Horticultural Therapy and Acquired Brain Injury: A Mixed Methods Systematic Review

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The candidate confirms that the work submitted is his own and that appropriate credit has been given where reference has been made to the work of others.

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Abstract

Background: Urbanisation drives reduced interactions between humans and nature, which has been suggested to negatively impact human health. Nature-Based Interventions are increasingly popular, and Horticultural therapy may improve depression, quality of life and cognition for people with acquired brain injuries. No systematic reviews of horticultural therapy and acquired brain injury have been conducted.

Methods: A mixed-methods systematic review was used to gather all available evidence. Theoretical supplementary searches were conducted to identify the relevant theories for horticultural therapy for the acquired brain injury population. A sequential exploratory approach to synthesis was adopted.

Results: 3522 records were identified through searches across seven database and. 14 studies were included in the final synthesis, five qualitative and nine quantitative. A logic model was developed, and the outcomes were tested using the quantitative studies.

Discussion: HT suggested to be effective for improving symptoms of depression and quality of life with mixed evidence for its effect on anxiety and cognition. Mechanisms of change include social interactions, restorative effects of nature and increasing self-efficacy. Future research should focus on high-quality quantitative research and consistent reporting of information. Clinicians should consider using HT alongside traditional rehabilitation for ABI and ensure the environment is accessible for all.

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Introduction

Aims

This project aimed to use a mixed methods systematic review to establish a theoretical framework for the use of Horticultural Therapy (HT) in the Acquired Brain Injury (ABI) population; develop a logic model to visually summarise the intervention components, mechanisms and outcomes; and to test this using quantitative data. The literature suggests Nature-Based Interventions (NBIs) can reduce distress, improve wellbeing and quality of life across both clinical and non-clinical populations. Few systematic reviews have been conducted investigating HT specifically, and none to the author's knowledge have investigated HT for people with ABI. This project aimed to evaluate the mechanisms of HT across a range of psychological outcomes including mood, anxiety, Quality of Life (QoL) and cognition. It is predicted that gathering information about how HT effects change, will lead to greater understanding of this complex intervention and therefore its use in clinical practice.

This introductory chapter will consider the context of growing interest in Nature-Based Interventions (NBIs) and an introduction to ABI and current rehabilitation practices. The literature around the efficacy of NBIs across clinical populations will then be considered before discussion of NBIs in the ABI population specifically. A critical summary of the Horticultural Therapy (HT) literature will then be provided and the current positions on HT definitions outlined which influenced the creation of inclusion criteria. Following this, the evidence for HT's effectiveness in the ABI population will be critically considered and proposed theoretical mechanisms outlined.

Urbanisation

Urbanisation has occurred at an unprecedented scale over the past 70 years with 54% of the world's population living in urban areas in 2014 (Zhang, 2016). Predictions suggest this trend will continue, placing the percentage of the population living in urban areas as 60% by 2030 (United Nations, 2018). Urbanisation causes the destruction of green spaces in several ways. Urban core densification refers to increased building within urban centres (Broitman & Koomen, 2020), which leads to reduction of green spaces. Urbanisation can also occur through increasing urban sprawl, referring to outward expansion of cities into previously rural, green areas (Onyekwelu, 2011). England's green belt urban planning system attempted to reduce the impact of urban sprawl, but the area of land designated as such has decreased over the past 20 years (Department for Levelling Up, Housing and Communities, 2023). Industrialisation has also changed the way humans interact with nature, shifting from a consumptive relationship based on subsistence to a mutualistic one of recreation and enjoyment (Keniger et al., 2013).

Urbanisation has been associated with numerous public health issues, such as higher rates of noncommunicable diseases including heart disease, diabetes, cancer and asthma (World Health Organization, 2025). This pattern can also be seen with mental health problems and increased prevalence of schizophrenia (Vassos et al., 2012), anxiety (Ventimiglia & Seedat, 2019), depression (Xu et al., 2023) and number of suicides (Kõlves et al., 2019) when adjusted for population size. A meta-analysis pooled 25 years of prevalence data across urban and rural areas, finding increased occurrence of all psychiatric disorders in cities, compared to urban areas,

at a ratio of 1.21 (Peen et al., 2010). Proposed mechanisms for worsening public health in urban areas include increased pollution, social isolation and negative changes to people's working habits (Zhang et al., 2022). Through the destruction of green spaces and the tendency of an urban population to access these less frequently, termed experience extinction (Pyle, 1993), research suggests that fewer nature interactions are associated with depression, reduced social cohesion and physical activity (Cox et al., 2018). Mental health services operate within this context and face increased pressure with the relationship between mental health difficulties and people living in urban areas.

Since the creation of nationalised health services in the United Kingdom the current pressure on mental health services is unprecedented. Prevalence of depression has risen year on year and has been further worsened by the COVID-19 pandemic and current cost of living crisis (Office of National Statistics, 2021; 2022). With this context in mind, current models of mental health services are struggling to meet the needs of many people and are unlikely to be able to in the future without significant changes to their structure or increased funding (O'Shea, 2020). A suggested solution is the adoption of a salutogenic approach, which broadly focusses on individual's maintenance of health as opposed to pathology or disease models (Bhattacharya et al., 2020). Part of this approach involves the use of existing assets, such as the natural environment.

Nature-Based Interventions

In recent years there has been renewed interest in the use of the natural environment to improve wellbeing of participants, partially in response to increased urbanisation, destruction of greenspaces and the limitation of available activities during the COVID-19 pandemic (Yang et al., 2023). Generally termed Nature Based Interventions (NBIs), they can be defined as "programmes, activities, or strategies that aim to engage people in nature-based experiences with the specific goal of achieving improved health and wellbeing" (Shanahan et al., 2019, p.1). A Delphi study identified 27 distinct NBIs through expert elicitation (Shanahan et al., 2019). The authors categorised these NBIs by those that aim to treat specific physical and mental health issues or prevent development of chronic health condition and/or

promote general wellbeing. These two categories were further subdivided as follows:

a) *Within the treatment group,* NBIs that altered the environment to promote nature interactions and programmes that engage clients with nature or change behaviour were outlined.
b) *Within the prevention group,* NBIs that altered the environment to promote nature interactions and programmes for education or nature engagement were separated.

For example, the authors categorised Horticultural Therapy (HT) as an intervention that aims to treat a specific physical, mental health or wellbeing issue, thus falling into the treatment group and sub-categorised as a programme that aims to change behaviour through nature interactions.

NBIs are used across a range of clinical contexts and examples include the use of NBIs in primary care to prevent development of health problems (Lauwers et al., 2020) and using natural environments to enhance therapy in secondary and tertiary care (Steensma et al., 2025). The Royal College of Psychiatrists also reference the potential benefits of NBIs at an individual, community and societal level (Roberts & Fisher, 2023).

Within the literature, NBIs have been investigated for effectiveness across a wide domain of outcomes and clinical populations (Natural England, 2016). For example, studies have investigated NBIs in autistic children (Fan et al., 2023), older adults (Tong et al., 2025) and people with long-term health conditions (Taylor et al., 2022). Regarding outcomes, the effectiveness of NBIs in reducing symptoms of depression (Rosa et al., 2023), anxiety (Kotera et al., 2021), QoL (Sprague & Ekenga, 2022) and improving cognition (Daniels et al., 2022) has been investigated. The following paragraphs will critically review highly cited studies in the NBI literature.

One prominent study investigated the psychophysiological effects of forest bathing in sub-clinical depression and non-depression participants (Furuyashiki et al., 2019). Participants engaged in 16-hour long sessions of forest bathing across a three-year period and completed the Kessler Psychological Distress Scale (K6)

(Kessler et al., 2002) & Profile of Mood States (POMS) (McNair et al., 1971). The study reported significant reductions in scores across mood subscales but also a significantly larger reduction in the group identified as having depressive tendencies. This suggests that forest bathing reduces negative affect and that this has a greater impact in those with depressive tendencies. However, the authors highlight the lack of follow-up measurement in their study. The authors also wished to investigate the effects of forest bathing in a sub-clinical population, or those with depressive tendencies to apply their findings to high stress working environments in Japan. Depressive tendencies are defined in this study as a score between 5-12 on the Kessler Psychological Distress Scale (K6) and this measure is classified as a non-specific measure of general psychological distress. A measure of emotional profiles was administered to participants before and after each bathing session, the POMS, which included a depression subscale, but their definition of depressive tendencies was not based on this. Therefore, the authors define a sub-clinical depression population but categorise it without a specific measure of depression. Overall, this means that their study offers promising evidence for NBIs effectiveness in sub-clinical populations but makes it difficult to generalise their results to a clinical one.

Considering the limited applicability of the previous study, Randomised Controlled Trials (RCTs) are often used to reduce potential bias and increase the generalisability of findings as a result (Bhide et al., 2018). One such RCT investigated the effectiveness of an NBI in reducing depressive symptoms in a population with a preexisting diagnosis of depression (Hyvönen et al., 2023). The authors used the Flow with Nature programme developed by Salonen et al. (2022), which was designed to reduce symptoms of depression and incorporates nature-based activities to build connectedness with nature. The results showed statistically significant improvements across outcome measures including the Beck Depression Inventory (BDI; Beck et al., 1988) and the Clinical Outcomes in Routine Evaluation-10 (CORE-10) (Evans et al., 2002) when comparing the experimental and control group. Between group effect sizes using Cohen's *d* were reported as small at post intervention for the BDI measure and medium at follow up Comparatively, effect sizes for the CORE-10 were in the medium range at both post and follow up timepoints which. Taken together these findings suggest a positive

impact on depression and psychological distress may. However, despite being an RCT, the paper offers insufficient information regarding their randomisation procedures which makes it more difficult to assess the level of bias.

An alternative methodology is also useful for considering the NBI efficacy literature, namely systematic reviews which gather and synthesise available evidence (Aromataris & Pearson, 2014). A systematic review considered the effectiveness of NBI in reducing stress across both clinical and non-clinical populations, including 36 studies (Corazon et al., 2019). Significant positive change was observed in well-being, QoL and mental health outcomes in five studies, with one reporting no change. On stress and burnout measures, four studies found significant positive differences and two found no difference. Studies measuring changes in positive and negative affect found positive significant differences comparing pre and post intervention in eight studies with no difference found in two. Overall, this review provides evidence that NBIs are efficacious in reducing psychological distress across multiple domains, but this is not a wholly consistent finding as four of the included studies reported no positive effect of NBIs. Within the context of the well-publicised positive publication bias in psychology (Joober et al., 2012), studies reporting positive results are more likely to be published in peer-reviewed journals. This may mean that studies included in this review are not fully representative of the efficacy of NBIs and thus further evidence will be outlined. Furthermore, the authors highlight that the timeframe of included studies was limited to the period of 2010-2018, which may have excluded relevant research published before and after which is particularly relevant given the recent renewed interest in NBIs.

In comparison, a more recent systematic review and meta-analysis included a broader range of publication dates (Coventry et al., 2021). In terms of psychological outcomes, studies which examined anxiety, depression, variability in mood states, general wellbeing, positive and negative affect across NBIs were included. 50 studies were included and the authors reported significant positive results with large effect sizes across NBIs for reducing anxiety, increasing positive affect and decreasing symptoms of depression. Across 4 RCTs, an overall moderate effect size for reducing negative affect was also recorded. This review provides a more

comprehensive synthesis of the NBI literature compared to earlier reviews (Corazon et al., 2019; Natural England, 2016) and the authors use of meta-analysis allows magnitude of effects to be compared across multiples studies within categories of outcomes. Importantly, this review and meta-analysis highlights the potential for improving mental health outcomes across multiple populations, both clinical and non-clinical. This suggests NBIs may prove effective for both prevention and treatment of mental health issues and that consideration of past and recently published studies is important in systematic reviews.

Furthermore, Silva et al.'s (2023) systematic review included a broader range of NBIs and outcomes. The author's included studies that assessed cognition and nature-interaction outcomes. Nature-interaction outcomes refer to concepts such as connections and attitudes towards nature post-intervention. Overall, 38 studies were included and the authors concluded that there was evidence of positive effects in reducing stress, improving mood and cognition. They also stated that natural environments are more restorative to mental and physical health when compared with urban settings. However, approximately half of the studies in this review used walking or viewing nature as the intervention which could be contrasted with the concept of an active NBI. Taken together, the literature paints a promising picture for the clinical use of NBIs.

Acquired Brain Injury

ABI is a broad definition that covers a range of injuries but can be defined as any damage occurring to the brain after birth (Teasell et al., 2007). Distinctions can be made within the ABI terminology based on the cause of injury and are categorised into Traumatic Brain Injury (TBI) and non-TBI. TBI refers to external events causing damage to brain tissue and non-TBI to any disease or ischaemic event causing damage to brain tissue (Bruns & Hauser, 2003). TBI can be categorised as mild, moderate or severe based on scores on the Glasgow Coma Scale, length of loss of consciousness and duration of post-traumatic amnesia (Brasure et al., 2012).

ABIs can affect different physical and cognitive functions depending on the location and extent of damage to brain tissue (Goldman et al., 2022). Physical symptoms can include full or partial paralysis, loss of sensation, visual impairment, weakness and tremor (Headway, n.d.). Cognitive symptoms can include difficulties in executive function, language comprehension or production, memory, attention and social communication (Goldman et al, 2022). A common consequence of ABI is fatigue, which is described as exhaustion driven by physical, psychological and cognitive elements (Ali et al., 2022). Estimates place the percentage of people suffering fatigue post injury as 70-80% in TBI (Mollayeva et al., 2014) and 23-77% post stroke (Hinkle et al., 2017).

Acquired Brain Injury Rehabilitation

Rehabilitation after brain injury in the UK is tailored to the individual's clinical presentation but is recommended to include a Multi-Disciplinary Team (MDT) (National Institute for Clinical Excellence, 2022). For example, speech and language therapists to support communication difficulties and specialist neurophysiotherapists for physical rehabilitation (Lee et al., 2019). The role of a clinical psychologist in rehabilitation services is varied but generally includes assessment of rehabilitation needs; provision of specialist neurorehabilitation and psychotherapy; and operating in leadership positions to ensure a biopsychosocial approach is maintained in teams (Caplan, 2010).

The stepped care model has been increasingly adopted across rehabilitation services within the NHS and attempts to categorise a patient's level of psychological need to identify the most appropriate professional to meet these (Kneebone, 2016). Specifically, the model highlights three separate levels of ascending need and complexity. Level one refers to sub-threshold problems which are mild or transitory issues with mood/cognition and can be supported by peers or members of the MDT. Level two is categorised as mild or moderate symptoms which can be addressed by non-psychology staff, or under the supervision of psychology. Lastly, level three refers to severe or persistent disturbances which require specialist assessment and intervention by psychology.

Mental Health & Acquired Brain Injury

Mental health difficulties are reported as more prevalent in individuals who have experienced an ABI compared to the general population. This includes increased anxiety (Menlove et al., 2015), depression (Lavoie et al., 2017) and symptoms consistent with personality disorders (Koponen et al., 2002). Contributing factors to mental health difficulties post-ABI include direct effects of injury, such as changes to personality with increased disinhibition leading to difficulties in existing relationships and changes in ability. Cognitive difficulties, due to their potentially wide-ranging impact post-injury have been suggested as particularly difficult to manage for individuals and families and may therefore contribute to increased incidence of mental health problems in this population. (Howlett et al., 2022). Social factors such as loss, or change of occupation, and increased reliance on others for support with activities of daily living are also potential consequences of ABI (Segal, 2010). Loss or impaired function can lead to reduction in social interaction and further affect mood (Goldfinger et al., 2014). A negative bi-directional relationship has been proposed between impaired cognition and depression whereby the presence of either can negatively impact the other (Ferro et al., 2016).

Fatigue has also been associated with reduced QoL and wellbeing post-injury (Cantor et al., 2008). Furthermore, fatigue is also associated with reductions in physical and social engagement which are likely important contributors to an individual's mood state (Stulemejier et al., 2006). Fatigue may therefore play an important role in contributing to increased prevalence of mental health problems in the ABI population.

There is some evidence that, in TBI specifically, the severity of the injury is related to the prevalence of mental health difficulties. A nuanced relationship has been suggested, however, within categories of TBI. For example, the prevalence of mental health difficulties has been reported as lower in individuals with severe TBI compared to mild or moderate (Howlett et al., 2022). Authors suggest this may be driven by limited insight and increased apathy in the severe TBI population (Nelson et al., 2021).

Within the context of ABI and rehabilitation, NBI's may prove an innovative method of reducing post-injury effects. As highlighted, the impact of ABI is highly variable, but the NBI literature shows promise across an equally wide range of outcomes (Silva et al., 2023). The adaptability of NBIs also hold further promise as the theory of enriched environments (Nithianantharajah & Hannan, 2006) suggests an increase in cognitive, sensory or social stimulation may play a role in promoting neuroplasticity after ABI (Janssen et al., 2010). Engagement and motivation have also been identified as key predictors of positive rehabilitation outcomes in ABI (Verrienti et al., 2023). Motivation and depression are highly correlated and individuals with ABI may not see a use in rehabilitation which can affect engagement (Kusec et al., 2019). Findings that suggest NBIs are effective at increasing motivation or engagement may therefore be of particular interest in the ABI population.

Nature-Based Interventions for Acquired Brain Injuries

This section will examine the evidence for the effectiveness of NBIs for the ABI population. Authors have investigated the impact of NBI in individuals with post-concussive syndrome (Corazon et al., 2024), which refers to a collection of symptoms that include, but are not limited to, headaches, memory difficulties, fatigue, depression and anxiety (Ryan & Warden, 2003). In this study, 30 participants completed a ten session NBI which took place in a forest therapy garden. Activities in the NBI included physical exercises, group psychoeducation activities and breathing exercises. The main outcome measures included the Mental Fatigue Scale (MFS) (Johansson et al., 2010), Warwick-Edinburgh Wellbeing Scale (WEMWBS) (Tennant et al., 2007) and the Quality of Life after Brain Injury measure (QOLIBRI) (von Steinbüchel et al., 2010). The results showed a significant improvement in scores on the Mental Fatigue Scale at the endpoint measurement with a moderate effect size. Similarly, scores on the WEMWBS significantly improved with a medium effect size. The authors concluded positive effects of the intervention across outcomes but highlighted that the scores on the MFS were still above the clinical threshold for no/mild symptoms of fatigue. However, this study used a control period where all participants would engage in a period of waiting equal to the length of the intervention, before beginning the NBI. Without a

comparison group independent of the intervention, it is difficult to make conclusions about the role of the NBI in improving scores on the included measures.

One other study piloted a goal planning and outdoor adventure intervention with 11 individuals with severe TBI which aimed to contribute to cognitive rehabilitation (Walker et al., 2005). The authors used a context-sensitive approach which promotes achievement of goals in a real-world setting to promote mastery and build self-esteem. The initial stage of this programme involved a nine-month period of fundraising complete by participants and supported by facilitators, followed by a nine-day adventure course. Activities on the adventure course included climbing, caving and hiking. Finally, the third stage required participants to meet fortnightly to identify goals and update their peers on their progress in achieving them. Outcomes assessed included progress or achievement towards goals set, depression, anxiety and stress using the DASS and general wellbeing. The results showed a goal achievement rate of 80% but across all psychological outcome measures there was no significant change reported. The authors attribute the lack of change across measures to their small sample size and other stressors reported by participants that related to medico-legal proceedings. However, the authors measured outcomes before and after the whole programme had been completed which means that positive change could have been driven by other stages of the programme, rather than the nature-based adventure portion.

A scoping review in 2019 gathered evidence for NBIs using the broad term nature-based rehabilitation (Vibholm et al., 2019). This definition encompassed all activities that used nature to achieve clinically defined goals, specifically in the ABI population. The authors sought to identify if nature-based rehabilitation is effective at reducing consequences of ABI in adults, including psychological, cognitive, behavioural and sensory-motor difficulties. Seven studies were identified for inclusion. Specifically, the duration of interventions ranged from two weeks to 24 months. Across these studies, improvements in independence, cognitive function, motivation to engage in rehabilitation, anxiety and general quality of life were reported. However, studies measuring improvement across symptoms of depression reported inconsistent findings. Interestingly, the duration of intervention did not

appear to be correlated with improvements across outcomes. The authors highlight that only 59% of statistical comparisons across studies were significant.

Within the literature thus far, there is much heterogeneity of included studies and often no distinction between structured therapeutic programmes and more passive exposure to nature. Attempts to categorise human-nature interactions have been made in the literature with some authors proposing a distinction between intentional, incidental and unintended interactions (Darcy et al., 2022). Intentional interaction refers to deliberate engagement with nature where the aim is to perform an activity or be present in nature. Incidental interactions are those where an individual is physically present but not intentionally engaged with nature whereas in unintended interactions the individual is not physically present. Considering Shanahan et al.'s (2019) Delphi categorisation of NBIs, the subcategories of programmes that engage and those that educate could be considered intentional interactions whereas programmes that alter the environment could be considered incidental or unintended interactions, depending on the NBI.

This may be important as there is some evidence of differential benefits when comparing interaction types. For example, Holt et al. (2019) found no correlation between passive exposure to nature and positive effects on quality of life or stress reduction amongst a sample of university students. On the other hand, intentional physical interactions with nature positively correlated with better outcomes on these same measures. These results suggest that active NBIs, such as HT, may prove especially beneficial for improving clinical outcomes. Also, considering the context in which rehabilitation often occurs following ABI, gardens are often present in hospital settings. This availability of resource combined with the active exposure element may mean HT is easily adopted by clinical teams.

Definitions of Horticultural Therapy

Considering definitions of HT, no consensus exists in the literature. One early definition describes it as "a discipline that uses plants, the activity of gardening and the innate affinity that we feel toward nature as a professional means in programs of therapy and rehabilitation" (Davis, 1998, p.1). The American Horticultural Therapy

Association (AHTA) offers further definition as “participation in activities facilitated by a registered horticultural therapist to achieve specific goals within an established treatment, rehabilitation or vocation plan” (AHTA, 2024). However, others suggest that HT is “the use of plants as a therapeutic medium by a trained professional to achieve a clinically defined goal” (Kam & Siu, 2010, p. 80). It is important to note that the terms horticultural therapy, social horticulture and therapeutic horticulture are often used interchangeably in the literature, but the AHTA highlights therapeutic horticulture as a non-clinical intervention and social horticulture as a leisure or recreational activity (AHTA, 2024).

HT is also a distinct intervention from therapeutic and social horticulture due to its clinical focus. A division between participatory or active engagement in horticultural activities, and ornamental HT which focusses on passive engagement, such as touring gardens has been proposed in the literature (Kim et al., 2018). This broadly matches categorisation of natural environments into those that are designed to improve wellbeing without clearly defined clinical goals, and those that use natural environments to achieve clinically defined goals (Stigsdotter & Grahn, 2011). As the title of horticultural therapist is not legally protected across many countries, the definition of the AHTA which requires a registered horticultural therapist for an intervention to be considered HT will not be used for this present study. In keeping with categorisations by Shanahan et al. (2019), and the definition proposed by Kam & Siu (2010), “the use of plants as a therapeutic medium by a trained professional to achieve a clinically defined goal”. This is consistent with previous systematic reviews investigating HT (Kamioka et al., 2014). Furthermore, this will include studies that used horticultural activities with an active component, as opposed to ornamental horticulture or greenspace exposure.

HT is often delivered in structured programmes comprising multiple sessions although specific activities, duration and setting are highly variable. Programmes are commonly delivered in a small group format and typically comprise multiple sessions. HT has been conducted in inpatient rehabilitation (Wichrowski et al., 2005), community (Noone et al., 2017), forensic (Heard et al., 2022) and occupational settings (Son et al., 2022). HT programmes are routinely facilitated by occupational therapists, physiotherapists and clinical psychologists (Haller & Capra,

2016). Common activities include but are not limited to weeding, sowing seeds, harvesting, flower arrangement, creative horticulture and maintaining the garden. As mentioned previously, considering Shanahan et al.'s (2019) categorisation of NBIs, HT falls into the treatment of a specific physical or mental health and wellbeing issue supra-category, and the programme or treatments that engage clients with nature or change behaviour sub-category.

HT's use as a therapeutic tool dates to the post first world war period where gardening was used as a rehabilitation tool for returning veterans experiencing post-traumatic stress disorder (Poulsen, et al., 2015). This led to the early development of HT as a profession in western countries (Davis, 1998). As with other NBIs, however, HT has gained recent attention and is being used in the United Kingdom's National Health Service (NHS). Recent examples include specific HT services (Devlin, 2024); programmes for improving staff wellbeing (Leeds Teaching Hospitals Trust, n.d.) and horticultural programmes designed to improve wellbeing in cancer patients (University Hospitals Plymouth NHS Trust, 2023). Recent amendments to the National Institute for Clinical Excellence (NICE) guidelines for people living with dementia have also recommended inclusion of gardening to promote meaningful activity (National Institute for Clinical Excellence, 2019). This may be reflective of the perceived potential of HT as an effective intervention for use across populations, and particularly in inpatient settings due to the availability of resources for conducting programmes of HT.

Mechanisms of Horticultural Therapy

Several mechanisms have been suggested to underlie the beneficial effects of HT with much discussion of two theoretical frameworks occurring in the literature. These frameworks both focus on the restorative aspects of nature and draw from the biophilia hypothesis (Wilson, 1984). The biophilia hypothesis suggests humans have an innate connection with nature which is evolutionarily advantageous as it increases positive feelings. Biophilia can be separated into two distinct components. Firstly, humans harbour positive feelings towards other living things and secondly, that this affinity is driven by genetic predisposition (Kellert & Wilson, 1993). The biophilia hypothesis is rooted in biology and suggests that evolutionary experiences

played a key role in development of biophilic tendencies due to humans ancestors' constant interaction with the natural world (Tooby & Cosmides, 1990).

The Attentional Restoration Theory (ART) (Kaplan, 1973; 1995) outlines a framework in which natural environments restore depleted attentional resources. ART draws from evolutionary ideas that this restoration is an evolved, adaptive function. ART differentiates between directed and involuntary attention, suggesting the former is a finite resource that requires an effortful process to focus on a stimulus. The theory proposes that natural environments offer "soft" fascination to individuals which is a state of attention that provides the opportunity for mental rest. Whilst remaining engaged with the environment. Specifically in HT the act of growing living material is suggested to drive attentional restoration as it captures attention involuntarily in a bottom-up manner (Jonides et al., 2008). Bottom-up attention is contrasted with top-down attention with the former referring to attentional capture by external stimuli, and the latter referring to intentional direction of attention (Katsuki & Constantinidis, 2014). Restoration is proposed to alleviate anxiety and improve cognitive performance across multiple domains (Taylor & Kuo, 2009).

Experimental studies have been conducted using different cognitive tasks to investigate ART, including Trail Making (Shin et al., 2011) and the Stroop task (Taylor & Kuo, 2009). These studies demonstrated that participants perform better on these tasks in natural environments. However, these tasks used to assess attention also require other cognitive functions to complete successfully which makes claims of better performance being purely related to effects of restored attention tenuous. For example, successful completion of the Stroop test requires participants to employ higher level executive functions such as inhibitory control (Faria et al., 2015). Criticism in the literature has also referred to the vagueness of some fundamental concepts in ART, such as "soft fascination" provided by natural environments which makes it difficult to operationalise and investigate (Joye & Dewitte, 2018).

The Stress Recovery theory (SRT) (Ulrich, 1983; Ulrich et al., 1991) suggests beneficial biopsychological responses occur when humans come into contact with

nature. These responses are proposed to stem from an innate preference for interaction with the natural environment and a decrease in stress responses when in nature (Huang et al., 2021). Beneficial responses to nature are said to occur immediately and beneath the level of conscious awareness. Ulrich (1986) suggests being present in a safe natural environment which holds complex perceptual cues can reduce feelings of stress or anxiety, if an individual was experiencing these before entering nature. This stress reduction is suggested to be evolutionarily adaptive as studies have demonstrated reduced immune function, increased prevalence of mental health problems and lower cognitive functioning in the presence of chronic stress (Marin et al., 2011; Mariotti, 2015). In the context of urbanisation, comparatively recent inhabitation of urbanised areas is proposed to explain a continued preference for natural environments and interactions in humans (Ulrich et al., 1991). Studies which report lower physiological markers of stress and anxiety, during and after interactions with nature, are suggested in the literature to offer support for SRT (Yao et al., 2021).

Criticism has been levelled at SRT however for its suggested non-specific positive response in humans towards nature, highlighting that in evolutionary terms, nature does not provide equal opportunities for food, sustenance or restoration (Joye & van den Berg, 2011). Both ART and SRT outline unequivocally positive interactions with nature whilst failing to address negatives. Nature can represent threats to human health through insect borne diseases, animal attacks and injury (Sreethran & van der Bosch, 2014; Soga & Gaston, 2022).

A further explanation may be found in the theory of environmental press which outlines the relationship between individual ability and the environments in which they operate (Lawton & Nahemow, 1973). For positive environment interactions to occur, which are characterised by positive affect and adaptive behaviour, there must be parity between the individual's level of ability and demands from the environment; termed environmental press. On the other hand, incongruence is proposed to lead to more negative affect and maladaptive behaviour. Achieving parity may prove more difficult for individuals with ABI due to injury related difficulties and reduced ability, or perceived reduced ability. Furthermore, environments are often improperly adapted for individuals with mobility needs

which further increases the disparity between ability and environmental demands (Casas, 2007). The production of self-sufficiency in HT may better enable individuals to increase their ability and therefore reduce environmental press. Enriching environments through HT may also provide greater stimulation for people with ABI and has been linked to better outcomes in rehabilitation (Adevi & Mårtensson, 2013).

Evidence for the theory of environmental press is provided by studies which measure levels of engagement, as high levels of imparity are suggested to result in non-engagement (Orsulic-Jeras et al., 2000). Some authors have suggested the use of HT in increasing personal competence and therefore increasing parity with environmental demands (Relf & Dorn, 1995; Jarrot et al., 2002). To assess this, authors have used measures of engagement to provide support. For example, one study used a HT programme to measure change across types of engagement (Jarrot & Gigliotti, 2010). The authors used an RCT methodology to assess active (direct handling of plants within the programme) and passive engagement (intently watching the HT activities), through observation in a sample of elderly people with dementia. Following the HT programme, they coded the observational data and performed statistical analyses. The results showed significantly higher levels of both types of engagement in the HT group compared with the treatment as usual group. The authors concluded that the flexibility of HT allowed for engagement across abilities, which may also be explained by increasing parity between environment and competence in the context of environmental press.

Considering systematic reviews, they have also highlighted an increase in engagement with one review using meta-analysis that demonstrated a 45% increase in engagement when participants completed a HT programme compared to controls across studies (Lu et al., 2022). These findings of increased engagement have been echoed across other similar reviews (Zhao et al., 2022; Murroni et al., 2021). However, the literature focusses heavily on engagement in the Alzheimer's population which limits the applicability of the concepts of environmental press across other groups. Also, as highlighted, increases in engagement may also be explained by other theoretical frameworks such as ART and SRT. In summary, the empirical evidence for a direct explanation of environmental press as a mechanism

in positive change for HT is limited without measurement of the concepts, such as environmental parity.

Salutogenic theory (Antonovsky, 1979) refers broadly to a collection of ideas around health promotion but is often referenced in the context of NBIs. Central to salutogenic theory is the concept of a sense of coherence which is formed by an individual's experiences. The Sense of Coherence (SOC) is summarised as an outlook on life as manageable, comprehensible and meaningful. Individuals with a strong sense of coherence are suggested to more easily navigate challenges in life and use their available resources more effectively. Salutogenic theory differentiates between disease/ease model of health and is generally critical of the dominant medical model (Mittelmark & Bauer, 2022). Authors have proposed that salutogenic mechanisms drive change observed in NBIs through nature being inherently meaningful and providing a range of varied yet achievable challenges (Hiemstra et al., 2024).

Evidence for the driving force of salutogenesis behind positive change in HT has been reported from studies that directly assess individual's sense of coherence. Building on the work of Antonovsky (1979), outcome measures have been developed that use the concepts of salutogenesis to measure sense of coherence. For example, the Antonovsky Sense of Coherence scale (SOC-13) (Antonovsky, 1987) assesses three interrelated factors in comprehensibility, which is the subjective experience of life and events making sense; manageability which is the perception of an individual that they have resources to manage life challenges and meaningfulness which is the belief that life has meaning and is worth living.

To the author's knowledge, one study used this measure in combination with a programme of HT to investigate change over time in a dementia population in long term care facilities (Jeung & Chen, 2022). The HT programme involved planting a range of seeds and ornamental activities with flowers over a 12 week period. The authors reported significant increases in SOC score in the experimental group compared to the control group at the 8 and 12 week timepoints. They conclude that HT may increase SOC through empowering participants to engage in activities and

offering space to reflect on meaningful activities. However, the authors did not include calculations of effect sizes so the magnitude of this effect is not clear. Although the evidence base is limited, this suggests that salutogenic theory may offer insight into the mechanisms of HT beyond ART and SRT.

Horticultural Therapy Effectiveness

This section will focus on the HT literature, considering the evidence for its effectiveness across outcomes and clinical populations. Similar to the broader NBI research literature, the usefulness of HT in improving outcomes such as depression (Patil et al., 2009), anxiety (Kam & Siu, 2010; Jarrot & Gigliotti, 2010), QoL (Lai et al., 2017) and cognition (Gi & Eun, 2003) has been investigated. Regarding populations, studies have assessed or systematically reviewed HT's use with older adults (Lin et al., 2022; Nicholas et al., 2019), people with mental health (Cipriani et al., 2017; Han et al., 2018) and learning difficulties (Joy et al., 2020).

One study sought to investigate the impact of HT on memory, depression, anxiety and stress (Hoseinpoor Najjar et al., 2018). 15 male participants with a diagnosis of depression in the experimental group engaged in 10 sessions of HT and completed the Rey-Osterreith Complex Figure test (ROCF) (Rey & Osterrieth, 1941) and the Depression Anxiety and Stress Scale (DASS-44) (Imam, 2008). HT activities included combing the soil, planting marigolds, water, weeding and harvesting. No information was provided regarding the control condition, but comparison showed a significant improvement in performance on the ROCF and significant reduction in scores on the DASS. The authors conclude that HT improves cognitive performance in those with depression and alleviates symptoms of depression. The ROCF is a brief cognitive task with a focus on visuospatial working memory, although it does tap other cognitive domains including attention; planning and concept organisation (Zhang et al., 2021). This means the findings are limited to those domains assessed by the ROCF. Also, it is unclear from the findings if improvements in cognition are driven by HT directly or by the reduction of depression, as this is associated with poorer cognition (Perini et al., 2019).

In contrast, one study used a more methodologically rigorous design and included both quantitative and qualitative data to investigate HT's effect on depression, anxiety and wellbeing in participants with diagnoses of depression, schizophrenia spectrum or bipolar disorder (Kam & Siu, 2010). The authors also collected qualitative data using semi-structured interviews to evaluate participant's experience, satisfaction, perceived benefits and suggestions for the improvement of the HT programme. Specifically, the authors compared scores on depression and wellbeing measures between controls and a HT group that engaged in 10 sessions across a 2-week period (Kam & Siu, 2010). Quantitative data showed significant reduction in depression scores for the HT compared to control group, but no differences were recorded on QoL measures which the authors suggest is driven by their choice of QoL measure and its insensitivity to change over a short two-week period. The qualitative data complimented other findings with participants expressing feelings of enjoyment, contentment and satisfaction in their horticultural work. Crucially, the duration of the HT programme was relatively short in this study and occurred over a two-week period which suggests positive impacts from a briefer HT intervention.

A systematic review of RCTs sought to gather evidence for the effectiveness of HT across all populations (Kamioka et al., 2014). Four studies met criteria for inclusion and outcomes reported included but were not limited to general affect, depression, anxiety and self-esteem. There was some evidence of positive effects of HT in the dementia and schizophrenia populations, but the authors stress the caution needed in interpreting their results due to inconsistent reporting around randomisation procedures. The RCT methodology may pose a problem for HT as the blinding of facilitators is not possible due to the nature of the intervention. Also, as HT is usually delivered in a group-based format, it is likely that a multi-centred approach would be required due to the maximum number of participants in any one HT group. This increases the cost and resource demand of the research and may result in RCTs lacking statistical power, leading to them being of low methodological quality (Tu & Chiu, 2020). Considering these difficulties, it may be useful to briefly consider reviews of the non-RCT literature.

A systematic review investigated the HT literature across all mental health conditions, identifying 14 studies for inclusion (Cipriani et al., 2017). 11 of these studies reported a significant positive effect across domains such as affect, interpersonal relationships and psychological wellbeing. The authors concluded there was moderate support for HT's effectiveness in the population. A more recent meta-analysis focussed specifically on psychosocial wellbeing and echoed the findings from the previous review (Spano et al., 2020). The authors included both HT and gardening interventions, reporting a moderate positive effect on broad psychosocial wellbeing.

In summary, the HT literature across populations, diagnoses and outcomes paints a cautiously optimistic picture about its usefulness as a clinical intervention despite poor methodological quality in some studies. HTs increasing use may be driven by the availability of resources and accessibility of the activities when compared with other NBIs such as wilderness or adventure therapy. This availability and accessibility may also prove especially useful for specific populations where access to nature is more difficult due to physical impairments, like the ABI population.

Horticultural Therapy & Acquired Brain Injury

With the context of NBIs, ABI and HT laid out, this section will critically review the literature of HT use in the ABI population. The potential of HT for the ABI population has been highlighted with participants describing improvements to their mood and gaining a new interest which they share with loved ones (Thrive, n.d.). Studies exploring the efficacy of HT with ABI have been conducted in both hospital (Kim et al., 2010; Barello et al., 2016; Ho et al., 2016) and natural environments such as forests or wilderness (Thomas, 2004; Chun et al., 2017).

One study introduced a HT programme to five hospital patients and measured independence, depression and activities of daily living (Mizuno Matsumoto et al., 2008). The authors conducted functional Magnetic Resonance Imaging (fMRI) scans of participants on simple perceptual recognition tasks following completion of the HT programme. The programme was comprised of 20 sessions of HT spanning one

month. Their findings showed that scores on measures of independence and activities of daily living were improved in the HT group. Also, fMRI showed increased activity in the fusiform gyrus which is an area of the brain associated with visual processing (Weiner & Zilles, 2016) and the cerebellum, associated with motor functions and proprioception (Boisgontier & Swinnen, 2014). The authors concluded that HT may therefore be associated with improvements in sensory-motor function. This suggests a form of neuroplasticity, which is the functional or structural reorganisation of the brain in response to external stimuli (Cramer et al., 2011). However, across participants no change was observed on measures of depressive symptoms. The authors suggest a more specific HT programme focussed on improving affect, across a longer duration, may be required to influence mood.

Another study investigated an HT programme in an inpatient setting with stroke patients, across 18 sessions (Lee et al., 2018). The authors conducted assessments of physiological functioning and depression. Motivation to engage in rehabilitation was also recorded using an established outcome measure (Han & Lim, 2002). Significant improvements were reported across multiple physical domains, including upper limb function and grip strength. The results showed significant reduction in depressive symptoms compared to control groups but no difference between groups, or pre-post intervention was reported for rehabilitation motivation. These findings appear to conflict with the results of Mizuno-Matsumoto et al. (2008), but the HT programme used in the current study was of a longer duration, which may suggest a dose-frequency relationship.

The breadth of evidence outlined suggests that HT is an effective intervention for supporting diverse groups of individuals with a range of difficulties. As highlighted by previous systematic reviews of HT (Lin et al., 2022), the evidence base is highly heterogeneous in terms of methodologies, which may mirror the variability in HT itself. However, this does limit the extent to which their findings can be generalised and is often cited as preventing the use of meta-analysis. Self-recruitment is also common in the literature and may present a possible positivity bias for those that enjoy nature (Corazon et al., 2019). This could impact findings from studies where a pre-existing enjoyment of nature leads to participants reporting more positive outcomes than is representative in the general population.

To the author's knowledge, one previous review of the HT and ABI literature has been conducted (Söderback et al., 2004). The authors evaluated the introduction of a HT programme for stroke patients in a hospital setting. No formal outcomes were collected by the authors however they reported observational increases in interactions between participants. This review was conducted in a non-systematic fashion with limited reference to their protocol. A search strategy is provided but the quality of included papers was not appraised by the authors. This paper aimed to provide a historical narrative of HT for the ABI population as opposed to being a systematic review of HT.

In summary, there is increasing interest around NBIs in the context of pressured health services and increasing urbanisation. NBIs are highly heterogeneous, and authors have begun to categorise them by their aims and uses (Shanahan et al., 2019). The literature suggests that NBIs can reduce depression, improve quality of life and cognitive performance across clinical populations. Similarly, there is some evidence that HT for the ABI population has similar effects for depression and cognitive performance. Systematically gathering evidence relating to psychological outcomes specifically may add useful insights to the literature. Furthermore, the reviews that have been conducted have focussed more on summarising quantitative data, or those specifically from RCTs. This offers much evidence for the efficacy of NBIs but does little to aid understanding of why these interventions work, or what people's experiences of them are.

Research Aims

This project aims to use a mixed methods systematic review to investigate three research questions:

1) In the ABI population, does the literature suggest HT is an effective intervention for:
    - reducing psychological distress
    - improving quality of life
    - improving cognition
2) What are participants with ABIs experience of engaging in HT?

3) In the ABI population, what are the theoretical underpinnings for HT and what are the mechanisms of change in the outcomes of interest?

Evidence from both the qualitative and quantitative literature will be used to answer the first outcome-based research question. Regarding participant experiences, evidence from the qualitative literature, or studies that use a mixed methodology will be used. Finally, evidence from quantitative, qualitative and mixed methodology studies will be used to gather information about the theoretical basis and mechanisms of change in HT and ABI.

Method

This section will outline the justification for the methods used in the project and summarise the initial plan for synthesising data from the included studies. The deviation from protocol section will then describe the decisions made to deviate from the initial plan for synthesis.

Systematic reviews gather information relevant to a research question and synthesise this to inform practice and research (Uman, 2011). They have become the standard for synthesising primary source data and are used to inform clinical guidelines, such as those provided by NICE. These methods allow comparison across the literature and a more thorough evaluation of the effectiveness of interventions, or other relevant research questions which offers an advantage over single studies (Chidgey et al., 2007). Systematic reviews can be divided into those that assess an intervention's efficacy; observational study reviews; RCT reviews; reviews of measurement instruments; qualitative reviews and mixed method reviews (Pollock & Berge, 2017). Meta-analysis, which refers to the combination of statistical findings from multiple studies, is often used in systematic reviews to calculate the overall magnitude of an effect or relationship (Cheung & Vijayakumar, 2016).

As with quantitative reviews, qualitative reviews or meta-syntheses aim to gather and combine information to answer a research question (Finlayson & Dixon, 2008). Meta-syntheses are conducted according to an epistemological position, similar to qualitative data analysis methods in primary research. Qualitative data is extracted from the primary studies and synthesised according to themes or meanings (Dawson, 2019). Qualitative systematic reviews or meta-syntheses can build understanding of the underlying theory of a specific intervention or provide information about participant's experience of it.

Quantitative and qualitative systematic reviews provide unique contributions to understanding of intervention efficacy and experience. However, conducting either type of review excludes the information that could be provided by the other. Recent methodological developments attempt to address this issue and provide dual streams of evidence for an intervention. For example, mixed method reviews can

collate information regarding an intervention's effectiveness through collection of quantitative data, and build understanding of client's perspectives of the intervention through collection of qualitative data. These methods in combination can inform if and why an intervention is effective (Plano Clark, 2017). Multiple approaches have been outlined in the literature for conducting mixed method reviews, but a commonality is the extraction of both quantitative and qualitative data.

Synthesis in the context of systematic reviews refers to the combining of data from included studies. Mixed method systematic reviews use two categories of synthesis to combine qualitative and quantitative data, namely convergent integrated and convergent segregated (Hong et al., 2017). These are umbrella terms for multiple methods that have been grouped together. Convergent refers to synthesis occurring simultaneously with both data types. Integrated and segregated describe at which stage data is transformed and synthesised. Convergent integrated involves data extraction followed by qualitization of quantitative data (BMJ, 2023), where narrative summaries are developed from numerical data. Both data types are then assembled and can be grouped by similarities in meaning. Sequential synthesis, where synthesis occurs consecutively, is another type of synthesis but is used less often in the literature (Hong et al., 2017).

Convergent integrated designs are recommended when a singular research question can be answered by both the quantitative and qualitative data (JBI, 2025). On the other hand, convergent segregated designs are recommended when review questions are attempting to investigate different aspects of an intervention. In convergent segregated designs, separate syntheses are performed on the quantitative and qualitative data (Stern et al., 2020). A meta-analysis or narrative summary is conducted using the quantitative data and qualitative data are pooled and a meta-aggregation or narrative summary is completed (Hong et al., 2017). Within convergent segregated designs, synthesis can occur in any order. Integration of these data sets then occurs, and the reviewer considers if findings complement each other. This design has also been used to identify any relationships between concepts and develop broader frameworks/theories (Pluye & Hong, 2014). Guidance provided by the Joanna Briggs Institute (JBI) for conducting mixed method systematic reviews has been used to create the following proposed methodology (JBI, 2024). The JBI

guidance for qualitative synthesis was also recently updated to provide more comprehensive guidance (JBI, 2025).

Other approaches to synthesis include the exploratory sequential approach (Ivankova et al., 2006). Broadly, this approach involves the collection of qualitative data followed by an integration or testing phase using quantitative data. The process occurs iteratively where hypotheses are generated and adapted based on the emerging qualitative data. In systematic reviews, this method has been used to investigate complex interventions with the use of logic models, where quantitative data is used to test the theories and mechanisms of change identified through the qualitative findings (Murray et al., 2019).

Logic Models

A logic model can be described as a visual representation of the relationship between components of an intervention and its outcomes, and they are increasingly used to aid synthesis in systematic reviews (Kneale et al., 2015). Logic models are used to develop theories of change and are informed by programme theory (Anderson et al., 2011). Specifically, which components of an intervention contribute to change in outcomes of interest and through what mechanisms. This approach lends itself particularly well to mixed methods research where the aim is often to identify what works and why. Similarly, the investigation of complex interventions may be aided by the creation of a simplified diagram representing these aspects.

Horticultural Therapy as a Complex Intervention

Complex interventions are defined as those with multiple components, multiple skills required to administer them, the differential outcomes they target or the flexibility of the intervention itself (Skivington et al., 2021). HT can be considered a complex intervention due to the range of outcomes it is used to target (depression, anxiety, physical health, QoL, cognition) and the variability of possible HT activities that can be included. As such, it is useful to consult guidance on conducting research into complex interventions. A framework commissioned by the

United Kingdom Medical Research Council (MRC) and the National Institute for Health Research (NiHR) updated previous guidance on conducting research on complex interventions (Skivington et al., 2021; Craig et al., 2008). This framework outlines different approaches to complex intervention research including investigations of efficacy, effectiveness, theories and systems. For the purposes of this systematic review, an effectiveness and theory-based approach will be used to investigate if HT is effective in a real-world setting and what factors drive any change that is reported.

Ethical Approval

NHS or University of Leeds ethical approval was not required for this doctoral project as primary data was not collected. All data included in this review were obtained from secondary published sources.

Protocol and Registration

To ensure transparency, reduce bias and confirm the present review did not duplicate previous work, a draft protocol was submitted to PROSPERO. This protocol was accepted to PROSPERO in May 2024 (Registration number: CRD420245479720).

Eligibility Criteria

The Population, Intervention, Comparator and Outcome (PICO) framework outlines considerations for establishing inclusion and exclusion criteria in systematic reviews (McKenzie et al., 2023) and was adopted for the present review. A summary of these criteria can be seen below in Table 1.

Table 1.

Inclusion and Exclusion Criteria.

Include	Exclude
Types of Studies	
• RCTs or quasi-RCTs.	• Non-scientific case studies.

• Cohort. • Case-Control/Case-series. • Qualitative, quantitative or mixed methods. • *Studies providing relevant information to the theoretical background of HT.	• Systematic reviews. • Commentaries or editorials.
Types of Participants	
• Participants who have experienced an ABI (Stroke, TBI of any severity). • Any age. • Staff perspectives on administering HT.	• Studies where participants have not experienced an ABI. • Studies where participants have a diagnosis of Alzheimer's or other dementia.
Types of Intervention	
• Studies using HT, as defined previously. • Any duration of HT. • Indoor or outdoor.	• Where the primary intervention involves non-active horticultural components (Ornamental or social horticulture).
Types of Outcomes	
• Studies measuring depression, anxiety, quality of life or cognitive function.	• Studies measuring only physical health outcomes (Blood pressure, limb function, MRI etc.).

Note: These studies were used to inform the theoretical understanding of HT but not included in the final synthesis.

Studies

RCTs, cohort and case series studies are eligible for inclusion in this review. Those that are designed to compare different NBIs will be included only if they differentiate between HT and other NBIs and report these outcomes separately. Non-scientific case studies, systematic reviews and commentaries/editorials are excluded.

Population

This review included studies where participants were primarily individuals with ABI, defined by any damage occurring to the brain after birth. This included TBI and cerebrovascular incidents. All ages were included initially, with a view to exclude participants below 18 if sufficient literature was identified in adult populations. This was thought to be relevant due to differences in neuroplastic reorganisation following injury in this age group (Johnston et al., 2009) at a later stage. The decision to include staff or facilitator perspectives was made where direct quotations were provided, as this increased contextual richness in the qualitative data. This review excluded studies where participants have diagnoses of Alzheimer's or other dementias. This is due to the literature focussing heavily on these topics thus far (Lu et al., 2020: Zhao et al., 2020; Wang et al., 2024).

Intervention

Studies that included HT, as defined by active engagement in horticultural activities designed to promote wellbeing, as the primary intervention were included in this review. HT is a heterogeneous intervention with few standardised programmes or a consensus around definitions in the literature. As highlighted previously, the broad definition proposed by Kam & Siu (2010), "the use of plants as a therapeutic medium by a trained professional to achieve a clinically defined goal", was used in this review. However, this excluded interventions that do not include an active interaction with nature, such as greenspace exposure. Commonalities across HT include activities such as raking, weeding, sowing seeds, harvesting and digging. No limits on duration of the HT intervention were applied.

Outcomes

Studies investigating the effects of HT on QoL, depression, anxiety and cognitive functioning were included. QoL is a diverse concept and further operationalisation is required. For the purposes of this review, studies using named measures in line with the World Health Organisation's (WHO) definition of QoL, 'An individual's perception of their position in life in the context of culture and value systems in which they live and in relation to their goals, expectations, standards and concern' (WHO, n.d.), were included.

No restrictions were placed on studies reporting qualitative data and included all approaches. Studies which assess only physical outcomes following HT were excluded.

Search Methods

Literature searching occurred across four distinct stages and is summarised below. Generally, search strategies were developed through an iterative approach where new terms and definitions were identified with each new search and then included into an overall strategy. This approach was used to ensure searching was carried out in a comprehensive, systematic fashion and that as many records as possible were identified. In addition, at each stage, references from included studies and those from systematic reviews in adjacent areas were hand searched to ensure all available data was included. Development of search strategies was supervised by an information specialist at the University of Leeds to ensure their accuracy. Records were kept of the date each search was ran, the strategy, database and number of records identified. De-duplication was performed using the method outline by Bramer et al. (2016) where the Endnote (Version 20) library was exported, the settings changed and then imported back into EndNote. The filters and field settings were changed and de-duplication performed at each stage to ensure all duplicates had been identified and removed.

Stage one – Preliminary Database Identification

Preliminary keyword searches were performed to identify databases with sufficient studies for inclusion in the review, and which would be important to include or exclude. From these searches seven databases were selected, CAB Abstracts, PsycINFO, Medline, Embase, Web of Science, CINAHL and SCOPUS. Searches of the grey literature were not performed due to the limited resource of this thesis project, and the availability of coscreeners. Also, due to the non-standardised nature of grey literature repositories, this was deemed to be too resource intensive for the scope of the project.

Stage Two – Main Search

A master search strategy was developed in Medline (Appendix A) which was designed to capture both qualitative and quantitative studies. Relevant MESH headings were identified and topics grouped by concepts such as "Acquired brain injury" and "Horticulture". The master strategy was adapted for the other databases, using the appropriate database specific commands.

Stage Three – Supplementary Searches

Supplementary search techniques refer to a range of techniques which aim to broaden the scope of a traditional systematic review, whilst maintaining the core purpose of being systematic, reproducible and transparent. Supplementary search techniques are increasingly used in the evaluation of complex interventions and aim to ensure that searches achieve conceptual richness and contextual thickness. In this review, CLUSTER searching (Booth et al., 2013) techniques were used and included forwards and backwards citation searching, and key author searching. Forward and backward citation searching involve screening all records that have cited included studies and all citations in included studies, respectively. To assist, the online tool CitationChaser (Haddaway et al., 2021) was used. Key author searching was completed by identifying the 15 authors who were cited or co-cited most often from the main searches. These author's publication histories were then searched to identify any studies that met inclusion criteria.

Stage Four – Theoretical Searches

During the previous stages of searching, notes were added to studies that included discussion or mention of theories or theoretical concepts. Additionally, a search strategy was adapted from an existing theory-based search filter (Academic Unit of Health Economics, University of Leeds, 2018) to identify theoretical concepts in the wider literature, relating to HT. Studies identified in this stage were not included in the final synthesis directly but were used to inform understanding of the theoretical basis of HT in ABI.

Screening

The titles and abstracts of papers identified through the first three stages of searching were initially screened against the inclusion and exclusion criteria. Following this, the papers that were selected for inclusion or where the decision was to maybe include, were put through for full-text screening. An independent co-screener (S.L) screened 33% of identified records at the title, abstract and full-text stages of screening to reduce the risk of bias. These records were not randomly allocated and the co-screener worked through these in order of appearance. Guidance recommends that multiple screeners screen all records for inclusion however this was not possible within the time and budget constraints of this thesis project. To ensure consistent decision making between screeners, an algorithm was created to show the hierarchy of inclusion and exclusion criteria and therefore support documentation of exclusion reasons (Appendix B). Rayyan software (Version 1.6.1) was used with the blind function enabled in the first instance to allow screening to take place simultaneously. After screening was completed, the blind function was disabled and discrepancies between screeners were resolved through discussion and consensus. Also, studies which discussed the theoretical basis of HT were tagged in the screening software for later development of the logic model. Lastly, where records were not written in English and an English version could not be found, Google translate was used to translate them.

Data Extraction

Data were extracted from records that met inclusion criteria, and stored in an Excel spreadsheet, grouped by quantitative (Appendix C), qualitative (Appendix D) and case series (Appendix E). These extraction spreadsheets were trialled jointly on three records with the co-screener (S.L) and adapted following this. Furthermore, changes were made to the spreadsheet to reflect the data in included studies as necessary. Records were stored in an EndNote library and grouped by include/exclude status and the database they were obtained from. Where data was missing from included studies, the authors were contacted to request this. Also, some records mentioned planned follow up studies and authors were contacted via email to establish if these had been conducted and published.

A variety of data was extracted from included studies, based on the outcomes recorded by authors and whether they adopted quantitative, qualitative or mixed method designs. Firstly, for all study types the following information was extracted regarding authors, title, year, language and country of origin. Secondly, the study design and research hypotheses/aims were extracted. Thirdly, information about participants including gender identity; age; diagnoses; time since injury; and Socio-Economic Status (SES) proxies. Fourthly, information about the activities included in the HT programme; duration; frequency; facilitators; and the same data for the control group. Fifthly, the outcome measures used; scores on pre and post measures with means and standard deviations; and the timing of outcome measurements. Sixthly, the type of statistical analysis used, *p* values and effect sizes were extracted. Lastly, the main findings, conclusions and strengths/limitations. In qualitative studies, the methodology; epistemological position; type of analysis; themes/concepts and sub-themes; and conclusions were additionally extracted.

Quality Appraisal

The methodological quality of included studies was appraised to ensure conclusions are made in the context of methodological rigour, and in line with JBI guidance on conducting systematic reviews (JBI, 2021). This review used the Mixed Methods Appraisal Tool (MMAT) (Hong et al., 2018) (Appendix F) which has been used in other recent mixed method systematic reviews (Morrison et al., 2022; Jackman et al., 2020). The MMAT is specifically designed for quality appraisal in mixed methods systematic reviews where study designs are typically highly heterogeneous. This tool is designed to appraise quality of quantitative, qualitative and mixed methods studies. The MMAT was used to assess whether the included studies used appropriate designs to answer their stated research questions, if conclusions drawn from the data were consistent and if authors adequately considered potential sources of bias. Compared to other quality appraisal tools, the MMAT does not recommend calculation of an overall quality score, but some authors have suggested use of high, moderate and low-quality descriptors (Rodriguez-Abad et al., 2021) which describes studies that meet 75-100%, 50-75% and less than 50% of criteria, respectively. These descriptors were used in this review to aid in overall synthesis of the quality of data. As with the screening and

extraction, 33% of included studies were appraised by co-screener (S.L) and discrepancies were resolved through consensus. Records for quality appraisal by the co-screener were not randomly allocated and completed in order of appearance in Rayyan. Where consensus could not be reached between screeners, decisions were made through discussion with the wider research supervision team.

Epistemological Position

The updated guidance for qualitative systematic reviews (JBI, 2025) includes recommendations for researchers to critically reflect on their own reflexivity when engaging with the literature. This includes consideration of the author's epistemological positioning, or the lens through which they engage with the qualitative literature. This section will outline my epistemological position and how it influenced my engagement with the data. A constructivist approach was considered for this project, which is concerned with individuals' subjective construction of reality (Lee, 2012). However, a pragmatist approach was ultimately adopted which suggests a focus on practical understanding of issues as opposed to the nature of objectivity and truth in other epistemologies (Kelly & Coredeiro, 2020). To achieve these aims, pragmatism does not specify a particular methodological approach but instead suggests the use of those most appropriate for answering the research questions. This approach is increasingly used in social sciences and lends itself to research which aims to answer specific questions, such as those proposed in this systematic review (Onwuegbuzie & Leech, 2005).

This pragmatist lens influenced my engagement with the qualitative literature as the process required me to identify concrete experiences of participants in HT programmes. During the initial clustering exercise, I separated the results of the qualitative papers into components, mechanisms and outcomes. I relied on participant's experiences representing a concrete truth in these instances to ensure that my synthesis stayed as true as possible to the original findings. I leaned towards a deductive analytic approach which emphasises previous research and theory. I used these to create the theoretical framework for the logic model. Also, considering the insider/outsider orientation of qualitative engagement (Ramanadhan et al., 2021), which highlights the value placed on participant/researcher contributions, I sat in the

middle of this. During the development of the logic model, I prioritised the contributions of participants to cluster findings into components, mechanisms and outcomes. However, to map these onto the theoretical framework, I used work created by academics and researchers in the theoretical groupings.

Deviations from Protocol

As highlighted, I initially planned to use a convergent segregated design where syntheses of the qualitative and quantitative data would be conducted independently before integration of findings. However, literature searching revealed a lack of RCTs investigating HT in ABI which would have limited the conclusions regarding effectiveness if the convergent sequential approach was used. I arranged a consultation session with an expert in review methods based at the University of Leeds to review the available options for synthesis. Instead, it was deemed more useful to establish the theoretical basis of HT in ABI and this lent itself better to a sequential exploratory s approach and the development of an overall logic model. This approach to synthesis was also informed by attendance at a three-day mixed method systematic review workshop hosted by the University of Leeds in March 2024.

The synthesis was based on the protocol outlined in Murray et al.'s Campbell sytematic review (2019). The authors in this study investigated another complex intervention in care farming but differed from the present systematic review in that they investigated care farming across different populations. The authors used a clustering exercise and logic models to establish links between intervention components, mechanisms of change and outcomes of interest and I also adopted this for the present review.

Synthesis

Synthesis occurred across four stages:

Stage One – Identifying a Theoretical Framework

The included studies which had been tagged from the screening process as discussing the theoretical basis of HT and those identified from the theoretical screening stage were investigated. Theories were extracted from these studies and

stored in an Excel spreadsheet that outlined the authors, title, years, name of the theory and a summary of the key concepts. Theories were then grouped by similarit of the key concepts and an overall category name was created.

Stage two – Identifying Components, Mechanisms and Proximal Outcomes

Themes, sub-themes and direct quotations from the included qualitative studies were extracted and placed into a separate Excel spreadsheet. Where they represented multiple findings, themes were deconstructed into constituent parts. Following this, the components, mechanisms and proximal outcomes were identified from the list of themes. These terms are defined by the complex intervention research framework (Moore et al., 2015) as follows:

- Intervention component: Facilities, activites and structure provided by the HT programme.
- Mechanism: The process through which a component might contribute to changes in an outcome of interest. Mechanisms often represented experiences of participants relating to a particular aspect of the intervention.
- Proximal outcome: An outcome directly linked to a mechanism highlighted in the findings and differing from the overall primary outcomes.
- Primary outcomes: Overall health and wellbeing outcomes informed by theoretical literature around expected changes following a programme of HT.

For example a component of the intervention (i.e, sowing seeds); effects change through a mechanism (i.e. challenging self-perceptions of abilities) and leads to an outcome (i.e. reduced stress). To examine the data in this way, each theme had to be separated and categorised as either a component, mechanism or outcome.

Stage Three – Clustering Exercise and Logic Model

To identify similarities and groupings across the deconstructed themes, a clustering exercise was used (Backoff & Nutt, 1988). This began with checking the categorisation of findings into components, mechanisms and outcomes. Each component, mechanism and outcome were written on a post-it note and, beginning with mechanisms, placed onto the floor (Appendix G). The post-it notes were grouped by similarity and these groupings were changed as further findings were placed. After all post-it notes were placed and grouped into categories, these were

named based on theoretical similarity. A similar process was then undertaken for the intervention components and outcomes. Finally, the groups of components, mechanisms and outcomes were mapped onto the theroetical concepts identified in stage one. This formed the basis of the logic model which was created using Microsoft Powerpoint to represent the overall clusterings in a visual format. To ensure quality, groupings were discussed in supervision sessions with thesis supervisors. This aimed to ensure that groupings remained true to the original findings and were mapped appropriately to the theoretical concepts.

Stage Four – Quantitative Testing

Finally, the extracted quantitative findings were mapped onto the outcomes. The results from the included quantitative studies were compared against the proximal and primary outcomes to assess if they represented a positive or negative finding. Where studies reported positive, negative or no effects for a specific outcome this was visually recorded on the overall logic model. Methodological heterogeneity and inconsistent reporting of data prevented grouping of data across outcomes.

This methodology outlined above was designed to answer the three research questions proposed by this systematic review:

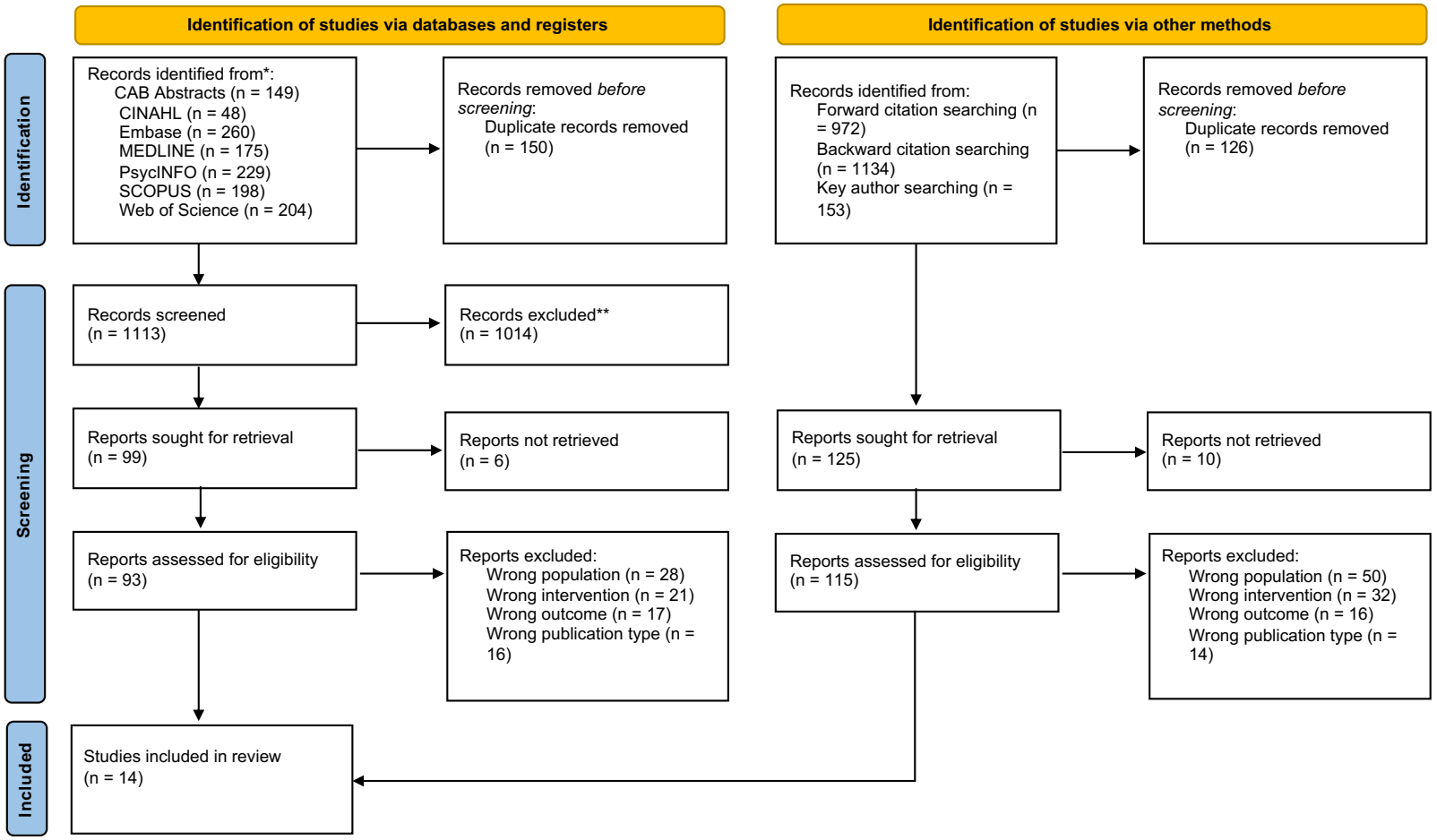
1) In the ABI population, does the literature suggest HT is an effective intervention for:
    - reducing psychological distress
    - improving quality of life
    - improving cognition
2) What are participants with ABIs experience of engaging in HT?
3) In the ABI population, what are the theoretical underpinnings for HT and what are the mechanisms of change in the outcomes of interest?

Results

Search Results

Searches were ran between April 2024 and January 2025 across the seven databases (CAB Abstracts, PsycINFO, Medline, Embase, Web of Science, CINAHL and SCOPUS). The searches identified 3522 records and 3498 were screened for inclusion following deduplication. 208 records were screened at the full text stage and 14 records were included in the final synthesis. This process is summarised in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) guidance (Page et al., 2021) in Figure 1. The searches were also run in Apil 2025 to check for any recent studies eligible for inclusion, but none were identified.

Figure 1.
PRISMA Flow Diagram.



Characteristics of Included Studies

Of the nine included quantitative studies (Table 2), five were conducted in South Korea, two in Japan, one in Sweden and one in the United States of America. Data from the quantitative studies relate to the first research question regarding the effectiveness of HT in the outcomes of interest. The most common study design was quasi-experimental with a non -equivalent control group which was used in four studies. Three used a case series design, one a controlled before and after design and one RCT. Regarding details of the control condition in non-case series studies, four studies reported these whilst two did not. Across all studies, participants had a stroke with only one study including TBI and other ABIs. Stroke aetiology was reported in four studies with two studies providing information about the side of hemiplegia. The total sample size across all included quantitative studies was 266 with the lowest being three in a case series study and the highest, 101 in the RCT. Gender identity was reported by all studies with a pooled sample of 120 females and 142 males representing percentages of 45% female and 55% male.

Table 2.

Characteristics of Quantitative Studies.

Authors/Year	Country	Study Design	Control Condition	ABI Details (n)	Sample Size (n)	Gender Identity (n)	Sample Age years (mean /SD/range)	Outcomes of Interest (Measures)
Kim et al. (2010)	South Korea	Quasi-Experimental with Non-equivalent Control Group	TAU (Occupational therapy)	Stroke (*NR*)	40	Female (14); Male (26)	*NR*/*NR*/40-95	Depression (Geriatric Depression Scale)
Kim et al. (2014)	South Korea	Quasi-Experimental with Non-Equivalent Control Group	TAU (Occupational therapy)	Stroke (Left Hemiplegia =10; Right Hemiplegia =14)	30	Female (12); Male (18)	60/*NR*/40-80	QoL (Stroke Quality of Life Scale)
Lee et al. (2018)	South Korea	Quasi-Experimental with	*NR*	Haemorrhagic Stroke (18); Ischaemic	31	Female (15); Male (16)	53.4 ± 12.6/*NR*	Depression (Korean version of short form of Geriatric Depression

		Non-equivalent Control Group		Stroke (12); TBI (1)				Scales); Rehabilitation Motivation (Self-Developed); Rehabilitation Stress (Rehabilitation Stress Survey)
Mizuno-Matsumoto et al. (2008)	Japan	Case Series	*NR*	Ischaemic Stroke (3), Haemorrhagic Stroke (2)	5	Female (2); Male (3)	60.2 ± 11.2/42-75	Depression (Self-Rating Depression Scale)
Mochizuki-Kawai et al. (2018)	Japan	Controlled Before and After	TAU (Normal activities at daycare facility)	TBI (14); Stroke (8); Other – Herpes Encephalitis, Multiple Sclerosis (5)	27	Female (4); Male (23)	Control (40.6 ± 12.3/*NR*); Experimental (43.8 ± 10.4/*NR*)	Cognition (Rey-Osterreith Complex Figure recall; Digit Span, Block Tapping); Apathy (Apathy Scale – Japanese Version)

Pálsdóttir et al. (2020)	Sweden	Single-blinded two-armed RCT	TAU (Individualised stroke rehabilitation approach)	Ischaemic Stroke (88), Haemorrhagic Stroke (11)	101	Female (60); Male (41)	67/*NR*/47-80	Depression (Hospital Anxiety and Depression scale); Anxiety (Hospital and Anxiety Depression scale); QoL (Euro-QoL-5 Dimension Questionnaire); Fatigue (Mental Fatigue Scale)
Park et al. (2015)	South Korea	Quasi-Experimental with Non-equivalent Control Group	*NR*	Stroke (Left Hemiplegia = 12, Right Hemiplegia = 6, Quadriplegia = 8))	26	Female (16); Male (10)	Control (65.4 ± 9.8/*NR*); Experimental (66.0 ±8.9/*NR*)	Depression (Geriatric Depression Scale)
Park et al. (2015)	United States of America	Case Series	*NR*	Stroke (3)	3	Female (0); Male (3)	66.3 ±12.8/54-84	Depression (Beck Depression Inventory); Self Esteem

								(Rosenberger Self Esteem Scale)
Shin et al. (2016)	South Korea	Case Series	*NR*	Ischaemic Stroke (2), Haemorrhagic Stroke (1)	3	Female (1); Male (2)	48 ± 9.4/35-52	Depression (Geriatric Depression Scale Short Form-Korean Version); QoL (Korean Version of World Health Organisation Quality of Life Scale); Cognition (Koren version Mini Mental State Examination)

Note: NR=Not Reported, indicates where the relevant information is not provided in the paper or is not applicable.

Five qualitative studies (Table 3) were included in this review and three were conducted in Europe (Norway, Sweden and Italy), one in the united Sates of America and one in Japan. Data from the qualitative studies related to the second and third research questions, specifically participant experiences of HT and the theoretical underpinnings and mechanisms of change. The largest sample in a single study was 27 and the lowest 13. The total sample of participants across the five studies is 95, which includes 35 members of staff. Similar to the quantitative studies, all participants had a diagnosis of stroke with two studies including TBI, two studies including Multiple Sclerosis and one study including participants with herpes encephalitis and brain tumour. Regarding methodology, interviews were used most regularly in three studies. One study conducted no analysis and reported participant feedback about the HT programme. Gender identity was not reported in two studies and the overall pooled sample comprises 15 females and 19 males which represents 44% and 56% of the sample respectively.

Table 3.

Characteristics of Qualitative Studies.

Authors/Year	Country	Methodology/Design/ Analysis	Participant Details	ABI Details (n)	Gender Identity	Sample Size (n)	Sample Age years (mean /SD/range)
Barello et al. (2016)	Italy	Semi-Structured Interviews and Diary Transcripts/Thematic Analysis	Service Users	Ischaemic Stroke (14); Haemorrhagic Stroke (8)	*NR*	22	*NR*/*NR*/60-88
Jonasson et al. (2007)	Sweden	Phenomenography/Semi-structured interviews	Service Users	Stroke (10), Multiple Sclerosis (3); Brain Tumour (1)	*NR*	14	*NR*/*NR*//38-81
Noda et al. (2022)	Japan	Questionnaires, Interviews and Observations/Text mining and Interpretive Structural Modelling	Service Users and Administrators of Hospitals	Stroke (6); TBI (5)	Female (0); Male (11)	Administrators (8); Participants (11)	Stroke (47/*NR*/36-60), TBI (23/*NR*/19-27)
Patil et al. (2019)	Norway	Clinical Notes/Qualitative Descriptive/Thematic Analysis	Staff Facilitators (Occupational Therapists)	TBI (14); Stroke (8); Other – Herpes	Staff:(Female =4; Male = 0)/*NR*	27	*NR*/*NR*/40-60

				Encephalitis, Multiple Sclerosis (5)			
Sarno & Chambers (1997)	United States of America	Observational/Participant Feedback	Service Users	Stroke	Female (11); Male (8)	13	*NR*/*NR*/40-90

Note: NR=Not Reported, indicates where the relevant information is not provided in the paper or does not apply.

Quality Appraisal

Generally, studies met the MMAT criteria however one study did not meet the criteria for the initial screening questions as no clear research questions were stated. Ratings for each relevant criterion in the MMAT for each included study can be seen below in Table 4, where they are arranged in order of study type. Therefore, it was unclear if collected data allowed answering of research questions, and further appraisal was not performed in this case (Sarno & Chambers, 1997). Across the sample of included studies, 71% met at least 75% of the MMAT criteria and were therefore classified as high quality (n=10) (Barello et al., 2016; Jonasson et al., 2007; Kim et al., 2010; Kim et al., 2014; Lee et al., 2018; Mizuno-Matsumoto et al., 2006; Mochizuki-Kawaii et al., 2018; Pálsdóttir et al., 2020; Park et al., 2015; Patil et al., 2009). 14% were classed as moderate quality (n=2) (Noda et al., 2022; Park et al., 2015) and 14% were classified as low quality (n=2) (Sarno & Chambers, 1997; Shin et al., 2016). Within the quantitative non-randomised studies, the most commonly unmet criterion was ‘Are the confounders accounted for in the design and analysis?” which was not met in three studies. For qualitative studies, one study did not meet criterion for “Is the qualitative approach appropriate to answer the question?” and “Is there coherence between qualitative data sources, collection, analysis, and interpretation?” (Noda et al., 2022).

Table 4.

Scoring for each Included Study on Relevant MMAT Criteria.

Authors/ Year	Mixed Method Appraisal Tool Criteria																				
	S1	S2	1.1	1.2	1.3	1.4	1.5	2.1	2.2	2.3	2.4	2.5	3.1	3.2	3.3	3.4	3.5	4.1	4.2	4.3	4.4	4.5
Barello et al. (2016)	✓	✓	✓	✓	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Jonasson et al. (2007)	✓	✓	✓	✓	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Noda et al. (2022)	✓	✓	✓	✓	X	✓	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Patil et al. (2019)	✓	✓	✓	✓	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Sarno & Chambers (1997)	X	X	X	X	X	X	X	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA

Pálsdóttir et al. (2020)	✓	✓	NA	NA	NA	NA	NA	✓	✓	✓	✓	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA
Kim et al. (2010)	✓	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	✓	✓	✓	✓	✓	NA	NA	NA	NA	NA
Kim et al. (2014)	✓	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	✓	✓	✓	X	✓	NA	NA	NA	NA	NA
Lee et al. (2018)	✓	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	✓	✓	✓	X	✓	NA	NA	NA	NA	NA
Mochizuki-Kawai et al. (2018)	✓	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	✓	✓	✓	X	✓	NA	NA	NA	NA	NA
Park et al. (2015)	✓	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	✓	✓	✓	✓	✓	NA	NA	NA	NA	NA
Mizuno-Matsumoto et al. (2008)	✓	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	X	✓	✓	✓	✓

Park et al. (2015)	✓	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	✓	X	✓	✓	X
Shin et al. (2016)	?	✓	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	NA	?	✓	✓	?	X

Note: NA= Not Applicable, indicates where MMAT criteria do not apply due to study type or methodology; ✓ = Criterion met; X = Criterion not met; ? = Cannot tell from provided information.

Screening Question 1 (S1) = Are there clear research questions?

Screening Question 2 (S2) = Do the collected data allow to address the research question?

1.1 = Is the qualitative approach appropriate to answer the research question?

1.2 = Are the qualitative data collection methods adequate to address the research question?

1.3 = Are the findings adequately derived from the data?

1.4 = Is the interpretation of results sufficiently substantiated by data?

1.5 = Is there coherence between qualitative data sources, collection, analysis and interpretation?

2.1 = Is randomization appropriately performed?

2.2 = Are the groups comparable at baseline?

2.3 = Are there complete outcome data?

2.4 = Are outcome assessors blinded to the intervention provided?

2.5 = Did the participants adhere to the intervention provided?

3.1 = Are the participants representative of the target population?

3.2 = Are measurements appropriate regarding both the outcome and intervention (or exposure)?

3.3 = Are there complete outcome data?

3.4 = Are the confounders accounted for in the design and analysis?

3.5 = During the study period, is the intervention administered (or exposure occurred) as intended?

4.1 = Is the sampling strategy relevant to address the research question?

5.2 = Is the sample representative of the target population?

5.3 = Are the measurements appropriate?

5.4 = Is the risk of nonresponse bias low?

5.5 = Is the statistical analysis appropriate to answer the research question

HT Programme Details

The details of the HT programmes used in included studies are summarised below in Table 5. Due to the heterogeneous nature of HT, there is much variety in the horticultural activities, number of sessions and duration of programmes. The most common activities included planting herbs or seeds in eight studies (Barello et al., 2016; Jonasson et al., 2007; Kim et al., 2010; Lee et al., 2018; Mizuno-Matsumoto et al., 2008; Park et al., 2015; Park et al., 2015; Sarno & Chambers, 1997) with the least common being hydroculture which was referenced in one study (Kim et al., 2014). The number of sessions in the HT programme was highly variable, ranging from 1-20 and similarly with the duration of each session ranging from 30-210 minutes. Four studies did not provide information about the number of sessions, three did not provide information about the length of each session and four provided no information about how often sessions occurred. Facilitators of the HT programme were most commonly Horticultural Therapists as cited in six studies however five studies did not provide this information. Finally, the setting of the HT programme was split evenly with three studies using indoor, outdoor and mixed settings respectively. Four studies did not report on the setting, however. Two studies report very similar HT programmes although there is no reference to a standardised protocol that they both use (Barello et al., 2016; Jonasson et al., 2007).

Table 5.

HT Intervention Details from Included Studies.

Authors/Year	Horticultural Activities	Programme Length (no. of sessions)	Session Length (mins)	Frequency	Facilitators	Indoors/ Outdoors
Barello et al. (2016)	Planting herbs on an adapted cultivation table, sowing beetroot seeds on a cultivation bench, transferring plants and onions from indoors to the garden, loosening soil in a flower bed, digging around an apple tree, harvesting tomatoes, collecting seeds, flower arranging for the lunch table, shaping bushes, and pruning trees.	10	45	5x weekly	Specialized Therapist	Outdoors
Jonasson et al. (2007)	Planting herbs on an adapted cultivation table, sowing beetroot seeds on a cultivation bench, transferring plants and onions from indoors to the garden, loosening soil in a flower bed, digging around	*NR*	30	*NR*	*NR*	Indoors and Outdoors

	an apple tree, harvesting tomatoes, collecting seeds, flower arranging for the lunch table, shaping bushes, planting onions and harvesting tomatoes.					
Kim et al. (2010)	Four phases - Motivation (the plant and its contacts), adaptation (Motion characteristic induction), sociality (expression of thoughts of oneself) and interpersonal relationships/communication (personal relationships). Water culture, using arrowhead vine, flower arrangement, making flower basket using milk pack, making calendars with plant leaves, sowing sprout vegetable seeds, planting seedlings, making pressed flower cards.	*NR*	*NR*	*NR*	*NR*	Indoors
Kim et al. (2014)	Hydroculture, flower arrangement in a cup, making art flower basket using milk pack, pressed flower basket making, making hydroculture, culture bottles, making herb soap, making topiaries, making dish gardens, making flower candy baskets.	12	30	1x weekly	*NR*	*NR*
Lee et al. (2018)	Planting plants, hydroponics, sowing seeds and stick cutting, garden design and making garden plots, making	18	60	3x weekly	Horticultural Therapist, 14	Indoors

	flower garden beds, making herb garden beds, planting transplants, digging and raking.				Horticultural Therapy assistants	
Mizuno-Matsumoto et al. (2008)	Weeding, readying soil, creating planting plan for flowerbeds, seedling selection, cultivating, terrarium making, planting flowerbeds, watering, crafts using moss, planting vegetables, making container gardens, making pressed flowers.	20	*NR*	4x weekly	Horticultural Therapist	*NR*
Mochizuki-Kawai et al. (2018)	Two floral arrangement patterns designed of differing difficulty, easier pattern on first day of each phase and more complex pattern on latter 2 days. Participants made same designed pattern twice within each session. Initially followed instruction provided by facilitator and prompt sheet. Second half instructed to follow sheet only with no assistance.	6	30-40	3x weekly	Neuropsychologist, Occupational Therapist or Psychiatrist	*NR*
Noda et al. (2022)	Growing plants, using tools, cultivating, harvesting, cooking.	*NR*	120	*NR*	*NR*	Outdoors
Pálsdóttir et al. (2020)	Garden utilised for multi-sensory stimulation for physical, emotional and cognitive stimulation. Morning gathering with herbal cup of tea, physical activities,	20	210	2x weekly	OT, horticulturalist, psychotherapist and physiotherapist.	Indoors and outdoors

	tricycling, on the spot exercises. Garden and horticultural occupation in group or on their own. Last session opportunity for participants to reflect on their own processes.					
Park et al. (2015)	3 phases - Conceptualization, skills acquisition and rehearsal, application and follow-through. Planting plants, making a ball topiary, division, flower arrangement, planting plants, hydroponics, sowing seeds, making a grass doll.	16	40	2x weekly	Horticultural Therapist, Horticultural Therapy assistant	Indoors
Park et al. (2015)	Retrieving trays, preparing soil, filling containers with soil, removing transplants, making holes for propagation, placing transplants in holes, firming soil, putting containers on saucers, putting water in container, preparing labels, placing labels in container. Four types of propagation - transplanting seedlings, vegetative propagation-cuttings, vegetative propagation-division and seed propagation.	16	60	2x weekly	Horticultural Therapist, 3 volunteers with HT background	Indoors

Patil et al. (2019)	Propagating plants from seeds or cuttings, potting, planting, watering, composting, harvesting plant materials, preserving material for tea or decorative purposes, making food or handicraft items using materials obtained from outdoors, sowing seeds, handling plantings.	1-17	*NR*	*NR*	*NR*	Indoors and Outdoors
Sarno & Chambers (1997)	Plant propagation included activities involving various methods for growing new plants from stem cuttings, single node cuttings, division and simple repotting. Small container cactus gardens made by mixing the proper soil components, choosing the individual plants for the garden, transplanting the small cactus and succulents, and finishing the project with sand and rocks. Fresh flower arranging. A kitchen gardening session included looking at many diverse plants grown from seeds and pits (date palm, grapefruit, coffee, macadamia plant, coconut palm) and selecting one to propagate. The	*NR*	60	7x weekly	Horticultural Therapist	Outdoors

	fruits were all cut, shared, and eaten before propagation. The projects were all brought home to grow.					
Shin et al. (2016)	Herb gardening, seed cultivation, tree making, hydroponic tree making, topiary making, flowerpot making, framing plants, natural humidifier making, natural hand sanitizer making, flower cake making.	10	60	5x weekly	Horticultural Therapist	*NR*

Note: NR=Not Reported, indicates where the relevant information is not provided in the paper or does not apply.

Theories

14 theories were identified through either the included studies or additional theoretical literature searching and were used to contribute to the third research question relating to the theoretical underpinnings of HT. These theories and, where applicable, included papers that cited them are summarised below in Table 6. Across the included papers, the majority of theories were cited only once but the stress recovery theory was cited twice. These theories provide explanations for how HT brings about positive change across a number of outcomes and formed the basis for development of the logic model.

Table 6.

Theories and Theoretical Concepts.

Theory/References	Summary of Theory
Attention Restoration Theory (Kaplan, 1973) *Patil et al. (2019)*	Natural environments restore depleted attentional resources and that this restoration is an evolved, adaptive function. Differentiates between directed and involuntary attention, suggesting the former is a finite resource which requires effort to attend to stimuli. The theory proposes that natural environments offer "soft" fascination to individuals, and specifically the act of growing things in HT, drives attentional restoration as it captures attention involuntarily in a bottom-up manner. Restoration is proposed to alleviate anxiety and improve cognitive performance across multiple domains. Four criteria suggested for restoration: 1) Scope to feel immersed; 2) Engaging in non-habitual activities; 3) Soft fascination; 4) Compatibility and desire to engage with nature.
Biophilia Hypothesis (Wilson, 1986) *Park et al. (2015)*	Humans have an innate connection with nature which is evolutionarily advantageous as it increases positive feelings. Biophilia can be separated into two distinct components. Firstly, humans harbour positive feelings towards other living things and secondly, that this affinity is driven by genetic predisposition. Biophilia is suggested to be driven by human's early reliance on the natural environment for survival.
Cognitive Stimulation Theory	Pathology following brain injury has been suggested to be worsened when there is a lack of stimulation. Use of techniques to provide stimulation has been associated with improvement in cognitive performance. Cognitive simulation is suggested to provide benefits for individuals through implicit learning, maintaining social

(Woods & Britton, 1977) *Mochizuki-Kawai et al. (2015)*	engagement and increasing cognitive resources. Three principles adopted in cognitive stimulation interventions which include generalised cognitive exercise, social interaction and a person-centred approach.
Enriched Environments (Luger et al., 1987) *Pálsdóttir et al. (2020)*	Origins in animal research where environments were made more or less stimulating and found to have positive impacts on cognition in animals. Greater enrichment linked to neurogenesis and evidence of improvements in age-related cognitive decline. Enrichment is described as greater multisensory stimulation and linked to reduced stress and improved memory performance.
Environmental Press (Lawton, 1977)	Initially sought to provide explanation for older persons adaptation to their environments. Outlines relationship between a person's abilities and environmental variables. An individual's competence is determined by physical, psychological and cognitive factors. The alignment of a person's abilities and the demands of their environment determine if a person is able to function well. The relationship changes dynamically based on the individual's ability, where decreases in function will increase the degree of environmental press.
Flow Theory (Csikszentmihalyi, 1990) *Patil et al. (2019)*	Flow is described as a state where individual's feel intrinsically motivated to engage in a task, regardless of the end outcome. The flow state is associated with increased focus, concentration the absence of self-consciousness. Flow is achieved where there is balance between the individual's perceived skill level and the difficulty of the task.

Group Work (Yalom & Crouch, 1990)	Group environments and settings can be powerful drivers of positive change. Groups provide opportunities for exploration of social dynamics in a microcosm of society through exposure to corrective experiences and development of interpersonal relationships. Group cohesiveness, shared goals and instillation of hope contribute to change in group settings.
Neuroplasticity (Konorski, 1948) *Lee et al. (2018)*	Describes the neurological reorganisation following injury to the brain. This process involves both structural changes, where neuronal connections grow or adapt through synaptic plasticity, and functional changes, where other areas of the brain perform functions previously managed by the damaged brain area. These processes are suggested to be experience dependent with repeated exposure leading to increased plasticity.
Salutogenic theory (Antonovsky, 1979)	An individual's ability to cope with distress or ill health is determined by their Sense of Coherence (SOC). SOC refers to an individual's orientation or outlook, and a high SOC means that challenges are perceived as comprehensible, manageable and meaningful. A high SOC also means the individual has confidence in using their available resources to manage challenges This effective use of resources determines movement on a health ease/dis-ease continuum.
Self-Efficacy Theory (Bandura, 1977)	Theory of behaviour change that outlines conditions under which new learning occurs. Four mechanisms through which self-efficacy achieved, cognitive, motivational, selection and affective. These processes determine the extent to which an individual believes they are able to complete a task, and this contributes to successful completion. Repeated successful task performance leads to increased ambition and feelings of mastery of tasks.

Social Cognition Theory (Bandura, 1986)	Individuals learn by observing and interacting with others which determines their ability to solve problems and navigate life as a social being. Three key processes include 1) Affect recognition – The ability to recognise affect in others 2) Mentalisation – The ability to understand others, and the individuals, feelings and the relationship between them. 3) Emotional Regulation – The ability to control one's own emotions in a manner appropriate for a social context.
Social Ecological Model (Bronfenbrenner, 1977)	Outlines five ecological levels which determine development and growth. 1) Chronosystem – Historical events and influences in wider society. 2) Macrosystem – Cultural level beliefs and attitudes 3) Exosystem – Social environments that are removed from the individual but still affect them 4) Mesosystem – Relationships between microsystems in an individual's life 5) Microsystem – Immediate and crucial social/familial relationships. Understanding of these factors that impact individuals can build awareness of barriers and facilitators in rehabilitation, for a specific individual.
Social Support Theory (Cobb, 1976)	Feeling socially supported is described as a perception that an individual is cared for, receives support from their social interactions and can access support from others. Support is provided across four areas: 1) Informational – Others provide information during difficult periods 2) Emotional – Receiving empathy from others 3) Appraisal – Positive feedback provided by others but relating to the individual's self-perception 4) Instrumental -Practical support provided to the individual.
Stress Recovery Theory (Ulrich,	Suggests beneficial biopsychological responses occur when humans have contact with nature. These responses are proposed as an innate preference for interaction with the natural environment causing a decrease in stress responses. Beneficial responses to nature are said to occur immediately and beneath the level of conscious

1983; Ulrich et al., 1991) *Mizuno-Matsumoto et al. (2008); Jonasson et al. (2007)*	awareness. Being present in a safe natural environment which holds complex perceptual cues can alleviate feelings of stress or anxiety, if an individual was experiencing these before entering nature. This reduction of stress is suggested to be evolutionarily adaptive as studies have demonstrated reduced immune function, increased prevalence of mental health problems and lower cognitive functioning in the presence of chronic stress.

Primary Outcomes

A summary of outcomes can be seen below in Table 7. The primary outcomes relate to the first research question regarding the effectiveness of HT. Effect sizes were calculated using the Campbell Collaboration Practical Meta Analysis Effect Size Calculator (Wilson, 2023). Where possible, the means, standard deviations and sample size were used with pretest scores to calculate an overall effect size (Cohens *d*). Effect sizes were also adjusted for directionality to account for reductions or increases representing positive change in different outcome measures. For example, if decreases on scores of a measure of depression represented positive change, or reduction of symptoms, a negative effect size was recorded as positive. Cohen's *d* is commonly interpreted by three qualitative descriptors where 0.2 represents small effects, 0.5 medium/moderate and 0.8 large effects (Lakens, 2013).

Meta-analysis to calculate an overall effect of HT on outcomes of interest was not possible in this instance due to the heterogeneity of included papers. Meta-analysis was also not possible due to the number of studies that did not report sufficient information for calculation of effect sizes, or where authors did not respond to requests for additional information. Specifically, only four studies provided sufficient data to calculate effect sizes (Kim et al., 2010; Park et al., 2015; Lee et al., 2018; Kim et al., 2018). Large effect sizes were recorded for three studies investigating depression (Kim et al., 2010; Park et al., 2015; Lee et al., 2018) and a small effect size for the study investigating QoL (Kim et al., 2018).

One study investigating cognition (Mochizuki-Kawai et al., 2018) presented their results for the Rey-Osterreith complex figure task in graphical format and therefore it was not possible to accurately extract this data. The authors also did not specify if values in a results table were standard deviations meaning effect sizes could not be calculated.

Regarding QoL, two studies used the Functional Independence Measure (Kim et al., 2010; Mizuno-Matsumoto et al., 2008) and one used the Stroke Impact Scale (Park et al., 2015) but are not reported here. This is due to the definition of QoL

adopted in the inclusion and exclusion criteria although there is considerable overlap with traditional QoL measures which will be further explored in the discussion section.

Table 7.
Primary Outcomes from Quantitative Studies.

Authors/Year	Outcome Measure	Pre-Intervention Mean/PP score (SD)	Post-Intervention Mean/PP score (SD)	First Follow-Up Mean (SD)	Second Follow-Up Mean (SD)	Author Conclusions	Magnitude of Effect & 95% Confidence Intervals (Cohens *d*)
			Depression				
Kim et al. (2010)	Geriatric Depression Scale	HT: 11.6(1.5) Control: 16.9(1.7)	HT: 6.0(0.8) Control: 15.1(1.6)	*NR*	*NR*	Significant reduction in depression in both control and HT group.	*d* = 2.37 [1.52 – 3.21]
Pálsdóttir et al. (2020)	Hospital Anxiety and Depression Scale	HT: 5.37(*NR*) Control: 5.86(*NR*)	*NR* *NR*	HT: 4.33(*NR*) Control: 4.68(*NR*)	HT: 4.74(*NR*) Control: 4.9(*NR*)	Significant improvement in both groups at follow-up one, significant	*NR*

						improvement in control group at second follow-up.	
Park et al. (2015)	Geriatric Depression Scale	HT: 18.8(1.9) Control: 22.8(3.8)	HT: 9.9(4.8) Control: 20.9(5.9)	*NR*	*NR*	Significant reduction in depression in HT group only.	d = 2.33 [1.26 – 3.39]
Park et al. (2015)	Beck Depression Inventory	PP 1: 6 PP 2: 19 PP 3: 22	PP 1: 6 PP 2: 5 PP 3: 9	*NR*	*NR*	Symptoms of depression decreased from moderate to mild in two participants.	*NR*
Lee et al. (2018)	Korean version of short form of Geriatric Depression Scale	HT: 7(4.5) Control: 6.5(3.3)	HT: 4.6(3.7) Control: 7.4(3.4)	*NR*	*NR*	Significant improvement in depression scores in HT group only.	d = .85, [.08-1.62]
Mizuno-Matsumoto et al. (2018)	Self-Rating Depression Scale	PP 1: 39 PP 2: 57 PP 3: 38	PP 1: 37 PP 2: 61 PP 3: 32	*NR*	*NR*	No significant effect across participants.	*NR*

		PP 4: 47 PP 5: 36	PP 4: 45 PP 5: 44				
Shin et al. (2016)	Korean version of short form of Geriatric Depression Scale	PP 1: 12 PP 2: *NR* PP 3: 12	PP 1: 13 PP 2: *NR* PP 3: 10	*NR*	*NR*	No significant effect across participants.	*NR*
				Anxiety			
Pálsdóttir et al. (2020)	Hospital Anxiety and Depression Scale	HT: 7.63(*NR*) Control: 7.94(*NR*)	*NR*	HT: 6.27(*NR*) Control: 7.39(*NR*)	HT: 6.30(*NR*) Control: 7.20(*NR*)	Significant improvement in HT group a first follow-up, significant improvement in control group at second follow-up.	*NR*

				Quality of Life			
Pálsdóttir et al. (2020)	Euro-QoL-5 Dimension Questionnaire	HT: 0.57(*NR*) Control: 0.56(*NR*)	*NR*	HT: 0.60(*NR*) Control:0.61(*NR*)	HT: 0.61(*NR*) Control: 0.60(*NR*)	No significant change across both HT and control group.	*NR*
Kim et al. (2014)	Stroke Specific Quality of Life Scale	HT: 151.4(36.5) Control: 124.9(31.2)	HT: 164.2(36.2) Control: 131.9(29.8)	*NR*	*NR*	Significant improvement across both HT and control groups.	d = 0.16 [-0.58 – 0.91]
Shin et al. (2016)	Korean Version of World Health Organisation Quality of Life Scale	PP 1: 68 PP 2: *NR* PP 3: 91	PP 1: 71 PP 2: *NR* PP 3: 102	*NR*	*NR*	Significant improvement in both reported participants.	*NR*

			Cognition				
Mochizuki-Kawai et al. (2018)	Digit Span Forwards	PR1 HT: 5.0(1.7) PR1 Control: 5.3(1.5) PR2 HT: 5.6(1.7) PR2 Control: 5.0(1.9)	HT: 5.3(1.4) Control: 4.8(1.8)	*NR*	PO HT: 5.6(1.7) Control: 5.0(1.9)	*NR*	*NR*
	Digit Span Backwards	PR1 HT: 3.2(1.3) PR1 Control: 2.8(1.3) PR2 HT: 3.9(1.4) PR2 Control:	HT: 3.5(1.7) Control: 3.0(1.7)	*NR*	HT: 3.8(1.7) Control: 3.1(1.7)	*NR*	*NR*

	3.1(1.4)					
Block Tapping Forwards	PR1 HT: 4.9(0.9) PR1 Control: 5.3(1.1) PR2 HT: 4.5(0.7) PR2 Control: 4.5(1.3)	HT: 5.2(1.3) Control: 4.5(1.8)	*NR*	HT: 4.9(1.1) Control: 4.9(1.3)	No significant improvement across groups.	*NR*
Block Tapping Backwards	PR1 HT: 4.6(1.4) PR1 Control: 4.5(1.1) PR2 HT: 4.2(0.8) PR2 Control: 4.4(0.8)	HT: 4.2(0.9) Control: 4.4(2.2)		HT: 4.7(1.2) Control: 4.4(1.1)	No significant improvement across groups.	*NR*

Shin et al. (2016)	Korean version of Mini Mental State Examination	PP 1: 30 PP 2: 0 PP 3: 29	PP 1: 30 PP 2: 0 PP 3: 29	*NR*	*NR*	No improvement across participants.	*NR*

Note: NR=Not Reported, indicates where the relevant information is not provided in the paper or does not apply; PP = Participant; PR1 = First pre intervention measurement, PR2 = Second pre intervention measurement.

Synthesis

Theories

The extent to which theories contributed to the overall synthesis of results varied across findings as some focussed on specific outcomes that may be affected by HT where others provided overarching hypotheses for how change comes about (Table 6). For example, the stress recovery theory explores how interactions with nature lead to a reduction in stress whilst self efficacy theory explores more broadly how an individual's perception of their ability determines the extent to which they can succesfully complete tasks. A number of similarities were observed in this study when compared with the paper that the protocol is based on, Murray et al. (2019). There was overlap in the identified theories which is likely driven by the nature-based design of the investigated interventions (HT and care farming). The key concepts from each theory were extracted and grouped by similarity to create four overarching theoretical categories:

- Sense of Mastery & Self Belief: Salutogenic theory, flow theory, self-efficacy theory, cognitive stimulation.
- Nature & Restoration: Biophilia hypothesis, attention restoration theory, stress reduction theory, neuroplasticity.
- Environments for Growth: Enriched environments, environmental press, social ecological model.
- Social Inclusion & Belonging: Group work, social support theory, social cognition theory.

Components

Four categories of intervention components were identified:

- Accessible Environments – This category related to a sense of inclusivity felt by participants, driven by their presence in an environemnt viewed as accessible. Findings included the importance for participants to "experience manageable tasks" and for them to feel "inclusive". Findings in this category were predominantly positive although some related to the inappropriateness of the environment such as "depending on the degree of disability the

activity is difficult" and "The flower beds are not suitable for hemiplegics or wheelchairs, so participation is difficult for those with these disabilites". These findings were both reported in the same study.

- Growing – This category described a connection that participants felt to the act of growing, and the meaning they made of this in relation to their own rehabiliation. Findings included "satisfaction in seeing things grow" and the view of growth as a "tangible representation of rehabiliation". All findings within this category were positive.
- Sensory – This category described the sensory elements of HT and included findings of "listening to the rain" and the "feel of the soil". Findings referred to the reported restorative effect of these experiences, and the invoking of previous memories before brain injury. One negative finding was reported here, where the sensory elements made the task more difficult, "rainy or hot days make it more difficult". All fndings in this category were positive in nature.
- Sharing Experiences – This category referred to the social aspects of HT and the experience of being in a group with a shared goal. Findings included "inclusive group environments", "opportunties to be a leader" and "offering and recieiving support".

Mechanisms

As highlighted in the methods section, a clustering exercise was performed to group the mechanisms by meaning and to inform the development of the logic model. Findings were clustered into 17 categories and are described below in Table 8. Specifically, in the clustering exercise the data which was used to identify mechanisms were taken from direct quotes or themes in the results sections of included qualitative papers. In the case of those studies which also included the views of staff members and their reflections of engaging in HT, the same approach was adopted. These individual findings were then mapped onto the theoretical framework and names for the gathered findings were created to represent their shared meaning. For example, findings such as 'When you have done a job like that and you look around … it looks nice and tidy … it is really satisfying to do things when the result is visible, it is the best form of rehabilitation.' (Jonasson et al., 2007) and 'walked straight to the pumpkin plants and was happy to see they had grown'

(Patil et al., 2019) formed part of the group of findings that were used to create the overall satisfaction mechanism.

Table 8.

Details of the Mechanisms Identified across Included Studies.

Category	Summary of Category
Satisfaction	Satisfaction was twofold, in that participants felt satisfied when they were engaging in the HT activities but also when they considered how far they had come.
Meeting Rehabilitation Goals	Where HT was framed as engagement in rehabilitation, participants felt rehabilitation was easier, as they were enjoying the activity they were engaging in.
Mastery in Function	Over the course of the HT programmes, participants felt they could see improvements in their function which led to increased feeling of mastery.
Visual Representation & Motivator to Engage	The visual representation of participant's engagement in HT could be seen in the things they had grown and made. This connection led to increased motivation to engage in the rehabilitation process.
Control over Activities &	The voluntary nature of engagement in the HT activities led to an increased sense of control for participants. This was contrasted with the sense of loss of control both physically and more generally, as a direct result of ABI.

Voluntary Engagement	
Meaningful	Where there was a pre-existing interest in horticultural activities, the engagement in HT was seen as a meaningful experience.
Letting Go of Difficult Thoughts	The worries associated with ABI and the difficult rehabilitation process were described as lessened across studies. Participants felt that engagement in the HT programmes provided a respite from their worries, encouraging them to be more mindful.
Evoking Pleasant Memories	The HT programme acted as a reminder for some participants of previous pleasant times engaging in horticultural activities or time spent in nature with valued people in their lives. This led to feelings of calm and increased rehabilitation motivation.
Watching Growth	The process of viewing the growth process through all of its stages was described as gratifying by participants. Seeing a plant grow from seed to something that could be harvested and interacted with also contributed to continued motivation to engage in the HT programme.
Offering Challenge	HT was seen as a challenging undertaking generally, but one that was perceived as achievable by participants. When it was felt that challenge had been given and surpassed, increased confidence was reported.
Varied Tasks	Across HT programmes, the variety of horticultural tasks was described as keeping rehabilitation interesting and promoting a sense of mastery. Also, the need to integrate multiple skills was described as contributing to this.
Informal Context	HT programmes provide an informal context that was valued by participants. The feeling of reduced pressure to engage in rehabilitation increased participant's enjoyment of the activity and reduced feelings of anxiety.

Everyday Applicability	The applicability of HT activities was compared with other rehabilitation methods, and it was felt by those with a pre-existing interest in HT that it was more relevant. However, this was not shared by all participants with some not seeing the use of engagement in HT for their everyday life.
Positive Interactions	Positive interactions were reported between group members and with the facilitators who offered the correct amount of feedback and challenge. This led to increased happiness and wellbeing.
Socially Supportive	Engagement in HT led to opportunities for sharing of stories between participants, building stronger social connections. Some experiences related to feelings of leadership where they had supported their peers through difficult horticultural activities.
Collaboration	In group settings, HT was perceived as a number of challenges that participants were navigating together as a group. Participants extrapolated this to recovery from ABI more generally, as being in it together.
Positive Feedback	Positive feedback received from facilitators and peers in the HT programme led to participants feeling valued. Feelings of satisfaction were reported in association with this.

Proximal Outcomes Suggested by Theories

The theoretical literature suggests outcomes may improve in the categories of confidence (social support theory, group work), increased self-esteem & self-efficacy (enriched environemnts, environemntal press, self-efficacy theory, flow theory, salutogenic theory), reduced fatigue (stress reduction theory, attention restoration theory) and reduced stress (stress reduction theory).

Proximal Outcomes from Qualitative Studies

From the included qualitative studies, 15 distinct proximal outcomes were identified (Table 9). It should be noted that these proximal outcomes from included qualitative studies were added to those identified from the theoretical literature to create the logic model. The outcomes varied in their specificty with some being defined as general physical and mental recovery whereas others specified imrpvoements in mood, communication, hope etc. The most commonly reported proximal outcomes were increased communicaion in two studies and increased self-efficacy in two studies.

Primary Outcomes Suggested by Theories

Improvments in cognition are suggested by the attention restoration theory, neuroplasticity, cognitive stimulation theory and enriched environments. Reduction in depression and anxiety suggested by attention restoration theory, stress reduction theory and group work. Improved QoL suggested by salutogenic theory.

Table 9.

Proximal Outcomes identified in Included Qualitative Studies.

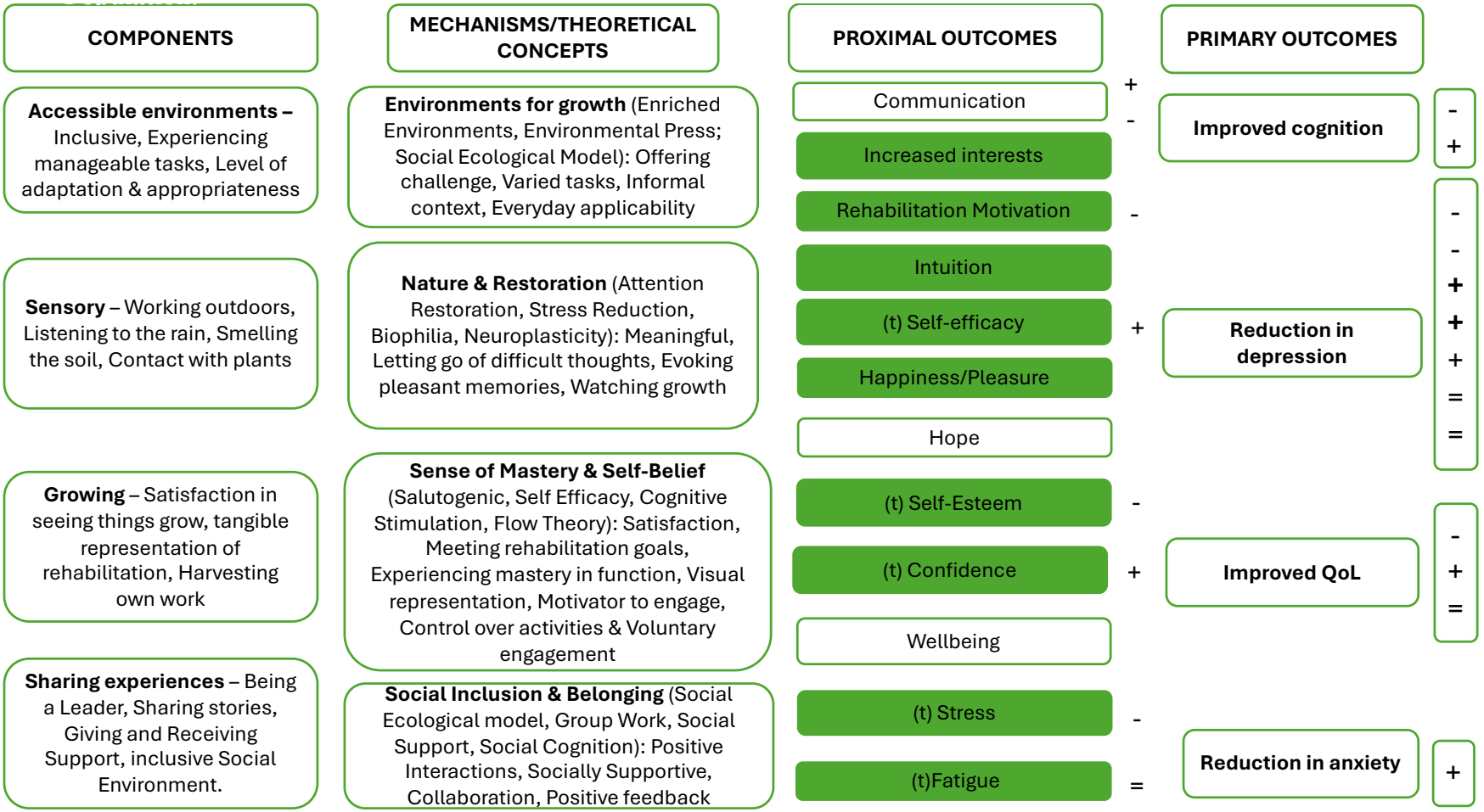
Authors/Year	Proximal Outcomes
Barello et al. (2016)	Relaxation, Improved mood, Feeling useful & empowered, Improved self-esteem, Increased self-efficacy, Increased hope
Jonasson et al. (2007)	Physical and mental recovery, Increased well-being, Increased confidence
Noda et al. (2022)	Increased self-efficacy, Increased emotional expression, Increased communication
Patil et al. (2019)	Increased relaxation, Restoration of mental resources, Increased understanding of others, Increased motivation in rehabilitation, Increased intuition
Sarno & Chambers (1997)	Increased communication, Feelings of pleasure

Logic Model

The logic model (Figure 2) was devleoped through the process outlined in the methods section. To summarise, each finding was separated into intervention components, mechanisms and outcomes. These findings were taken directly from the included qualitative papers where authors had reported direct quotes or themes from their analysis.The intervention components form the first column, highlighting the grouping of different aspects of HT identified from qualitative studies. The second column is composed of the overarching concepts identified from the grouping of core concepts from theories relevant to HT, and the mechanisms identified through the clustering exercise (Tables 6 and 8). These mechanisms were mapped onto the theoretical concepts that best fit their description. The proximal outcomes identified in both the theoretical literature (highlighted in green) and included qualitative studies are listed (Tables 6 and 9). Finally, the primary outcomes suggested by the theoretical literature are summarised in the fourth column .

Figure 2.

Logic Model summarising the Components, Mechanisms, Proximal and Primary Outcomes of HT in the ABI population.



(t): Proximal outcomes identified from theoretical literature; Green: Positive finding from included qualitative studies; +/- : Significant positive or negative findings from included quantitative studies; =: Significant improvements in both intervention and control groups.

Quantitative Testing of Logic Model

The quantitative studies were used to assess if HT had an impact on outcomes that it was predicted to, resulting from qualitative findings and the theoretical literature. The quantitative testing of the logic model relates to the first research question around HTs effectiveness in improving the outcomes of interest. Specifically, as meta-analysis was not possible to claculate an overall effect, anarrative synthesis of the quantituative studies was performed. The relevant data for each primary (Table 6) and proximal (Table 9) outcome of interest was extracted from quantitative studies. The findings were added to the logic model (Figure 2) to represent positive, negative or equivalent findings acorss intervention and control groups. Of the quantitative studies, no studies were incldued that investigated increased interest in horticulture, intuition, self-efficacy, happiness/pleasure, wellbeing or hope.

Primary Outcomes.

Depression & Anxiety. Six quantitative studies investigated depression (Lee et al., 2018; Kim et al., 2010; Pálsdóttir et al., 2020; Park et al., 2015; Mizuno-Matsumoto et al., 2008; Shin et al., 2016) and reported a positive picture regarding the efficacy of HT in reducing symptoms. Two studies reported a positive effect in reducing depression in the HT group only (Lee et al. 2018; Park et al 2015) with another two reporting significant improvements in both the experimental and control group (Kim et al. 2010; Pálsdóttir et al., 2020). The RCT reported significant improvements in both groups at the first 8 month follow-up but only in the control group at 14 month follow-up (Pálsdóttir et al., 2020). On the other hand, two studies reported no significant effect of HT on depression (Mizuno-Matsumoto et al. 2008; Shin et al., 2016). One quantitative study measured anxiety and reported a significant positive effect when compatring the experimental and control groups (Pálsdóttir et al., 2020).

QoL.. Three studies investigated QoL (Pálsdóttir et al., 2020; Park et al., 2015; Shin et al., 2016; Kim et al., 2014). All studies apart from Pálsdóttir et al.'s RCT study reported a significant positive impact of HT on measures of QoL.

Cognition. Three studies investigated cognition (Pálsdóttir et al., 2020; Mochizuki-Kawai et al., 2018; Shin et al., 2016) although one only recorded results at baseline (Pálsdóttir et al., 2020) and was therefore excluded from quantitative testing of the logic model. Mochizuki-Kawai et al. (2018) reported a positive effect and Shin et al. (2016) reported no significant efffect.

Proximal Outcomes.

A summary of the proximal outcome data can be seen below in Table 10 and these findings related to the second research question regarding participant experiences of HT.

Rehabilitation Motivation. One study investigated the impact of HT on rehabilitation motivation (Lee et al., 2018) using a self-developed measure but reported no significant effect.

Self-Esteem. One study investigated self-esteem (Park et al., 2015) across three cases, but no inferential statistical analyses were performed. There was some evidence of positive impact of HT on self-esteem however, as scores for all participants increased from pre to post intervention measurements which represents an increase in self-esteem in the outcome measure used.

Confidence. One study investigated participant confidence, but specifically in relation to falling (Lee et al., 2018). On the falls efficacy scale, the authors reported a significant improvement for the experimental group but no significant effect in the control group.

Stress. One study investigated stress (Lee et al., 2018); however this was specifically in relation to rehabilitation stress. The authors reported no significant improvement in scores for the experimental group.

Fatigue. One RCT study investigated the impact of HT on fatigue (Pálsdóttir et al., 2020) using the mental fatigue scale and reported significant improvements for both control and HT groups at the first eight month follow up measurement. However, no significant improvement recorded at 14-month follow-up.

Communication. Two studies included a measure of communication (Park et al. 2015; Kim et al., 2010). Park et al. used a case series design and reported pre and post scores for a measure of communication however, only descriptive statistics were reported. One out of three participants showed an increase in their score on this measure, whilst two showed no improvement. Kim et al. (2010) conducted statistical analyses of the subscales of the functional independence measure and reported significant improvements in the communication subscale.

Table 10.

Summary of Data for Proximal Outcomes in Quantitative Studies.

Authors/Year	Outcome Measure	Pre-Intervention Mean/PP score (SD)	Post-Intervention Mean/PP score (SD)	First Follow-Up Mean (SD)	Second Follow-Up Mean (SD)	Author Conclusions	Magnitude of Effect & 95% Confidence Intervals (Cohens *d*)
			Communication				
Kim et al. (2010)	Communication subscale of Functional Independence Measure	HT: 9.8(0.6) Control: 11.7(0.7)	HT: 12.2(0.3) Control: 12.0(0.7)	*NR*	*NR*	Significant improvement in HT group only.	*d* = 3.22 [2.23 – 4.20]

Park et al. (2015)	Communicati on subscale of Functional Independence Measure	PP 1: 80 PP 2: 51.4 PP 3: 42.0	PP 1: 77.1 PP 2: 68.6 PP 3: 42.9	*NR*	*NR*	No comment from authors on the results.	*NR*
			Rehabilitation Motivation				
Lee et al. (2018)	Self-Developed Rehabilitation Motivation survey	HT: 85.7(28.3) Control: 95.5(24.5)	HT: 95.7(23.6) Control: 98.6(19.7)	*NR*	*NR*	No significant effect across either HT or control group.	*NR*
			Self-Esteem				
Park et al. (2015)	Rosenberg Self-Esteem Scale	PP 1: 18 PP 2: 15 PP 3: 15	PP 1: 23 PP 2: 20 PP 3: 16	*NR*	*NR*	Improvements across participants.	*NR*

			Confidence				
Lee et al. (2018)	Korean Falls Efficacy Scale	HT: 69.0(26.8) Control: 95.5(24.4)	HT: 44.4(27.7) Control: 70.8(16.2)	*NR*	*NR*	Significant improvement in fall confidence in HT group only.	d = 0.01 [-0.72 – 0.73]
			Stress				
Lee et al. (2018)	Self-Developed Rehabilitation Stress survey	HT: 74.4(20.6) Control: 78.8(20.0)	HT: 63.6(18.6) Control: 98.6(19.7)	*NR*	*NR*	No significant improvement across either HT or control group.	*NR*
			Fatigue				

Pálsdóttir et al. (2020)	Mental Fatigue Scale	HT: 11.41(*NR*) Control: 12.43(*NR*)	*NR* *NR*	HT: 8.90(*NR*) Control: 11.06(*NR*)	HT: 9.67(*NR*) Control 11.47(*NR*)	Significant improvement in both groups although no significant difference between them, Fatigue decreased to below clinical threshold for HT group only.	*NR*

Note: NR=Not Reported, indicates where the relevant information is not provided in the paper or does not apply.

Reflexivity & Critical Reflection

I have an interest in ABI generally and have worked with people with ABI across different contexts. I have also been involved in HT programmes for people with stroke and have seen the value of it in ongoing rehabiliation. On a personal level I enjoy being in nature and it has been an important part of my upbringing and life. I have my own understanding and relationship with nature, and its benefits for my mental health and wellbeing. I therefore undertook this project with an assumption that HT is beneficial for this population. At various points through this project, I have engaged with qualitative data. My vested interest in this area may have influenced my engagement with, and interpretation of, the data. I grouped findings across studies and deconstructed overall themes into components, mechanisms and outcomes. I may have interpreted the data in a favourable way which gives more weight to the positive findings. I held an awareness of this throughout the synthesis, endeavouring to maintain a critical stance. I used my research supervision to explore this and ensured to check the groupings of my data with the wider research team.

I come from a background of quantiative research with relatively few experiences of qualitative data anlysis. This could have influenced my position in a number of ways. I have previously relied on the supposed objectivity of outcome measures in quantitative papers. However, I found it difficult in this project to apply a different lens when trying to make sense of the meaning of participant's experiences in HT programmes. This was a very unfamiliar way of engaging with the data to me. I attended a three day mixed methods systematic review workshop which gave me more insight into the overlap between quantitative and qualitative data. I took a less polarised view of quantitative and qualitative data following this which helped me to see how they could complement each and enhance my overall understanding of this topic.

Discussion

This section will outline the findings of this systematic review in the context of existing evidence and the theoretical bases of HT and ABI. Firstly, a summary of the main results will be provided. Secondly, the populations identified will be outlined and the impact on generalisability to the ABI population as a whole will be considered. Thirdly, the evidence for the effectiveness of HT will be discussed. Fourthly, evidence for participant experiences will be interpreted in the context of mechanisms of change and theory. Finally, the clinical implications and strengths and limitations of this review will be explored.

This systematic review aimed to answer three research questions regarding HT and ABI:

1) In the ABI population, does the literature suggest HT is an effective intervention for:
    - reducing psychological distress
    - improving quality of life
    - improving cognition
2) What are participants with ABIs experience of engaging in HT?
3) In the ABI population, what are the theoretical underpinnings for HT and what are the mechanisms of change in the outcomes of interest?

Summary of Main Results

Included studies had a pooled participant sample of 361 and all included participants that had experienced a stroke. A theoretical framework was developed based on findings from five qualitative studies and 14 theories either mentioned explicitly in included studies or identified through additional specific theoretical literature searches. Using this information, a logic model was developed which outlines potential mechanisms of change for HT in the ABI population. The logic model suggests that engaging in sensory activities where plants are grown, as part of a collaborative and supportive social group; and in an accessible, adapted environment provides participants with a sense of mastery; enables them to feel restored through their nature interactions; and increase feelings of belonging. In turn, the evidence suggests that participants experience improved QoL; and

proximally feel more confident to engage in their post-injury rehabilitation. The logic model highlights the complex relationship between intervention components, mechanisms of change and the outcomes of interest. Due to the model's complex nature, it is difficult to link one component to another in a causal manner, and it is likely that multiple theories and mechanisms contribute to changes seen in outcomes. Testing of the logic model using included quantitative studies suggest that HT is effective at reducing symptoms of depression in the ABI population with some evidence for positive impact on QoL. However, there is more limited evidence for HT's impact on anxiety and cognition.

Populations

This section will briefly outline findings related to the type of ABI of included participants and its impact on interpreting results from this systematic review. This project aimed to investigate HT's effectiveness across the broad spectrum of ABI, however one finding is that the literature heavily focusses on stroke. All included studies included participants that have experienced stroke with only one study having a majority of participants with TBI (Mochizuki-Kawai et al., 2018). The focus on stroke may reflect differences in prevalence as estimates suggests 40,000 people experience TBI annually (NICE, 2023) compared to 100,000 experiencing stroke (NICE, 2023). This may limit the generalisability of these findings to other ABI, such as TBI, due to differences between populations but poses an interesting finding in itself. For example, the average age of stroke survivors is higher than that of TBI. Although there is some variation across studies, a large cohort study conducted in the UK reported the mean age of stroke onset as 73 (Li et al., 2022) compared with 27 for TBI (Lawrence et al., 2016). Due to the increased age of stroke survivors, the likelihood of existing care needs and post-injury disability is higher. In the findings from this review, a pooled sample age could not be calculated due to inconsistent reporting, but multiple studies report a mean age in the 60s which indicates the sample is older overall.

There may also be differences in rehabilitation when comparing stroke and TBI populations because of age differences. As highlighted in the rehabilitation & ABI section, occupational therapy and physiotherapy are often used in post-ABI

rehabilitation and pre-existing health difficulties may limit the extent to which individuals can engage as intensely. There is some evidence for this with one study reporting that 22% of their small sample were categorised as frail prior to their stroke (Dalton et al., 2024). Therefore, prior to HT interventions the stroke population may have received rehabilitation, which is less intense, or made less progress in this which could lead to a more positive perception of the opportunity for further rehabilitation.

A pre-existing interest in gardening was also highlighted in included qualitative papers within this review as a factor that influenced engagement in HT interventions. There is some evidence which suggests engagement in gardening is more prevalent in older populations (Nicklett et al., 2016). This may be potentially confounding as positive results from HT studies may be driven by non-specific engagement in a previously enjoyed activity, as opposed to specific aspects of HT interventions. Similarly, the older age of participant samples in this present review may lead to overly positive conclusions and the issue of growing nature apathy in younger people could be neglected. Nature apathy is defined as a general decreased interest in nature interactions, suggested to be partially driven by increased technological engagement (Pergams & Zaradic, 2006).

Effectiveness

Depression & Anxiety

The included studies paint a positive picture of the impact of HT on depression. Of the studies using an experimental design with intervention and control groups, two studies reported a significant positive change in the HT group only (Lee et al., 2018; Park et al., 2015). However, two studies reported significant positive changes in both the HT and control group (Pálsdóttir et al., 2020; Kim et al., 2010). The presence of significant effects in both groups means that improvements cannot be concluded to be driven exclusively by HT (Moser, 2020). However, this does not necessarily conclude that HT is not effective at reducing symptoms of depression, rather that HT is equivalent to the control group in reducing symptoms of depression. Further consideration of the control conditions may offer insight into this.

One study used an Occupational therapy group (Kim et al., 2010) and the other used TAU which comprised occupational therapy, physiotherapy and speech and language therapy, where it was indicated for participants as part of usual rehabilitation (Pálsdóttir et al., 2020). Interestingly, the two studies that reported positive effects exclusively in the HT group did not provide details about the control condition (Lee et al., 2018; Park et al., 2015). Kim et al. (2010) provided information about the activities in the control condition, but it is not explicitly stated how many sessions this group participated in, their duration or frequency. Pálsdóttir et al. (2020) also provided information about activity in the control group but again there was no reporting of the exact number of typical rehabilitation sessions that control participants engaged in. There is some evidence that longer and more frequent interactions with nature are associated with improved health outcomes compared with less frequent interactions (Shanahan et al., 2016). The authors of this paper created a dose-response curve for depression and nature interaction which showed increasingly positive effects on measures of depression when participants spent longer in nature. Therefore, without information about the control groups from the mentioned studies, it is difficult to assess HT's effectiveness for reducing symptoms of depression compared with typical rehabilitation.

Considering the case series studies, two reported no effect of HT on depression whilst one reported a positive trend. However, it is important to note that only one of the three included case series studies conducted statistical analyses of participant scores over time, which limits the conclusions that can be made from findings. It may be useful to compare the above findings with the general literature on HT and depression.

Although previous studies have not focussed on ABI specifically, two systematic reviews, to the author's knowledge, have been conducted investigating HT and depression in older populations (Zhang et al., 2022; Xu et al., 2023). For example, Xu et al. (2023) found significant positive impact of HT on depression in their meta-analyses which adds to the broader picture of HT's effectiveness in depression. The authors also reported a significant subgroup analysis where HT activities that were classified as participatory, or active, showed a significant effect

on depression whereas observational activities did not. However, the authors quality appraisal identified the majority of included studies as moderate to low. Taken together, this may suggest that HT generally has a positive impact on depression in older adults which appears consistent with findings from the present review, although this should be interpreted with caution given the low quality of included studies in other review.

Furthermore, there is some evidence that right or left hemisphere stroke is associated with differing prevalence of post-stroke depression (Chen et al., 2015). Specifically, a systematic review suggested that right hemisphere stroke is more often associated with post-stroke depression, although the authors highlighted methodological concerns relating to risk of bias in included studies (Wei et al., 2015). This is consistent with evidence for emotional lateralisation which is suggested to be driven by specific attentional and emotional processing cortical networks in the right hemisphere (Gainotti, 2021). In the present review, only one study provided demographic information about hemispheric side of participant stroke (Lee et al., 2018). However, this was reported indirectly as the authors described the side of paralysis, termed hemiparesis. Physical impairment from stroke occurs contralaterally so studies listing right hemiparesis are referring to left hemisphere stroke (Yourganov et al., 2021). In Lee et al.'s study (2018), 65% of the control group was described as having left hemiplegia and therefore right hemisphere stroke. However, the HT group had 35% of participants with left hemisphere stroke and 30% experiencing a dual hemisphere stroke. Crucially, if right hemisphere stroke is more heavily associated with depression post-stroke, then a greater degree of these participants in the control group may partially explain improvements in depression seen across both groups. More broadly, hemispheric side of stroke may be a confounding factor that is not accounted for when considering depression across studies and may explain improvements seen in both the control and HT groups in the previous studies (Kim et al., 2010; Pálsdóttir et al., 2020).

Considering changes to individuals' mood over time caused directly or indirectly by stroke, there is some evidence that post-stroke depression is relatively common in the initial stages, but prevalence reduced following the acute phase

(Kim, 2016). Similar to participant's pre-existing physical function and stroke hemisphere, time since injury may be another confounder when it is not recorded or adequately controlled for in assignment to groups. In summary, the evidence suggests that HT is beneficial for reducing symptoms of depression, and that this is comparable with typical rehabilitation, but that a number of confounding factors may contribute to these benefits.

Anxiety was only investigated by one RCT study (Pálsdóttir et al., 2020) which found a significant reduction in anxiety in both the HT and control groups. The literature also shows a paucity of studies investigating HT and anxiety. A systematic review of RCTs sought to gather evidence for the effectiveness of HT across specific health conditions (Kamioka et al., 2014). Four studies met criteria for inclusion and outcomes included, but were not limited to general affect, depression, anxiety and self-esteem. The authors reported a general positive impact of HT on mental health, which included anxiety. However, as with other reviews in the area, the authors reported the majority of included studies were rated as moderate to low quality with issues in allocation, randomisation and high risk of bias which limits the conclusions that can be drawn from it. Some primary research also suggests a positive impact of HT on anxiety, although this was in a mental health population as opposed to ABI (Joubert et al., 2024).

As only one study investigated anxiety in the present review it is therefore difficult to make any strong conclusions about the impact of HT on anxiety in the ABI population, but this represents a finding of interest in itself. As highlighted in the introduction section, prevalence of anxiety in the stroke population is significantly higher compared to overall population with one in four stroke survivors experiencing this compared to approximately 4% of the general global population (Knapp et al., 2020; Javaid et al., 2023). However, the lack of focus on anxiety may represent wider inequalities in mental health research. A 2020 report investigated the global patterns of mental-health related research funding and found that depression research receives approximately $319 million in funding compared to $97 million annually for anxiety (Woelbert et al., 2020). This may reflect a perception of depression as a more severe disorder and the role it played in increasing psychiatry's status as a scientific specialty (Horwitz, 2010).

QoL

The included studies also show a mixed pattern across measures of QoL following HT. One of the experimental studies reported positive effects in both HT and control groups (Kim et al., 2014) whilst the RCT reported no improvement in either group on QoL (Pálsdóttir et al., 2020). Considering the case series study (Shin et al., 2016), two of the three participants showed positive trends in measures of QoL and the degree of this improvement was above the minimally clinical difference suggested by the WHOQOL. The other participant did not complete the WHOQOL due to severe cognitive impairment. As highlighted, this may represent a positive effect of HT on QoL, but one that is comparable to traditional rehabilitation methods. However, with the RCT bring the most methodologically sound this may limit the conclusions that can be drawn about the effect of HT on QoL.

This appears consistent with the broader HT literature where a previous systematic review of HT in older adults highlighted that only four of eleven included studies which measured QoL reported a significant effect (Heród et al., 2022). The authors highlighted that the majority of studies were of moderate methodological quality with a high risk of bias, concluding that caution should be employed when interpreting their results. However, the findings of this review conflict with those of another review that investigated the effect of HT on psychosocial wellbeing in a Chinese older adult population (Lin et al., 2022). The authors identified 16 studies for inclusion and six of these measured QoL. Four studies reported positive effects of HT on QoL whilst two reported no effect. The authors suggest results from the studies which reported no effect may be driven by shorter duration and lower frequency of HT programmes. The authors also highlighted the high risk of bias in their included studies driven by issues in randomization and handling of incomplete outcome data which limited the conclusions drawn. For comparison in the present review, one study used 16 sessions of HT, two times a week which lasted 30 minutes (Kim et al., 2014). The case series study used a programme of 10 sessions lasting 60 minutes (Shin et al., 2016). The RCT which reported no effect had the highest dose of HT with 20, 60 minute sessions administered twice a week (Pálsdóttir et al., 2020). Therefore, this suggests that the dose of HT is not driving the results reported for measures of QoL here.

One explanation for these apparently contradictory findings may be found in the concept of QoL itself and measurement of it. Compared to other outcomes such as depression and anxiety which have specific clinical definitions, QoL as a concept is much broader. Measures of QoL in the included studies are varied and include the Euro-QoL-5 Dimension Questionnaire, Stroke Quality of Life Scale, Korean Version of World Health Organisation Quality of Life Scale and Stroke Specific Quality of Life Scale. The subscales from these measures differ greatly with examples including mobility, vision, language, thinking, personality etc. The Euro-QOL-5-dimension questionnaire used by Pálsdóttir et al. (2020) may also neglect important aspects of HT highlighted form the qualitative findings and the literature. Specifically, subscales of this measure do not capture the social aspect of HT or psychological wellbeing, which has been suggested from this review to be key outcomes and mechanisms for HT in ABI. Therefore, the lack of effect seen in their study may be driven by this and also offer explanation for conflicting results with previous reviews. Similarly, the conceptualisation of QoL has been criticised in the literature (Moons et al., 2006) and inconsistency of findings in the present review may represent heterogeneity in QoL itself, and the measures used to assess it.

In one study, authors conducted further statistical analysis of the subscales in QoL measures, and this may offer further information about the specific aspects of QoL that HT may impact. Specifically, Kim et al. (2010) reported significant improvements in the HT group but not control on the communication and social cognition subscales of the functional independence measure. This may suggest that HT positively impacts these factors specifically and appears to be consistent with qualitative findings from this review. This relationship will be further considered in following sections outlining the mechanisms of change. As with depression, it appears that HT may be effective for improving QoL but comparable with traditional rehabilitation.

Cognition

Cognition was investigated in only two included studies (Mochizuki-Kawai et al., 2018; Shin et al., 2015). One study used the Rey-Osterreith complex figure test as the authors aimed to investigate visuospatial abilities of participants and

reported improved figure copy scores in the HT group, but this was only reported at follow up (Mochizuki-Kawai et al., 2018). In addition, the data is only reported in graphical format meaning further consideration of results is not possible. The authors highlighted improved recall scores in the HT group only. For the digit span and block tapping conditions however, no difference was observed across groups. As highlighted in the introduction, the ROCF is a brief cognitive task with a focus on visuospatial working memory, although it does tap other cognitive domains including attention; planning and concept organisation (Zhang et al., 2021). Therefore, the evidence for the impact of HT on cognition is positive in this case but limited to these cognitive domains. The other study found no change in scores on a cognitive screening measure in a case series study (Shin et al., 2015). This difference in finding may be driven by the assessments used as the latter study adopted a cognitive screening instrument, the Mini Mental State Examination.

The extent and nature of cognitive impairment post-stroke can be varied, and assessment of possible cognitive difficulties is recommended to inform rehabilitation. Cognitive screening assessments are often conducted in stroke rehabilitation settings and further referral to neuropsychology is indicated where impairments are reported. Research suggests that selection of assessments and the use of results to inform rehabilitation is heterogeneous within stroke services (Lees et al., 2014). This may be driven by the lack of specific evidence-based guidance provided by clinical governing bodies, as highlighted by a systematic review conducted by Mcmahon et al. (2022). Specifically, the authors investigated the quality of guidelines relating to cognitive assessment with stroke patients and highlighted a lack of specific detail in the selection of assessments. Although the guidance is unclear, it is suggested that assessment should be comprehensive, measuring across cognitive domains. This highlights the need for comprehensive neuropsychological assessment beyond the scope of a cognitive screening measure in the HT literature. Due to the limitations of screening measures, more nuanced differences may have been found by Shin et al. (2015) if this was adopted.

More broadly, the effects of HT on cognition are poorly studied in the literature and exclusion criteria often states that participants must have mild or no cognitive impairment in studies assessing mental health outcomes (Lee et al., 2018;

Kim et al., 2010). This may mean that the effectiveness of HT across the broad spectrum of cognitive impairment is not represented, and no inferences can be made about differing effectiveness between groups. Furthermore, research suggests that increased severity of cognitive impairment is associated with poorer rehabilitation progress and improvement in other rehabilitation related outcomes (Benedictus et al., 2010; Spitz et al., 2012). Spitz et al. (2012) also highlight through regression modelling that introduction of executive functioning scores into their models best explained progression in functional outcomes.

Across outcomes, there appears to be key differences in the qualitative studies which formed the foundation of the logic model, and the quantitative studies which were used to test it. Particularly in the findings which highlight the positive impact of the social aspect of HT, where participants discussed the sense of collaboration and working as a collective towards a goal. This suggests that quantitative measures are not accurately capturing the wide range of benefits experienced by participants.

In summary, comparing HT with typical rehabilitation or other control conditions provides mixed outcomes and it cannot be concluded that it provides better outcomes. The evidence does show, however, that HT was associated with improvements across mental health measures and that this is reflected in qualitative findings that consistently outline positive experiences of participants.

Experiences, Theoretical Underpinnings & Mechanisms of Change

This review identified multiple mechanisms through which HT may contribute to change in outcomes of interest which were directly informed by participant experiences described in qualitative studies. Broadly, these were categorised into environments for growth; nature and restoration; sense of mastery and self-belief; and social inclusion and belonging. This section will attempt to explore these in greater detail, specifically in relation to ABI and consider how they may contribute to change in the context of the wider literature.

Environments for Growth

This category was composed of three theories and findings from qualitative studies that highlighted the perceived real-world applications of HT applied in an informal context. Informality as a concept is most often referred to in occupational psychology literature but the findings from this may offer further information as to why this was valued by participants. One author suggests that informal contexts help to put participants at ease and provide greater opportunities for developing social bonds (Misztal, 2002). Relaxation is inherently linked to stress, and it is well documented that higher levels of stress affect both physical and psychological functioning (Rodrigues et al., 2018). Furthermore, relaxation has also been linked to increased feelings of focus (Smith, 2005) which may offer explanation for participants valuing the informal environment, as they are able to concentrate better and form more meaningful social bonds.

The presumption in the literature is often that human-nature interactions are largely positive, but the theory of environmental press highlights the complexity of this relationship for individuals with disabilities. Briefly, environmental press refers to the relationship between an individual's ability and the demands of their environment (Lawton, 1977). ABI is often associated with disability and environmental press may provide further information for how HT helps individuals with ABI to redefine their relationship with nature. The concept of person-environment fit is associated with environmental press and suggests that where the environment matches personal competencies, functioning is optimised (Wahl & Gitlin, 2007). However, where individuals have mobility, visual or cognitive impairments the environment is often inappropriately adapted and represents a form of environmental injustice (Lasky et al., 2023).

Natural environments specifically can provide multiple barriers such as limited access, steep inclines and lack of appropriate height areas for wheelchairs. This environmental injustice may play a key role in perpetuating negative perceptions of self for those living with disabilities and contribute to increased mismatch in environmental press (Imrie & Thomas, 2008). The findings from the present review suggest that when the HT environment is appropriately adapted and a manageable level of challenge is provided by activities, the level of environmental press is

reduced. Repeated exposure to this more aligned level of person-environment fit may allow participants to develop new, more positive relationships with nature which facilitate improved QoL and confidence. Specifically, negative qualitative findings from the included studies in this review most commonly related to the lack of adaptation to the environment in which HT was conducted and highlights the importance of appropriate environments.

In the case of individuals with ABI, the natural environment may also not represent a safe, unthreatening setting. For example, the ABI population is more likely to experience mobility issues which may limit individual's ability to engage with nature (Williams & Morris, 2009). ABI has also been associated with changes in self-perception with individuals reporting increased identification with vulnerability (Kendall & Terry, 2009). Nature may therefore be viewed as dangerous rather than restorative and suggests these frameworks may not offer the most appropriate explanation for HT mechanisms in the ABI population. Although not specific to NBI, engagement with the natural environment has been reported as lower in this population (Olofsson et al., 2017).

Nature and Restoration

This category was informed by four theories and findings from qualitative studies highlighted the role of HT specifically, but nature more broadly, in facilitating mental rest. Of note here is the reference to nature evoking pleasant memories and the perception of HT as meaningful. Participants described HT as helping them to forget about their illness and noticed an increase in their sensory capacity.

Specifically, participants discussed the role of HT in helping them to let go of difficult thoughts. This appears consistent with elements of the stress reduction theory (Ulrich, 1983; Ulrich et al., 1991) which highlights the role of coping responses in managing stress. Avoidant coping responses such as substance use or disengagement are described as perpetuating stress responses but findings from this review suggest that being in nature, and engaging in HT, allowed participants to reach a degree of acceptance and find respite. This is consistent with the HT literature with a previous study measuring physiological markers of stress after an

indoor HT programme (Xiaoyi et al., 2024). In this study, blood pressures were measured and electroencephalogram (EEG) used to track brain activity before, during and after a HT intervention. Findings showed significantly reduced blood pressures in the HT group compared to the control and patterns in the EEG data were consistent with elevated relaced states in the HT group exclusively. Taken together, the findings from the resent review suggest HT offers opportunity for restoration and this may be partially driven by biological mechanisms.

However, it is important to note that although much of the broader literature focusses on positive nature interactions, some authors consider of negative experiences. For example, this review has outlined the concepts of the biophilia hypothesis which appears to underline many NBIs, but other theories highlight aversions or negative affect caused by human-nature interactions, termed biophobia (Soga et al., 2023). There is much overlap between the two theories with biophobia also suggesting an evolutionarily adaptive element in aversion to dangerous elements of nature (Bertels et al., 2020). Engagement in the included studies may have been driven by a lack of biophobia, and therefore mask potential negative experiences of HT.

Sense of Mastery & Self-Belief

This category comprised four theories and findings from qualitative studies represented feelings of satisfaction, mastery of function, meeting rehabilitation goals and HT as a visual representation of rehabilitation. Findings also suggested that the voluntary nature of participation in HT was important for participants and helped them develop a more positive self-perception.

Previous research has investigated the factors which contribute to self-perceptions after stroke and highlighted the role of engagement with others and their communities (Diéz-Acasso et al., 2011; Pallesen, 2014; Skoglund et al., 2019; Nicholas et al., 2020). In one study, Pallesen (2014) interviewed stroke survivors five years post-injury and identified that participants perceived their bodies as unreliable which was associated with increased worry about further deterioration. Similarly, participants referenced difficulties in encountering barriers in their lives

and some participants described their lives as less active, and being more homebound in general. These findings typify worries from stroke survivors about their self-efficacy and navigating life with a disability.

Considering self-efficacy theory, it suggests that four factors contribute to development of self-efficacy (Bandura, 1994). Firstly, successful performance of task can lead to feelings of mastery and is hypothesised to be the strongest influence in developing self-efficacy. Secondly, modelling, where the individual observes others completing the task. Thirdly, social influence where an individual receives encouragement. Fourthly, physiological state where individuals gather information about self-efficacy based off their internal responses to a situation. Considering the intervention components identified in the present review, the category of growing encompassed findings such as satisfaction in seeing things grow and the harvesting of something the participant worked hard to grow. In the context of the theories, the opportunity provided by HT for participants to experience mastery, and to see this visually, may promote self-efficacy. As highlighted by the logic model, HT provides opportunities for development of self-efficacy across all four domains, whereby completed tasks develop a sense of mastery; modelling occurs in the group setting; encouragement is provided by peers and facilitator; and individuals develop greater sensory awareness through HT activities.

Social Inclusion & Belonging

Qualitative findings from the present review highlighted the impact of positive interactions with other participants in the HT programme and a sense of collaboration when working together on horticultural activities. Social interaction is central to the human experience and social isolation is associated with increased prevalence of mental health difficulties, and increased mortality (Holt-Lunstad et al., 2015). Multiple stroke-specific factors are related to increased feelings of social isolation such as loss of employment; increased reliance on partners for care needs which leads to changes in intimate relationships; and reduced interaction with friends driven by limited environmental access (Pallesen, 2014).

Communication was also referred to regularly in the findings with one finding suggesting that the participant viewed HT as an opportunity to train their

communication. There is some evidence that, alongside general anxiety, social anxiety is also more prevalent in the ABI population (Chaves et al., 2012). HT may therefore provide an opportunity for participants to practice, or rehabilitate, social skills following brain injury. This may represent a distinct finding for participants with speech impairment post-stroke however as it is not stated in included studies if there is presence of speech difficulties for participants.

The natural environment has been suggested to increase levels of social cohesion for groups (White et al., 2020). Other qualitative studies that have investigated the use of HT with other marginalised groups, such as asylum seekers, suggest increased feelings of social inclusion (Bishop & Purcell, 2013). Social inclusion refers to the opportunities for individuals of all backgrounds to engage in society and is positively associated with wellbeing, self-esteem and meaningful social connections (Saran et al., 2021). For HT specifically, the literature suggests that participants perceived friendships made within HT groups as essential for sustaining their engagement in the programme and contrasted these with wider social difficulties they faced outside of HT (Harris, 2017). In combination with findings from this review, which highlight the importance of collaboration for participants, those of Harris (2017) and Pallesen (2014), they suggest that stroke is associated with reduced social functioning, but HT provides an opportunity to facilitate this.

Alternative Models of HT

This section will consider the logic model produced by the present review in relation to previous models of HT. Multiple models exist in the literature (Relf, 1973; 1981; 1999; Sempik et al., 2003). Relf's initial model (1973) outlined four domains across which HT had positive benefits. These were emotional, social, physical and intellectual. The 1981 model (Relf, 1981) was revised to reflect the more complex nature of this relationship and sought to provide further information about the mechanisms of HT. This iteration suggested three distinct processes which were interaction, action and reaction comprised of multiple sub-processes. Critically, these early models were developed before the emergence of more rigorous experimental studies.

Sempik et al. (2003) sought to bring all the aspects together in a model which connects the aspects of HT, with a focus on distinguishing between HT and social horticulture. The authors conducted a literature review of over 300 papers; however, it is unclear from the brief paper how this information was used to develop the model. The model is built on biophilia and had separate sections for passive and active interactions with nature that are inter-connected through multiple mechanisms and lead to improved health and well-being. Mechanisms include skills development; social processes; employment; physical activity; attention restoration and recovery from stress; food, cultivation and consumption; tranquillity, peace and spirituality; and rehabilitation, acceptance and social inclusion. Compared with the logic model from the present review there is considerable overlap, including the restorative elements of nature; social processes; skills development in sense of mastery and self-belief; and social inclusion/acceptance. These similarities are outlined below in Table 11.

Table 11.

Combination Model of Current Logic Model and Sempik et al. (2003) highlighting Similarities.

Sempik et al. (2003)	**Pegler et al. (2025) – Components & Mechanisms**
Rehabilitation, Acceptance, Social Inclusion; Social Processes, Interaction, Esteem-Building	Social Inclusion & Belonging; Sharing Experiences
Tranquillity, Peace, Spirituality	Sensory
Attention Restoration, Recovery from Stress; Physical Activity	Growing; Nature & Restoration
Employment; Skills Development	Sense of Mastery & Self Belief; Accessible Environments; Environments for Growth

Clinical Implications

This review can provide insight for clinicians into important factors when facilitating, or considering facilitating, HT interventions. Overall, the findings from this review suggest that there is value in the use of HT, particularly for reducing mental health related difficulties despite the lack of robust evidence. Research needs to further evaluate the specific impacts of HT but it does not appear to increase mental health related distress and qualitative findings suggest that participants enjoy it.

The negative findings were often related to the appropriateness of the environment. Clinicians should ensure that HT interventions are conducted in an environment that has been adapted to meet the mobility and sensory needs of all participants. This will allow for engagement with the programme in the first instance but also the development of a sense of mastery. This review provides promising evidence for the use of HT with stroke survivors as this is where the majority of studies focussed. As a result, potential facilitators of HT interventions should hold this in mind when considering delivering HT interventions to other ABI populations.

Regarding specific aspects of HT, the social component is highlighted as a key mechanism of change, allowing for development of relationships and collaboration. Therefore, consideration of running HT as a group intervention, where possible, is indicated by the findings of this review.

Future Research

A number of avenues for further research have been highlighted by the present review. Firstly and most importantly, there is a need for further testing of the logic model presented here. This can be facilitated by further high quality research into the outcomes of interest drawn from the qualitative and theoretical literature. The continued development of a body of evidence assessing HT will likely provide the largest benefit to clinical populations. In general, future research should also include all relevant information regarding the HT programme and full demographic

information of participants to support future evaluations. Similarly, consideration should be given to the activities used in any control conditions and the composition of participants in these. This is because of the potential confounders highlighted in terms of time since injury, hemispheric side of stroke and age.

At present, there is also a heavy focus in the literature on participants who have experienced a stroke with limited attention paid to other forms of ABI. Further investigation of other clinical populations such as TBI would be beneficial in developing an overarching model of HT and ABI, and also allow comparisons between groups. Similarly, primary outcomes identified from the theoretical literature, namely anxiety and cognition, are investigated less than depression and QoL. Further research into these outcomes will allow future authors to more thoroughly test the theoretical framework of HT.

Strengths & Limitations

This project adopted a mixed methods systematic review methodology which requires consideration of both quantitative and qualitative data and this is a particular strength of the review. This allowed for the development of a theoretical framework which was tested with quantitative data, offering insight into HT's effectiveness and potential mechanisms of change. The systematic approach, supported by an information specialist, provided the opportunity to include as much evidence as possible in the final synthesis. Also, quality appraisal was conducted on inclued studies and highlighted that most papers were considered high quality on the criteria of the MMAT. Despite this, issues related to methdological quality of individual studies were considered throughout the review.

With this in mind, however, the number of studies included in this review is relatively low and they disproportionately focus on stroke. This means that the mechanisms discussed in this review are informed by a relatively small pool of participants. Furthermore, the focus on stroke makes it difficult to apply recommendation to the broader ABI population. Taken together, these limitations restrict the generalisability of the findings from the present review.

Only 33% of the records in this review were screened by both the author and a coscreener which increases the risk of bias in decision to include or exclude studies. JBI methodology guidance for systematic reviews highlight the importance of coscreening throughout all stages of a systematic review. This is especially pertinent in the use of a clustering exercise which is recommended to be done in collaboration with co-researchers to reduce the risk of bias. The clustering exercise required the author to extract intervention components, mechanisms and proximal outcomes which in many cases could be open to interpretation.

Finally, as highlighted by the complex intervention research framework, a key process is the involvement of stakeholders. Due to the change in synthesis approach at a late stage of this project, it was not possible to share the logic model but this would be particularly valuable in future research. Involvement of experts by experience would have strengthened this project particularly in the sharing of the mechanism findings with a HT group for people with ABI.

Conclusions

This systematic review represents the first attempt to gather information about the available evidence for the effectiveness of HT in the ABI population for depression, anxiety and cognition. Furthermore, the creation of a logic model also provides information about how HT works, derived from data obtained in included qualitative studies. The findings specifically suggest that HT is promising for improving symptoms of depression and anxiety with a mixed picture regarding anxiety and cognition. Potential mechanisms of change include social interaction, the restorative aspect of nature and improving self-efficacy. Also, qualitative studies suggest that participant experiences are mainly positive and that this may prove a promising intervention for ongoing use in neurorehabilitation. Gaps in the literature have also been identified from the present review which highlight a need for further high-quality investigation of HT to enable further evaluation of the logic model presented here.

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List of Abbreviations

ABI – Acquired Brain Injury

TBI – Traumatic Brain Injury

HT – Horticultural Therapy

QoL – Quality of Life

NBI – Nature-Based Intervention

RCT – Randomised Controlled Trial

TAU – Treatment As Usual

BDI – Beck Depression Inventory

MDT – Multi-Disciplinary Team

ART – Attention Restoration Theory

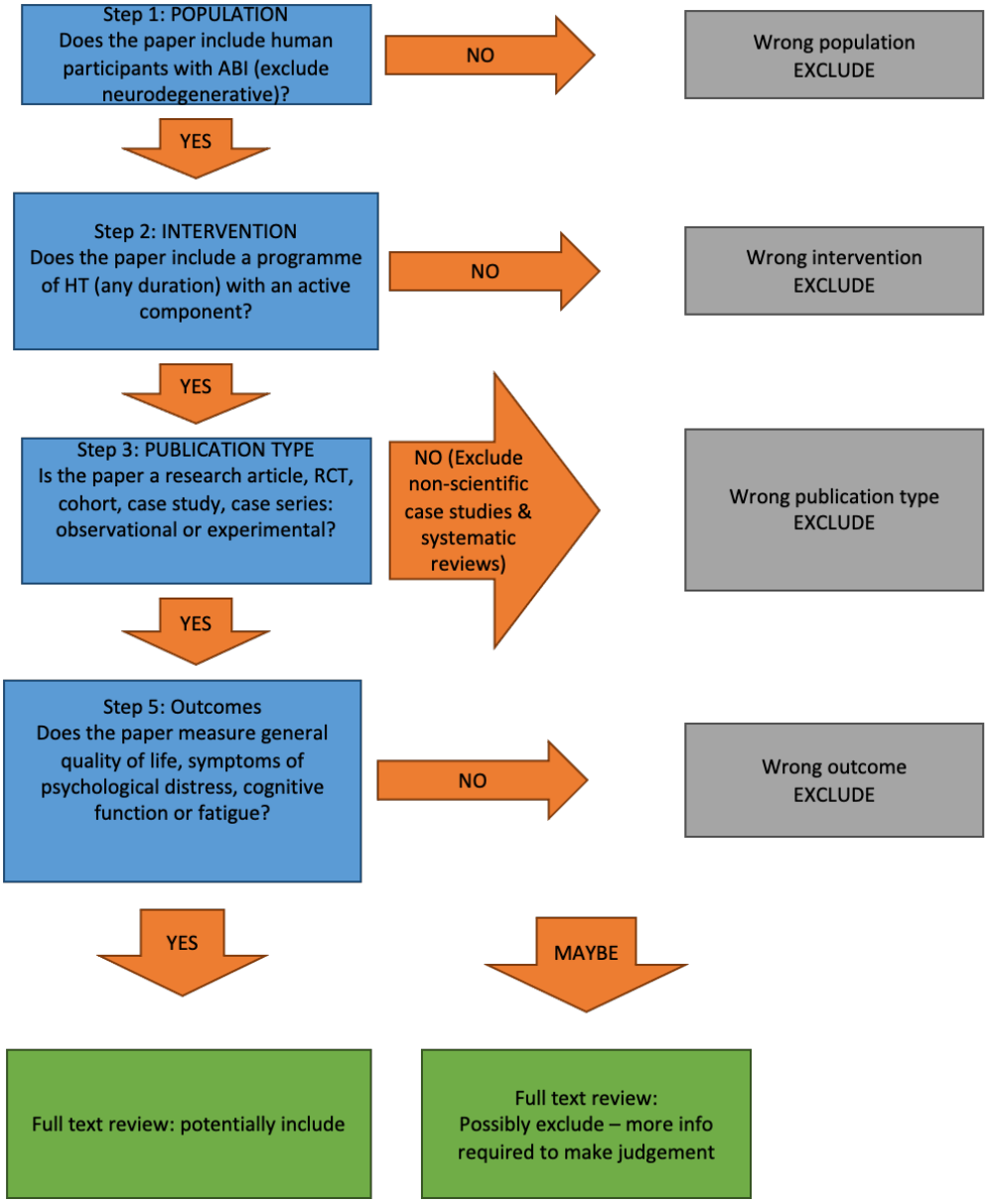
SRT – Stress Restoration Theory

CBA – Controlled Before and After

Appendix A – Master Search Strategy for Medline

1	exp Brain Injuries/
2	brain injur*.tw,kf.
3	acquired brain injur*.tw,kf.
4	head injur*.tw,kf.
5	cerebral injur*.tw,kf.
6	intracranial injur*.tw,kf.
7	right hemisphere injur*.tw,kf.
8	brain lacerat*.tw,kf.
9	exp stroke/
10	stroke.tw,kf.
11	subarachnoid* he$morrhage.tw,kf.
12	brain he$morrhage.tw,kf.
13	cerebral he$morrhage.tw,kf.
14	intracranial he$morrhage.tw,kf.
15	brain infarct*.tw,kf.
16	cereb* infarct*.tw,kf.
17	lacunar infarct*.tw,kf.
18	head trauma.tw,kf.
19	craniocerebral trauma.tw,kf.
20	transient isch$emic attack.tw,kf.
21	cerebrovascular trauma.tw,kf.
22	brain anoxia*.tw,kf.
23	brain hypoxia*.tw,kf.
24	cerebral anoxia*.tw,kf.
25	cerebral hypoxia*.tw,kf.
26	encephalop*.tw,kf. or encephalitis.tw,kf.
27	exp Horticulture Therapy/
28	garden*.tw,kf.
29	garden* therap*.tw,kf.
30	green.tw,kf.
31	horticultur*.tw,kf.
32	green prescri*.tw,kf.
33	nature prescri*.tw,kf.
34	nature play.tw,kf.
35	green space.tw,kf.
36	greenspace.tw,kf.
37	community garden*.tw,kf.
38	allotment*.tw,kf.
39	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9 or 10 or 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21 or 22 or 23 or 24 or 25 or 26
40	27 or 28 or 29 or 30 or 31 or 32 or 33 or 34 or 35 or 36 or 37 or 38
41	39 and 40

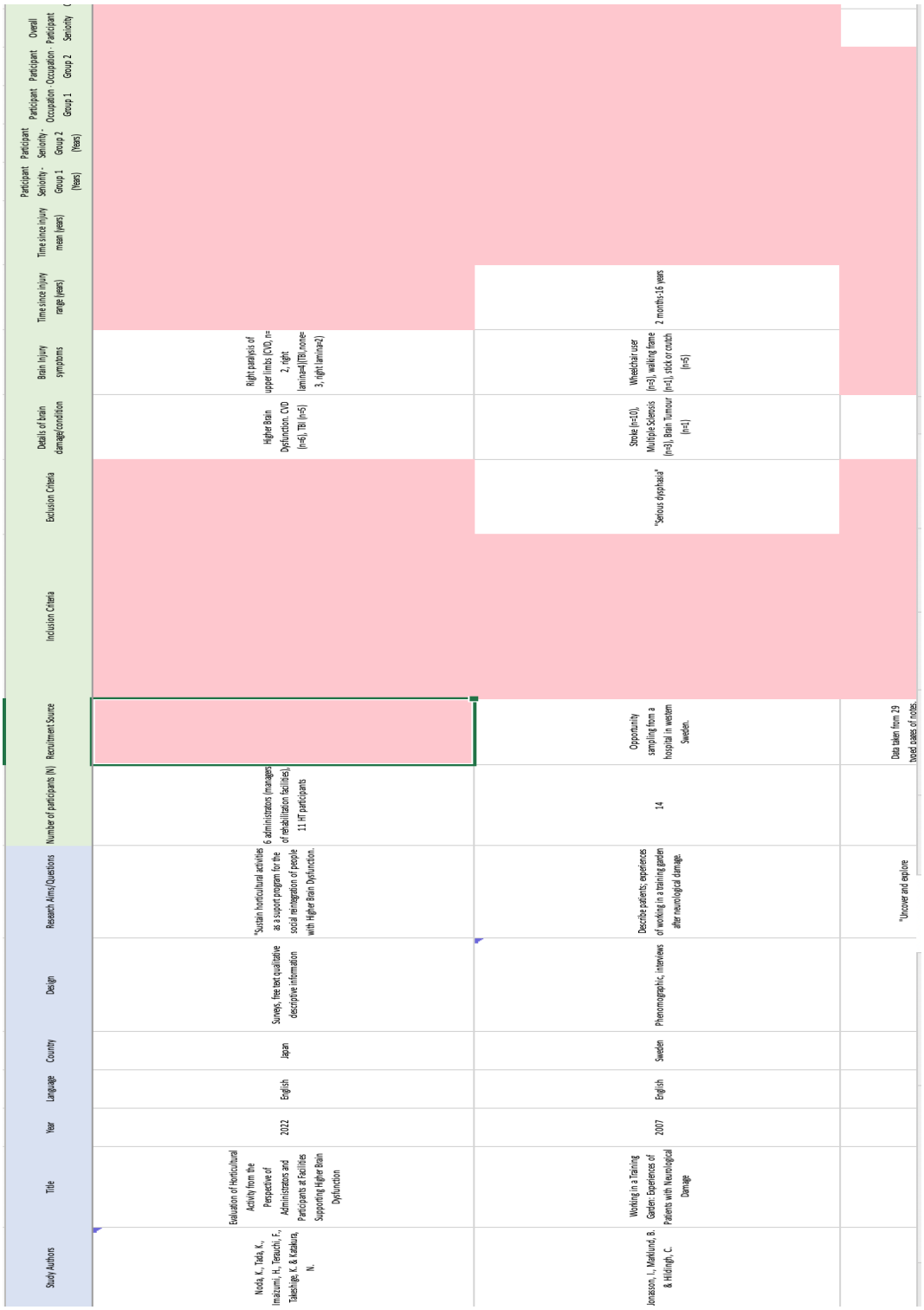
Appendix B – Screening Algorithm



Appendix C –Quantitative Data Extraction Form example

	Study Authors	Title	Year	Language	Country	Design	Research Aims/Questions	Number of participants total (n)	Number of participants experimental (N)	Number of participants control (N)	Recruitment Source	Inclusion Criteria	Exclusion Criteria	Details of brain damage/condition experimental group	Details of brain damage/condition control group	Hemispheric damage Experimental	Hemispheric damage Control	Right Hemiplegia Experminetal (n)	Right Hemiplegia Control (n)	Left Expe
Not provided	Lee, A.Y., Park, S.A., Park, H.G., & Son, K.C.	Determining the Effects of a Horticultural Therapy Program for Improving the Upper Limb Function and Balance Ability of Stroke Patients	2018	English	South Korea	Quasi-experimental with nonequivalent control group	The objective of this study was to assess the physical and psychological effects of an 18-session horticultural therapy (HT) program based on task-oriented training in stroke patients and investigate patient satisfaction.	31	14	17	Inpatient stroke rehabilitation unit Rehabilitation Hospital B Seongnam, South Korea - Flyers, registration forms (opportunity)	Current inpatient, able to perform horticultural activities, MFT score >4/3, able to move in a wheelchair, mild cognitive impairment only (>18), minimal communication impairment, has a relative/caregiver.	Patients able to perform <65% of horticultural activities voluntarily.	Cerebral haemorrhage (n=7, 50%), ischemic stroke (n=6, 42.9%), traumatic brain injury (n=1, 7.1%)	Cerebral haemorrhage (n=11, 64.7%), Ischemic stroke (n=6, 35.3%)	Right (n=5, 35.7%), Left (n=5, 35.7%), Quadriplegia (n=4, 28.6%)	Right (n=6, 35.3%), Left (n=11, 64.7%)			
Sig.	Kim, M.Y., Kim, G.S., Mattson, N.S. & Kim, W.S.	Effects of Horticultiural Occupational Therapy on the Physical and Psychological Rehabilitation of Patients with Hemiplegia after Stroke	2010	English	South Korea	Quasi-experimental with nonequivalent control group	Compare effects of HT on psychological and physical rehabilitation of stroke patients compaared with existing OT.	40	20	20	Hospitalised patients across three hospitals in Seoul.	Able to understand instructions from a therapist, perform simple activities, scored 20> on MMSE-K, 10> Geriatric Depression Scale, hemiplegia.						7	8	
							Determine whether NBR as add on to standard care has a long-term				Skane university hospital admission &	Patients in sub-acute phase (3 months post-stroke), patients in								

Appendix D – Qualitative Data Extraction Form



Appendix E – Case Study Data Extraction Form

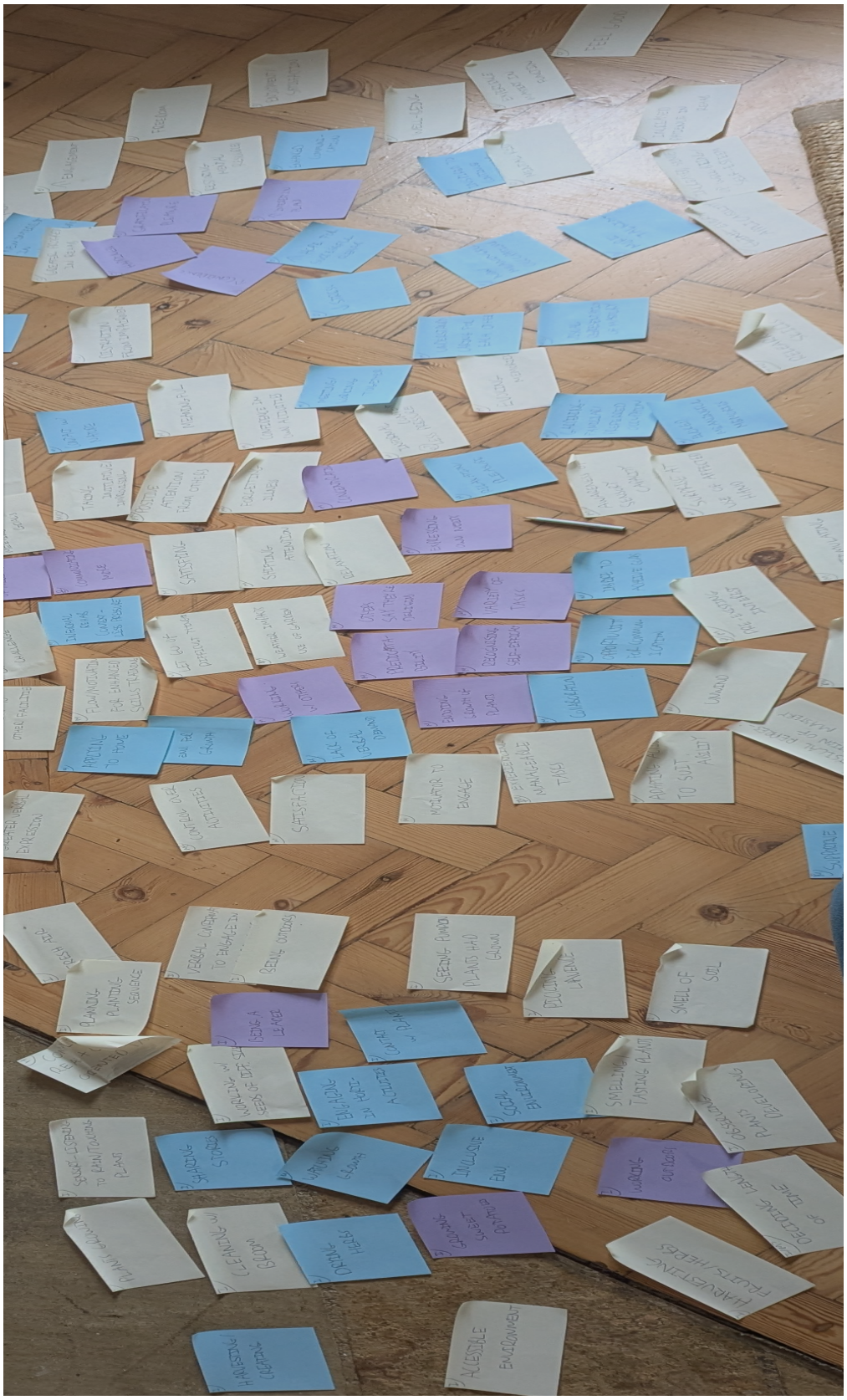
	Study Authors	Title	Year	Language	Country	Design	Research Aims/Questions	Number of Cases (n)	Recruitment Source	Inclusion Criteria	Exclusion criteria	Details of brain damage/condition experimental group	PP 1 brain damage details	PP 2 brain damage details	PP 3 brain damage details	PP 4 brain damage details	PP 5 brain damage details	Date of brain injury/time since PP 1
Not provided	Park, S.A., Shoemaker ,C.A., Harms, S., O'Nell, D. & Oh, D.M.	An eight week horticultural therapy program for Stroke Outpatients: A Case Study	2015	English	United States of America	Case Study	Determine the effects of an eight week HT program for Stroke outpatients on the hand function abilities, eye-hand coordination, self-esteem, depression, and health-related quality of life. Programming costs and satisfaction with programme also investigated	3	Posters in places frequented by older people - senior center, community learning centre, nursing homes, dependent faiclities and a hospital. Word of mouth. (Opportunity)	50> years old, physician approval to participate		Damage to facial nerves 6, 7, 8 (n=1).						11.28.2007
	Mizuno-Matsumoto ,Y., Kobashi, S., Hata, Y., Ishikawa, O., & Asano, F.	Horticultural Therapy has Beneficial Effects on Brain Functions in Cerebrovascular Diseases	2008	English	Japan	Case Series	Assess effectiveness of HT for improving brain functionality in brain damaged patients.	5	Ishikawa Hospital				Right internal carotid occlusion, left hmiplegia and dysarthria.	Left cerebral infarction, right hemiplegia and aphasia.	Right ACA occlusion, left hemiplegia.	Right thalamic bleeding, left hemiplegia.	Right frontal bleeding, left hemiplegia and dysarthria.	
	Shin, S.B., Kim, T.U., Lee, J.H., Kim, J.Y. & Lee, S.	Horticultural Therapy in Patients with Stroke: Three Case Series	2016	English	Korea	Case Series	Investigate whether HT has additional benefitsbeyond psychological.	3	Dankook University Hospital				Left posterior inferior cerebellar infarction, ataxia.	Left middle cerebral arterial infarction, right hemiparesis, global aphasia, severe cognitive impairment.	Intracerebral haemorrhage in right basal ganglia, left hemiparesis.			58 days

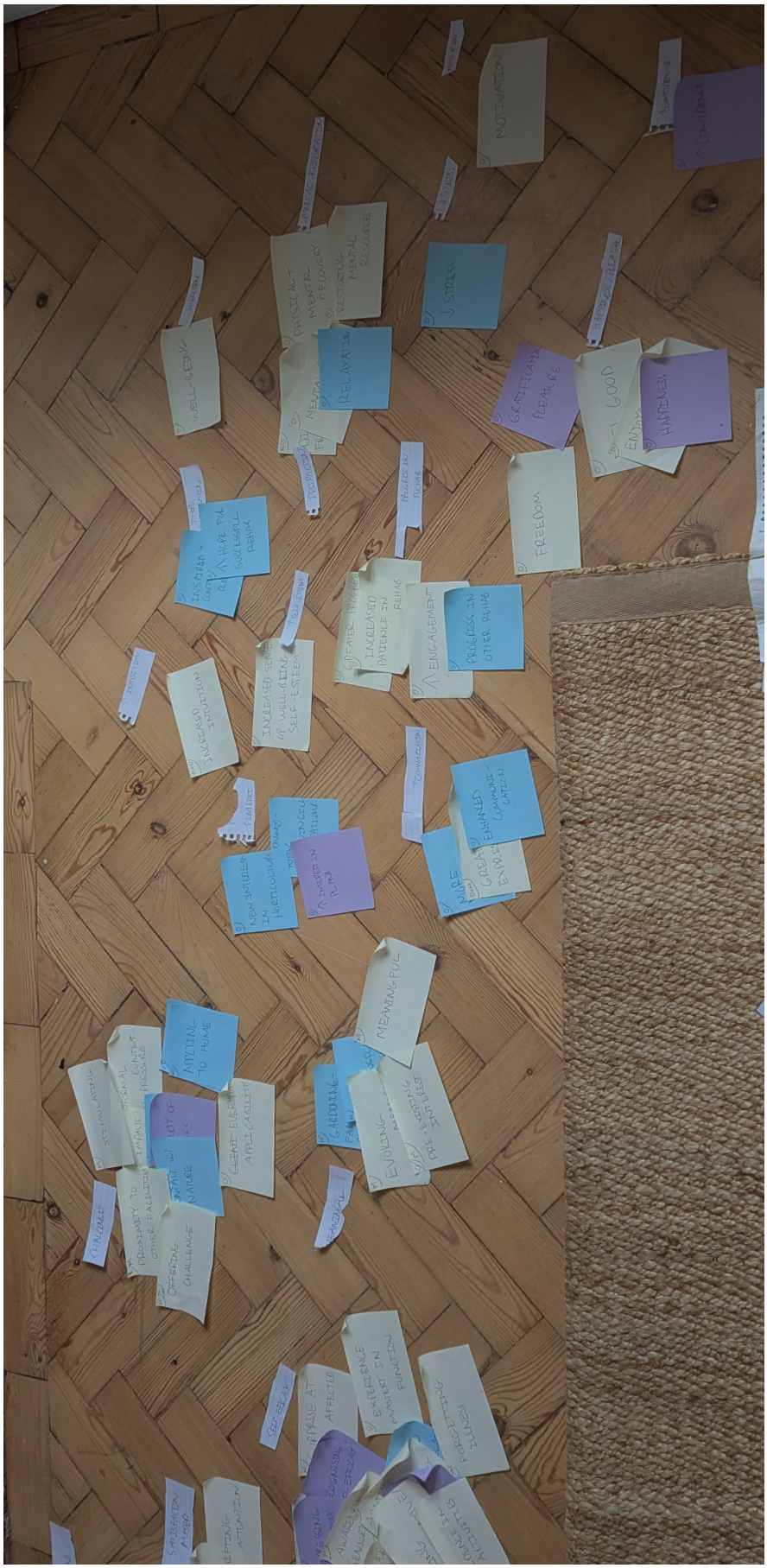
Appendix F – Mixed Methods Appraisal Tool

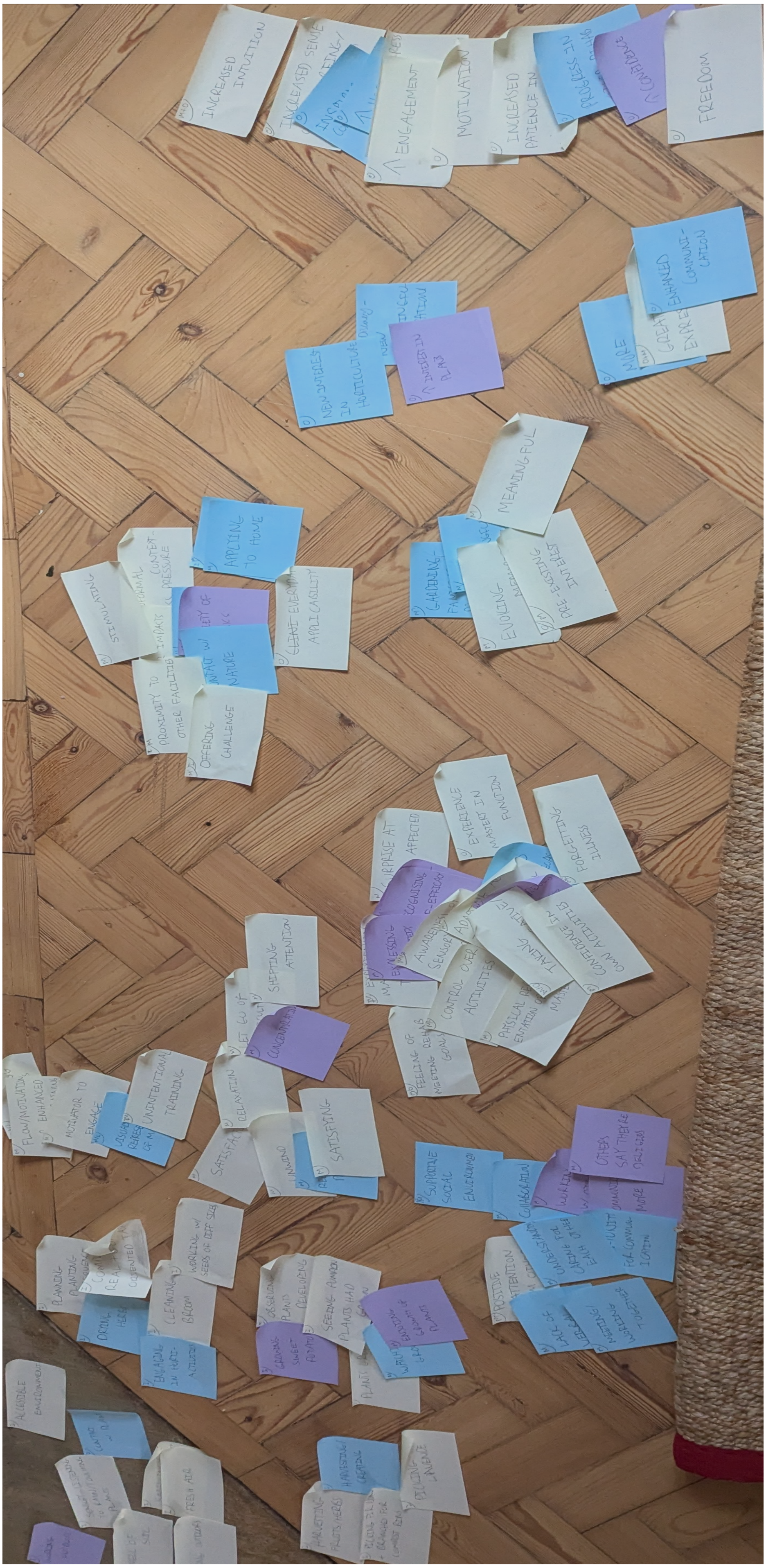
Part I: Mixed Methods Appraisal Tool (MMAT), version 2018

Authors:	**Title:**	**Year:**			
Category of study designs	**Methodological quality criteria**	**Responses**			
		Yes	No	Can't tell	Comments
Screening questions (for all types)	S1. Are there clear research questions?				
	S2. Do the collected data allow to address the research questions?				
	Further appraisal may not be feasible or appropriate when the answer is 'No' or 'Can't tell' to one or both screening questions.				
1. Qualitative	1.1. Is the qualitative approach appropriate to answer the research question?				
	1.2. Are the qualitative data collection methods adequate to address the research question?				
	1.3. Are the findings adequately derived from the data?				
	1.4. Is the interpretation of results sufficiently substantiated by data?				
	1.5. Is there coherence between qualitative data sources, collection, analysis and interpretation?				
2. Quantitative randomized controlled trials	2.1. Is randomization appropriately performed?				
	2.2. Are the groups comparable at baseline?				
	2.3. Are there complete outcome data?				
	2.4. Are outcome assessors blinded to the intervention provided?				
	2.5 Did the participants adhere to the assigned intervention?				
3. Quantitative non-randomized	3.1. Are the participants representative of the target population?				
	3.2. Are measurements appropriate regarding both the outcome and intervention (or exposure)?				
	3.3. Are there complete outcome data?				
	3.4. Are the confounders accounted for in the design and analysis?				
	3.5. During the study period, is the intervention administered (or exposure occurred) as intended?				
4. Quantitative descriptive	4.1. Is the sampling strategy relevant to address the research question?				
	4.2. Is the sample representative of the target population?				
	4.3. Are the measurements appropriate?				

Appendix G – Clustering Exercise




MOTIVATION
PHYSICAL
MENTAL
RECOVERY
RESTORING
MENTAL
RESOURCES
STRESS
RELAXATION
WELL-BEING
GRATIFICATION
PLEASURE
GOOD
ENJOY
HAPPINESS
FREEDOM
INCREASED
MOTIVATION
INCREASED
PATIENCE IN
REHAB
ENGAGEMENT
PROGRESS IN
OTHER REHAB
INCREASED
SELF-ESTEEM
INCREASED
COMMUNI-
CATION
MEANINGFUL
APPLYING
TO HOME
EVOKING
CHALLENGE
EXPERIENCE
MASTERY IN
FUNCTION
FORGETTING
ILLNESS


INCREASED INTUITION
ENGAGEMENT
MOTIVATION
FREEDOM
MEANINGFUL
STIMULATING
APPLYING TO HOME
OFFERING CHALLENGE
EXPERIENCE MASTERY IN FUNCTION
FORGETTING ILLNESS
SHIFTING ATTENTION
UNINTENTIONAL TRAINING
SATISFYING
SUPPORTIVE SOCIAL ENVIRONMENT