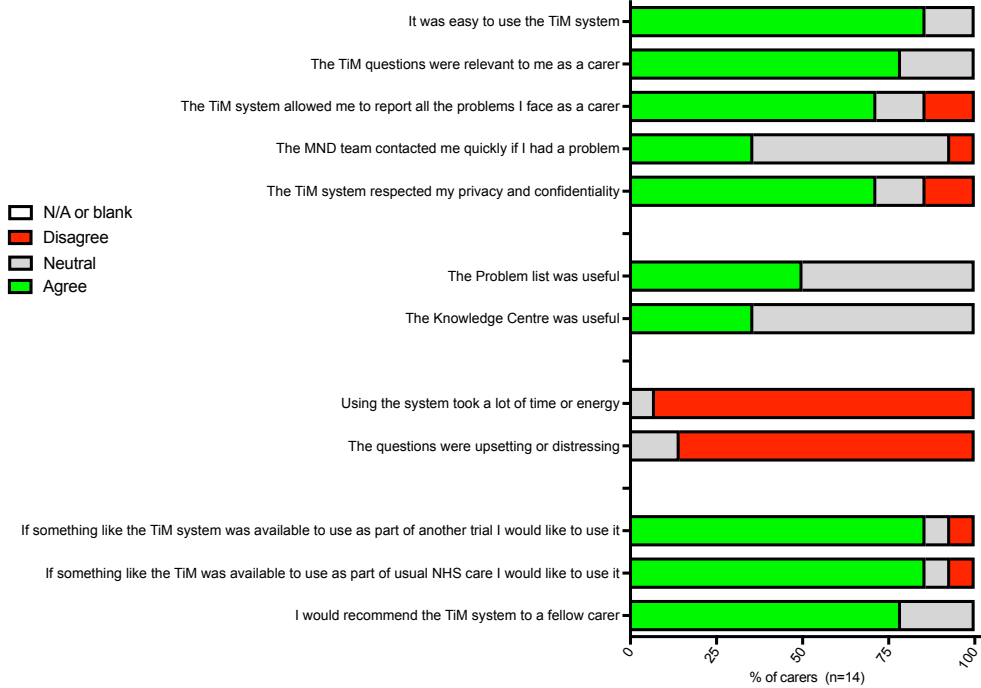


### Patient 12 months

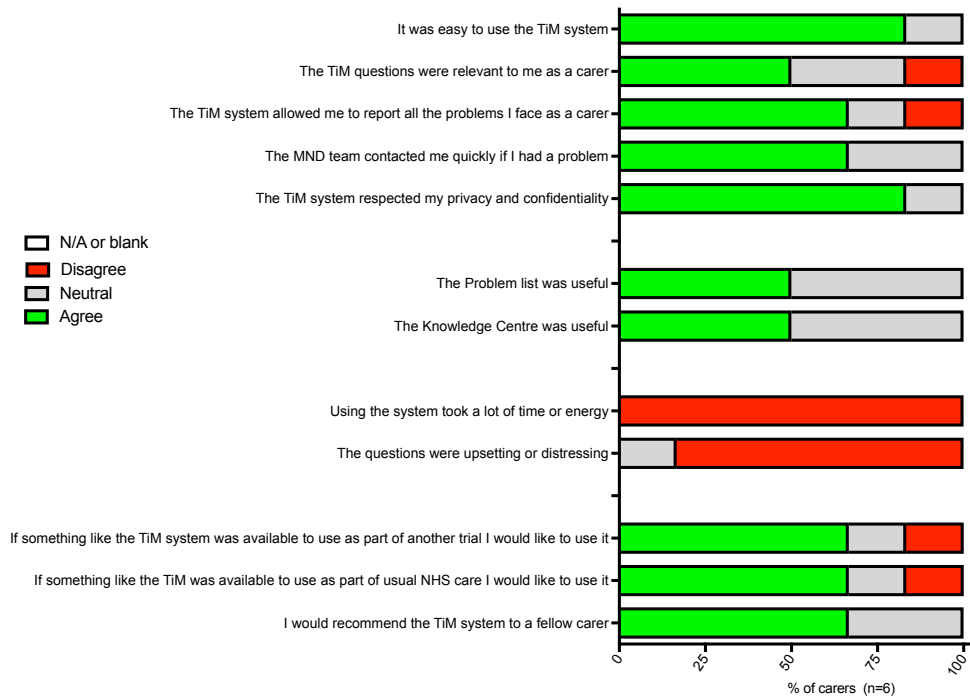


Appendix A Table 5.3 Carer satisfaction with Tim system at 3 and 12 months.

### Carer 3 months



### Carer 12 months



## Appendix B: Supporting data for Chapter 6

### Appendix 6.1

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### Appendix 6.2

- Q6.1 Participants' motivations and barriers to participation in research.
- Q6.2 Barriers to participation in research.
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- Q6.4 Participants' attitudes towards and knowledge of research.
- Q6.5 Participant reaction to the TiM research questionnaires.
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Appendix 6.1

A6.1 Patient-36 physical (PCS) and mental (MCS) sub-scores. The mean and standard deviation (SD) of the mean scores, the mean change from baseline and the 95% confidence interval of the mean change from baseline. These are standardised to a normative reference population in which the mean is 50 and Standard deviation is 10.

Patient SF-36	Base-line	3 months		6 months		12 months	
	Mean (SD)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)
<b>Telehealth</b>							
PCS	n=18	n=16	n=15	n=16	n=16	n=6	n=6
Mean (SD/CI)	30.1 (9.1)	30.7 (7.7)	-0.7 (-3.3, 1.9)	28.2 (8.6)	-3.1 (-7.1, 0.9)	22.6 (4.1)	-5.8 (-15.0, 3.4)
MCS	n=18	n=16	n=15	n=16	n=16	n=6	n=6
Mean (SD/CI)	52.3 (10.0)	50.7 (11.7)	-1.4 (-5.4, 2.6)	52.3 (12.3)	-0.2 (-4.2, 3.8)	48.8 (15.8)	-5.7 (-18.8, 7.2)
<b>Control</b>							
PCS	n=20	n=14	n=14	n=12	n=12	n=6	n=6
Mean (SD/CI)	28.0 (8.7)	26.6 (5.8)	-0.6 (-5.4, 4.3)	27.0 (7.9)	-0.1 (-7.8, 7.6)	23.7 (3.0)	-6.6 (-13.8, 0.5)
MCS	n=20	n=14	n=14	n=12	n=12	n=6	n=6
Mean (SD/CI)	54.3 (9.5)	55.1 (13.5)	0.9 (-5.4, 7.3)	50.8 (12.1)	-3.6 (-10.7, 3.6)	54.7 (9.2)	-1.3 (-17.8, 15.3)
<b>Total</b>							
PCS	n=38	n=30	n=29	n=28	n=28	n=12	n=12
Mean (SD/CI)	29.0 (8.8)	28.3 (7.2)	-0.7 (-3.2, 1.9)	27.7 (8.2)	-1.8 (-5.5, 1.9)	23.2 (3.5)	<b>-6.2 (-11.0, -1.4)</b>
MCS	n=38	n=30	n=29	n=28	n=28	n=12	n=12
Mean (SD/CI)	53.3 (9.7)	52.7 (12.6)	-0.3 (-3.8, 3.2)	51.7 (12.0)	-1.7 (-5.2, 1.9)	51.8 (12.7)	-3.5 (-12.2, 5.2)

A6.2 EQ-5D-3L and EQ-5D plus dignity bolt-on and the EQ5D thermometer. Scores range from 1 (best QoL) to -0.59 (worst QoL).  
Thermometer scores range from 100 (best QoL) to 0 (worst QoL).<sup>18</sup>

Patient	3 months			6 months			12 months		
	Mean (SD)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)		
<b>EQ-5D</b>									
Telehealth	n=17	n=16	n=14	n=16	n=15	n=6	n=6		
EQ5D-3L	0.52 (0.31)	0.49 (0.27)	-0.04 (-0.13, 0.05)	0.49 (0.30)	-0.07 (-0.20, 0.06)	0.39 (0.36)	-0.09 (-0.38, 0.21)		
EQ5D-3L+D	0.46 (0.40)	0.48 (0.30)	-0.02 (-0.18, 0.14)	0.47 (0.35)	-0.04 (-0.24, 0.16)	0.26 (0.54)	-0.15 (-0.63, 0.33)		
Thermometer	61.1 (22.5)	63.8 (25.0)	-2.1 (-8.7, 4.6)	61.6 (20.5)	-3.7 (-9.6, 2.3)	57.5 (22.3)	-5.8 (-12.8, 1.1)		
<b>Control</b>									
EQ5D-3L	n=20	n=15	n=15	n=12	n=12	n=6 <sup>19</sup>	n=6 <sup>3</sup>		
EQ5D-3L	0.53 (0.27)	0.50 (0.29)	0.02 (-0.10, 0.14)	0.46 (0.25)	-0.11 (-0.22, 0.01)	0.37 (0.33)	-0.25 (-0.50, 0.0)		
EQ5D-3L+D	0.49 (0.37)	0.44 (0.41)	0.01 (-0.10, 0.14)	0.44 (0.29)	-0.10 (-0.21, 0.01)	0.26 (0.48)	-0.27 (-0.59, 0.04)		
Thermometer	64.5 (20.6)	64.6 (26.8)	0.9 (-13.5, 15.4)	61.7 (25.3)	-6.7 (-19.8, 6.5)	60.9 (21.6)	-7.0 (-37.2, 23.2)		
<b>Total</b>									
EQ5D-3L	n=37	n=31	n=29	n=28	n=27	n=12 <sup>3</sup>	n=12 <sup>3</sup>		
EQ5D-3L	0.53 (0.29)	0.50 (0.27)	-0.01 (-0.01, 0.06)	0.47 (0.27)	<b>-0.09 (-0.17, -0.01)</b>	0.38 (0.33)	-0.17 (-0.33, 0.00)		
EQ5D-3L+D	0.48 (0.37)	0.46 (0.35)	-0.01 (-0.10, 0.08)	0.46 (0.32)	-0.07 (-0.18, 0.05)	0.26 (0.49)	-0.21 (-0.45, 0.03)		
Thermometer	63.0 (21.3)	64.2 (25.5)	-0.5 (-8.2, 7.1)	61.6 (23.0)	-5.0 (-11.2, 1.2)	59.3 (21.1)	-6.4 (-20.7, 7.7)		

<sup>18</sup> Patients who had died were excluded from analysis. The number of patients for whom scores were available was the same for the EQ5D-3L, EQ5D-3L+D. Three patients left the Mobility question blank, writing that they were neither able to walk (score 2) nor in confined to bed (score 3). The trial statistician agreed to score these as 2.

<sup>19</sup> Control group n=6 in EQ5D calculations and n=7 in thermometer calculations at both 6 and 12 months.

A6.3 EQ-5D-3L and EQ-5D plus dignity bolt-on and the EQ5D thermometer. In these calculations, patients who had died were included in the scoring and were assigned a score of 0. Thermometer scores are unchanged.

Patient EQ-5D	Base- line	3 months		6 months		12 months	
	Mean (SD)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)
<b>Telehealth</b>							
n= *	17	17	15	17	16	8	8
EQ5D-3L Mean (SD/CI)	0.52 (0.31)	0.46 (0.29)	-0.05 (-0.14, 0.03)	0.46 (0.31)	-0.08 (-0.20, 0.04)	0.35 (0.37)	-0.12 (-0.33, 0.08)
EQ5D-3L+D Mean (SD/CI)	0.46 (0.40)	0.44 (0.41)	-0.03 (-0.18, 0.12)	0.44 (0.35)	-0.05 (-0.23,0.14)	0.20 (0.47)	-0.17 (-0.50, 0.15)
Thermometer n=	17	16	14	16	15	6	6
Mean (SD/CI)	61.1 (22.5)	63.8 (25.0)	-2.1 (-8.7, 4.6)	61.6 (20.5)	-3.7 (-9.6, 2.3)	57.5 (22.3)	-5.8 (-12.8, 1,1)
<b>Control</b>							
n=*	20	15	15	14	14	8	7
EQ5D-3L Mean (SD/CI)	0.53 (0.28)	0.50 (0.28)	0.02 (-0.10, 0.14)	0.39 (0.28)	-0.12 (-0.26, 0.01)	0.28 (0.33)	-0.28 (-0.48, - 0.08)
EQ5D-3L+D Mean (SD/CI)	0.49 (0.37)	0.44 (0.41)	0.00 (-0.12, 0.12)	0.38 (0.31)	-0.08 (-0.23, 0.07)	0.19 (0.43)	-0.28 (-0.51, 0.10)
Thermometer n=	20	15	15	12	12	7	7
Mean (SD/CI)	64.5 (20.6)	64.6 (26.8)	0.9 (-13.5, 15.4)	61.7 (25.3)	-6.7 (-19.8, 6.5)	60.9 (21.6)	-7.0 (32.6)
<b>Total</b>							
n= *	37	32	30	31	30	16	15
EQ5D-3L Mean (SD/CI)	0.53 (0.29)	0.49 (0.28)	-0.02 (-0.09, 0.05)	0.43 (0.29)	-0.10 (-0.19, - 0.02)	0.29 (0.33)	-0.20 (-0.33, 0.08)
EQ5D-3L+D Mean (SD/CI)	0.48 (0.37)	0.44 (0.41)	-0.02 (-0.10, 0.07)	0.41 (0.33)	-0.06 (-0.18, 0.05)	0.20 (0.43)	-0.23 (-0.40, - 0.05)
Thermometer n=	37	31	29	28	27	13	13
Mean (SD/CI)	63.0 (21.3)	64.2 (25.5)	-0.5 (-8.2, 7.1)	61.6 (53.0)	-5.0 (-11.2, 1.2)	59.3 (21.1)	-6.4 (-20.7, 7.7)

Table 6.4: Patient ALSFRS-R scores. Scores range from 0 (severe disability) to 48 (no disability). Scores highlighted in bold indicate scores that have changed significantly from baseline.

	Baseline		3 months		6 months		12 months	
	Mean (SD)	n	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)
<b>ALSFRS-R</b>								
<b>Telehealth</b>								
	n=18	n=16	n=15	n=16	n=16	n=6	n=6	
Mean	31.9 (9.7)	32.1 (10.4)	-0.06 (-2.6, 3.4)	31.1 (9.0)	-0.3 (-2.6, 1.9)	28.7 (7.6)	<b>-4.7 (-8.5, -0.81)</b>	
<b>Control</b>								
	n=20	n=15	n=15	n=12	n=12	n=7	n=7	
Mean	32.1 (8.0)	29.8 (8.7)	-1.5 (-4.1, 1.0)	29.4 (9.0)	-3.7 (-6.8, -0.5)	25.9 (6.0)	-5.1 (-12, 1.3)	
<b>Total</b>								
	n=38	n=31	n=30	n=28	n=28	n=13	n=13	
Mean	32.0 (8.7)	30.9 (9.5)	-0.6 (-2.2, 1.0)	31.1 (8.9)	-1.6 (-3.6 - 0.4)	27.9 (9.6)	<b>-4.9 (-8.4, -1.4)</b>	



A6.5 TiM study participants' HADS sub-scores and UK normal population values for adults aged 60-65 years (258).

	HADS Anxiety sub-score			HADS Depression sub-score		
	Mean (SD)	At least mild symptoms (score ≥8)	Moderate/severe symptoms (score ≥11)	Mean (SD)	At least mild symptoms (score ≥8)	Moderate/severe symptoms (score ≥11)
<b>Study patients</b>						
Total (n=37)	5.4 (4.0)	11 (30%)	3 (8%)	4.8 (3.1)	8 (22%)	1 (3%)
Female (n=11)	6.9 (4.3)	5 (46%)	2 (18%)	6.1 (2.9)	5 (46%)	0 (0%)
Male (n=26)	4.8 (3.7)	6 (23%)	1 (4%)	4.2 (3.0)	2 (8%)	1 (4%)
<b>Study carers</b>						
Total (n=34)	6.1 (4.0)	13 (35%)	4 (11%)	3.6 (3.0)	3 (8%)	2 (5%)
Female (n=28)	6.2 (4.1)	11 (39%)	4 (14%)	5.6 (3.7)	3 (11%)	2 (7%)
Males (n=6)	5.6 (4.0)	2 (33%)	0 (0%)	3.8 (2.0)	0 (0%)	0 (0%)
<b>UK population</b>						
Female (n=399)	6.3 (3.9)	32%	15%	4.1 (3.3)	15%	5%
Male (n=364)	4.9 (3.6)	22%	8%	3.9 (3.5)	17%	7%

A6.6 Patient HADS Anxiety sub-scores and the number (%) of patients with borderline scores and abnormal scores. 0-7 normal, 8-10 borderline/mild symptoms, 11-21 abnormal: moderate/severe.

HADS	Baseline		3 months		6 months		12 months	
	Mean (SD)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)	
<b>Telehealth Anxiety</b>								
	n=17	n=16	n=16	n=16	n=15	n=6	n=6	
Mean	6.0	5.7	-0.2	4.7	-0.9	5.7	-0.7	
(SD/CI)	(4.0)	(4.3)	(-2.3, 1.9)	(3.7)	(-2.1, 0.4)	(2.4)	(-3.3, 2.0)	
Score ≥8	8 (47%)	4 (25%)	-	3 (19%)	-	1 (6%)	-	
Score ≥11	1 (6%)	2 (13%)	-	1 (6%)	-	0 (0%)	-	
<b>Control Anxiety</b>								
	n=20	n=15	n=15	n=12	n=12	n=7	n=7	
Mean	4.9	4.6	-0.5	5.1	-3	6.0	0.9	
(SD/CI)	(3.9)	(4.4)	(-2.1, 1.2)	(5.1)	(-1.8, 1.3)	(4.8)	(4.7)	
Score ≥8	3 (15%)	4 (27%)	-	3 (20%)	-	2 (13%)	-	
Score ≥11	2 (10%)	3 (20%)	-	2 (13%)	-	1 (7%)	-	
<b>Total Anxiety</b>								
	n=37	n=31	n=31	n=28	n=27	n=13	n=13	
Mean	5.4	5.2	-0.3	4.9	-0.6	5.8	0.2	
(SD/CI)	(4.0)	(4.3)	(-1.6, 0.9)	(4.3)	(-1.5, 0.3)	(3.8)	(-2.1, 2.4)	
Score ≥8	11 (30%)	8 (26%)	-	6 (19%)	-	3 (10%)	-	
Score ≥	3 (8%)	5 (16%)	-	3 (10%)	-	1 (3%)	-	

A6.7 Patient HADS Depression sub-scores and the number (%) of patients with borderline scores and abnormal scores. 0-7 normal, 8-10 borderline/mild symptoms, 11-21 abnormal: moderate/severe.

HADS	Baseline		3 months		6 months		12 months	
	Mean (SD)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)	
<b>Telehealth Depression</b>								
	n=20	n=16	n=16	n=16	n=15	n=6	n=6	
Mean (SD/CI)	5.9 (2.9)	5.6 (2.7)	-0.3 (-2.1, 1.6)	5.8 (3.0)	0.3 (-1.0, 1.6)	7.5 (4.3)	1.7 (-1.0, 4.4)	
Score ≥8	5 (29%)	6 (38%)	-	6 (38%)	-	3 (19%)	-	
Score ≥11	0 (0%)	0 (0%)	-	0 (0%)	-	3 (19%)	-	
<b>Control Depression</b>								
	n=20	n=15	n=15	n=12	n=12	n=7	n=7	
Mean (SD/CI)	3.9 (3.0)	6.1 (3.8)	1.5 (-0.4, 3.3)	5.8 (3.3)	0.8 (-1.7, 3.3)	6.4 (3.6)	0.9 (-3.4, 5.1)	
Score >8	3 (15%)	4 (27%)	-	3 (20%)	-	3 (20%)	-	
Score ≥11	1 (5%)	3 (20%)	-	1 (7%)	-	1 (7%)	-	
<b>Total Depression</b>								
	n=37	n=31	n=31	n=28	n=27	n=13	n=13	
Mean (SD/CI)	4.8 (3.1)	5.8 (3.2)	0.6 (-0.7, 1.9)	5.8 (3.1)	0.5 (-0.7, 1.7)	6.9 (4.6, 9.2)	1.2 (-1.0, 3.5)	
Score ≥8	8 (22%)	10 (32%)	-	9 (29%)	-	6 (19%)	-	
Score ≥11	1 (3%)	3 (10%)	-	1 (3%)	-	4 (13%)	-	

A6.8 “Current” and “worst” pain scores over previous week (rated on a modified Likert score from 0-10)

Pain scores	Base-line	3 months		6 months		12 months	
	Mean (SD)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)
<b>Current pain (0-10)</b>							
Control	20	15	15	13	13	7	7
Mean (SD/CI)	1.4 (1.4)	1.6 (2.0)	0.33 (-0.5, 1.2)	1.4 (2.0)	0.2 (-1.1, 1.4)	2.6 (2.5)	-0.9 (-2.6, 0.9)
Telehealth	17	16	15	15	15	6	6
Mean (SD/CI)	1.7 (1.9)	2.1 (2.4)	0.1 (-1.3, 1.4)	1.8 (2.3)	1.8 (0.7, 2.9)	1.8 (1.6)	0.8 (-1.2, 2.9)
Total	37	31	30	28	28	13	13
Mean (SD/CI)	1.5 (1.7)	1.9 (2.2)	0.2 (-0.5, 0.9)	1.6 (2.2)	1.0 (0.2, 1.9)	2.2 (2.1)	-0.1 (-1.3, 1.1)
<b>Worst pain (0-10)</b>							
Control	20	15	15	13	13	7	7
Mean (SD/CI)	3.2 (2.7)	3.4 (3.1)	-0.1 (-1.3, 1.0)	2.6 (2.7)	-0.2 (-0.8, 0.4)	3.9 (3.1)	0.3 (-1.0, 1.6)
Telehealth	17	16	15	15	15	6	6
Mean (SD/CI)	2.9 (2.8)	3.4 (3.1)	0.1 (-1.2, 1.5)	3.0 (2.8)	3.1 (1.6, 4.7)	3.5 (2.2)	0.3 (-2.4, 2.1)
Total	37	31	30	28	28	13	13
Mean (SD/CI)	3.0 (2.7)	3.2 (2.9)	0.0 (-0.8, 0.8)	2.8 (2.7)	1.6 (0.5, 2.6)	3.7 (2.7)	0.1 (-1.0, 1.1)

A6.9 CSS-MND saliva severity scores (mean, SD) and change from baseline (mean, 95% confidence interval). Scores range from 0 (no problems with oropharyngeal secretions) to 36 (severe secretions).

CSS MND	Baseline	3 months		6 months		12 months	
	Mean (SD)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)
Telehealth	n=17	n=16	n=14	n=16	n=16	n=6	n=6
Mean (SD)	4.2 (6.0)	4.8 (6.4)	1.9 (0.2, 3.5)	2.6 (1.2)	0.0 (-2.8, 2.8)	2.3 (3.2)	0.2 (-1.4, 1.9)
Control	n=20	n=15	n=14	n=12	n=12	n=7	n=6
Mean (SD)	4.1 (5.2)	5.5 (6.2)	1.0 (-1.5, 3.5)	2.8 (1.1)	0.1 (-1.56, 1.7)	3.4 (4.5)	-0.7 (-0.7, 3.4)
Total	n=37	n=31	n=29	n=28	n=28	n=13	n=12
Mean (SD)	4.1 (5.5)	5.1 (6.2)	1.4 (0-2.9)	2.6 (1.1)	0.0 (-1.6, 1.6)	3.4 (4.5)	0.2 (-1.4, 1.9)

A6.10 Carer SF-36 physical and mental sub-scores. These scores are standardised to a normative reference population in which the mean is 50 and standard deviation is 10.

Carer SF-36	Base-line	3 months		6 months		12 months	
	Mean (SD)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)	Mean (SD)	Change from baseline Mean (CI)
<b>Telehealth</b>							
Physical	n=16	n=14	n=13	n=15	n=14	n=4	n=4
Mean (SD/CI)	52.4 (11.1)	49.0 (9.6)	-1.9 (-8.0, 4.2)	51.6 (9.7)	0.10 (-4.9, 5.2)	51.0 (3.1)	-3.6 (-13.8,6.6)
Mental	16	14	13	15	14	4	4
Mean (SD/CI)	47.9 (13.1)	50.5 (14.5)	3.3 (-1.1, 7.7)	48.6 (14.4)	1.2 (-2.8, 5.2)	45.3 (14.5)	-2.9 (-9.6, 3.8)
<b>Control</b>							
Physical	n=18	n=13	n=13	n=11	n=11	n=7	n=7
Mean (SD/CI)	52.9 (7.7)	51.9 (7.0)	-3.2 (-8.1, 1.8)	49.1 (8.8)	-4.7 (-8.9, -0.4)	52.2 (9.6)	-3.0 (-10.2,4.2)
Mental	n=18	n=13	n=13	n=11	n=11	n=7	n=7
Mean (SD/CI)	50.6 (10.3)	51.2 (8.7)	1.7 (-2.2, 5.5)	51.8 (10.5)	0.70 (-6.8, 8.1)	51.7 (10.3)	2.4 (-4.5, 9.3)
<b>Total</b>							
Physical	n=34	n=27	n=26	n=26	n=25	n=11	n=11
Mean (SD/CI)	52.7 (9.3)	50.4 (8.4)	-2.5 (-6.1, 1.1)	50.1 (9.2)	-2.0 (-5.3, 1.3)	51.8 (7.6)	-3.2 (-7.9, 1.5)
Mental	n=34	n=27	n=26	n=26	n=25	n=11	n=11
Mean (SD/CI)	49.3 (11.6)	50.8 (11.8)	2.5 (-0.3, 5.2)	49.9 (12.8)	1.0 (-2.7, 4.6)	49.4 (11.7)	0.4 (-4.1, 5.0)

Table 6.7 Patient estimated hours of paid and unpaid care received per week.

	<b>Baseline</b>	<b>3 month</b>	<b>6 months</b>	<b>12 months</b>
<b>Telehealth</b>				
Paid carer hours	n=17	n=16	n=15	n=5
Mean (SD)	12.7 (33.2)	20.9 (52.4)	34.7 (64.6)	66.6 (89.0)
Median (Range)	0 (0-110)	0 (0-168)	0 (0-168)	5 (0-168)
Unpaid carer hours	n=12	n=16	n=15	n=5
Mean (SD)	66.6 (70.2)	43.5 (58.6)	42.8 (57.4)	19.6 (20.5)
Median (Range)	47.5 (0-168)	10 (0-168)	20 (0-168)	10 (0-168)
<b>Control</b>				
Paid carer hours	n=18	n=13	n=12	n=6
Mean (SD)	3.6 (8.4)	2.4 (5.7)	4.3 (11.4)	2.5 (4.5)
Median (Range)	0 (0-28)	0 (0-20)	0 (0-40)	0 (0-11)
Unpaid carer hours	n=20	n=14	n=12	n=5
Mean (SD)	33.4 (64.9)	36.6 (55.4)	38.2 (53.3)	99.8 (90.2)
Median (Range)	12.0 (0-168)	18.5 (0-168)	18 (0-161)	161 (0-168)
<b>Total</b>				
Paid carer hours	n=35	n=29	n=27	n=11
Mean (SD)	8.0 (24.0)	12.6 (39.7)	21.2 (50.4)	31.6 (65.6)
Median (Range)	0 (0-110)	0 (0-168)	0 (0-168)	0 (0-168)
Unpaid carer hours	n=32	n=30	n=27	n=10
Mean (SD)	52.7 (66.7)	40.3 (56.3)	40.7 (54.6)	59.7 (74.8)
Median (Range)	14.5 (0-168)	14.5 (0-168)	20 (0-168)	12 (0-168)

A6.11 The adverse events recorded during the trial.

	Telehealth		Control		Total	
	Number of events	Number of patients/carers (%)	Number of events	Number of patients/carers (%)	Number of events	Number of patients/carers (%)
<b>MND related</b>						
Chest infection/respiratory symptoms	7	7 (35%)	4	4 (20%)	11	11 (55%)
Falls	8	7 (35%)	3	3 (15%)	11	10 (50%)
Musculoskeletal symptoms	3	3 (15%)	0	0 (0%)	3	3 (15%)
Excessive saliva / choking	2	1 (5%)	0	0 (0%)	2	1 (5%)
Elective PEG insertion	2	2 (10%)	1	1 (5%)	3	3 (15%)
PEG site problem	0	0 (0%)	1	1 (5%)	1	1 (5%)
Patient psychological distress	0	0 (0%)	1	1 (5%)	1	1 (3%)
Carer psychological distress	11	5 (29%)	6	5 (26%)	17	10 (27%)
<b>Other adverse events</b>						
Other medical	7	3 (15%)	5	5 (25%)	12	8 (40%)
Other surgical	0	0 (0%)	2	1 (5%)	2	1 (5%)



A6.12 Summary of health encounters for the three months prior to baseline

	<b>Total in 3 months<sup>20</sup></b>	<b>Total physicians<sup>21</sup></b>	<b>Total nurses<sup>22</sup></b>	<b>Total therapists<sup>23</sup></b>
<b>Telehealth</b>				
Total (n=18)	133	38	43	52
Mean (SD)	7.4 (6.3)	2.1 (2.3)	2.4 (2.6)	2.9 (3.1)
Median	5.5	1	1.5	2
Range	0-28	0-8	0-10	0-11
<b>Control</b>				
Total (n=20)	211	45	72	88
Mean (SD)	10.6 (8.5)	2.3 (2.1)	3.6 (5.1)	4.4 (4.3)
Median	8	2	1	4
Range	1-30	0-10	0-19	0-13
<b>Total</b>				
Total (n=38)	344	83	115	140
Mean (SD)	9.1 (7.7)	2.2 (2.2)	3.0 (4.1)	3.7 (3.8)
Median	7	2	1	2.5
Range	0-30	0-10	0-19	0-13

<sup>20</sup> Total excluded ambulance journey and unrelated/non-NHS services

<sup>21</sup> Physicians included were MND neurologists, palliative care physicians and general practitioners.

<sup>22</sup> Nurses included district nurses, MND specialist nurses in hospital and community and hospice nurses.

<sup>23</sup> Therapists included speech and language therapists, physiotherapists, occupational therapists, respiratory specialists, dieticians and PEG nurses.

A6.13 Summary of patient reported MND related health-care encounters between months 0-3 of the study.

	<b>Total<sup>24</sup></b>	<b>Total physicians<sup>25</sup></b>	<b>Total nurses<sup>26</sup></b>	<b>Total therapists<sup>27</sup></b>
<b>Telehealth</b>				
Total (n=16)	152	40	51	61
Mean (SD)	9.5 (9.1)	2.5 (2.3)	3.2 (3.6)	3.8 (4.7)
Median	8	2	2	3
Range	2-35	0-8	0-13	0-18
<b>Control</b>				
Total (n=15)	160	38	55	59
Mean (SD)	10.7 (17.6)	2.5 (4.2)	3.7 (9.6)	3.9 (3.7)
Median	8	1	1	3
Range	0-73	0-17	0-38	0-11
<b>Total</b>				
Total (n=31)	312	78	106	120
Mean (SD)	10.1 (13.6)	2.5 (3.3)	3.4 (7.0)	3.9 (4.2)
Median	6	2	1	3
Range	0-73	0-17	0-38	0-18

<sup>24</sup> Total excluded ambulance journey and unrelated/non-NHS services

<sup>25</sup> Physicians included MND neurologists, palliative care physicians and general practitioners.

<sup>26</sup> Nurses included district nurses, MND specialist nurses in hospital and community and hospice nurses.

<sup>27</sup> Therapists included speech and language therapists, physiotherapists, occupational therapists, respiratory specialists, dieticians and PEG nurses.

A6.14 Summary of patient reported MND related health-care encounters between months 3-6 of the study.

	<b>Total<sup>28</sup></b>	<b>Total physicians<sup>29</sup></b>	<b>Total nurses<sup>30</sup></b>	<b>Total therapists<sup>31</sup></b>
<b>Telehealth</b>				
Total (n=16)	241	45	143	53
Mean (SD)	15.1 (29.3)	2.8 (3.0)	8.9 (28.3)	3.3 (4.9)
Median	8	2	1	1.5
Range	0-121	0-12	0-115	0-17
<b>Control</b>				
Total (n=12)	83	16	41	26
Mean (SD)	5.2 (1.5)	1.3 (0.9)	3.4 (4.0)	2.2 (1.6)
Median	4	1	2	2.5
Range	2-17	0-3	0-12	0-4
<b>Total</b>				
Total (n=28)	310	61	184	79
Mean (SD)	11.3 (22.2)	2.1 (2.4)	6.8	2.8 (3.9)
Median	4	2	1	2
Range	0-121	0-12	0-115	0-79

<sup>28</sup> Total excluded ambulance journey and unrelated/non-NHS services

<sup>29</sup> Physicians included MND neurologists, palliative care physicians and general practitioners.

<sup>30</sup> Nurses included district nurses, MND specialist nurses in hospital and community and hospice nurses.

<sup>31</sup> Therapists included speech and language therapists, physiotherapists, occupational therapists, respiratory specialists, dieticians and PEG nurses.

A6.15 Summary of patient reported MND related health-care encounters for the six months between months 6-12 of the study.

	<b>Total in 6 months<sup>32</sup></b>	<b>Total physicians<sup>33</sup></b>	<b>Total nurses<sup>34</sup></b>	<b>Total therapists<sup>35</sup></b>
<b>Telehealth</b>				
Total (n=6)	101	18	52	30
Mean (SD)	16.8 (17.2)	3.0 (1.4)	8.8 (13)	5.0 (3.9)
Median	9.5	3	3	4
Range	3-49	1-5	1-35	1-10
<b>Control</b>				
Total (n=7)	98	26	32	40
Mean (SD)	14.0 (10.7)	3.7 (1.8)	4.6 (8.0)	5.7 (6.3)
Median	8	4	1	5
Range	5-32	1-6	0-22	1-19
<b>Total</b>				
Total (n=13)	199	44	87	70
Mean (SD)	15.3 (13.5)	3.4 (1.6)	6.5 (10.5)	5.4 (5.1)
Median	8	4	2	5
Range	3-49	1-6	0-35	1-19

<sup>32</sup> Total excluded ambulance journey and unrelated/non-NHS services

<sup>33</sup> Physicians included MND neurologists, palliative care physicians and general practitioners.

<sup>34</sup> Nurses included district nurses, MND specialist nurses in hospital and community and hospice nurses.

<sup>35</sup> Therapists included speech and language therapists, physiotherapists, occupational therapists, respiratory specialists, dieticians and PEG nurses.

Table 6.6 The number of admissions (and number of patients) and days in hospital reported by patients in the three months prior to recruitment.

	Telehealth (n=18)		Control (n=20)		Total (n=38)	
	Number of admissions (number of patients)	Nights in hospital	Number of admissions (number of patients)	Nights in hospital	Number of admissions (number of patients)	Nights in hospital
<b>Elective</b>						
PEG insertion	0	0	4 (3)	15	4 (3)	15
Diagnosis	1 (1)	1	0	0	1 (1)	1
<b>Total elective</b>	1 (1)	1	4 (3)	15	5 (5)	16
<b>Emergency</b>						
Fall	0	0	1 (1)	9	1 (1)	9
Choking	3 (1)	16	0	0	3 (1)	16
Gastrostomy site infection	0	0	1 (1)	2	1 (1)	2
<b>Total emergency</b>	3 (1)	16	2 (2)	11	5 (3)	27
<b>Unrelated to MND</b>						
Total unrelated admissions	0	0	0	0	0	0

A6.16 The total number and reason for hospital admissions reported by all participants during the first 12 months of the study and the number of overnights stayed in hospital.

	Telehealth		Control		Total	
	Admissions (patients)	Nights	Admissions (patients)	Nights	Admissions (patients)	Nights
<b>Elective</b>						
PEG insertion	2 (2)	21	1 (1)	6	3 (3)	27
Symptom control	2 (2)	14*	0	0	2 (2)	14*
<b>Total elective</b>	<b>4 (4)</b>	<b>72*</b>	<b>1 (1)</b>	<b>6</b>	<b>5 (5)</b>	<b>41*</b>
<b>Emergency</b>						
Respiratory symptoms	1 (1)	6	2 (2)	15	3 (3)	21
Collapse, poor oral intake	1 (1)	2	0	0	1 (1)	2
<b>Total emergency</b>	<b>2 (2)</b>	<b>8</b>	<b>2 (2)</b>	<b>15</b>	<b>4 (4)</b>	<b>23</b>
<b>Unrelated to MND</b>						
Elective: hip replacement	2 (1)	6	0	0	2 (1)	6
Emergency: lung cancer	0	0	4 (1)	50	4 (1)	50
Emergency: postural hypotension	0	0	1 (1)	3	1 (1)	3
<b>Total unrelated</b>	<b>2 (1)</b>	<b>6</b>	<b>5 (2)</b>	<b>53</b>	<b>7 (3)</b>	<b>59</b>

\*It was not possible to establish the number of nights from one patients' admission so these nights are not included.

Table A6.17 Patient estimated hours of paid and unpaid care received per week.

	<b>Baseline</b>	<b>3 month</b>	<b>6 months</b>	<b>12 months</b>
<b>Telehealth</b>				
Paid carer hours	n=17	n=16	n=15	n=5
Mean (SD)	12.7 (33.2)	20.9 (52.4)	34.7 (64.6)	66.6 (89.0)
Median (Range)	0 (0-110)	0 (0-168)	0 (0-168)	5 (0-168)
Unpaid carer hours	n=12	n=16	n=15	n=5
Mean (SD)	66.6 (70.2)	43.5 (58.6)	42.8 (57.4)	19.6 (20.5)
Median (Range)	47.5 (0-168)	10 (0-168)	20 (0-168)	10 (0-168)
<b>Control</b>				
Paid carer hours	n=18	n=13	n=12	n=6
Mean (SD)	3.6 (8.4)	2.4 (5.7)	4.3 (11.4)	2.5 (4.5)
Median (Range)	0 (0-28)	0 (0-20)	0 (0-40)	0 (0-11)
Unpaid carer hours	n=20	n=14	n=12	n=5
Mean (SD)	33.4 (64.9)	36.6 (55.4)	38.2 (53.3)	99.8 (90.2)
Median (Range)	12.0 (0-168)	18.5 (0-168)	18 (0-161)	161 (0-168)
<b>Total</b>				
Paid carer hours	n=35	n=29	n=27	n=11
Mean (SD)	8.0 (24.0)	12.6 (39.7)	21.2 (50.4)	31.6 (65.6)
Median (Range)	0 (0-110)	0 (0-168)	0 (0-168)	0 (0-168)
Unpaid carer hours	n=32	n=30	n=27	n=10
Mean (SD)	52.7 (66.7)	40.3 (56.3)	40.7 (54.6)	59.7 (74.8)
Median (Range)	14.5 (0-168)	14.5 (0-168)	20 (0-168)	12 (0-168)

A6.18 The estimated treatment effect for the quality of life and health utility measures and ALSFRS-R. Table and calculation prepared by trial statistician.

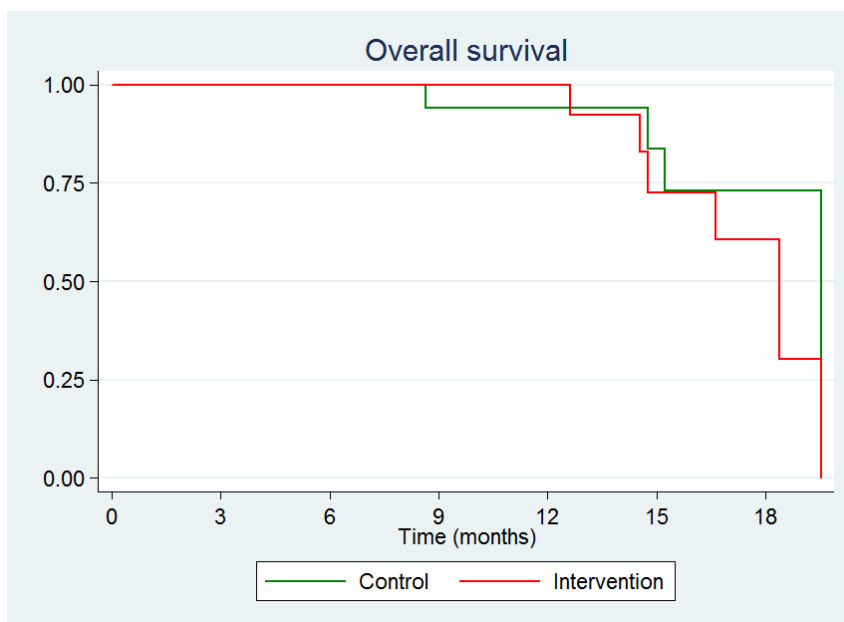
Measure	Baseline SD	Difference (95% CI) at 6 months	
		Mean difference*	Standardised mean difference**
<b>ALSAQ-40 (n=28)</b>			
Physical mobility	32.3	-1.5 (-12.7, 9.7)	-0.05 (-0.39, 0.30)
Activities of daily living	29.5	-7.3 (-18.1, 3.4)	-0.25 (-0.61, 0.12)
Eating and drinking	28.4	7.2 (-3.7, 18.1)	0.25 (-0.13, 0.64)
Communication	35.4	-1.9 (-10.1, 6.3)	-0.05 (-0.28, 0.18)
Emotional	16.9	1.1 (-9.7, 12.0)	0.07 (-0.58, 0.71)
Total	19.6	-1.6 (-9.1, 5.9)	-0.08 (-0.47, 0.30)
<b>SF-36 (n=28)</b>			
PCS	8.8	-0.2 (-6.5, 6.1)	-0.03 (-0.74, 0.68)
MCS	9.7	2.9 (-4.3, 10.1)	0.30 (-0.44, 1.05)
<b>EQ-5D (n=27) (standard version)</b>	0.29	0.03 (-0.13, 0.20)	0.11 (-0.46, 0.68)
<b>ALSFRS-R (n=28)</b>	8.7	2.2 (-1.0, 5.5)	0.28 (-0.13, 0.69)

\* Derived from analysis of covariance with treatment group and baseline score as the covariates

\*\* Mean difference/Baseline standard deviation



A6.19 A Kaplan - Meier plot reports survival recorded at the end of the trial. This graph was produced by the trial statistician.



A6.20 Patient compliance with questionnaires.

	<b>Base- line</b>	<b>3 month s</b>	<b>6 month s</b>	<b>12 month s</b>	<b>18 month s</b>
<b>Telehealth</b>					
Patients available for follow up	n=20	n=19	n=17	n=9	n=0
Completed questionnaire	n=19	n=16	n=16	n=6	n/a
<b>% Eligible questionnaires completed</b>	<b>95%</b>	<b>95%</b>	<b>94%</b>	<b>67%</b>	<b>n/a</b>
Reason not completed					
Questionnaire not returned	n=1	n=3	n=2	n=3	n/a
Patients not available for follow-up					
Died	n=0	n=1	n=1	n=1	n=1
Withdrawn	n=0	n=0	n=2	n=2	n=2
Follow-up complete	n=0	n=0	n=0	n=8	n=17
<b>Control</b>					
Patients available for follow up	n= 20	n=20	n=18	n=8	n=2
Completed questionnaire	n=20	n=15	n=12	n=6	n=1
<b>% Eligible questionnaires completed</b>	<b>100%</b>	<b>79%</b>	<b>67%</b>	<b>75%</b>	<b>50%</b>
Reason not completed					
Questionnaire not returned	n=0	n=4	n=5	n=4	n=1
Trial administration error <sup>36</sup>	n=0	n=1	n=0	n=0	n=0
Patients not available for follow-up					
Died	n=0	n=0	n=2	n=2	n=2
Follow-up complete	n=0	n=0	n=0	n=10	n=16
<b>Total</b>					
Patients available for follow up	n=40	n=39	n=35	n=17	n=2
<b>% Eligible questionnaires completed</b>	<b>98%</b>	<b>87%</b>	<b>80%</b>	<b>71%</b>	<b>50%</b>

<sup>36</sup> One carer questionnaire data was lost at the study site, one patient and carer were not sent follow-up questionnaire.

A6.21 Carer compliance with questionnaires.

	<b>Baseline</b>	<b>3 months</b>	<b>6 months</b>	<b>12 months</b>	<b>18 months</b>
<b>Telehealth</b>					
Carers available for follow-up	n=18	n=17	n=15	n=9	n=0
Completed questionnaire	n=17	n=14	n=14	n=6	n=0
<b>% Eligible questionnaires completed</b>	<b>100%</b>	<b>82%</b>	<b>93%</b>	<b>67%</b>	<b>n/a</b>
Reason not completed					
Questionnaire not returned	n=0	n=3	n=1	n=3	n/a
Patient died	n=0	n=1	n=1	n=1	n=1
Patient withdrawn	n=0	n=0	n=2	n=2	n=2
Follow-up complete	n=0	n=0	n=0	n=8	n=15
Trial administration error	n=1	n=0	n=0	n=0	n=0
<b>Control</b>					
Carers available for follow-up	n=19	n=18	n=18	n=9	n=2
Completed questionnaire	n=18	n=14	n=13	n=6	n=1
<b>% Eligible questionnaires completed</b>	<b>95%</b>	<b>78%</b>	<b>72%</b>	<b>67%</b>	<b>50%</b>
Reason not completed					
Questionnaire not returned	n=0	n=4	n=4	n=4	n=1
Completed but not within the follow-up window	n=1	n=0	n=0	n=0	n=0
Patient died	n=0	n=0	n=2	n=2	n=2
Follow-up complete	n=0	n=0	n=0	n=9	n=15
<b>Total</b>					
Carers available for follow-up	n=37	n=35	n=33	n=18	n=2
<b>% Eligible questionnaires completed</b>	<b>97%</b>	<b>80%</b>	<b>82%</b>	<b>67%</b>	<b>50%</b>

## Appendix 6.2

### Q6.1 Participants' motivations to participation in research.

<b>Incentives to participating in trials</b>	
Low burden of the study	<i>"Oh I was interested in that because it's so easy to do; it literally takes five minutes from home." P317</i>
Able to participate in trials without leaving home	<i>"My care's here. I can't have anything that takes it away from what I'm doing with P." It's got to be very simple things. I can sit with my iPad and I can fill in a questionnaire. Done, dusted, finished." C184</i>
Clear information about what is involved	<i>"If it was local and we were going anywhere or people were coming here and; I could always look at each one individually but I think I wouldn't want to spend a lot of time away from home. So that would be my main criteria. P408</i>
<b>Motivations to participating in research</b>	
To help find a cure	<i>"If I can be of any help to any research, you know, which'll help try and find a cure." P056</i>
To help other people with MND	<i>"It might come along too later to help me but it will help people who come after me." P122 "Just trying to help other people; if me pressing a few buttons ...can help in the future, it's not a problem" P354</i>
In gratitude to the clinicians	<i>"I think that the people at the Hallamshire are just about the best in the, in the, in the game" P062</i>
To do something positive	<i>"... it's that feeling of doing something positive." C402 "I like that idea that moving forward" P423</i>
To learn about research	<i>"I've always been interested in medical science...so I said any research that they're doing I want to get involved in." P423</i>
To help their family, who may be at risk	<i>"C: I gave blood as well.. because ...we've got the boys ... I think that's quite a big thing for me" C381</i>
To have better contact with MND team	<i>"It was good because, it meant, in the first year I was going to the clinic every month." P122</i>
To receive better treatment	<i>"I'm offering my services ... but in return ... I'm getting a repeating MOT." P313</i>
To find out more about their condition	<i>"That led to the, the obvious question "Well if you find anything wrong will you tell me?"." P313</i>
To increase the chances of them being involved in a treatment trial	<i>"I do believe that if you're not in the loop then if something comes along then you're on the wrong side of the fence. If you're involved with different ... then you're more likely to be selected for possible hopeful cures..." P232</i>

Q6.2 Barriers to participation in research.

<b>Barriers to participation in research</b>	
Additional burden	<i>" Well, just another job.... To remember" C217</i>
Research is time consuming	<i>"Initially it is a bit overwhelming ... we do seem to have signed-up for absolutely everything..." C402</i> <i>"It's difficult, ... sometimes you get to the stage where you think: you know what? I just don't feel like this, I've just had enough" C402</i>
Intrusion or disruption of family life	<i>"C:I just don't think; ... we, we just try to keep ourself and look after him, look after him and that's it.</i> <i>Q: ...Have any of those worries been the case during the study?</i> <i>C: No." C228</i> <i>"I don't want the family life to be disrupted, that's really important to us." P408</i>
Time spent away from home	<i>"I'd need to know about the, the time that would be needed to be spent, if I needed to spend time away from here, from home" P408</i>
Research can be tiring	<i>"On Thursday I went for my research, had the lumbar puncture, the tissue sample, blood samples I think. So then I came home. For two days after that I was more or less housebound." P184</i>
Travel to hospital is expensive	<i>"...the train tickets are a bit expensive, so we've driven the last few times. But ... we got the free parking and things like that..." C392</i>
Travel difficult	<i>"It's gonna be a lot more difficult with a wheelchair" C392</i>

Q6.3 Participants' attitudes towards recruitment and randomisation in the TiM trial.

<b>Recruitment and randomisation to the TiM trial</b>	
Recruitment process provided sufficient information	<i>"I think it were all pretty much straight forward, in the letter that you sent out, plus when you came, I think it were all pretty straight forward, yeah." P145</i>
Patients were willing to be randomised as they understood the research question	<i>"Q: Was there a particular arm of the study that you wanted..?"</i> <i>P: No, because it's a subject that not very much seems to be known about, so if I can help in any area of it, I will." P166</i>
Patients would prefer to be in the intervention arm	<i>"Q: And how did you feel about being assigned to the Telehealth side?"</i> <i>P: Well I've preferred that side of it." P381</i>
Patients were not demoralized if they were assigned the control arm	<i>"I should think most people would probably want to have tablet. I think, they'd think "this is alright." But quite frankly it doesn't bother me." P070</i>
Involving the control arm in interviews avoided resentful demoralization	<i>"I read the notes. Some would get the interview, some would get the tablet" C070</i>
Researchers could influence the randomisation process	<i>"P: We thought: they'll put [my sister] on the real drug because they can monitor her for longer.</i> <i>Q: Do you think that the study researchers can have an influence on which arm of the study you go in?</i> <i>P: Probably not, no. Probably it's the drug company who are pulling the strings. They are paying the money aren't they?" P184</i>

Q6.4 Participants' attitudes towards and knowledge of research.

<b>Participants' attitudes towards and knowledge of research</b>	
Patients gain information about research and new treatments through...	
Clinic	<i>"I like having a chat with you and finding out what's happened, what's new, because all we have is hope, we don't have a lot more". P134</i>
Friends and fellow patients	<i>"It's really just through word of mouth. " P122</i>
MND Association	<i>"The MNDA puts posts on about research" P145</i>
Internet	<i>"I mean we have found, for instance, a website; you can actually see it on YouTube, called Deanna Protocol" P317</i>
Social media/ peer networks	<i>"There's also a long term ALS survivors' website where people, have been diagnosed with it... and been told that you've only got a year left to live, but they've done radical changes, ....and those people have halted it" P317</i>
Patient seek out, evaluate and use unproven treatments	<i>"I don't follow regimes as strict as the Deanna protocol but I just pick out certain things that I think would help me, hence the reference to moringa and coconut oil." P232</i>
Frustration with the speed of drug development	<i>"I just feel like, after 30 years with millions ... of pounds spent we've still got a tablet that [has little evidence]" P184</i> <i>"We need to be getting a move on... Some day, we've got to stop messing around with mice." P184</i> <i>"I don't hold out too much confidence about the UK system of getting drugs to market and funding them with the likes of NICE posing usual financial constraints." P232</i>
Time is running out for a cure	<i>"Once you get to what I always call "frank" stage ...I don't think there's any drug that would bring you out of that." P184</i>
Patients have little to lose	<i>"We being the patients with MND, have nothing to lose... There's always risk in life." P232</i>
Learning about research makes patients hopeful	<i>"[you think] There's got to be things that we can do, come on, we're gonna really give this a hundred percent; and the more we looked the more intrigued we became.... you can see people that have had really good benefits from it." P317</i> <i>"We're all kind of pinning our hopes ...on GM604" P232</i>
Patients recognize information may be giving false hope	<i>"Too much information could fill people with a false hope and you've gotta manage people's expectations" P122</i>
Putting trust in the doctors to run safe trials in the best interests of the patient	<i>"Q: Did you consider the downsides, the risks of having a lumbar puncture when you came? P: No. I just thought, well if that's all I've got to put up with. But if a doctor can't do a lumbar it's a bad job." P184</i> <i>"I would have complete faith in [consultants] team saying "Right, lets get some people in now and let's do it" P184</i>
Wanting to see tangible benefits of treatments which reverse the disease	<i>"No one will ever convince me that they know [riluzole] works. ...How do they know I've had three months more life?...Who would know? .. I can't walk any better, I can't speak any better, I can't do anything any better." P184</i> <i>"...it doesn't have to cure you it just has to make things better." C232</i> <i>"If there was a magic bullet and I had to sell everything to purchase that bullet, I would." P232</i>

Q6.5 Participant reaction to the TiM research questionnaires.

<b>Were questions acceptable?</b>	
Questions posed in the questionnaire were acceptable	<i>"No. To be quite frank, doctor, I wouldn't care a monkey's what you ask ...I have no hang-ups about any questions, however personal, the team think it's necessary to ask; I've seen it all, done it all and got the t-shirt." C229 "P: I was fine about doing them." P116</i>
There was a limit to the number of questions participants were willing to answer	<i>"P: You don't want another one of them hundred and fifty page things to fill out, that were, whatever it was last year." C248</i>
Questions on emotions were acceptable to those experiencing emotional distress	<i>"It's more the emotional ones that I have trouble filling in cos I've been depressed for quite a ...and it's, it's just hard admitting that yes, maybe some days it's not great and I know that I'm not great at the moment but. But no, they seemed good. They were really clear, and it wasn't too, too much to do." P408</i>
Participants wanted questions to cover all potential aspects of MND	<i>"At the moment I've not got a lot of problems with my legs, but in 18 months I might need a wheelchair, or I might be having to use a breathing machine. So every question is relevant." P070</i>
Questions about future complications were acceptable because patients were aware of what may occur	<i>"When you read things about these questions: it brings things home to you. Well yeah, I have deteriorated.... It doesn't really significantly affect me at all because, I like to think I'm a reasonably intelligent man and I know things are deteriorating." P184</i>
<b>Which questions best reflected the experiences of patients and carers?</b>	
Questions about mood/emotions best reflected their experiences	<i>"I think the best ones are the ones about how it makes you feel and how it affects your mood etc. That's very important ...." P122</i>
The carer burden accurately captured the experience of carers	<i>"It was a strange one cos [the ZBI] was asking you what I feel about spending the time with him, that I don't have time for meself... Yeah, it is quite a thing cos you're always thinking... "Has he got enough drinks? ... then anything to eat?"... I don't like to be too far away from him, even though I'm in the house ... in case summat happened and he needs me." C091</i>
Carer strain is linked to patient and carer wellbeing	<i>"...obviously if strains exist, become too much for the carer, then the patient, to a degree, suffers.." C229</i>
Mood/emotions affected patients health and functional abilities	<i>"Feelings of anxiousness can affect my legs, and I know that. I try not to control, try not to get anxious about situations but sometimes it's hard when you know, your are going to move from A to B, you're going to get anxious about it." P076</i>

Q6.6 Weaknesses with the questionnaires identified.

<b>SF-36 questionnaires failed to reflect the experience of life with MND</b>	
SF-36 questions were too subjective	<i>"That's sort of looking at question [SF-36], and putting down, you're limited and then you sort of realise; I can't really do that; and you don't think about it all the time do you? Some of them I wanted to put "sometimes", you know... sometimes I have but I've just gone for on the whole" P408</i>
Patients found it difficult to assess their global health and were unsure whether to include MND in the assessment	<i>"P: It's slightly confusing when they ask about health because it's hard to take the MND out of the equation, I think. Apart from that I would be very healthy." P116 "P: My health other than the illness? (Pause) Taking the illness into account I would say poor, but if I ignore the, the illness I would say very good." P137 [referring to SF-36]</i>
Patients felt "healthy" despite having MND	<i>"To be honest, I feel great. So does that say I'm excellent. But you know that you're not, so you can't be excellent." P175 [referring to SF-36]</i>
Carers felt they had no health problems and felt the QoL questions were not relevant	<i>"I mean this: [reads] "I feel as if I'm slowed down"; it's not because of caring for you but because I'm getting older... I can't do a forward roll over a gatepost anymore!" C137 [referring to SF-36]</i>
Those with severe disability had few "daily activities" on which to assess the impact of MND	<i>"P: It doesn't affect my work because I don't do any! Q: It's housework as well. P: No. I don't do any! I do a little bit." P070 [referring to SF-36]</i>
<b>Other weaknesses</b>	
Participants found it difficult to quantify the time taken by domestic jobs that are usually shared	<i>"But there are things now... I'll say "its time for a cup of tea". It will always be me that makes it. I'm not saying I resent it, because P can't do it... But I don't class that as care... C175 [referring to informal care question]</i>
Questions should better reflect patients' functional abilities and coping strategies	<i>"It's about monitoring really, and with these questionnaires you are not able to say how you manage. If we know we are going out for a full day, then P knows not to plan anything for the next day because he's gonna be tired." C076</i>
Answering questions may be difficult if they not want to admit they have problems	<i>"....It's like C was saying, you've just got to be honest and sometimes that's really hard cos you don't want to admit that maybe you're not as good as you were". P408</i>





## **Facilitating access to specialist care for patients and carers living with motor neurone disease using telehealth**

Written by:  
Dr Esther Victoria Hobson

### **Volume Two**

#### **Contents:**

**Appendix C:** Publication supporting Chapter Two  
Using technology to improve access to specialist care in amyotrophic lateral sclerosis: A systematic review. Hobson et al. (2016)

**Appendix D:** Documents supporting Chapter Four  
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4.5 Example of Patient Questionnaire

**Appendix E:** Publication supporting Chapter Seven  
“Anything that makes life’s journey better.” Exploring the use of digital technology by people living with motor neurone disease. Hobson et al. (2017)

**Appendix F:** list of figure, boxes, tables and abbreviations

## Appendix C

### **Using technology to improve access to specialist care in amyotrophic lateral sclerosis: A systematic review.**

Hobson, E. V., Baird, W. O., Cooper, C. L., Mawson, S., Shaw, P. J., & McDermott, C. J. (2016).

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“Using Technology to Improve Access to Specialist Care in Amyotrophic Lateral Sclerosis: a Systematic Review..”

*Amyotrophic Lateral Sclerosis & Frontotemporal Degeneration* 17, no. 5 (July 2016): 313–24. doi:10.3109/21678421.2016.1165255.

## Appendix D

- 4.1 TiM trial protocol v1.5 April 2015
- 4.2 TiM Statistics Analysis Plan
- 4.3 Patient information leaflet V1.2
- 4.4 Topic guides
- 4.5 Example of Patient Questionnaire



## **Telehealth in Motor Neurone Disease**

Telehealth in Motor Neurone Disease: A single centre, randomised controlled feasibility and pilot study of the use of the TiM telehealth system to deliver highly specialised care in Motor Neurone Disease at a distance



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Sheffield Teaching Hospitals   
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## Abbreviations

AE	Adverse event
ALS	Amyotrophic lateral sclerosis
ALSAQ-40	Amyotrophic Lateral Sclerosis Assessment Questionnaire – long form
ALS-FRS-R	Amyotrophic lateral sclerosis rating scale-revised
BiPAP	Bi-level positive pressure non-invasive ventilation
CBI	Carer burden inventory
CI	Chief Investigator
CLRN	Comprehensive Local Research Network
CONSORT	Consolidated standards of reporting trials
CRF	Clinical Research Facility, Sheffield Teaching Hospitals
CSS-MND	Clinical Saliva Scale for Motor Neurone disease
CTRU	Clinical trials research unit, University of Sheffield
EQ-5D-3L	EuroQol Group Health Questionnaire,
GCP	Good clinical practice
GP	General practitioner
HADS	Hospital Anxiety and Depression Scale
HTA	Health Technology Assessment
MCSI	Modified Caregiver Strain Index
MDT	Multidisciplinary team
MND	Motor neurone disease
NICE	National Institute for Health and Clinical Excellence
NHS	National Health Service
NIHR	National Institute for Health Research
NIV	Non-invasive ventilation
PHQ	Patient Health Questionnaire
PI	Principal Investigator
SAE	Serious adverse event
SCHARR	School of Health and Related Research, University of Sheffield
SF-36 RAND	36-Item Short Form Survey from the RAND Medical Outcomes Study
SITraN	Sheffield Institute of Translational Neuroscience
STH	Sheffield Teaching Hospitals
SU	Sheffield University
Telecare	A system of sensors, alarms or communication in the home used to support safe living
Telehealth	Remote monitoring of patients physiology or patient reported measures, forwarded to a central service with the aim to diagnoses or monitor a medical condition
Telemedicine	Videoconferencing consultation
TMG	Trial management Group
TSC	Trial Steering Committee
TiM	Telehealth in Motor neurone disease
TM	Trial manager

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Appendix 1 Drugs produced by Abbott Healthcare Ltd.

Appendix 2 CONSORT flow diagram

Appendix 3 Qualitative interview topic guides

This document describes a clinical study. The protocol is not intended for use as a guide to the treatment of other patients. Amendments may be necessary; these will be circulated to investigators in the study.



## **1. Telehealth in Motor Neurone Disease: The TiM™ Study**

Telehealth in Motor Neurone Disease: A single centre, randomised controlled pilot study of the use of the TiM™ telehealth system to deliver highly specialised care in Motor Neurone Disease at a distance.

### **Abstract**

#### **Objectives**

People with motor neurone disease benefit from the specialist care provided by multidisciplinary teams. As their disease progresses patients struggle to attend hospital and find it difficult to access the care they need. The aim of the TiM system is to improve access to this specialist care by using technology to monitor, educate and communicate with our patients and their carers.

This is a pilot study of the TiM™ telehealth system. The pilot study is designed to assess the feasibility, acceptability and safety of the telehealth system in clinical practice and of conducting a full study of the system. It will also allow a process evaluation of the system to determine how the telehealth system could be effectively utilised within an NHS service.

#### **Methods**

This is a single-centre, randomized controlled mixed methods pilot study of the TiM™ telehealth system. It will recruit 40 patients along with their primary informal carer. 20 will be assigned to use the TiM system for a minimum of 6 months (intervention) and 20 will be assigned usual care (control). Quantitative outcome data will be collected at baseline, three and six months, six monthly thereafter and at the end of the trial. Qualitative interviews with participants and staff and analysis of the system in use will enable a process evaluation of the system and the trial methodology. It will also assess the safety of the system in a clinical setting.

#### **Results**

Results of this pilot will determine whether a large, multi-centre full trial is appropriate and enable further development of the TiM system. It is proposed that the TiM system could be adopted into the care of patients with MND throughout the UK.

## **2. Lay summary**

Motor neurone disease is a condition affecting approximately 5 000 people in the UK. It results in progressive weakness in muscles causing paralysis, disability, and eventually death after an average of only three to five years. To receive the expert care provided by motor neurone disease multidisciplinary teams most patients have to travel to regional centres, whilst community-based care is usually provided by non-specialist teams. Between clinic appointments and towards the end of their lives when patients are unable to travel to clinic and they may be unable to access the specialist assessment and care provided in these centres.

Telehealth has been shown to increase access to specialist care in patients with chronic disease, regardless of geography or the ability to travel. The overall purpose of this pilot study is to test the feasibility and acceptability of the TiM telehealth system. The TiM system is web-based system that enables weekly monitoring of patients and carers' health and wellbeing. It has been developed by the Sheffield Motor Neurone Disease Care Centre team in partnership with industry (Abbott Healthcare Products Ltd and Carematix) and other experts within the NHS and the University of Sheffield. The study will also determine whether it would be feasible to conduct a larger study of the system to examine the effectiveness of the TiM system.

Patients with motor neurone disease who are cared for by the Sheffield motor neurone disease clinic will be invited to take part in the trial. 40 patients will be recruited. Their primary informal carer (usually their spouse or close relative) will also be invited to participate in carer monitoring. All patients will continue their usual care but half will also be randomised to use the TiM telehealth system for a minimum of six months.

Information about the participants will be collected at the start, three and six months, and then every six months until the end of the trial by postal questionnaires and during routine appointments. Up to 20 participants in the control group will be interviewed at the start at the trial to explore their experiences on completing the postal questionnaires. Up to 20 participants who are using the TiM system will be interviewed at one and six months to understand the effect the trial and the system has on their lives in more depth. The clinical staff will also be interviewed at the end of the trial.

A pilot study is a small-scale study that is carried out to determine whether a larger study is practical. It will also enable the identification and resolution of any problems with either the telehealth system or the trial procedures.

### **3. Background**

There are approximately 5 000 people in the UK suffering from motor neurone disease (MND) at any one time (1). MND is an incurable disease causing progressive weakness of muscles involving the limbs, speech and swallowing leading to progressive disability and eventual respiratory failure. The average life expectancy following diagnosis is two to three years but the course of MND can vary from only a few months to over 10 years. The distress and burden of the disease affects patients, their family and carers and the relenting progression of disability causes social, emotional and financial strain (2, 3).

There are 22 specialist multidisciplinary MND care centres in the UK. Expert clinicians and therapists offer interventions such as riluzole (which can improve survival by approximately two to three months) and gastrostomy feeding to promote good nutrition (4). Treatment of respiratory failure with non-invasive ventilation (NIV) improves both quality of life and life-expectancy by, on average, 11 months (5). Attendance at specialist MND clinics has also been reported to improve survival independent of these other interventions (6, 7).

The traditional model of care is to review patients at the MND centre at fixed regular intervals. This model is not responsive to patient or carer needs (which can change rapidly) and requires the patient and their family to undertake progressively more difficult journeys to clinic at a time predicted by the clinician at their last meeting. Given the burden associated with travelling to clinic, it is important that visits occur when they are most needed. Some patients whose needs have not changed may not benefit from a clinic appointment at the previously predicted interval whereas others may need more timely intervention.

The highly specialist services provided by the MND clinic are contrasted by the services most patients receive in their community (8). These community teams, who have limited experience in caring for patients with MND, are usually the first point of contact for patients between clinic visits. Lack of expertise in MND amongst community teams and limited access to specialist staff and equipment (particularly at the end stages of the disease) causes patients and their carers to experience significant difficulties (2, 3, 9-12). Research conducted in SITraN and by others, highlights the major impact that caring for someone with MND has on the physical and emotional well being of carers, as well as patients (3, 11, 13-16). Where access to specialist services and community support is limited, this impact is even more notable (3, 11, 13-16). This is particularly a problem in the later stages, when it is usually impossible to attend clinic, when arguably the most care is needed. It is therefore essential that the input from the specialist centre is still possible both between visits and when patients become unable to travel.

#### **Telehealth to provide specialist care in MND**

In the last few years, technology has developed sufficiently to allow high quality communication between patient and their care team at a potentially reasonable cost.

Trials have shown that telehealth is an acceptable way to improve access to specialist expertise and facilitate self-management patients with long-term health conditions (17-21). In some cases this approach has been associated with a reduction in hospital admissions (17, 18, 20). In 2012, in response to research evidence and the need to provide cost-effective care to an expanding population of patients with chronic disease, the UK government created the “3millionlives” campaign (22). This project aims to foster NHS, academic and industry collaboration in order to provide telehealth services to up to three million people with chronic health and social care needs in the UK.

The problems faced in MND are unlike many common chronic diseases in which telehealth has been previously trialed. Care for MND requires holistic and multi-disciplinary expertise and the use of uncommon interventions such as non-invasive ventilation and gastrostomy feeding. To date, use of telehealth in MND is limited, although small studies do show promise in certain niche areas. Telehealth systems using telephone consultation have been developed with some success in Italy and Portugal, to remotely manage patients who require home ventilation. These systems were associated with a reduction in emergency healthcare usage; more efficient use of staff time and potential cost savings (23-28). In Holland and rural Scotland, MND services have used video-conferencing (29, 30). Both approaches have potential benefits but telehealth used in this way is labour intensive and costly and care is driven by the priorities identified by the clinician rather than those of the patient. No telehealth system has been developed to provide frequent, holistic and highly specialist care to patients with MND at all stages of their illness.

We propose that telehealth could enable people with MND to have better access to the specialist monitoring and care that they require. Patients with MND are able to accurately report their level of disability and appropriate questions can identify new symptoms or early signs of respiratory failure (31-33). These features would suggest that a system of remote, question-based monitoring could provide regular, accurate clinical information to enable the clinician to detect and better manage problems without the patient needing to attend hospital. Telehealth provides the opportunity to provide education and reassurance and support to enable patients to better manage their own care (a core requirement of the National Service Framework for Long-term Conditions (34)).

There are estimated to be 10 million people in the UK living with a neurological condition (1). Both the common diseases such as Parkinson’s disease and epilepsy and rarer conditions such as muscular dystrophy and MND require specialist, multidisciplinary support from specialist services. A successful telehealth system may therefore be able to improve the services provided to many patients in the UK and their families.

#### **4. Summary and hypothesis**

##### **Summary**

We will undertake a pilot study of the use of the TiM telehealth system to improve the care of patients and their carers living with motor neurone disease. Whilst telehealth services have been used successfully in other long-term conditions, no service of this kind exists for patients with motor neurone disease. A pilot randomised controlled trial will employ a mixed methods approach to explore the feasibility and acceptability of using the TiM system to improve access to specialist care in MND. The pilot study will also explore the feasibility of a full-scale trial.

## **Hypothesis**

The TiM telehealth system will:

- Improve the quality of life of patients with MND
- Improved clinical outcomes for patients with MND
- Improve quality of life and other measures of well being for the primary informal carers of patients living with MND.
- Be acceptable to patients, carers and staff
- Lead to more cost effective utilisation of health care resources

## **5 Research objectives**

### **5a. Objectives of the pilot study**

- Determine the requirements of a full-scale study of the TiM system
  - Determine recruitment, retention and withdrawal rates.
  - Determine the most acceptable and appropriate outcome measure(s) that reflect the impact of the TiM system on patients and carers and health resources.
  - Provide an estimate of the resources required to conduct a full-scale study.
- Study the use of the TiM system in clinical practice
  - Assess the relationship between the benefits of the TiM system perceived by staff and participants with those captured by the outcome measures
  - Assessing participants' use and compliance with the TiM system
  - Health-care staff qualitative interviews and focus group
- Assess the safety of the TiM system using:
  - A shadow monitoring protocol
  - Health-care staff qualitative interviews and focus group
  - Analysis of technical and clinical adverse events

### **5b. Objectives of the full-scale study**

#### **Proposed primary end-point**

- Patient quality of life (outcome measure(s) to be determined in the pilot trial)

#### **Proposed secondary end-points**

##### Patient outcomes

- Severity of pain
- Severity of oropharyngeal secretions
- Incidence of depression and anxiety
- Time from diagnosis to death

##### Carer outcomes

- Quality of life
- Carer Burden
- Incidence of depression and anxiety

Health economic outcomes involving a cost utility analysis using costs of the system, costs of associated care requirements, EQ5D and patient survival

##### Safety of the TiM system

- Frequency of adverse events

### **5c. Justification of the pilot study**

Since this type of telehealth has never been evaluated in those with MND a pilot study is necessary to determine how a full-scale evaluation of its clinical and cost-effectiveness could be conducted and to gain a better understanding of how the TiM system would work. This includes evaluating recruitment and retention, as well as resource requirements. By evaluating compliance and safety monitoring and using qualitative the study will also enable a better understanding of how the telehealth system is used by patients, carers and staff.

A number of the proposed benefits of telehealth such as improving quality of life, providing reassurance and support, prompting self-care and a more efficient use of resources (18, 35-40) may be difficult to quantify. The validated measures of quality of life most commonly used in research (EQ5D and SF-36) were not specifically designed for patients with MND or their carers. The ALSAQ-40 tool better encompasses dimensions of life that are particularly affected by MND such as social and emotional function but it is unclear whether the ALSAQ-40 would fully reflect the impact of telehealth (41).

Data from quantitative elements of a randomised controlled trial will not, in isolation determine which outcome measures best reflect the impact of the intervention. It would also not fully explain how the TiM system would be used in the real world and what factors would influence its adoption and success. Utilising mixed methods will allow the combination of quantitative data with more in-depth results from qualitative interviews that will explore participants' experiences in more depth. It will also allow explanation of outcomes that occurred (particularly those that were unexpected) and understand why (and in what context) aspects of the system were successful or unsuccessful which could lead to improvements in the TiM system.

## **6. Study Methodology**

We will conduct a randomised controlled pilot trial comparing the TiM telehealth service and standard care with standard care alone. The intervention and follow-up period will be a minimum of 6 months. Quantitative data will be collected at 0, 3 and 6 months then every six months until the patient finishes the trial. Qualitative data will be collected at baseline in the control arm and at 1 and 6 months for a selection of patients in the intervention arm.

### **6a. Participant recruitment and selection**

Pre-screening will identify a list of potential patients who cared for by the Sheffield Teaching Hospitals MND care centre clinic as part of usual care using the MND care centre "ARC" clinical database. Each patient will be assigned a number. The Clinical Research Facility at the Royal Hallamshire Hospital, Sheffield Teaching Hospitals NHS trust will generate random numbers to identify the patients to invite. These patients will be sent a letter of invitation to participate. This will be accompanied by patient and carer information leaflets and a return slip to indicate their interest. Those who do not return the slip will be followed up by telephone or at clinic, if appropriate a minimum of once and a maximum of twice. A log will be kept in order to complete the CONSORT diagram (Appendix 2) (42).

Patients and their primary carer who express an interest will be invited to discuss the trial in a face-to-face meeting with the PI and also via telephone with their consultant neurologist (Dr. Christopher McDermott or Professor Dame Pamela Shaw, Sheffield Teaching Hospitals MND Care Centre). The Sheffield MND Care Centre sees approximately 120 new patients with MND per year. At any time there are approximately 300 patients attending clinic. We expect to be able to recruit a minimum of four patients per month.

Participants in the intervention arm will be invited to participate in qualitative interviews, conducted at month one and month six. Purposive sampling will be used to reflect the variation and predefined patient prognostic factors thereby capturing a range of experiences. Interviews will continue until data saturation is reached or 20 interviews have been conducted. All participants assigned to the control arm will be invited to be interviewed after completion of the baseline questionnaires to determine the feasibility and acceptability of these measures and their views on participating in the trial. The qualitative component will provide information not easily obtained from questionnaires that will facilitate understanding of the intervention from the perspective of all stakeholder groups.



## **6b. Consent**

Following indication of their interest to participant potential participants will be met at a mutually agreeable location, preferably the patients' home. They will have further opportunity to discuss the trial with the PI and decide whether they wish to participate. Willing participants will be asked to give informed written consent or use an appropriate witnessed alternative (which may include verbal consent or via a communication device) for screening and involvement in the trial. Carer consent will be obtained by full written consent.

In versions prior to V1.5 of the protocol both patient and carer consent were required. V1.5. has amended the inclusion criteria to allow a patient to participate with carer participation.

If one or both consent to the study a member of the study team will initiate the screening process. Participants will be screened and recruited by the PI according to the CONSORT principles and Good Clinical Practice (42, 43).

Those who decline participation will be invited to give their reasons in order to identify common factors; this may help recruitment strategies and identify potential problems for compliance. Basic anonymised details of these patients (age, gender, reason for exclusion) will be collected on all eligible patients in order to fulfill the CONSORT flow chart (Appendix 2) (42, 43).

## **6c. Randomisation**

Once recruited, randomisation will be performed using the independent web-based system <http://www.sealedenvelope.com> using block randomisation. All patients and carers will be assigned an anonymous individual study code, and a recruitment log held by the research team in SITraN.

## 6b. Inclusion and exclusion criteria

### Inclusion criteria:

- Patients aged 18 years or over who have attended the MND clinic at the Royal Hallamshire Hospital, Sheffield.
- Patients with amyotrophic lateral sclerosis diagnosed by a consultant neurologist with symptom onset within the last three years.
  - Or
- Patients with amyotrophic lateral sclerosis, primary muscular atrophy or progressive lateral sclerosis diagnosed by a consultant neurologist with a deterioration in their condition as evidenced by a deterioration in the ALS functional rating score (ALSFRS-R) by at least two points during the previous 18 months.
- Live within 120 minute drive from Sheffield

### Exclusion criteria:

The main circumstances where patients or carers will be excluded are those in which individuals would be unable to use the telehealth system or give informed consent.

- Patients attend another MND care centre in the UK.
- Significant impairment in decision making capacity preventing informed consent by the subject due to a major mental disorder including fronto-temporal dementia.
- Patient unable to use the TiM system due to physical, intellectual or language difficulties and unwilling to permit carer to operate it on their behalf. Patients will be asked to complete two questions used within the TiM system, with, or without the help to their carer to verify their ability to use the system.
- ~~• The patient has no eligible informal carer willing to participate in the trial (V1.5)~~
- Insufficient mobile telephone reception in the patients' home to use the TiM system.
- Any other major impairment that may affect their ability to participate in the study

### Carer inclusion criteria

- Age 18 years or older
- Person identified by the patient as the major provider of informal care (emotional and/or practical support) to the patient and provides more than one hour per week of unpaid care
- Carer willing to allow data they provide during the trial to be shared by the research team with their own doctor in the event of serious clinical need.

### Carer exclusion criteria

- Significant decision making capacity preventing informed consent due to a major mental disorder.
- Carer unable to use the TiM system due to physical, intellectual or language difficulties. Carers will be asked to complete two questions used within the TiM system to verify their ability to use the system.

- Inability to participate in the study due to other major physical or mental illness or language difficulties.
- Professional carers receiving direct payment for their services.

## **6e. Withdrawal**

Participants will be followed up until the end of the study, death, or withdrawal. Those wishing to withdraw will be given the opportunity to speak to a member of the study team. Participants are free to withdraw from the intervention or study at any time. As a pilot study, importance of understanding reasons for withdrawal is recognised. This will be explained to the participants in the information leaflets. The importance of understanding reasons for withdrawal and the characteristics of these participants is recognised given the nature of the study. This will be explained to the participants in the information leaflets.

### **Withdrawal criteria**

1. Patient request
2. Carer request
3. Patient loses capacity to continue to provide consent

If a Patient withdraws from the study arrangements will be made for the equipment to be collected or returned. Where appropriate participants will be invited to give the reasons for withdrawal.

Patients will also be given the option of:

1. Withdrawal from the intervention but remain within the study. Study data will only be collected at clinic visits at 3 and 6 months and six monthly until the end of the study.
2. Withdrawal from the study. Unless the participant objects, any data collected up to this point would be retained and used in study analysis. Participant agrees to allow contact to give safety and survival data.
3. Withdrawal from the study entirely. Unless the participant objects, any data collected up to this point would be retained and used in study analysis. If the participant does not wish to be contacted with regard to safety or survival data, no further contact with regard to this study will be made.

In the event that the patient dies or loses the capacity to provide consent they will be withdrawn from the trial but any data collected up to that point would be retained and used in study analysis. Carers would also be withdrawn at this point.

If the carer participant withdraws the patient can opt to continue to use the system or withdraw. If appropriate, carers will be invited to give reasons for withdrawal.

## **6f. Compliance**

Steps have been taken to encourage compliance with the weekly schedule. Patients will receive regular messages on the system to invite them to complete a scheduled telehealth session. They will receive feedback on their compliance record and an

encouraging message at the start of each visit. Those who fail to complete the session within one day will be reminded by text and via the telehealth system. If after two weeks they do not enter data they will be contacted by the PI and offered more support and training. Compliance data will be analysed as part of the process evaluation.

Compliance with the patient reported outcome measures would be monitored by the CRF nurse. She will contact the participants to support data collection, identify and chase missing data and feedback to the PI. In the event of missing data the CRF nurse will telephone the patients/carer after two weeks. She will contact them a minimum of twice and a maximum of three times to chase the data. A contact log will be kept.

## **6g. Sample size**

The study aims to recruit a total of 40 patients and their carers. 20 patients and their primary carer will be randomised to the intervention arm (a minimum of 6 months use of the TiM telehealth plus usual care) and 20 patients and their carer in the control arm (usual care).

Since the proposed trial is primarily an assessment of the acceptability of the intervention and the feasibility of a full trial, the proposed sample size is not based on standard statistical parameters such as a clinically relevant difference between groups. Instead, the sample size is justified on the grounds of quantifying patient variance (i.e. the standard deviation) in the proposed outcome measures (in particular quality of life measures) and on feasibility of the full trial, as follows:

- A sample size of 40 patients allows a standard deviation to be estimated to within a precision of  $\pm 20\%$  of its true underlying value with 90% confidence. This estimate will be synthesised with standard deviations observed in other published studies (e.g. (41, 44-47) and on-going trials within SITraN (48, 49), to provide a robust estimate for use in the sample size calculation for the full trial.
- Given the rarity of MND, any definitive study will be infeasible if the required sample size is substantial. Assuming the upper limit for feasible UK study is around 200-300 patients in total, it follows that the full study would need powering to detect a standardised effect size of at least 0.4 SDs. This pilot trial will provide a preliminary assessment of whether the intervention might feasibly achieve this, and inform the choice of outcome measures for the proposed full study.

This sample size is also in keeping with the proposal of 12 evaluable patients per arm in a pilot study (after withdrawal or drop-out) (50).

## **6h. Blinding**

The PI will not be blinded to the randomisation as they are responsible for training the participants to use the TiM system and any on-going technical or training requirements. The treating clinicians will not be blinded to the arm of the intervention as they are responsible for the clinical care of the patient and reviewing the data and the Shadow Monitoring System.

The PI will enter screening baseline data. Participant reported outcome measures after this will be collected by an independent research nurse from the Sheffield Teaching Hospitals Clinical Research Facility who will facilitate collection of these surveys by post or, if preferred by the patient, in person. They will enter the details into the study database.

Following the end of the trial and database lockdown the PI will analyse the two groups of data whilst remaining blinded to the allocation of the two groups. The STH CRF will hold the database code to identify the allocated groups.

The PI will conduct the qualitative interviews and collect the system use data and will not be blinded to these measures.

## **7. Study treatment**

### **Standard clinical care – Intervention arm and Standard care arm**

Usual clinical care will continue throughout for participants in both arms of the study. All participants will continue to be invited to the Sheffield MND Care Centre Clinic for routine review. They will be seen by their consultant neurologist and the MND multidisciplinary team, according to their routine two- to three-monthly schedule. All patients will have access to the MND telephone helpline provided by the Sheffield MND care team.

### **The TiM system - Intervention arm**

Those in the intervention arm will use the TiM system, in addition to standard clinical care. All necessary hardware, software, data transfer and support costs for the TiM system will be met by Abbott Healthcare Products Ltd in collaboration with Carematix.

Patients will be provided with a TiM patient hub: a handheld, touch screen Samsung Galaxy tablet computer that communicates with the MND specialist nurse's TiM clinician system at the Sheffield MND Care Centre. Patients will be asked to use the system at least weekly. Each week the telehealth hub asks the patient a series of questions to detect common problems found in MND, such as worsening mobility, or swallow, symptoms of depression, anxiety, pain, saliva and spasms. Some of the questions closely match validated scoring scales (e.g. the ALS Revised Functional Rating Score (51) and the depression and anxiety short screen: PHQ-4) but others have been specifically designed by the clinical team to be used in the telehealth system. The TiM system also enquires about symptoms of respiratory insufficiency and infection, nutrition and social care. Patients using specialist equipment, such as non-invasive ventilation or gastrostomy tubes will additionally be asked to report problems related to the intervention. The TiM system can also weigh patients weekly and monitor patients' overnight oximetry using established telehealth monitors.

Carers will also be asked to complete a weekly telehealth session in order to monitor their well being. The TiM system includes a carer strain screen and the PHQ-4 depression and anxiety screen. There is also the opportunity with the telehealth system for patients or carers to trigger an adhoc session if issues arise during the week about which they wish to inform the centre. Interspersed through the questions are educational messages and users have access to a bank of educational resources within the hub.

The patient and carer responses are transmitted (via an encrypted 3G mobile signal) to the Carematix server. The responses undergo immediate computational analysis, using pre-determined clinical algorithms, which assigns an alert level to each response. This limits the amount of nurse's time required to use the system. An automated acknowledgement is sent back to the user indicating whether to expect contact from the MND centre based on the results and the timescale for the response.

Each day the MND nurse will log into the TiM system and will be presented with the responses from all patients using the TiM system. They will be automatically alerted to any important changes. Urgent alerts include any new and severe symptom or any new problem that poses a major risk to the patient or carer (e.g. choking, falling, respiratory insufficiency). Routine alerts include any other deterioration in the patient's ALSFRS-R or any new symptom. An appropriately timely response will be made to each alert level. Patients will be reminded to seek urgent medical attention in an emergency.

The information on patient status may facilitate rescheduling of appointments according to patient need rather than the fixed intervals used at present (e.g. the appointment could be delayed if the patient is well, and the TiM system has activated no new alerts). As the feasibility and safety of the TiM system has not been previously evaluated, during the TiM trial patients will continue to attend routine clinic appointments and no patient will have their clinic delayed. The feasibility and safety of rescheduling appointments will be examined using a shadow monitoring protocol (detailed later).

Patients and carers will undergo a training session and a follow-up telephone call after two weeks. The TiM system has been designed to be user friendly and to encourage compliance with the weekly sessions. Face-to-face training with the hub system will be offered at the start of the intervention. Support will be available throughout the trial in the hub. Compliance will be monitored and should patients not complete the TiM system for three weeks in a row, contact will be made to offer more training or support.

The TiM system has been designed by the applicant in collaboration with her supervisors, the Sheffield MND team, Abbott Healthcare Products Ltd. and Carematix. Carematix have experience in delivering similar home telemonitoring systems in other diseases. In developing the system, expertise has also been sought from those developing telehealth services in other diseases in the University of Sheffield and NIHR CLARHC for South Yorkshire. These included the School of Health and Related Research (SchARR) SMART consortium (Self Management supported by Assistive, Rehabilitation and Telecare technologies), NIHR CLAHRC SY Telehealth & Care Technologies (TaCT) for Long Term Conditions theme, and Devices for Dignity (52).



## **8. Data collection**

### **8a. Quantitative data collection**

Data collection will occur at baseline, three months and six months at the end of the study. Participant data will be completed using postal and telephone questionnaires to minimize patient burden and cost. The study will continue for a minimum of six months. Follow-up will continue until the last participant has used the system for six months. The maximum proposed follow-up will be 18 months.

#### **Patient measures**

Baseline measures:

- Age
- Gender
- Experience with technology (frequency of use of a computer, tablet or smart phone)
- Major health condition that could impact on the use of telehealth (including mood disorder, other symptomatic chronic disease)
- Medication

Outcome measures will be collected at 0, 3 and 6 months, then every six months until the end of the study and finally at the end of the study:

- Quality of life measures
  - ALSAQ-40 (an MND disease specific quality of life score (41))
  - SF-36-RAND
  - EQ-5D+D (EQ-5Q-3L with a dignity bolt-on)
- Clinical outcomes
  - ALSFRS-R (an MND disease specific functional rating score (51))
  - Pain score (modified Likert scale)
  - CSS-MND Saliva Severity Scale (designed for use with MND patients) plus global change scale
  - Hospital Anxiety and Depression Scale
- Health resource usage questionnaire
- Patient experience questionnaire



### **Carer measures**

Baseline measures:

- Age
- Gender
- Frequency of use of a computer, tablet or smart phone
- Major health that could impact on the use of telehealth
- Relationship to patient
- Number of hours spent per week providing care for patient

Outcome measures will be collected at 0, 3 and 6 months and at the end of the study:

- SF-36 RAND
- 12 item Zarit Burden Inventory (53)
- Hospital Anxiety and Depression Scale (54)
- Carer satisfaction questionnaire

Data will be collected to evaluate the conduct of the trial including:

- Participant compliance with the weekly telehealth session
- Rate of completion of outcome measures
- Rates of recruitment and withdrawal
- Participant actual and perceived time burden associated with the system
- Time spent by the MND nurse using TiM system and responding to alerts or queries generated by the system.

## **8b. Qualitative sub-study**

### **Intervention patient and carer interviews**

Qualitative semi-structured interviews will be conducted with patients and carers in the intervention arm. Participants randomized into the intervention arm will be invited to take part in interviews. Baseline interviews will occur at one month after the intervention is started. A further interview will be conducted at 6 months. Six months is considered an appropriate timeframe for patients to become familiar with the intervention and its impact on quality of life.

Interviews will be conducted until data saturation is reached. The interviews will draw directly upon peoples' own experience and views, within the context of everyday lives to explore topics including

- Participants experience and expectations of technology
- Participants' expectations of telehealth services
- Barriers and aids to recruitment
- Compliance with the TiM system
- How the TiM system is used at home by patients and their carers
- The impact of using the TiM system on their lives and well-being
- The impact of education on their day-to-day lives
- The experiences of carers monitoring
- Whether the outcome measures used capture the changes in participants well being associated with using the TiM system.
- How the system would be used outside a trial

The early phase interview will explore participants' expectations of technology and the TiM system, the views on the system, their experiences of training and using the equipment. The later phase will explore further how the TiM system influenced their care and quality of life, mental well being as their condition changed. It will also identify barriers and facilitators to adoption of the TiM system.

The applicant will agree pre-defined topic schedules (see Appendix B) developed from the literature, expert consensus and discussion with the trial management group with supervision from Dr. Wendy Baird, an experienced qualitative researcher (School of Health and Related Research, Sheffield University). The PI will conduct interviews in the participants' home. The PI will conduct qualitative interviews until data saturation is reached (55). Interviews will be audio- recorded, transcribed verbatim and analysed with coding and retrieval of data supported by NVivo software.

Due to the nature of MND consideration will be given to participants' needs. The research team has experience in conducting qualitative interviews with patients and carers and these interviews will be conducted in a similar fashion. Often patients with MND prefer to be interviewed with their carer. This also aids communication where patients have speech difficulties and allows participants to support each other whilst discussing sensitive issues. Patients can use communication devices and all participants will be provided with a brief topic guide prior to the interview to facilitate participation for those with communication difficulties. Interviews will be limited to approximately one hour to reduce burden and fatigue. If participants prefer to be interviewed together carers will also be offered separate interviews where possible.

Field notes will also be collected by the PI during the face-to-face training using the TiM system to determine participants' early reactions to using the system and their needs for training.

### **Control group interviews**

Following randomization, those patients and carers who are assigned the control arm will complete the baseline questionnaires. They will then have a short (15-20 minute) semi-structured interview with the PI. This will focus on their experiences and opinions of the baseline questionnaires. It will examine whether they were easy or difficult to complete, whether they were acceptable or caused distress to complete and which questions most reflected their condition and current quality of life.

The interviews, topic guides and analysis will be conducted in the same way as described in the previous section. Topic guides will not be provided before the interview but participants invited to submit any further comments to the research team either in writing or telephone following the interview. It is expected that patients and carers will be interviewed together. Interviews will continue until data saturation is reached or a maximum of 10 interviews conducted.

### **Staff interviews**

At least five staff that care for the participants will undergo one-to-one semi structured interview by the PI during and at the end of the intervention. This will include the two responsible consultant clinicians (Dr Chris McDermott and Professor Pamela Shaw), at least one MND specialist nurse who has used the telehealth system and two members of the MND community team who have cared for participants. They will allow them to draw on their experiences of the TiM system in more depth. A staff information leaflet will be provided and written consent will be required prior to any interview.

Topics will include

- The day-to-day use of the TiM system
- The impact of the TiM system on clinical care of patients and carers
- The safety and accuracy of the system
- Barriers and aids to adoption of the TiM system.
- Views on amending the appointment schedule

These will be planned and conducted in the same manner as the participant interviews under the supervision of Dr Wendy Baird. An interview with the MND nurse and clinicians using the system will be scheduled early in the trial to capture any problems with training and set up of the system. At the end of the trial further interviews will be held with the MND team as described above.

Following the interviews a focus group with the clinical team will be held to draw together all the information gathered from the patient and staff interviews. It will be chaired by Dr Wendy Baird, independent qualitative researcher, transcribed and analysed by the PI under her supervision.

The qualitative findings will facilitate the exploration of any issues and challenges, which may arise from using TiM from the perspective of all stakeholder groups. The findings will enhance understanding of the feasibility of using TiM and assist with the interpretation of the clinical data from the perspective of patients and clinicians.

### **8c. Shadow monitoring protocol**

In order to determine the safety of a remote monitoring system that may enable clinicians to make decisions regarding a patient's management the trial will also collect data on clinicians' opinion on the accuracy of the data displayed by the TiM system. This is referred to as the shadow monitoring protocol.

Prior to each patient's face-to-face visit (depending on their appointment schedule) the treating MND doctor will be asked to conduct a remote assessment of the patient by reviewing the TiM system clinical information. They will be asked to indicate, given the information provided by the TiM system, whether they would change their patient's appointment. The patient would attend the appointment as scheduled and after the appointment the clinician would be asked whether the appointment schedule time was correct. They would also be asked to indicate whether they felt that the information displayed on the TiM system was a safe and accurate reflection of the patient's condition and whether it influenced their clinic visit. Clinicians will also indicate whether the TiM system had affected the consultation. They will also report any adverse events identified. Should patients be unable to travel to clinic they will be offered a telephone consultation at the usual scheduled time. The same Shadow Monitoring questions and need to report adverse events will apply.

The results of this shadow monitoring will be triangulated with the qualitative sub-study and will influence the later interview topic guide.

### **8d Process evaluation**

Data regarding the TiM system use by patients, carers and staff will be collected in order to understand how the system could be used in the NHS MND care process. It will also collect data regarding the extra time and resources required to manage the problems generated by the TiM system. It will be triangulated with data gained from the qualitative sub-study, adverse event log and shadow monitoring protocol.

## 9. Analysis

The PI will conduct analysis with regular supervision from the TMG.

### 9a. Feasibility and quantitative analysis

The feasibility of a full trial will be determined by analysis of

- Recruitment rates
- Retention rates
- Compliance rates
- Sample size calculations as detailed above

The safety, acceptability and feasibility of use of the TiM system

- Incidence of adverse events (clinical and related to the TiM system functionality)
- Information collected using the Shadow Monitoring process
- Qualitative data analysis

The PI and the CRF study nurse will be responsible for chasing missing data. The CRF nurse is responsible for chasing the questionnaire data and will telephone the patients a minimum of once and maximum of twice to chase unreturned questionnaires or clarify missing data within the questionnaire packs. They will report monthly to the PI. For the main outcome measures, (SF-36 and ALSAQ-40) protocols are provided for managing missing data if necessary. Participants who withdraw will be encouraged to continue to be followed up and reasons for withdrawal ascertained where possible. In the proposed larger, efficacy trial intention to treat analysis will be adopted.

Quantitative analysis will be undertaken in a similar manner for all endpoints. The change from baseline at each time point will be analysed using analysis of covariance in which the covariates are treatment group and the baseline value. For instance, the change in ALSFRS-r at six months will be analysed with treatment group and baseline ALSFRS-r as covariates. The mean (standard deviation) change in each group, the difference between groups and its associated 95% confidence interval will be reported. No formal hypothesis testing will be undertaken for this pilot study.

## **9b. Qualitative analysis**

Data from the interviews will be recorded, transcribed and undergo Framework analysis (56). Although Framework analysis was developed for applied policy it has proved useful in applied health research. Analysis will be ongoing and iterative involving concurrent data collection and analysis, with systematic efforts to check and refine developing categories of data. Themes and hypothesis identified in the early phases of data collection will inform the areas of investigation in later interviews. Regular meetings with supervisors will review the data analysis, explore respondents' underlying reasoning, discuss deviant cases and reach agreement on recurrent themes and findings. The PI's field notes and reflexive diary will also be reviewed and used to inform the analysis of qualitative data. Dr Wendy Baird, an independent, experienced qualitative research, will supervise this stage of the work.

Results from the qualitative analysis will be triangulated, for example, to explore the reasons why problems with the trial methodology or TiM system have occurred. Both themes and anonymous verbatim comments will be published to demonstrate the findings.

## **10. Data entry, security and confidentiality**

Clinical quantitative data input will be the responsibility of the PI (baseline) and CRF study nurses (months 3 and 6, and at the end of the study). Data quality will be the responsibility of CRF nurses and PI who will report back to the TMC and TSC. The qualitative data and system usage data will be the responsibility of the PI. Data (including audio-recordings) will be collected and retained in accordance with the Data Protection Act 1998 and Caldicott Principles. Anonymised study data will be entered onto a validated database system designed to an agreed specification between the PI and Sheffield CTRU and securely stored on the SU intranet. The PI and the CRF research nurses will have access to data on the database through the use of usernames and encrypted passwords. Study documents will be retained in a secure location during and after the study has finished.

All source documents will be retained for a period of at least 5 years following the end of the study, as per the CTRU SOP. Where study related information is documented in medical records those records will be retained for at least 5 years after the last patient last visit

The data provided through the TiM system will be collected using a secure web-app accessed by the participants by a unique username and password. It will be stored on a secure server that will be available through a web-portal hosted by Carematix to the clinical team using secure usernames and password.

For the purposes of the trial each participant will be given a unique TiM system code. This will allow all data to be relayed through the web-app without any associated patient identifiable features. This code will be held separately and stored securely on the STH intranet to allow individual identification by the MND care team. The clinician will display only the anonymous code. This will be accessed through a secure portal with usernames and passwords. No identifiable information will be stored on the patient hub or on the TiM server. The technology providers will have no access to patient identifiable information. Any technology problems will be dealt with by the research team and participants will have no contact with the technology providers.

The system has a full electronic audit trail and will be regularly backed up and will be held in a way that conforms to STH information governance procedures.

### **Access to source data**

Monitoring and audit by the relevant health authorities will be permitted by the sponsor. These include the Research Ethics Committee and local R&D departments. The sponsor will be allowed to monitor and audit the study at each site and be allowed access to source data and documents for these purposes.

## 11. Safety and safety assessments

We do not envisage any serious safety or adverse events associated with the intervention. The system does not give individual advice to a patient or recommend change in management without input from a clinician. The trial protocol requires patients to continue with their usual care including planned outpatient appointments and the Shadow Monitoring Protocol will evaluate whether the data provided by the TiM system is felt to accurately reflect the patients' clinical condition. The responsible clinician who is a consultant neurologist with specialist experience in MND and research will continue to review the patient on a regular basis (unless the patient is unable to attend clinic) and will have overall responsibility for their care throughout the trial. The specialist MND nurses using the TiM system have extensive experience in managing patients via the existing MND helpline.

The database will automatically alert the trial manager to any carer scoring 11 or more of the Hospital Anxiety and Depression score collected as part of the outcome measures. This will allow the trial manager to identify those carers who may require further support.

### **Adverse Event Reporting**

All adverse events will be reported in accordance with the Sheffield CTRU Adverse Event and Serious Adverse Events SOP.

Participants will be monitored for adverse clinical events and efforts will be made to ascertain whether the TiM system influenced the event or could have predicted the event. These include unplanned admissions and deaths. Non-clinical events relating to the use of the telehealth hub will be recorded e.g. failure to record or deliver information to and from the clinical interface.

In research other than CTIMPs an adverse event is defined as: is any unfavorable and unintended sign (including an abnormal laboratory finding), symptom, or disease having been absent at baseline, or, if present at baseline, appears to worsen AND is temporally associated with medical treatment or procedure, **REGARDLESS** of the attribution (i.e., relationship of event to medical treatment or procedure).

### **Serious Adverse Event (SAE)**

In research other than CTIMPs, the National Research Ethics Service defines a Serious Adverse Event (SAE) as an untoward occurrence that:

- (a) results in death;
- (b) is life-threatening\*;
- (c) requires hospitalization\*\* or prolongation of existing hospitalization\*\*;
- (d) results in persistent or significant disability or incapacity;
- (e) consists of a congenital anomaly or birth defect; or
- (f) is otherwise considered medically significant by the investigator.

\*"life-threatening" in the definition of "serious" refers to an event in which the patient was at risk of death at the time of the event; it does not refer to an event which hypothetically might have caused death if it were more severe. \*\*Hospitalisation is defined as an inpatient admission, regardless of length of stay, even if the



hospitalisation is a precautionary measure for continued observation. Hospitalisations for a pre-existing condition, including elective procedures that have not worsened, do not constitute an SAE.

### **Adverse event exclusions**

The only adverse event that will be excluded is:

1. Standard or expected disease progression.

### **Adverse event inclusions**

All serious adverse events will be reported. These include deaths of participants and emergency admissions. We will attempt to determine whether the use of the TiM system contributed to the event, in particular whether there was any delay in seeking help due to the use of the system.

### **Assessment of Adverse Events**

The following criteria will be used when assessing adverse events: Intensity (severity):

Mild - does not interfere with routine activities

Moderate - interferes with routine activities

Severe - impossible to perform routine activities

Relationship to the study treatment:

Unrelated - There is no evidence of any causal relationship. N.B. An alternative cause for the AE should be given

Unlikely - There is little evidence to suggest there is a causal relationship. There is another reasonable explanation for the event (e.g. the participant's clinical condition, other concomitant treatment).

Possible - There is some evidence to suggest a causal relationship. However, the influence of other factors may have contributed to the event (e.g. the participant's clinical condition, other concomitant treatments).

Probable - There is evidence to suggest a causal relationship and the influence of other factors is unlikely.

Definite - There is clear evidence to suggest a causal relationship and other possible contributing factors can be ruled out.

Not assessable - There is insufficient or contradictory information which cannot be supplemented or verified

### **Reporting procedures**

All study participants will be encouraged to contact and inform their site research team if they experience any new medical problem or are admitted to hospital. Those that are not picked up through general contact will be identified at their routine 2-3 monthly outpatient appointments either in person or by telephone as part of the Shadow Monitoring Protocol. The patients' consultant neurologist (Dr. Chris McDermott or Professor Dame Pamela Shaw) will enquire about any adverse events since the previous visit and record these on the adverse event paper CRF and database. For any Serious Adverse Events an SAE paper CRF and database entry will be completed. The PI and consultant neurologist will assess the event and the CRF will be kept in the site file. Serious adverse events will be reported to the TSC, TMG and the sponsor if deemed by

either to be related to the trial. Reports of related and unexpected SAEs will be submitted to the ethics committee within 15 days of the chief investigator becoming aware of the event. This will use the National Research Ethics Service Report of Serious Adverse Event form. Information will also be included in the routine progress reports to the sponsor and ethics committee. Routine safety data and all SAEs that the TMG or TSC deems to be related to the trial will also be reported to the technology provider in the same manner.

Any suspected adverse drug reaction would be assessed and reported to the MHRA as part of clinicians' routine pharmacovigilance responsibilities using the Yellow Card Scheme. The technology provider, Abbott Healthcare Products Ltd. manufactures a number of drugs (listed in Appendix A). Any suspected adverse drug reaction involving an Abbott Healthcare Products Ltd. drug would also be reported to the manufacturer in the same manner, within 24 hours of receipt by the CI or the next working day for reports received out of hours. Such reports should be sent to [ukpharmacovigilance@abbott.com](mailto:ukpharmacovigilance@abbott.com). On a monthly basis the PI will send a reconciliation list of all the reports sent to the Abbott Pharmacovigilance Department within that month to ensure that all the appropriate information has been exchanged. Should any discrepancies arise, both parties will immediately seek to resolve them.

## 12. Ethical considerations

The study will be conducted in accordance to Good Clinical Practice Guidelines and subject to Research Ethics Committee favourable opinion. The study received a favorable approval from an independent panel representing the NIHR, which funds Dr. Esther Hobson's NIHR Doctoral Fellowship Award.

The study has approval from the Sheffield Teaching Hospitals NHS Foundation Trust's Research and Development department. It has also received favourable review from Dr. Mike Bradburn, study statistician at SchARR, Dr. Cindy Cooper, director of CTRU and SchARR, and Dr. Wendy Baird of the Yorkshire and Humber Research and Design service, Professor Alicia O'Cathain, Professor of Health Services Research, SchARR and Professor Dame Pamela Shaw, SITraN. The application will be submitted through the IRAS central allocation system. The approval letter from the ethics committee and copy of approved patient information leaflet, consent forms, CRF's and questionnaires will be present in the site files before initiation of the study and patient recruitment.

It is recognized that patients with MND may be frail and nearing at the end stages of their lives. The research team has extensive experience in conducting clinical trials in this population. The study design has attempted to limit the burden imposed by the study by avoiding unnecessary study visits (by combining them with scheduled visits), collecting data in the participants' homes at their convenience and limiting the study procedures to the minimum necessary. The intervention has been designed in collaboration with patients and carers to maximize ease of use and minimize impact on participants' lives. It is appreciated that there are a number of questionnaires that require completion. Given one aim of the study is to determine the most appropriate outcome measures to evaluate efficacy of the TiM system there are more questions than would be used in a large scale trial. These have been reviewed by the Sheffield MND Research Advisory Group (the local PPI group) and the lay members of the TSC (David Stelmach) and TMG (Anne Quinn) to ensure acceptability. Participants will be supported by the CRF nurse to complete these at their convenience in a manner selected by the participant (either by post, telephone or in person).

There are other clinical studies ongoing in the Sheffield MND care centre. Involvement in other studies would not preclude patients from entering this study. Consideration of the burden involved in the study, potential impact on the outcome of the study and the patients' expressed priorities will be considered before patients are approached to be involved. If involvement in this study excludes patients from entering another clinical trial patients will be given the option to withdraw from this study.

The potential conflict of interest between the role of the clinical team in caring for patients and their role as researchers is recognized. The study design has considered the impact of this conflict on the participants choices and also any potential bias. Whilst PI is a doctor working within the MND team she is a specialty training registrar and overall responsibility for the patients' clinical care will remain with the consultant neurologist rather than the PI. Whilst she may have already cared for potential participants, following an invite to participate in the trial will no longer see these patients in their routine clinical appointments and her role will be as a researcher.

The dual role of the PI as a doctor and researcher has been previously evaluated. The professional background of a doctor may actually aid the building of a research relationship, allow patients to be more open and comfortable with discussing their health with someone who they already trust (56). In order successfully identify any potential bias the purpose of the research and nature of the PI's role will be emphasized throughout the study, the PI will keep a reflexive diary and field notes and identify any potential bias. Where bias is most likely, i.e. in the collection of outcome measures steps have been taken to limit this: the quantitative outcome measures will be collected by an independent study nurse and the qualitative interview structure and topic guides have been planned with supervision from an independent researcher Dr. Wendy Baird. The PI will be supervised, as part of her PhD by independent academics: Dr. Cindy Cooper and Dr. Mike Bradburn (focusing mainly on the trial methodology and conduct, and quantitative data analysis), Dr. Wendy Baird and Professor Sue Mawson (qualitative work and service evaluation). If, during the research, participants identify any medical problems, the PI has a duty of care and will make arrangements to deal with these problems. This might involve signposting them to appropriate services or liaising with the clinical team. A log of these activities will be kept and reviewed by the TMG.

When the participants have prior knowledge of the researcher they may feel a sense of duty and feel pressurized to participate (57). Ground rules, informed consent, confidentiality, freedom to stop and what to expect will be discussed with all participants. Participants will be approached by letter and they will be required to contact the study team allowing them to consider the trial in detail first. It will be explained to the patient (both verbally and in the information leaflets and consent forms) that participation is voluntary and will not affect their ongoing care. The information leaflet differentiates the research process and their usual care. It will be made clear, particularly in the interview phase that the PI's role is as a researcher and the aim of the study is to critically analyse service provision and that whilst comments, particular negative comments, will be passed back to the care team they will be treated with confidence and respect.

Whilst the carer participant is not a patient of the Sheffield MND team the research team have a duty of care to the carer. There may be circumstances where the carer may disclose information that requires medical care, for example disclosing symptoms of depression or anxiety. At the start of the trial the carer participants' GP will be informed of the trial. In the event of a serious risk being identified the research team will discuss this in confidence with the carer and make arrangements to resolve the problem. This might include referral to his or her own GP or other health professional. Carer participants will be informed of these procedures in the Carer information leaflet and consent form. Confidentiality will be maintained in accordance with the General Medical Council's guidance on Confidentiality (58).

Upon publication of the qualitative interviews it may be possible to identify participants' comments although this will be avoided if possible. This is explained to participants in the Interview Information Leaflets and on the consent form.

### **13. Finance and indemnity**

The trial has been financed through an NIHR doctoral fellowship grant and details have been drawn up in a separate agreement.

This is an NHS sponsored study. If there is negligent harm during the clinical trial when the NHS body owes a duty of care to the person harmed, NHS indemnity will cover NHS staff, medical academic staff with honorary contracts and those conducting the trial.

The University of Sheffield has in place insurance against liabilities for which it may be legally liable and this cover includes any such liabilities arising out of this clinical trial.

### **14. Reporting and dissemination**

Results of the study will be disseminated in peer reviewed scientific journals and clinical and academic conferences. Details of the study will also be made available on the SITraN and SchARR websites, blogs and social media and through local MND groups. Summaries of the research will be updated periodically on the SITraN website to inform readers of the ongoing progress. Following publication contact with other UK MND care centres will be made to disseminate the findings and assess buy-in potential for a full study if this is appropriate.

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**Appendix 1: Drugs produced by Abbott Healthcare Ltd.**

Fenofibrate  
Pancreatin  
Moxonidine  
Estradiol/dydrogesterone  
Mebeverine  
Betahistine  
Fluvoxamine maleate  
Lactulose  
Estradiol, oral applications  
Influenza virus vaccine  
Eprosartan mesylate  
Ibuprofen  
Flurbiprofen  
Propafenone  
Clarithromycin  
Verapamil

## **Appendix 4.2**

### **TiM trial statistics analysis plan version 1.3**



## Telehealth in Motor Neurone Disease

Telehealth in Motor Neurone Disease (TiM): A mixed methods, randomised controlled, pilot study of the use of the TiM telehealth system to deliver highly specialised care in Motor Neurone Disease, at a distance

### Statistical Analysis Plan Version 1.3 17/8/16

*Authored by*

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## List of Abbreviations

AE	Adverse event
ALS	Amyotrophic lateral sclerosis
ALSAQ-40	Amyotrophic Lateral Sclerosis Assessment Questionnaire – long form
ALS-FRS-R	Amyotrophic lateral sclerosis rating scale-revised
CI	Confidence Interval
CONSORT	Consolidated standards of reporting trials
CRF	Case Report Form
CSS-MND	Clinical Saliva Scale for Motor Neurone disease
CTRU	Clinical trials research unit, University of Sheffield
EQ-5D-3L	EuroQol Group Health Questionnaire
EQ-5D+D	EQ-5D questionnaire with dignity bolt-on
HADS	Hospital Anxiety and Depression Scale
ICH	International Conference on Harmonisation of Technical Requirements for Registration of Pharmaceuticals for human use
ITT	Intention To Treat
QoL	Quality of life
MND	Motor neurone disease
NIV	Non-invasive ventilation
SAE	Serious adverse event
SAP	Statistical analysis plan
SD	Standard deviation
SF-36 RAND	36-Item Short Form Survey from the RAND Medical Outcomes Study
SITraN	Sheffield Institute of Translational Neuroscience
SOP	Standard operating procedure
Telehealth	Remote monitoring of patients physiology or patient reported measures, forwarded to a central service with the aim to diagnoses or monitor a medical condition
TMG	Trial management Group
TSC	Trial Steering Committee
TiM	Telehealth in Motor neurone disease
TM	Trial manager (EH)
ZBI	Zarit Burden Index

## 1. Introduction, Study Design & Objectives

This Statistical Analysis Plan (SAP) is written in conjunction with the ICH E9 (International Conference on Harmonisation of Technical Requirements for Registration of Pharmaceuticals for human use; ICH Harmonised Tripartite Guideline: Statistical Principles for Clinical Trials E9), applicable standard operating procedures (SOPs) from the Sheffield Clinical Trials Research Unit (CTRU) and trial documents (Protocol, case report form (CRF) and Data Validation Specifications). This SAP will guide the trial manager (TM) and Trial Statistician during the statistical analysis of all quantitative outcomes in order to answer the objectives of the study.

### 1.1 Study Background

This is a single-centre, pilot, mixed methods, randomised controlled trial to explore the feasibility and acceptability of using the TiM (Telehealth in Motor Neurone Disease (MND)) system in clinical practice and explore the feasibility of a larger, multicentre trial. This plans refers to the TiM trial protocol V1.5 April 2015.

All analyses will be performed in a validated statistical software package such as GraphPad prism.

### 1.2 Primary Objectives

As this is a pilot study, no formal primary clinical outcome will be defined. Instead, the trial will assess the feasibility and requirements of a full-scale study of the TiM as defined by the as successful recruitment of 40 eligible patients and their primary carer; and the feasibility, acceptability, safety and use of the TiM system within a health service. The specific objectives and outcomes of this study are separated into two groups: feasibility and clinical outcomes.

#### 1.2.1 Feasibility Outcomes

##### **Feasibility of a full-scale study**

- To make a decision on the primary outcome for the main trial. The mechanism for choosing this outcome will be informed by statistical considerations which are detailed in section 6.7.
- Number of potentially eligible patients among the pool of patients under the care of the Sheffield MND care centre
- Number/characteristics of eligible patients approached for the study:
- List of reasons for declining/refused consent;
- Participant attrition rate
- List of reasons for attrition
- Number of missing values/incomplete cases .
- Treatment receipt/adherence;

- Patient, carer and clinician views on intervention/research protocol (using qualitative methods).

Feasibility/safety of TiM system:

- Treatment receipt/participant and staff adherence
- Participant and clinician acceptability of the intervention (using qualitative methods and the TiM system experience questionnaire and Shadow monitoring protocol)
- Patient, carer and clinician views on intervention (using qualitative methods);
- Incidence of TiM system technical problems;
- Incidence of adverse events related to intervention.

Participant and clinician views will be investigated using qualitative interviews (described in the protocol). Participant and clinician acceptability will be reported based on TiM system experience questionnaire and Shadow monitoring questionnaire.

### 1.2.2 Clinical Outcomes

The following clinical outcomes will be reported using self-completed questionnaires baseline, 3, 6, 12 and 18 months.

Patient outcomes

- Quality of life (QoL) measures
  - ALSAQ-40 (an MND disease specific quality of life score)
  - SF-36-RAND
  - EQ-5D+D (EQ-5Q-3L with a dignity bolt-on)
- Clinical outcomes
  - ALS-FRS-R (an MND disease specific functional rating score)
  - Pain score (modified Likert scale)
  - CSS-MND Saliva Severity Scale (designed for use with MND patients) plus global change scale
  - Hospital Anxiety and Depression Scale (HADS)
- Health resource usage questionnaire
- Patient experience questionnaire
- TiM experience questionnaire

Carer outcomes

- SF-36 RAND
- 12 item Zarit Burden Inventory (ZBI) (53)
- Hospital Anxiety and Depression Scale (54)
- Carer satisfaction questionnaire



The following safety outcomes will be assessed at every clinical visit:

- Incidence of adverse events (AEs)
- Clinician satisfaction

## 2 Sample Size Estimation

The study aims to recruit a total of 40 patients and their carers. 20 patients and their primary carer will be randomised to the intervention arm (a minimum of 6 months use of the TiM telehealth plus usual care) and 20 patients and their carer in the control arm (usual care).

Since the proposed trial is primarily an assessment of the acceptability of the intervention and the feasibility of a full trial, the proposed sample size is not based on standard statistical parameters such as a clinically relevant difference between groups. Instead, the sample size is justified on the grounds of quantifying patient variance (i.e. the standard deviation) in the proposed outcome measures (in particular quality of life measures) and on feasibility of the full trial, as follows:

- A sample size of 40 patients allows a standard deviation to be estimated to within a precision of  $\pm 20\%$  of its true underlying value with 90% confidence. This estimate will be synthesised by combining baseline measurements of quality of life measurement standard deviations with those observed in other published studies and on-going trials within SITraN, to provide a robust estimate for use in the sample size calculation for the full trial.
- Given the rarity of MND, any definitive study will be infeasible if the required sample size is substantial. Assuming the upper limit for feasible UK study is around 200-300 patients in total, it follows that the full study would need powering to detect a standardised effect size of at least 0.4 SDs. This pilot trial will provide a preliminary assessment of whether the intervention might feasibly achieve this, and inform the choice of outcome measures for the proposed full study.

This sample size is also in keeping with the proposal of 12 evaluable patients per arm in a pilot study (after withdrawal or drop-out) (1).

### **3 Randomisation & Blinding**

Randomisation is conducted according to the protocol.

The patient, clinicians, TM and trial team are not blinded to the outcomes. Data entry for follow-up clinical outcomes was performed by an independent research nurse, not involved in the study. Blinding of this nurse was impractical given additional measures were collected for those in the intervention group. The TM will undertake the analysis under the supervision of the independent trial statistician. Blinding during analysis was impractical given the small number of participants who had with unique and characteristics which are likely to be identifiable to the TM. This will be reported as a limitation

### **4 Interim Analysis & Study Monitoring.**

This is a pilot study with no planned interim analysis or early stopping. Two committees have been set up to govern the conduct of the study:

- Trial Steering Committee (TSC)
- Trial Management Group (TMG)

Decisions to stop the trial early on grounds of safety will be made by the Trial Steering Committee or funding body. There will not be a Data Monitoring and Ethics Committee for this study as it is considered low risk. No interim analysis is planned.

The TM will receive notifications of all carers whose Hospital Anxiety and Depression subscores exceed 11. These events will be recorded as AEs, reported to the TMG and TSG during the study and reported in the analysis.

### **5 Data Sources, Evaluability & Study Populations**

#### **5.1 Data Sources**

Data used in this study will come from data entered onto CRFs and questionnaires and from data entered directly on the CTRU database (PROSPECT). The data will be stored on the database with the exception of the randomisation list which is held on [www.sealedenvelope.com](http://www.sealedenvelope.com) and allocation verified by the data management team. Electronic data will be extracted from the system during the trial for the purpose of checking (validating) and trial progress reports. Access to PROSPECT is controlled by usernames and encrypted passwords, and a privilege management feature will be used to ensure that users have access to only the minimum amount of data required to complete their tasks. This will be used to restrict access to personal identifiable data.

## 5.2 Data Collection

Data will be collected from the participants and their carers at:

- Consent and Screening, eligibility and baseline
- Month 3, 6, 12 and 18
- Each clinic visit (Shadow monitoring protocol)
- End of study (participant status alive/dead and date of death).

**Due to the pilot nature of the study there are no predefined protocol non compliances other than misrandomisation or randomisation in error. Intervention adherence will be assess as an outcome (see section 6.5).**

## 5.3 Protocol non compliances

**Due to the pilot nature of the study there are no predefined protocol non compliances other than misrandomisation or randomisation in error. Intervention adherence will be assess as an outcome (see section 6.5).**

## 5.4 Study Population

Described in the protocol.

## 5.5 Analysis Populations

The intention to treat population (ITT) includes all patients for whom consent is obtained and who are randomised to treatment. This is the primary analysis set and endpoints will be summarised for the intention to treat population unless stated otherwise.

## 6 Statistical Analysis

### 6.1 General considerations

As the trial is a pilot parallel group randomised controlled trial, data will be reported and presented according to the proposed modifications for reporting pilot trials as well as the Consolidated standards of reporting trials (CONSORT) statement (2,3). The analysis will be performed on an ITT basis. The final analysis will be performed after data lock by the TM under the supervision of the study statistician who will also be responsible for quality checking the results.

**Each planned follow-up timepoint will use a time window to ensure that responses have been collected within a reasonable time frame. The time windows allow a slippage of four weeks at 3 months and six weeks thereafter, as outlined below:**

**3 months: within 61-91 days following randomisation**

**6 months: within 140-224 days following randomisation**

**12 months: within 323-407 days following randomisation**

**18 months: within 506-590 days following randomisation**

### 6.2 Recruitment and attrition rates

Relevant summaries related to recruitment, consent and patient throughput will be reported and presented in a CONSORT flow diagram (see appendix, Figure 1).

The following will be reported:

The number of (potential) participants;

- Potentially eligible as identified by the study team at participating centres,
- Approached for the study,
- Not randomised (with reasons),
- Randomised,
  - allocated to treatment
  - allocated to control
- Withdrawn and lost to follow up (with reasons),
- Discontinuing TiM intervention,
  - reasons for discontinuation
- Included and excluded from analysis,
  - Reasons for exclusion.

#### 6.2.1 Eligibility

Described in the study protocol

### **6.2.2 Participant Attrition**

The rate of attrition will be reported (defined as the proportion of the consented and randomised participants who withdrew or were lost to follow up). The reasons for attrition, where provided, will be reported as number and percentage in each category.

### **6.3 Status of participants and completion of outcome measures**

We will report the status of patients and carers at each time point.

At each time-point we will report the number of patients and carers:

- Returning the postal questionnaire booklet
- Completing each questionnaire

We will report these by treatment group and overall.

For the patient and carer questionnaires the response rate at each time point (measured as the total number of questionnaires completed as a fraction of total number of patients alive) will be reported. An example table is given in section 0 (Table 1).

### **6.4 Baseline Characteristics**

The baseline demographics and clinical characteristics of the participants will be reported. For the continuous variables, (e.g. age) either mean and standard deviation will be presented or median and inter quartile range (IQR) depending on the distribution of the data. The number of observations used in each calculation will be presented alongside the summaries. For the categorical variables, the number and percentage of participants in each of the categories and the total number of observations will be presented.

All baseline summaries will be presented and reported for each treatment group and in total. An example of the table of baseline summaries is given in section 0 (

Table 2). No statistical significance testing will be done to test baseline imbalances between the intervention arms but any noteworthy differences will be descriptively reported.

The following summaries will be presented:

Demographics	Age, gender, technology use
MND Characteristics	Age of onset, disease duration, classification of MND (e.g. ALS, PMA, PLS), clinical stage of MND, use of non-invasive ventilation (NIV)/gastrostomy, riluzole use
Carer demographics	Age, gender, relationship to patient, technology use
Patient reported outcomes	ALS-FRS-R (including upper limb function), ALSAQ40, RAND36 and subscores, CSS-MND, HADS, pain score, EQ-5D+D, patient experience, health resource use (number and type of clinical encounters and hospital admissions in last 3 months, carer requirements)
Carer reported outcomes	RAND36, ZBI, HADS, carer experience

#### 6.5 TiM Treatment adherence

**Intervention adherence will be reported as the number of TiM sessions attended within between recruitment and the end of March 2016 and the mean and SD of percent adherence. We will also report adherence at 1, 3, 6, 9, 12, 15 and 18 months.**

**We will also report**

- **The number and percentage of participants that completed 50% and 75% of expected sessions.**
- **A description of the adherence of each patient and carer using the TiM over the course of the trial.**

**Any reasons for poor adherence will be reported where available although it was not possible to identify reasons for all missed sessions.**

**Cumulative session attendance will be displayed for each participant using a spaghetti plot to illustrate intervention adherence.**

**The number and percentage of participants that withdrew from the TiM intervention will be reported, alongside listings of:**

- **Reasons for withdrawing from intervention, where provided**
- **Number of TiM sessions (and %) before withdrawing from intervention**

## 6.6 Clinical outcomes

Descriptive statistics will be presented for the clinical outcomes; significance testing will not be undertaken. Continuous outcome measures will be presented as mean differences between groups and their associated 95% confidence intervals (CI). For categorical outcomes, the number and percentages falling into different categories and potential differences between groups in terms of the percentages in each category will be presented, together with their confidence intervals. Clinical outcomes will be presented for the ITT set with available 6 month and 12 month outcome data.

### 6.6.1 Patient outcomes

The following outcomes measured at 3, 6, 12, 18 months will be presented by group and overall.

The following patient –reported quality of life outcomes will be reported.

ALSAQ-40	Individual scores of five sub-scales and a summary aggregate score: <ul style="list-style-type: none"> <li>▪ physical mobility</li> <li>▪ activities of daily living and independence</li> <li>▪ eating and drinking</li> <li>▪ communication</li> <li>▪ emotional reactions</li> </ul>
RAND-36	A summary of the eight sub-scales and two aggregated scales: <ul style="list-style-type: none"> <li>▪ Physical Functioning</li> <li>▪ Role Limitations due to Physical Problems</li> <li>▪ General Health Perceptions</li> <li>▪ Vitality</li> <li>▪ Social Functioning</li> <li>▪ Role Limitations due to Emotional Problems</li> <li>▪ General Mental Health</li> <li>▪ Health Transition</li> <li>▪ Aggregate physical health</li> <li>▪ Aggregate mental health</li> </ul>
EQ-5D+D	Health utility (as derived from the five questions) Thermometer health scale Health utility plus dignity (as derived five questions plus



	dignity bolt-on)
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In each case the within-group results will be summarised as mean (SD), and the difference between the two as the mean difference together with its CI. Forest plots of confidence intervals of different widths (e.g. 95%, 90%, 80%) with respect to the treatment difference in the overall ALSAQ40 score and RAND36 (mental and physical domain) will be used to illustrate the strength of preliminary evidence (see Figure 2) (Lee, 2014).

In each case, the summaries will be presented by treatment group and time point (see Table 3 and

Table 4) and will comprise the following:

- The number of patients alive and the number of patients completing the outcome
- The score mean and SD
- The mean and SD of the change from baseline

Each outcome measure will be scored as described below and compared, where possible and relevant to population values.

The RAND-36 will be scored as described in Ware et al (4). In the case of partially completed questionnaires, scores will be calculated for domains in which at least 50% of the questions have been answered. Taking physical functioning as example, if at least five of the ten questions comprising the domain have been answered, the physical function score will be calculated as

$PF = (\text{total sum across non-missing questions}) \times (10 / \text{number of non-missing answers})$ .  
These scores will be standardised to US population norms.

The ALSAQ-40 will be scored according to ALSAQ Scoring Algorithms (5). There are five domains plus an overall summary score. The domains are physical mobility (Q1-10), activities of daily living/independence (Q11-20), eating and drinking, (Q21-23) communication (Q24-30), emotional functioning (Q31-40). Each question is scored 0 (never) to 4 (always/cannot do at all).

Physical mobility =  $((Q1 + Q2 + Q3 + Q4 + Q5 + Q6 + Q7 + Q8 + Q9 + Q10) / 40) \times 100$ .

Activities of daily living / independence =  $((Q11 + Q12 + Q13 + Q14 + Q15 + Q16 + Q17 + Q18 + Q19 + Q20) / 40) \times 100$ .

Eating and drinking =  $((Q21 + Q22 + Q23) / 12) \times 100$ .

Communication =  $((Q24 + Q25 + Q26 + Q27 + Q28 + Q29 + Q30) / 28) \times 100$ .

Emotional functioning =  $((Q31 + Q32 + Q33 + Q34 + Q35 + Q36 + Q37 + Q38 + Q39 + Q40) / 40) \times 100$ .

An overall total (ie total/160 x100) will be reported as an overall summary measure. (6)

As with the RAND-36, any partially completed domains will be pro-rated providing at least 50% of the items have been completed.

The EuroQol 5D questionnaire 3-level format plus dignity bolt-on (EQ-5D+D) will be used to derive three health utility outcomes:

- The standard EQ-5D score, derived based on the UK population {Dolan:1996fw}
- The modified EQ-5D+D total score which incorporates the additional dignity question and is scored using an as yet unpublished algorithm (Dixon et al, unpublished data).
- The EQ5D “thermometer” scale

In all three, an imputed score of zero will be used for patients who have died.

The following other clinical outcomes will be presented:

Hospital anxiety and depression score	The Anxiety and Depression subscores
Pain (Likert scale)	Current and average weekly score
ALS-FRS-R	Total score
CSS MND	Total score % patients reporting a clinically significant improvement or worsening (according to Global change CSS-MND self-reported statement)
Clinical encounters	The number of clinical encounters in the 6 months following randomisation, by type and location and reason
Hospital admissions	The number and percentage of patients admitted to hospital, and the number of hospitalisations, by type, location and reason

The HADS anxiety and depression inventories will be scored using the approach of Zigmond and Snaith (7). Each domain will be calculated as the sum of seven questions, each of which is scored 0-3, giving a total score which ranges from 0 and 21. In the case of partially completed questionnaires, the domain will be scored and upweighted provided at least four of the seven questions have been answered.

Self-completed revised ALS functional rating scale (ALS-FRS-R) consists of 12 questions scoring 0-4 (8). Sub-domains include upper limb, lower limb, bulbar and respiratory.

Pain score: the current level of pain (0-10 likely scale) and the average current weekly level of pain (0-10) will be represented as a mean and SD.

Modified CSS MND saliva score is awaiting validation. The total score is the total of all answers scoring 0-3 for each question A to J (9). The percentage of patients reporting a change on the saliva clinical change assessment will be reported.

### 6.6.2 Carer clinical outcomes

The following carer-reported QoL outcomes will be presented in the same manner as described for the patients.

- RAND 36
- HADS

- Zarit Burden Index

The each of the 12 items in the shortened Zarit burden inventory is scored 0 (Never) to 4 (nearly always) (10). A total score between 0 and 48 will be reported.

### 6.6.3 Health economic outcomes

A complete health economic analysis is beyond the scope of this plan. However, descriptions of the following clinical outcomes will be reported, by group and overall:

Clinical encounters	The number of clinical encounters recorded at each encounter following randomisation, by type and location.
Hospital admissions	The number and percentage of patients admitted to hospital recorded at each encounter. the number of hospitalisations
Informal care requirements	The number of hours of informal care recorded by patients.
Formal care requirements	The number of hours of formal care recorded by patients.

### 6.6.4 Patient experiences

The following will be reported by group and overall.

Patient care experience	Percentage of patients agreeing and disagreeing with each satisfaction statement
Carer care experience	Percentage of carer agreeing and disagreeing with each satisfaction statement
Patient TiM experience (intervention only)	Percentage of patients agreeing and disagreeing with each satisfaction statement
Carer TiM experience (intervention only)	Percentage of carer agreeing and disagreeing with each satisfaction statement

All free text responses will be reported.

### 6.6.5 Safety

Adverse events are recorded at every clinic appointment and patients will report health resource use and hospital admissions. Reported admissions will be followed up by the

TM and records as serious adverse events. HADS carer scores will be calculated and reported to the TM for action on an ongoing basis during the trial if either the depression or the anxiety subscore exceeds 11. These will be reported to the TSC during the trial and reported in the analysis and recorded as adverse events.

Advents Events (AEs) will be reported as number and percentage of patients overall and by treatment group but no formal statistical analysis is planned. The following summaries will be presented;

<i>AEs</i>	The number and percentage* of patients reporting an AE and the number of AEs in total
<i>AEs by category</i>	The number and percentage* of patients reporting an AE and the number of AEs for each pre-defined category (pain, acute infection, fractures)
<i>Serious AEs (SAEs)</i>	The number and percentage* of patients reporting an SAE and the number of SAEs in total
<i>Treatment-related AEs</i>	The number and percentage* of patients reporting a treatment related AE and the number of treatment related AEs
<i>All AEs</i>	A listing of all AEs including <ul style="list-style-type: none"> <li>- Description / Site / Signs and Symptoms</li> <li>- Severity</li> <li>- Relationship</li> <li>- Action taken</li> <li>- Outcome</li> <li>- Seriousness</li> </ul>

\*defined as a percentage of all patients randomised.

### 6.7 Estimation of primary outcome and sample size for a main trial

The variability in clinical outcomes will be reported as standard deviation by treatment group and overall alongside their upper 80% confidence limits to get a robust estimate of SD (as recommended by Kieser, 2007), and observed treatment difference.

Descriptive assessment will be used to inform sample size calculations for the definitive study. These assessments will be calculated for candidate measures for the full trial (RAND-36 and ALSAQ40), and will be based on:

- Observed treatment difference at 6 and 12 months
- Standard Deviation;
- Correlation between baseline and 6 month measurements;
- The extent of missing data in each outcome;
- Participant feedback on the most appropriate assessment (analysed qualitatively).

The standard deviation used in the sample size calculation will be derived from the residual variance of the regression model for which the outcome is the 6-month response and the covariates are treatment group and baseline.

A table of sample size estimates for a definitive study stratified by outcome measure and power (80%, 90%) will be provided. E.g. Table 5

### 6.8 Economic Evaluation Analysis

No economic analysis will be conducted but patient health resource use will be reported.

### 6.9 TiM process evaluation

The following will be reported:

Patient and carer feasibility:

- The time taken to complete each TiM session by patient and carer (mean, range). TiM session time is automatically recorded by the application but total time between starting and completing and session is recorded. This includes any time delay because the patient pauses using the session and recommences it later e.g. the next day. Outliers will be identified and excluded with definition of outlier reported (e.g. > 600% of the average time);
- Adherence to weekly TiM sessions (see 6.5);

Clinical feasibility:

- Number, range and % of patient and carer sessions that trigger an overall red, amber and green flag;
- Number, range and % of patient and carer sub-sections that trigger an overall red, amber and green flag;
- Time taken for nurse to use the telehealth system per week, collected by nurse diary (mean, range, SD and time per patient enrolled in the system);
- Number of notes entered per patient.
- Shadow monitoring protocol (intervention)
  - Number of pre-clinic shadow monitoring forms completed
  - Number of clinic shadow monitoring forms completed
  - Clinician satisfaction: % agree/disagree with each statement
  - Free text comments will be reported.

## **7 Detailed Statistical Methods & Calculations**

### **7.1 Missing Spurious & Unused Data**

The extent of missing data will be reported. No sensitivity analyses involving imputation for missing data will be performed. Any spurious data will be queried and checked for consistency with data management before data lock.

Patient and carer questionnaires will be scored only if all relevant items that make up a domain are completed with the exception of RAND 36, HADS and ALSAQ40.

## **8 Implementation of the Analysis Plan**

This SAP will be used as a work description for the statistician involved in the trial. All analyses will be performed by the TM (under the supervision of Trial Statistician MB).

Initially, blinded data will be delivered to the TM and MB by the data manager to define analysis sets and test statistical programs. Any queries will be communicated to the study and data manager prior to database lock. The database will be locked after agreement between the statistician, data manager and study manager. No changes will be made once the data has been locked. Database freeze and lock will be conducted in accordance with SOP DM012.

## **9 Modifications to the Original Protocol Analysis Statement**

**None**

## 10 Appendix

Figure 1: CONSORT flow diagram

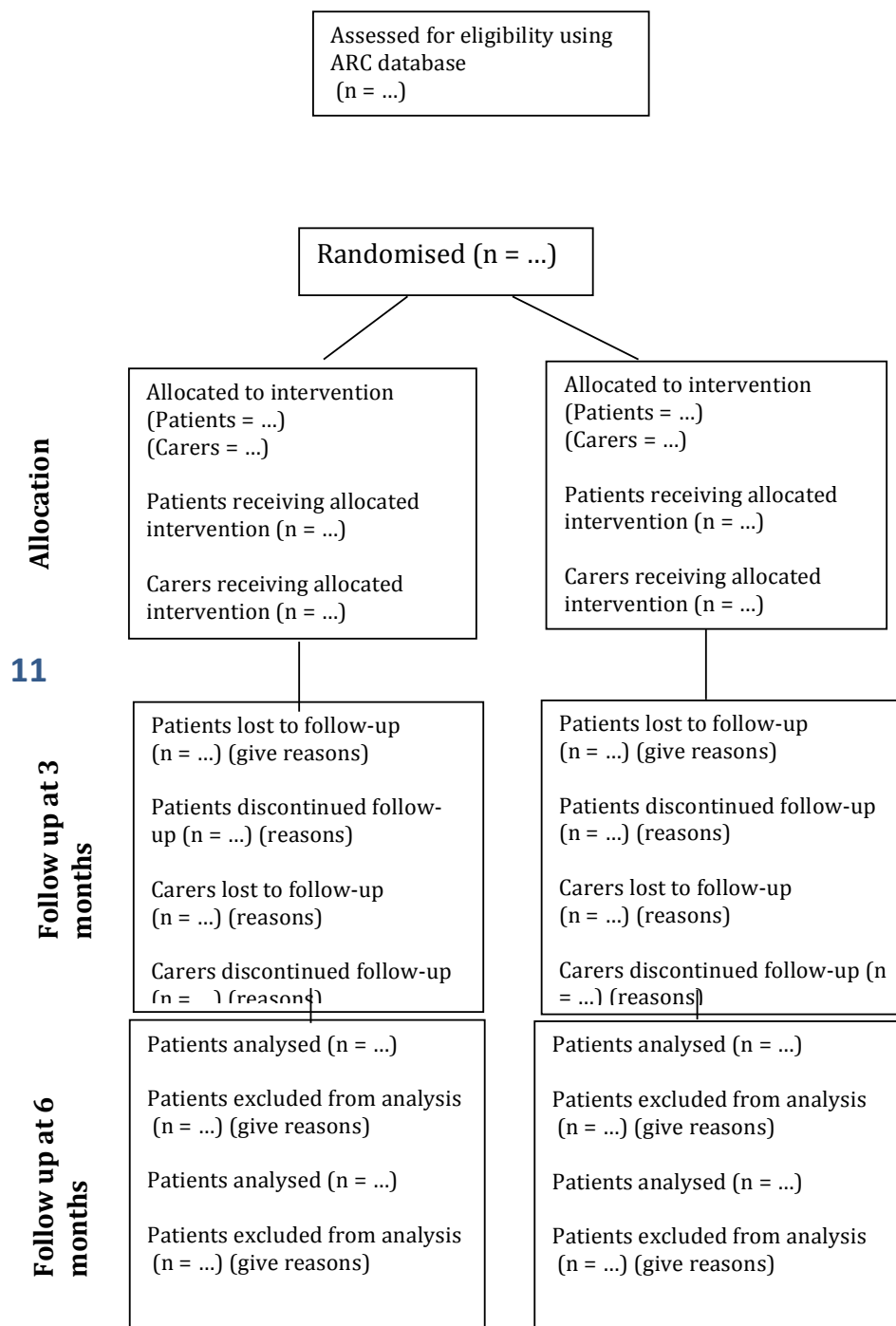
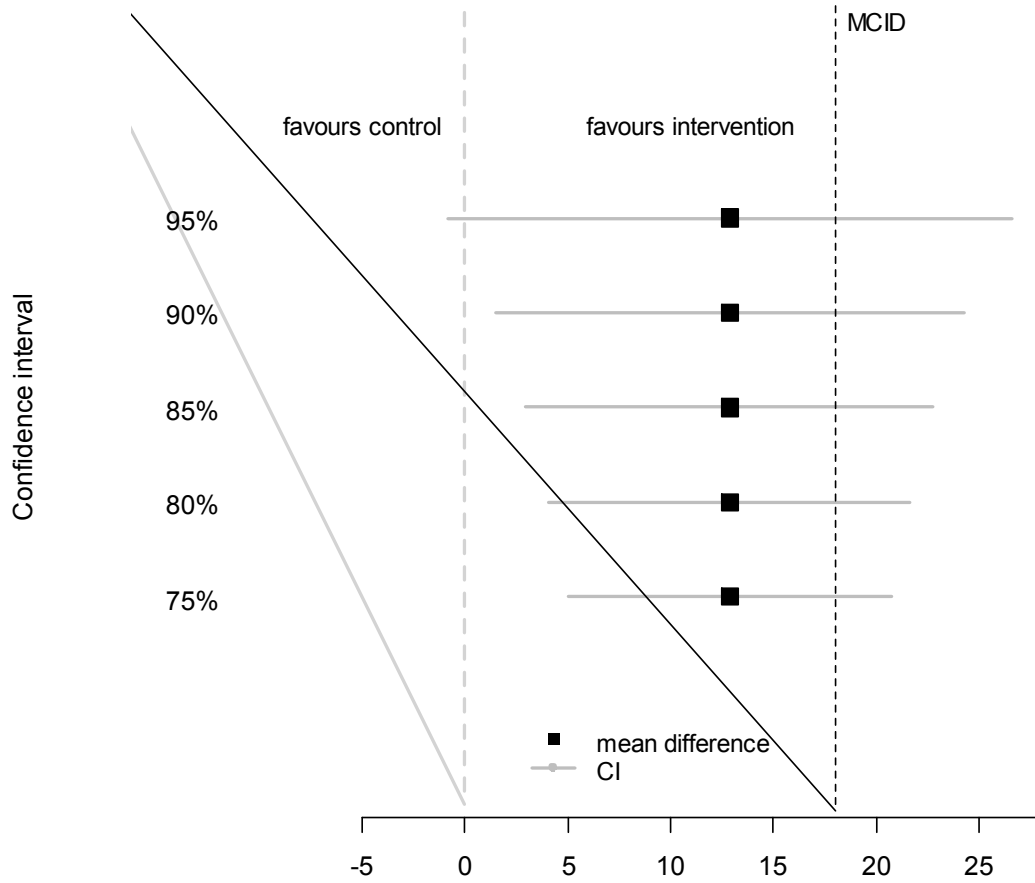




Figure 2: Mean difference in ALSAQ40 with confidence intervals



## 10.2 Example Tables and Figures

Note: The following tables are examples and do not include all outcome measures that will be included in the analysis.

*Table 1: Participant status*

	3 months	6 months	12 months	18 months
<b>Telehealth</b>				
Completed	N=	N=		
Not completed				
Died				
Withdrew from study				
Completed questionnaire but not within time window				
Incomplete				
<b>Control</b>				
Completed	N=	N=		
Not completed				
Died				
Withdrew from study				
Completed questionnaire but not within time window				
Incomplete				

\*Completed includes questionnaires that were sufficiently complete to be used in the statistical analysis. Uncompleted refers to questionnaire booklets that were not returned. Incomplete refers to questionnaire booklets that were returned but insufficiently complete to be used in statistical analysis.

Table 2: Participant baseline characteristics by treatment group

Characteristic	Scoring	Control (n=xx)	Intervention (n=xx)	All (n=xx)
Age (years)	Mean(SD, range) N	x (xx) n	x (xx) n	x (xx) n
Gender	Male	n (%)	n (%)	n (%)
	Female	n (%)	n (%)	n (%)
	N	N	n	n
ALS-FRS-R	Mean(SD, range) N	x (xx) n	x (xx) n	x (xx) n
King's clinical stage	Stage 1	x (xx)	x (xx)	x (xx)
	Stage 2...etc.			
	N	n	n	n

*This will be extended to include the other baseline variables measured.*

Table 3: Display of outcome data by time, illustrated for pain

	Baseline	3 months			
Outcome		Mean (SD)	Change from baseline	<i>...repeat for other timepoints</i>	
Current pain: Mean (SD)	Mean (SD)	N= Mean (SD)	Mean (CI)		
Control	Mean (SD)	N= Mean (SD)	Mean (CI)		
Average pain: Mean (SD)	Mean (SD)	N= Mean (SD)	Mean (CI)		
Control	Mean (SD)	N= Mean (SD)	Mean (CI)		

Table 4: Clinical outcomes at six months: control vs intervention

Outcome	Change from baseline						Mean difference (95% CI)
	Intervention			Control			
	n	Mean	SD	n	Mean	SD	
ALSAQ40	x	xx	xx	x	xx	xx	xx (xx to xx)
RAND 36 (agg. physical)	x	xx	xx	x	xx	xx	xx (xx to xx)
RAND 36 (agg. mental)	x	xx	xx	x	xx	xx	xx (xx to xx)
HADS anxiety	x	xx	xx	x	xx	xx	xx (xx to xx)
HADS depression	x	xx	xx	x	xx	xx	xx (xx to xx)
Pain	x	xx	xx	x	xx	xx	xx (xx to xx)
...							

Table 5: Sample size considerations for candidate primary outcome measures

Outcome	Effect size		Standard deviation		Power (%)	Number /group	Number /group + attrition
	MCID	Observed*	Observed	Upper 80%CI			
ALSAQ-40 total	xx	Xx	Observed	xx	80	NN	NN
				xx	90	NN	NN
			Upper 80%CI	xx	80	NN	NN
				xx	90	NN	NN
RAND-36							
Agg physical	5	Xx	Observed	xx	80	NN	NN
				xx	90	NN	NN
			Upper 80%CI	xx	80	NN	NN
				xx	90	NN	NN
Agg mental	5	xx	...				
<i>...repeat for other candidate measures</i>							

*\*nb Observed effect size is for reference and is not used in sample size calculation*

#### Trial Documents

Title	Version
Study Protocol	1.4

#### CTRU Standard Operating Procedures

Title	Version	Date	Location
DM012 Study database lock and retention	3	24 <sup>th</sup> March 2014	N:\projects\CTRU\Quality Assurance\SOPs\Current SOPs

## 12 References

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**Appendix 4.3**  
**Patient information leaflet V1.2**



Study reference: STH17165  
NIHR portfolio reference: 17022

## **INFORMATION SHEET FOR PATIENTS**

You are being invited to take part in a research study. Before you decide whether to take part it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully and discuss it with friends, relatives and your GP if you wish. The contact details of the study team are at the bottom of this leaflet if you would like more information.

### **What is the purpose of this study?**

Motor Neuron Disease (MND) is a disease affecting the nervous system that causes progressive muscular weakness as well as other symptoms such as fatigue and emotional difficulties. Currently, patients and their carers are invited to attend the specialist MND clinic at the Royal Hallamshire Hospital where they receive care from doctors, nurses and therapists. Patients and their carers may want, and may benefit from, better access to this specialist care on a more regular basis without having to travel to hospital more frequently.

The Sheffield MND care team have developed a telehealth system that can allow patients and their carers to keep in touch with the MND clinic using a handheld tablet computer. It is called the TiM (Telehealth in Motor neurone disease) system. The TiM system allows patients and their main carer (usually a partner or close relative) to complete questions on a weekly basis about their condition and wellbeing. The information is transmitted over a secure internet connection to alert the Sheffield MND team to any problem or change in patients' condition

The aim of this project is to see whether using the TiM system is acceptable to patients and carers and if the system can provide the information we need to monitor and improve the care for patients and their carers. If it is found to be successful then we would use the information gathered to modify the TiM system and to test it in a larger trial of many patients with MND.

### **Why have I been invited to participate?**

You have been chosen because you have attended the Sheffield Motor Neuron Disorders Clinic and expressed an interest in contributing to our research efforts.



**What would happen if I take part?**

If, having reading this information leaflet you and your carer are interested in taking part then a member of the study team will arrange a mutually convenient time to meet, usually at your own home. They will discuss the study in detail and answer any questions you have before you make a decision. You may wish to discuss it first with your family, or your medical team. If you wish to discuss it with your MND consultant neurologist we will arrange this.

If both you and your main carer decide to take part we will ask you to sign a consent form. Written consent would take place prior to any study procedures. The study researcher will then go through a basic screening with you and your carer to check that you are eligible to take part.

If you are both eligible to take part you will be randomly assigned to one of two groups. Half of the patients and their carers will continue as usual but complete questionnaires about their condition at the start and after three months and then six monthly during the trial. These can be completed at home and take approximately 20 minutes for the patient, and less time for carers. Patients in this arm will continue to be invited to come to your usual appointments as scheduled and have no changes to the care you receive from the MND team.

After completing the first questions you and your carer will also be invited to take part in a short interview (approximately 15 minutes) with the researcher to discuss your opinion on the questionnaires you have filled in. This will be audio-recorded and analysed in order to see whether these questionnaires can be improved in the future. This is known as the control arm.

The other half of the patients will be assigned to use the TiM system. They will continue to be cared for in the usual way and, like the control group also asked to complete questionnaires throughout the trial. They will also be given a tablet computer to use during the trial. A member of the study team will show you how to use it and they will be available during the study for further help. Patients may wish to ask a carer to help you use the system.

For those assigned to use the TiM system we ask that both you and your carer complete questions using the TiM system once a week (and more often if you wish). There are different questions for you and your carer. They ask you about your condition, your mood and any other symptoms from which you may be experiencing. You may wish to complete the questions together or separately. The time it takes to complete a weekly session depends on whether your condition is changing, usually taking about 15 minutes per

week. You can try out the tablet computer at home with the study team before deciding whether to join the trial. Once all the information is entered it is sent via a secure internet connection to the MND team in Sheffield where the MND nurse will look at the information. If the TiM system reports any problems they will contact you to discuss how these can be resolved.

Patients and carers assigned to use the TiM system will be invited to take part in some interviews. These will be scheduled in your own home up to twice during the study, once at one month after starting to use the system and again at six months. We would like to understand your thoughts and experiences of using the telehealth system and being part of the study. In our experience many patients and carers prefer to be interviewed together but you can be interviewed separately. The interviews will last up to one hour. The study team are experienced in interviewing people with MND and you are welcome to use a communication aid or give written answers before or after the interview.

This research project does not require any change to your day-to-day activities. You will continue to be invited to attend all regular appointments. If you are unable to attend your appointments we will arrange telephone consultations with your consultant.

### **Do I have to take part?**

It is up to you to decide whether or not to take part. If you decide to take part you are still free to withdraw at any time and without giving a reason. This would not affect the usual care you receive. To help us identify problems with the study we may invite you to give reasons why you decided not to take part or to stop taking part. We would like to invite your main, unpaid carer to participate. Your carer will also sign a consent form, and be free to withdraw at any time. We would ask that at least initially, both you and your carer take part in the study.

### **How long will the study last?**

Participants will be asked to complete questionnaires at the start of the study, after three and six months and then six monthly. The study will last for a minimum of six months and a maximum of 18 months.

### **Are there any benefits or disadvantages to taking part?**

This is a pilot study to see if it is possible to use this type of system. There have been no studies in patients with MND like this before and, whilst we hope it will improve the way we care for patients, we do not know for certain. We hope in the future to conduct a larger study to see if it helps improve care in MND. You may be invited to take part in this study.

The aim of the TiM system is not to replace the service that we offer in Sheffield, rather to improve the service and make it more available to patients. As such, we will not be changing your usual medical care. Being involved in a study does take some time but you will not be required to attend hospital any more frequently. Both the telehealth questions and the trial questionnaires can all be completed at your convenience at home and a member of the study team will be available by telephone should you need help.

**Will it cost me anything to take part?**

All equipment including the internet connection are provided. Other than keeping the tablet computer charged there would be no cost for using the telehealth system or being part of the trial. We would ask that you return the equipment at the end of the study. All study visits will be in your own home or during your routine appointments but if you do incur travel expenses coming to extra appointments these will be reimbursed.

**Will there be any effects on my treatment?**

If you are using the telehealth system your MND nurse will have access to the information that you record. Should they feel your treatment needs to change they will contact you or your carer to discuss this. Whilst the some of the study team are members of the MND care team in Sheffield their care for you as a patient will not change, whether or not you decide to take part in the study.

**What about my hospital appointments?**

You will continue to be invited to attend all your usual clinic visits at the schedule agreed with your doctor. If you are unable to attend clinic a member your consultant will arrange a telephone interview with you or your carer. This will allow you to discuss your condition and any problems with your doctor.

**Will the information obtained in the study be confidential?**

All personal information would be kept strictly confidential. The technology we are using complies to strict NHS information governance and security regulations and the Data Protection Act. Only your usual MND team and the study team have access to your information and this will be monitored. No information would be stored on the handheld computer so there is no possibility of anyone gaining access to the information if it is lost or stolen. The technology company would not have any access to any identifiable data.

If you participate in the interviews they will be audio-recorded, transcribed and stored securely. Quotes will be anonymised and may be shared with the MND team and used in publication and it might be possible for someone who knows you well to identify them. As this is a research study is important that we learn about both the good and bad things about your experiences, what you say will not affect your treatment.

**Will anyone else be told about my participation in the study?**

Your GP and neurologist looking after you would be informed about your participation in the study.

**How will this information be used?**

The results of research will be published in medical and scientific journals. However, complete confidentiality will be maintained and no individual person will be identified in these publications. In the future if this study is a success we may be able to use the information to further develop the telehealth system and potential use it for many patients with MND and other chronic conditions.

**Who will profit from this study?**

There is a significant cost involved in developing and maintaining these sorts of services. The TiM system and the computers has been provided by a pharmaceutical company called Abbott working together with a telehealth company called Carematix with support from the Motor Neurone Disease Association. The study is funded by the National Institute for Health Research. The results of this study may lead to the development of patents and/or to commercial benefits for Abbott, Sheffield Teaching Hospitals NHS Trust and the University of Sheffield. You would not be entitled to receive any financial benefit. No member of the study team or your MND care team are entitled to any financial benefit.

**What happens if something goes wrong?**

If you have any concerns or other questions about this study or the way it has been carried out, you should contact the chief investigator or your consultant (address below) in the first instance who will do their best to address your concerns. You may contact the hospital complaints department in the Chief Executives Office at the Royal Hallamshire Hospital on (0114) 2713898.

**Who has reviewed the study?**

All research in the NHS is looked at by independent group of people, called a Research Ethics Committee, to protect your interests. This study has been reviewed and given favourable opinion by the Leeds Bradford Research Ethics Committee

**Study Investigator contact details**

**Dr Christopher McDermott**

Chief Investigator and Honorary Consultant Neurologist

**Dr Esther Hobson**

Co-investigator and NIHR Doctoral Research Fellow

Sheffield Institute for Translational Neuroscience

University of Sheffield

385A Glossop Road, Sheffield S10 2HQ

Telephone 0114-2222260

## Appendix 4.5

### Topic guides

#### Topic guide Patients/carers at baseline

##### Patient questionnaires

- Some are asking quite personal questions. How do you feel about that?
- Do you think the questionnaires asked questions about your life with MND?
- Did you find any of the questionnaires confusing?
- Did you find any of the questionnaires upsetting?
- What would you think about filling in these questionnaires again?
  - If so, how would you fill them in?
- If you needed help, how would you fill in your questionnaire?

##### Carer questionnaires

- Did you find any of the questionnaires confusing?
- Did you find any of the questionnaires upsetting?
- Some are asking quite personal questions. How do you feel about that?
- What would you think about filling in these questionnaires again?

##### Previous experiences in MND care

- Can you tell me a little about how you came to get the diagnosis of MND?
- What have your experiences been since then?
- Can you tell me about your last MND hospital clinic visit?
- Have you used the MND helpline?
- How do you manage if you have a question or problem?
- What would you say you are most worried about?
- How do you think your MND team have helped you?
- How do you think your care could be better?
- What problems do you think have been most troublesome?
- How much do you know about MND?

##### Carer experiences

- How do you get the support you need as a carer?
- How do you find the help the MND team gives?
- How do you think your care could be better?
- What problems do you think have been most troublesome?
- How much do you know about MND?

## **Topic guide Patients/carers at one month**

### **Previous experiences in MND care**

- Same questions as baseline topic guide

### **Carer experiences**

- Same questions as baseline topic guide

### **Expectations of the TiM system**

- Before the start of the study what technology did you use?
- What did you expect the TiM system would be like?
- Is there anything you would have hoped it would have?
- Is there anything that worried you about it?

### **Experiences of training and starting to use the TiM system**

- What did you think when you first saw it?
- How did you find the training?
- Do you remember what it was like using it for the first time?

### **Barriers and facilitators to using the TiM system**

- Is there anything things you like about it?
- Is there anything you don't like?
- Has it worked every time as you expected?
- Do you think you will continue to use it regularly? Why?
- What have you told your friends about it?

### **For the carer**

- How have you found using the TiM system?
- What was it like using it for the first time?
- How have you found the questions?

## **Topic guide for intervention patients/carers at month 6**

### **Your illness**

- How have you been since we last met?
- How has your illness changed?
- How has your life changed?
- What are the main problems & priorities you face at the moment?

### **Telehealth**

- Has telehealth made an impact on this?
- Can you tell me what it is like filling in the telehealth?
- Can you recall a time when Theresa has phoned your or your nurse has spoken about the telehealth?
- Do you think it had an impact on your condition?
- What things do you think TW MUST contact you about?
- What other things do you think it's important that she knows about?
- What do you think happens to the data?
- Has it ever gone wrong? Have you ever expected a call and not received one?

### **Clinic/medical care**

- Have you spoken to your doctor about the telehealth? Or clinic? Tell me about that?
- Can you tell me about your most recent clinic visits? Impact of telehealth on clinic?
- Who do you think holds the responsibility for your care?
- Can telehealth help you make those choices?
- Do you make choices about your condition? Who makes those choices?

### **Progression**

- People with MND change at different rates. How has your condition changed? Do you think you can show that on the telehealth?

### **Self management**

- What do you think your role is in the management of your condition?
- Are there things you don't want to learn about? Or are there times where you didn't want to know about something?

### **Compliance**

- How do you think we could encourage people to use the system more?
- Some people might say this was an intrusion in your life. What do you think about this?

### **Dealing with emergencies**

- Can you tell me about a time when you've been unwell or something about your condition changed? What happened?
- If there was an emergency, how would you act? What would you do about the telehealth?

### **Feedback**

- Have you received feedback? Are there situations where you would expect feedback?
- How would you improve the telehealth?
- Is there anything that you think is important?



**Carer**

- How do you find filling it in for you/your husband/wife?
- How are you doing that?
- How has your life changed since we last met?
- What do you think could be improved?
- How has that reflected in the questions?
- How do you think your condition has impacted on your husband/wife?
- How do you think the TiM system has impacted on you?
- What do you think is the role of the MDT for you?
- If someone were to call you up with concerns about your TiM answers, how would you feel?

**Information**

- Have you used any of the other features of the telehealth?
- Would you like to see any other features?

## **Telehealth nurse interview 1**

### **Role**

- Can you tell me a bit about your day-to-day role as an MND nurse?
- What do you think are the most important aspects of the work you do?
- How do you think MND teams in the community could best work together with you?

### **Carers**

- How do you think care should be improved for carers?
- What do you think their biggest problems are?

### **Unmet needs**

- Do you think MND care varies throughout the UK?
- What do you think are the biggest priorities for improving care for patients with MND?
- How would you improve care if you had the opportunity?

### **TiM initial use**

- Can you tell me about when you first started using it?
- Can you tell me about how you are using the TiM on a day to day basis?
- What happens when the people you are using it with come to clinic?
- Has it changed the way you work?
- Have any of the patients called?
- Did they say anything about it?
- What changes would you recommend making to make it better?

### **Flags**

- What do you do if a flag is raised?
- Have you been calling people about every flag?
- How do you decide who to call?
- What do you think are the most important things you need to know about?

### **Features:**

- Can you tell me about using the portal?
- Which features do you think are relevant?
- Are there any irrelevant ones?
- How does this impact on your time?

## **Telehealth nurse interview 2**

Topic guide prepared by Wendy Baird following suggestions from EH and Sue Mawson. Interview by Wendy Baird.

### **If I were another MND nurse**

- What would you say about the system?
- Walk me through how I would use it.

### **Which would lead on to**

- Tell me what works
- It looks a bit complicated, how easy was it to get used to the system?
- How reliable is the information?
- Can you really rely on it to make clinical decisions?
- How do you decide when to contact the patients?
- Are the flags useful - do you always follow them up?
- Do patients realise that the information they include will raise a flag - will they think its unusual if you do/ do not respond to information?
- Do you worry about not responding to flags?
- What have others said about using this type of technology
- How do you explain this to patients?
- What do the patients think about using this kind of technology?
- What kind of patients/ carers are using it the most?
- Would it be more useful for some types of patients?
- Do you think this would help reduce the workload of MND nurses / teams?
- Do you think other MND nurses will be able to use the system?
- What kind of training do you think they would need - information pack?
- Would this be of use to the wider clinical team?
- Who else might benefit from access to this information?

## **Community nurse interview**

### **Community service**

- Describe your role? How does your day to day job work?
- How often do you visit patients? Does this change at different periods e.g. newly diagnosed? Are you reactive or regular?
- How does this combine with the rest of the MDT and the hospital team(s)?
- What would be their your arrangement?
- What are the limitations of their service?
- What is your role with carers?
- What are the challenges in your population?
- How do you keep up to date with what is going on?

### **Telehealth**

- Review patients using telehealth
- Have they showed you the telehealth or mentioned it?
- Any experience of patients' interaction with telehealth?

### Discuss specific patients

- Patient at end of life
- Carer anxiety
- Information withheld/ value of additional information

### **Future of telehealth**

- Would you want to have access to this? Or someone to feed back to you
- How do you delegate work?
- Internet access "in the field"
- Attitude to technology
- Attitude to new ways of working



Telehealth in Motor Neurone Disease

# Patient questionnaire

<Time-point>

---

Identifier <identifier>

Date of completion     
d d m m y y y y

---

Thank you for your time, participating in the TiM study.

This is the booklet for the **PATIENT** to complete.

Please complete ALL the questions in the enclosed booklet. You do not need to complete it all in one sitting but please try to complete it all in the same day and return as soon as possible. It is important that you try to complete the whole booklet if possible.

Some of the questions may seem repetitive. This is because we are trying to find out which are the best questions to ask.

Your answers will only be seen by the research team and will not affect the care you receive.

If you have any questions or problems completing the questionnaires you can contact Staff Nurse Charlotte Morgan. She is a research nurse at the Royal Hallamshire Hospital Clinical Research Facility. She can also help you complete the questionnaires either by telephone or in person. Her telephone number is 01142713339.

Once both booklets have been completed please:

- 1) Check all the questions have been answered
- 2) Place **both** booklets in the enclosed stamped addressed envelope
- 3) Post them off as soon as you can

Once again, thank you for your contribution to this research.

Pages 419 to 440 have been removed by the author of this thesis for copyright reasons.

Over the **last three months**, how many times have you seen any of these people **for your MND?**

	At home	At hospital / surgery / hospice
GP (routine appointment)	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>
GP (emergency appointment)	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>
Hospital MND doctor	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>
Hospice doctor	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>
Respiratory team	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>
Attendance at accident & emergency		<input type="text"/> <input type="text"/>
Attendance at walk-in centre		<input type="text"/> <input type="text"/>
Physiotherapist	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>
Occupational therapist	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>
Dietician	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>
Speech therapist	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>
MND nurse / care worker	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>
District nurse	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>
Palliative care / Macmillan nurse	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>
Ambulance (routine trip e.g. to a hospital appointment)		<input type="text"/> <input type="text"/>
Ambulance (emergency call, treated at home only)	<input type="text"/> <input type="text"/>	
Ambulance (emergency call, taken to hospital)		<input type="text"/> <input type="text"/>
Other (describe) <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>
Other (describe) <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>
Other (describe) <input type="text"/>	<input type="text"/> <input type="text"/>	<input type="text"/> <input type="text"/>

Approximately how many hours a week do you have **paid** carers help you?

Approximately how many hours a week do you have unpaid carers help you in the house? (this might include friends and family helping with shopping, cooking, dressing etc.)

In the last 3 months, have you stayed in hospital overnight?  Yes  No

If "yes", please complete one line in the table below for each admission

Date <i>record day if known</i>	Which hospital?	Reason for admission	Number of nights	Emergency? <i>Tick "No" if planned</i>
<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>			<input type="text"/> <input type="text"/>	<input type="checkbox"/> Yes <input type="checkbox"/> No
<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>			<input type="text"/> <input type="text"/>	<input type="checkbox"/> Yes <input type="checkbox"/> No
<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>			<input type="text"/> <input type="text"/>	<input type="checkbox"/> Yes <input type="checkbox"/> No
<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>			<input type="text"/> <input type="text"/>	<input type="checkbox"/> Yes <input type="checkbox"/> No
<input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/> <input type="text"/>			<input type="text"/> <input type="text"/>	<input type="checkbox"/> Yes <input type="checkbox"/> No



Please consider your MND care over the **last 3 months**.  
Please tick **one box** for each question.

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
1 I am in close contact with my MND team	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2 I feel that my MND is being closely monitored	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3 I feel that I'm getting the best treatment for my MND	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4 I am satisfied with my hospital MND appointments	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5 I am satisfied with my hospital MND nurse	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6 I am satisfied with my community MND nurse	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7 If I have a problem with my MND I know who to contact	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8 If I have a problem with my MND it gets solved quickly	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9 I understand enough about my condition	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
10 My MND team involve me in decisions about my treatment and care	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

You can use this space to write any other comments

Please consider how you have found the TiM system over the **last 3 months**.  
Please tick **one box** for each question.

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
1 It was easy to use the TiM system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
2 The TiM questions were relevant to me	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
3 The TiM system allowed me to report all the problems with my MND	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
4 The MND team contacted me quickly if my condition changed or I had a problem	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
5 The questions were upsetting or distressing	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
6 Using the system took a lot of time or energy	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
7 The TiM system respected my privacy and confidentiality	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
8 The Knowledge Centre was useful	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
9 The Problem list was useful	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

You can use this space to write any other comments

In the future something like the TiM system may be used in other trials or to care for patients.

Please tick **one box** for each question.

	Strongly disagree	Disagree	Neither agree or disagree	Agree	Strongly agree
10 If something like the TiM system was available to use as part of another trial I would like to use it	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
11 If something like the TiM was available to use as part of usual NHS care I would like to use it	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
12 I would recommend the TiM system to a fellow patient	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
13 If I were unable to travel to clinic I would like to use the TiM system	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
14 If my doctor reviewed the TiM system results and found my condition was stable I would be happy for them to delay my appointment until I need it	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

	Daily	Every few days	Weekly	Fortnightly	Monthly
15 If you were to use the TiM system again how often would you want to use it?	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

You can use this space to write any other comments

Thank you! You have finished all the questions.

Please take a little time to check you have answered every question. Once you have both finished please put both booklets in the stamped addressed envelope and post them back as soon as you can.

Your contribution to this research is very important to improve the care for patients and carers.

## Appendix E

**“Anything that makes life’s journey better.” Exploring the use of digital technology by people living with motor neurone disease.**

Hobson, E. V., Fazal, S., Shaw, P. J., & McDermott, C. J. (2017).

*Amyotrophic Lateral Sclerosis & Frontotemporal Degeneration*, 0(0), 1–11.  
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Technology by People Living with Motor Neurone Disease.”  
*Amyotrophic Lateral Sclerosis & Frontotemporal Degeneration* 34 (February 20,  
2017): 1–10.

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## Abbreviations

ALS	Amyotrophic lateral sclerosis
ALSAQ-40	Amyotrophic Lateral Sclerosis Assessment Questionnaire – 40
ALS-FRS-R	Amyotrophic lateral sclerosis rating scale-revised
ARC	Database of patients attending the Sheffield MND clinic
CI	Confidence interval (95% unless otherwise stated)
CONSORT	Consolidated standards of reporting trials
CSS-MND	Clinical Saliva Scale for Motor Neurone disease
EH	Esther Hobson
EQ-5D-3L	EuroQol Group Health Questionnaire
fMND	Family members of those with motor neurone disease
GP	General practitioner
HADS	Hospital Anxiety and Depression Scale
MCS	Mental component score of the SF-36
MCSI	Modified Caregiver Strain Index
MDT	Multidisciplinary team
MND	Motor neurone disease
MNDA	Motor Neurone Disease Association
MRC	Medical Research Council
NICE	National Institute for Health and Clinical Excellence
NHS	National Health Service
NIHR	National Institute for Health Research
NIV	Non-invasive ventilation
OT	Occupational therapist
PCS	Physical component score of the SF-36
PHQ	Patient Health Questionnaire
PLS	Primary lateral sclerosis
PMA	Progressive muscular atrophy
QoL	Quality of life
RCT	Randomised Controlled Trial
SD	Standard deviation
SF	Saima Fazal
SF-36	36-Item Short Form Survey version 1
SITraN	Sheffield Institute of Translational Neuroscience
TMG	Trial management Group
TiM	Telehealth in Motor neurone disease
WSD	Whole System Demonstrator
ZBI	Zarit Burden Index