

Mobile Smartphone Applications for Healthcare Practitioners

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Abstract

Mobile Smartphone Applications (apps) have emerged in the last decade as a potentially beneficial tool for doctors. This thesis employs a novel investigative approach based on Realist Evaluation to investigate their prevalence, the outcomes of their use, and uncovers the key causal mechanisms and contexts that influence their use.

The first part of the thesis sets the scene for the investigation by explaining the need for this research in an environment where much has been claimed for and against app use, but with a limited evidence base on which to base such claims. A scoping study is used to assess the nature of the extant literature and identify key questions that need to be addressed about app use.

The next stage sets the scene for the realist empirical portion of the thesis, by explaining the need to take a theory-based perspective of the issues. The rationale for employing a realist methodology is described in terms of the need to examine causal explanations and contextual elements, with reference to the methodological implications for the rest of the enquiry. The elicitation of initial programme theory is then undertaken to provide a theoretical starting point for the thesis.

The final part of the thesis describes an interview study and a mixed-methods study, which in turn develop and then test theories relating to the decision to use an app. The thesis concludes with a discussion of the key findings, presenting an outline theoretical model as well as recommendations designed to enhance the development, implementation and safe use of apps.

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Chapter 1 - Introduction

Mobile Smartphone Applications (or apps as they are commonly known) are an emerging technology in healthcare but they are not without controversy, and research into their use in clinical practice is limited (Moore, Anderson & Cox, 2012). This thesis presents a three phase research project conducted in an English acute NHS Trust to investigate how and why apps are used by doctors in practice. This introductory chapter provides an overview of apps and their relevance in healthcare, identifying key issues pertaining to their use and why research in this area is important for clinicians and patients. The chapter will conclude with an outline of the research questions and an account of how this thesis addresses these questions. Subsequent chapters will investigate the use of apps applying a methodological framework grounded in a realist philosophy (Pawson & Tilley, 1997) that develops causal theories (phase one), refines these theories (phase two) and tests these theories using empirical studies (phase three), which in turn will provide practical knowledge that can be applied to the safe development, implementation and use of apps in healthcare. The thesis concludes with a discussion chapter incorporating implications for the introduction and use of apps in healthcare and future research in this area for future practice and research.

1.1 Apps

Mobile Smartphones, while possessing the text and voice calling communication capabilities of conventional mobile phones, are capable of providing internet access and sending and receiving email. They are also capable of running software applications (Mosa, Yoo, & Sheets, 2012), commonly referred to as Mobile apps. The term app also applies to software applications that support peripherals that attach to a smartphone or other mobile communication devices, or a combination of accessories and software (Boulos, Brewer, Karimkhani, Buller, & Dellavalle, 2014). As with software on conventional personal computers, there are apps that are

designed for a range of purposes from entertainment and gaming to business software. The availability of apps has expanded rapidly over the last decade, with a plethora now available to users through a number of online stores such as the Apple Appstore, Google Play, as well as being downloadable directly from some vendor and developer websites. Apps can be free or paid, or come in different versions, with “vanilla” versions of the app being free to users but containing only basic functionality, with premium versions of the software requiring the user to pay to access more advanced features or functionality.

1.2. App Use in Context

Hospitals are information-rich environments and this aspect of medicine has been the subject of considerable study (Reddy & Dourish, 2002). From information about patients, referring to medical research and protocols to diagnose or treat a condition, to working out who to contact to make sure tasks related to are done, information-seeking is an integral part of the professional life of hospital staff. Within this context, the ready availability of information is important for both efficiency and accuracy (Reddy & Spence, 2006) and it is within this context that the use of apps as useful tools for healthcare professionals is being studied. Apps in this study are seen as a potentially useful tool for healthcare professionals, and as an information technology innovation that is as worthy of study as any other.

1.3 Smartphones in Clinical Practice

Healthcare apps can be categorised into those aimed at healthcare professionals and those aimed at the general public. Apps have been shown to support a variety of routine medical tasks (Lewis & Wyatt, 2014), and it is apps designed for use by healthcare professionals in clinical practice that are the focus of this thesis. Apps have been promoted by some as beneficial for clinicians, for instance because they can potentially reduce clinical errors and encourage self-directed learning (Phillippi & Wyatt, 2011). There are those that are more cautious and highlight the

risks of relying on apps in any way because of the lack of evidence to ensure that they are safe to use in a clinical environment (McCartney, 2013).

1.3.1 Apps Available to Healthcare Professionals

There are a number of types of app available to healthcare professionals, with the Apple Appstore and Google Play having sections dedicated to apps for healthcare professionals. The use of mobile devices in healthcare is not a new phenomenon (Kho, Henderson, Dressler, & Kripalani, 2006), but the computing power and widespread availability of smartphones in combination with the additional functionality afforded by apps makes them a more compelling proposition than previous generations of devices (Free et al., 2013). One systematic review described the range of apps available, with the following types of uses identified: Disease Diagnosis; Drug Reference; Medical Calculator; Literature; Clinical Communication; Health Information System Client; Medical Training; and General Applications (Mosa et al., 2012). There is a large potential market for apps within the medical community, making the development of healthcare apps a relatively attractive commercial proposition (Boulos, Wheeler, Tavares, & Jones, 2011).

1.3.2 Affordances of smartphones compared to other resources

Smartphones have particular affordances that make them an intriguing proposition for use in medical practice. Affordances are design features or properties of an object that an actor can perceive, suggesting or determining how that object can be used in a given environment (Gibson, 1979). The small size and lack of dependence on wired connections of smartphones means that they are portable to an extent where a healthcare practitioner can carry them on their person without imposing restrictions to their mobility. Beyond this portability, their small size means that smartphones possess a particular affordance known as micro-mobility, which refers to the way in which an object can be moved or manipulated around a particular locale or setting in order to fulfil a specific purpose (Luff & Heath, 1998). Within the context of a medical consultation, this means that a smartphone can be easily passed from one actor to another,

repositioned or rotated to allow for better visibility, or moved to a different area according to the needs at the time – useful, for instance, when one wants to share visual information with a colleague or patient. This is a considerable advantage over conventional desktop and laptop computers, which are much bulkier and more awkward to reposition (Jayewardene, 2013).

The data processing power, user interface and display screen available on a smartphone means that these devices have the ability to hold a great deal of data that can be manipulated and displayed, giving them additional functionality over a paper record. Additionally, smartphones are able to access information not stored on the device itself owing to their connectivity, through either conventional mobile data or wireless internet access. All of this means that smartphones offer certain affordances over and above conventional information technology (IT) and traditional paper resources.

Some of these affordances of smartphones are reliant on other factors. The ability to connect to the internet requires sufficient wireless signal, and their micro-mobility is in part owing to their running on a fixed capacity battery. This means that the onus is on a user to ensure that there is a sufficient charge in the device to allow for use over the course of a working day or shift. Furthermore, whilst smartphones are effectively miniature computers, they are unlikely to possess as much processing capacity as their larger equivalents, and have a smaller screen. This may mean that they are not as fast as larger devices, and they are less adept at displaying large quantities of usable information in a user-friendly manner.

1.4 Prevalence of App Use within Healthcare

There is limited published evidence on the extent of app use in healthcare settings, and on how often different groups of clinicians use smartphones and healthcare apps (Devices 4 Ltd (d4) 2010; Franko & Tirrell 2011). One of the earlier surveys of the use of smartphones at work (Devices 4 Ltd, 2010), 80% (n=474) of healthcare professionals said they carried a smartphone at work, and 18% of these respondents ran work-related

software or apps. However, more recent surveys of clinicians in the literature suggest that ownership of apps is quite common and growing. In contrast to the D4 survey, a more recent study of medical students and junior doctors in the East Midlands region of the UK demonstrated an increased ownership of medical apps by doctors (76%, n=98) and medical students (80%, n=203) (Payne, Wharrad, & Watts, 2012), but the frequency of usage varied widely, ranging from several times a day to never. An online survey of doctors and nurses in the UK conducted in conjunction with colleagues at Bradford Institute for Health Research also found smartphones were widely used; of the 416 respondents, 77% (58% of nurses and 83% of doctors) reported that they use smartphones at work (Moore & Jayewardene, 2014). Formularies and online textbooks were the type of apps most widely used, with clinical calculators also widely used.

A larger survey, this time from the United States, was of doctors on Accreditation Council for Graduate Medical Education training programmes (Franko & Tirrell, 2012). More than 85% of 3306 respondents said they used smartphones, with 63.5% of respondents using apps. A qualitative trend was suggested proposing that app use was higher among those respondents with less medical training, yet the study design does not afford this to be a causal link. There was also a substantial variation in use between medical specialties, with use in emergency and family medicine substantially higher than in more specialised areas such as paediatrics.

The results of these surveys suggest smartphone use in medicine is becoming more widespread, that doctors are more likely to use apps than nurses, and that straightforward reference material is the most common form of app used. There are, however, limitations to these findings. In all of the surveys, potential respondents were contacted by email, and response rates were often not reported. Studies could have been subject to response bias, in that the respondents may have been more interested in smartphones in the first place, thus responding more positively than the general population of healthcare practitioners. Therefore, while it seems safe to conclude that smartphone use amongst healthcare professionals is increasing and that app use is becoming more widespread, there is not enough data to give a reliable assessment of prevalence within the

healthcare community. Moreover, none of the surveys described go into detail as to what the drivers and barriers to using apps (and smartphones in general) are – in that way they have little explanatory power.

1.5 Potential effects of app use

The surveys described in section 1.4 tell us little about constitutes safe use of apps, and what the effects of app use are. Drawing on extant literature, the following sections describe some of the potential benefits and risks of clinicians using smartphone apps in healthcare.

1.5.1 Proposed Benefits of App Use

1.5.1.1 Availability of information at point of care

The affordances described above mean that smartphone apps offer some specific benefits to users. A fundamental benefit available to users is the ability to retrieve information from where they are at a given moment and clinicians can access information with “unprecedented ease” (Lewis & Wyatt, 2014). For instance, a ward computer may be at the nurse’s station, or a text book may be left on a trolley which could be located anywhere on the ward. In theory, this means that healthcare practitioners do not need to leave the patient’s bedside to look up certain information, although this will be dependent upon the particular information available to the doctor (for instance, through an app). This one affordance creates the opportunity for a number of potential benefits in terms of clinician efficiency, well-being and patient safety.

1.5.1.2 Increased efficiency and effectiveness

A corollary of this availability of information at the point of care is that healthcare professionals can look up information on the spot, meaning that, in theory at least, they can reduce their reliance on other sources of information, such as ward computers or books that may be in use by colleagues, located some distance from the point of care, or simply scarce or hard to locate. This means that certain tasks requiring additional information can be completed in real time, reducing the time required to complete a particular task. Furthermore, this ability to potentially complete

a task then and there, rather than having to put it on a to-do list for a less busy time, potentially reduces delays to decisions that may have an influence on patient care. In time-critical situations, this could have a profound influence on patient care. Much has been made of the potential of apps to improve efficiency and improve quality of care by providing access to high functionality at the point of care, and numerous thinkpieces have been published espousing their benefits within specific fields, such as orthopaedics (Al-Hadithy, Gikas, & Al-Nammari, 2012) and neurology (Buis, 2010). In these cases, much is made of the time-saving opportunities made available by having information in the palm of one's hand.

As well as increasing speed of action, it is possible that an app could facilitate the making of better-informed decisions by providing accurate information at the point of care that an individual may not be able to bring to mind or otherwise access because of time constraints. For instance, reputable apps such as the British National Formulary app that contains medication dosage information make potentially safety-critical information available to users at the bedside, allowing clinicians the opportunity to check and calculate a safe dosage without delaying administration of the dosage. This could theoretically prevent a clinician from making an incorrect decision, thus reducing the likelihood of errors leading to patient harm.

1.5.1.3 Reduction in Stress

This increased efficiency could lead to additional benefits for the individual clinician. By making certain tasks quicker, the clinician may thus be able to more easily fit tasks into allotted work time, reducing the need to work beyond rostered hours. An app making information available at the point of care may result in a reduction in either perceived or actual work demands, thus reducing the stress and strain placed upon an individual. An increased availability of resources to match job demands has been theorised to benefit an individual through improved wellbeing (Karasek, 1979), and may also have patient safety implications – tired and stressed

clinicians are more prone to mistakes that might compromise patient safety (Landrigan, 2004).

1.4.1.4 Improved Communication with Patients

Apps could be used for increasing patient awareness of their own conditions and care activities, for instance through the use of self-monitoring apps or shared care plans. The patient can keep the information on them at all times when they have their phone rather than having to carry separate documentation or devices. Apps can also be used to support clinician awareness of patient symptoms, for instance through capture of information prior to the clinician-patient encounter, or even through the provision of a means for patients to more easily communicate their experience of the symptoms (Leon, Schneider & Davlaud, 2012).

1.5.2 Risks and Concerns relating to app use in healthcare

1.5.2.1 Absence of evidence for safe use

The proposed benefits of app use have yet to be validated, unlike other areas of medicine, whereby the use of different treatments and medicines are usually evidenced by research from clinical trials and other research evidence. The rate of growth of the app market is not without its risks, and this rate of growth has exceeded the ability of the research base to keep up (Visvanathan, Hamilton, & Brady, 2012). As such, the evidence base for their efficacy and safety is sparse, with very few evaluation studies published (Ozdalga, Ozdalga & Ahuja, 2012)

1.5.2.2 Paucity of Regulation

Unlike many other medical technologies, apps are available on the open market and usually marketed directly to users. They are also often created by commercial entities that are motivated by profit. This in itself may not be harmful but there are few if any safeguards to ensure that the content is accurate and that they do what they say, and little or no training available to ensure that they are used correctly (Buijink, Visser, & Marshall, 2013).

Regulatory bodies have been relatively slow to act, although the EU, MHRA and (in the United States (US)) the FDA have issued draft guidance on how

they should be regulated (Sherwin-Smith & Pritchard-Jones, 2012). However, this guidance reflects the difficulties in classification of apps, particularly with reference to whether they should be regulated as medical devices or not (Barton, 2012). More recent guidance on the assessment of apps was released in 2017, and while this guidance is still in draft form, at least it has provided clearer guidance on the status of certain apps as medical devices – essentially anything that uses patient-specific information (Mulryne & Clemence, 2017). However, certain apps aimed at clinicians may not fit this definition precisely. This ambiguity in the regulatory guidance has the effect of making the market more uncertain for developers, as the cost of compliance with the regulations may discourage app developers, whilst leaving the vast majority of apps already on the market relatively untouched; to date, only one consumer app (for acne treatment) has been withdrawn from the market in the US, and even this was not for medical reasons. It was sanctioned because it flouted marketing rules, making unsubstantiated claims to remedy acne through the use of light from an app (Hamilton, & Brady, 2012).

1.5.2.3 Patient harm arising from erroneous use of apps

There is a potential risk of clinical errors that might not otherwise be made because of using an app. Incorrect inputting of information through mistyping could lead to an incorrect output, for instance when inputting information into a drug dosage calculator, which could lead directly to patient harm through prescribing an incorrect medication dose. Such inputting errors, though essentially errors made by the user, may be made more likely through poor user interface design and as such one might argue that the error is at least in part attributable to the use of an app. One must caution, however, against assuming that such errors occur purely in the domain of app use, since many medical errors are attributable to the incorrect use of regulated medical devices (Zhang, Patel, Johnson & Shortliffe, 2004)., Indeed the influence of other system-level factors (such as physical environment and workload on errors is acknowledged in theories addressing the occurrence of errors, such as Reason's Swiss Cheese Model (Reason, 2000) and the Yorkshire Contributory Factors Framework (Lawton et al., 2012) . Indeed, the use of apps may in some

cases prevent errors occurring through, for instance, the reduction of possible error in a manual calculation. It would therefore be inaccurate to assume that this is an entirely novel risk that is exclusive to app use or to deny the possibility that they might assist in the prevention of errors that might otherwise occur.

1.5.2.4 Use of apps containing inaccurate or incorrect information

Another source of risk that may be posed by app use is the potential for apps to contain incorrect information that may lead to incorrect conclusions being drawn by the user. For instance, an app claiming to contain information about protocols may contain information that is outdated or simply inaccurate. No conscientious clinician would deliberately use an app that they knew to be unsafe, but the lack of information available to a user about whether a given app is safe to use or not, in part owing to the lack of regulation described earlier, may mean that the onus is on the user to verify the content of the app. It is impractical for a user to verify every single piece of information in an app, and with use of incorrect information possibly leading to patient harm, this does appear to be a genuine risk created by app use.

1.5.2.5 Patient Perceptions of App Use

One risk that has been highlighted in the literature is the impact on patient perceptions (Hsieh, Yun, Bhatia, Hsu, & De Luzuriaga, 2015). If a patient sees a clinician using their mobile phone on the ward, it may lead them to believe that they are engaging in non-work activities. This may lessen the confidence of the patient in the professionalism of the staff treating them, lessening the likelihood that the patient adheres to medical advice or instructions issued by those staff and increasing the likelihood of poorer patient outcomes. In addition, the patient may simply feel more uncomfortable at a time which is already likely to be difficult for them. Even if a patient is aware that a member of staff is using their phone to refer to information pertinent to their care, this may undermine their confidence in the staff member, and as such have similar outcomes to those relating to beliefs that the staff member is being unprofessional. A corollary to this is the idea that few clinicians would wish to be seen as

incompetent or unprofessional by patients, and as such, this may actually be a barrier to using smartphones (at least in patient areas) . As with the other risks highlighted thus far, the lack of research in the area means that there is insufficient evidence to determine whether such ideas are purely speculative or actual risks to patient safety.

1.5.2.6 Other Risks Associated with App Use

Evidence suggests that smartphones are an infection risk because of the bacteria that they carry (Ulger et al., 2009), potentially leading to risks to patient health and wellbeing. Many hospitals have strict infection control policies and protocols that lessen the risk of such infection, but many of these will not have been devised with smartphones in mind.

The distracting effect of mobile phone use has also received some attention within the literature (Broussard & Broussard, 2013). Whilst the user may intend to use an app for a care-related task, the fact that the app is on a mobile phone may mean that use is interrupted by the receipt of non-work related communication such as a text message or telephone call. This may not only interfere with the completion of that particular task, but the alert associated with the communication may distract or annoy colleagues undertaking work-related tasks.

1.6 The Need for Additional Research

1.6.1 Existing evidence base for app use

Whilst apps potentially possess many qualities that make them attractive, there are a number of unanswered questions as to the impact of their use and relating to the circumstances within which they are most likely to be used. There have been many papers describing how such apps are developed, and stating how the app will fulfil unmet needs, but limited evidence of research activity and/or reviews of app effectiveness. A comprehensive review of the empirical literature in this area is presented in Chapter 2.

1.6.2 Absence of theoretical basis for apps as an intervention

Research studies to date have focused on testing whether an app can be used to accomplish a task as well as the standard method or protocol (e.g. Jenny, 2012; Walter, Kosy & Cove, 2013), often in laboratory settings. An apparent assumption underlying such work is that evidence of the efficacy of the app is sufficient to persuade the community to use them. What is known from other research in the medical technology field is that an understanding of the context within which the technology will be used is crucial to its safe and effective implementation (Karsh, 2004). There is very little exploration of the factors that affect whether an app will be used or what impact it will have. Some surveys have been undertaken to find out perceptions and attitudes to apps (Moore & Jayewardene, 2014), but these have often been undertaken in quite general terms, and have assessed relatively few factors. There is a striking absence of theory across the literature as a whole.

Apps are unique compared to other technology in healthcare in that they are often something that the user can choose to use, with relatively few healthcare organisations or professional bodies mandating their use in the same way as other equipment. Apps are often used on personal smartphones rather than organisationally owned equipment, and organisations may not have governance in place that has been designed to address such situations. This lack of mandate and formal governance suggests proximal factors are likely to have an effect on decisions to use apps. Furthermore, the regulated nature of healthcare professions and affiliations of staff to professional bodies may also have an effect on how or whether apps are used – endorsement or prohibition by a relevant Royal College would likely have an effect on usage rates.

Much of the literature suggests that apps may have the potential to be a useful addition to a clinicians' toolkit, but also highlights a number of potential risks inherent in their use. The small amount of empirical research relating to their efficacy or actual threat to safe care means that there is a pressing need for research in this area to provide robust evidence. Very little is known about what factors affect the use and effectiveness of apps, and owing to the discretionary nature of their use, it

is unclear what extant theory relating to technology adoption is directly applicable. This thesis will address these gaps.

1.7 Research Context

1.7.1 Background to the project

This PhD is funded by the Bradford Institute of Health Research (BIHR) at the Bradford Teaching Hospitals NHS Foundation Trust (BTHFT), and is in part informed by a previous bid for funding by this group. The emphasis of the original bid was on the creation of knowledge that has a practical application within healthcare organisations so the goal of the thesis is to provide information that will have utility for healthcare professionals, organisations and also app developers.

1.7.2 Utility of a non-technological focus

The perspective taken in this research is that the investigation of apps is not purely a technological issue, but that a psychological perspective can also offer valuable insight into how and why apps are used and what effects they may have (intended or otherwise). Such a perspective is reflected in the literature regarding other health technologies (Eason, 2007).

1.7.3 Types of apps to be investigated

1.7.3.1 Selection of Reference Apps as Area of Investigation

One potential pitfall when investigating an area as broad as app use is the wide range of apps that are available and potentially within scope. The range of potential apps is vast – it would be the equivalent of investigating utility of desktop computers in healthcare – so for this reason, the investigation will focus on those apps that are designed to allow the user to refer to information at the point of care. There are three main reasons for this choice.

- 1) Such apps are easily relatable to the benefits and risks discussed in section 1.4. They are subject to all of the issues relating to mobile smartphone use in general, whilst being relatively uncontroversial.

- 2) Based on research to date, these are the apps that appear to be most commonly used, so the probability of finding users of these types of app is likely to be higher than finding users of more specialised apps.
- 3) Colleagues at the BIHR developed an app called Ignaz, designed with trainee doctors in mind but available to other healthcare professionals within the Trust and other Trusts in the region that have signed up to the app.

1.7.3.2 Ignaz

Ignaz was conceived by doctors working within BIHR as a complementary resource to the Junior Doctor's handbook issued by NHS Trusts. The logic is that trainees rotate regularly between hospitals and Trusts, and usually have to familiarize themselves every few months to a new department and/or hospital and/or Trust. Ignaz has been designed to hold information local to particular hospitals, making it easier to find out information regarding bleep systems, nearest ECG machines, the canteen opening hours and so on, in order to facilitate the transition of trainees between hospitals. Typically, this information is discovered by an individual over time, through access to websites, colleagues and paper resources. By providing this information on a mobile phone and the affordances that such a device provides this information is immediately available at the location and time that it is needed. Thus the aim of Ignaz is to streamline working, thereby improving patient safety and quality of care.

The original intention of this research was to use the evaluation of Ignaz as a means of answering wider questions about app use and its effects. As explained at the end of this chapter, this focus altered as the research progressed. Nevertheless, Ignaz served as a useful reference point throughout the research as a concrete example of an app that was designed for use by doctors, and access to those involved in its development was invaluable as a source of data throughout the thesis.

1.7.4 User Population

From the surveys described in section 1.3., it is apparent that doctors are more likely to use apps than nurses. Furthermore, whilst it has been noted

that there is a lack of guidance and regulation around app use, nurses have been actively discouraged from using their personal mobile phones in clinical areas by the Royal College of Nursing (Royal College of Nursing, 2012). For this reason, the current study will examine app use amongst doctors.

1.8 Thesis Aims and Objectives

1.8.1 Aim

This chapter has shown that apps are becoming more widely used, but that relatively little is known about app use among doctors, the factors that affect app use and the impacts of that use. This thesis aims to close these gaps by investigating how and why apps are used by doctors in a hospital setting. By doing so, this thesis will generate usable, practical knowledge through the development of appropriate theory, that can inform the effective and safe design, development and use of apps in healthcare. In order to achieve this aim, the thesis describes a research programme intended to elucidate the nature of app use among doctors in a hospital setting, identifying patterns of use and factors that affect that use, as well as identifying factors that affect the effectiveness of that use.

1.8.2. Objectives

The original plan for this PhD was to conduct a realist evaluation of a specific app called Ignaz. Chapters 3 and 4 explain in detail why this would have been an appropriate method of investigation. As will become clear, the thesis shifted focus part way through the empirical work to an investigation, employing realist methods, into what “causes” smartphone app use in doctors. This was due to a number of reasons, which are discussed in more detail in Chapters 6 and 7, but can be briefly summarised as follows: the lack of availability of Ignaz as an evaluand due to slower roll out than anticipated; the inconsistent pattern of app use among doctors; and the realisation on the part of the researcher that the adoption and use of smartphone apps by doctors was in itself an under-researched area and that there was an opportunity to add to knowledge of

the causal processes relating to app use. As such, the research questions are as follows:

- 1) Discover to what extent apps are used by doctors in live settings, and identify patterns of use related to users across different contexts;
- 2) Identify which types of apps are used most extensively;
- 3) Identify the key causal mechanisms that lead to app use;
- 4) Identify relevant contextual elements and how they:
 - a) Influence the firing of key mechanisms identified
 - b) Influence the response of users when those mechanisms are fired; and
- 5) Use the information gathered on contexts, mechanisms and outcomes to generate better theory relating to the use of apps by doctors, and apply this learning to generate guidance for the design, implementation and use of apps by doctors.

1.9. Thesis structure

The remainder of the first part of this thesis continues by providing a scoping review of the extant literature on app use in healthcare settings, which will gather evidence not only relating to the extent of app use, but also to the types of factors that influence app use, and draw out any theoretical approaches that have been used and been shown to be useful in elucidating issues around app use (Chapter 2). The middle chapters move on to the theoretical underpinnings of the research. Following an outline of the realist approach and reasons for selection of this approach (Chapter 3), the application of the realist approach to this thesis is described (Chapter 4). Initial theories are developed and elaborated, drawing on grey literature and empirical studies of related technologies (Chapter 5). The final three chapters describe the empirical research and findings. Chapter 6 describes an interview study designed to further develop and refine these theories Chapter 7 describes the next stage of the empirical work, which involved the use of mixed methods to further refine

and test the theory. These empirical chapters will provide evidence to address the extent to which apps are actually used as well as providing information pertaining to the specific circumstances within which apps are and are not used. The final chapter of the thesis (Chapter 8), is a general discussion of the findings from the scoping study and empirical studies, and will focus on interpretation of the findings and the theoretical contribution and practical implications for app use in healthcare, incorporating recommendations pertaining to app use in healthcare as well as suggested avenues for future research.

Chapter 2 – Scoping Study of App Literature

2.1 Introduction

This chapter describes the main literature review portion of the thesis, which takes the form of a scoping study (Arksey & O'Malley, 2007). Following an explanation of the reasons for choosing a Scoping Study, the methods employed in selecting and appraising the extant literature are described, findings related and the implications for the present thesis are discussed.

2.1.1 Selection of review methodology

The literature review portion of the thesis needed to fulfil a several criteria. First of all, it was necessary to situate the present research in an appropriate practical context. Thus, it had to find out what research had been done, where the gaps in the literature were and what approaches had been used in the study of app use by doctors. The type of understanding required was both in terms of the types of research undertaken and appreciation of theoretical considerations – what factors have been identified that might affect app use and why. Furthermore, it was desirable that the chosen approach yield an output that is useful on a practical level for users of the research – that is, to produce an output that would generate findings that have practical value to researchers and practitioners alike. An additional issue outlined in the introductory chapter of this thesis was the relatively small body of empirical research available to survey. Therefore, it was also desirable that the chosen literature review methodology was able to take account of a range of empirical study designs to maximise the evidence base available for review.

In order to meet these needs, it was decided that a scoping study would be the most appropriate form of literature review. A firm definition of a scoping study is difficult to establish (Arksey & O'Malley 2007), but it can be characterised in terms of its general form as reconnaissance about the relevant area (Davis, Drey & Gould, 2009). It aims to map the key concepts underpinning a specific research area as well as the main

sources and types of evidence available, with the emphasis on addressing the breadth of literature available quickly (Mays, Roberts & Popay, 2001).

Arksey and O'Malley (2007) suggest that scoping reviews can either serve as the precursor to a systematic review addressing a specific research question or as an end in and of themselves, with the primary purpose of mapping the overall landscape of the evidence base. It is in this second sense that a scoping study is used in this thesis.

2.1.2 Strengths and Limitations of Scoping Studies

Understanding the range of extant literature aids in identifying gaps and innovative approaches in the literature (Ehrich, Freeman, Richards, Robinson & Shepperd, 2000), allowing one to identify potentially fruitful avenues of research. It is also a flexible method, with sufficient transparency of methodology to ensure rigour whilst offering the opportunity to adapt the data to be extracted to meet the needs of the review (Rumrill, Fitzgerald & Merchant, 2010). This flexibility also involves the ability to involve stakeholders in the conception of the study, helping to assure that the study will cover material of interest to stakeholders in a practical sense.

Scoping studies do have clear weaknesses. The need for quality assessment is not explicitly addressed in much of the literature on scoping studies and is usually not undertaken, opening the methodology up to criticism for a lack of rigour in study selection (Arksey & O'Malley, 2005). Were the nature of the research question to assess whether apps “work” or not, a systematic review would have been appropriate, and a formal quality assessment would have been essential. The purpose of this particular study in understanding the breadth of empirical research available and crucially, in identifying gaps in the overall body of research, means that the quality of the body of research is less important than its form.

Another potential drawback of the scoping study approach is the potential for a researcher to be overwhelmed with data (Levac, Colquhoun & O'Brien, 2010) due to the relatively “low bar” for inclusion of studies in terms of quality and form. This is something that has the potential to make the study unwieldy and dense. Therefore, this was a consideration during paper selection and data extraction.

Two issues relating to the synthesis of evidence also arise. Not only do scoping studies not produce a synthesis of findings, but neither is there an attempt to tackle this perceived shortcoming (Arksey & O'Malley, 2005). This in part is due to the emphasis on inclusion of different forms of evidence. The explicit purpose of this study, however, is to provide a summary rather than a synthesis of the evidence, and for that the scoping study meets the purpose. To use an analogy, the output of the scoping study will be a map which one can read and then choose to plot a route through, rather than a step-by-step set of directions. This could be seen as limiting the utility to other users, but to do otherwise might at best risk over-interpreting limited evidence or worse, make invalid comparisons between disparate sources of evidence leading to logically flawed conclusions. Therefore, it is with caution and eyes open that the scoping study methodology is employed in this instance.

2.2 Methods

The approach employed to undertake this study is similar to that described by Arksey and O'Malley (2005) comprising five stages. Following the identification of appropriate research questions (1), appropriate papers were identified (2), selected (3), and the data then extracted and charted (4). The final stage was the collation and summary of evidence (5).

2.2.1 Identification of appropriate research questions

Given the nature of the extant literature, and initial broad focus of the scoping study, a two-pronged approach was employed in choosing the research questions for the study. An initial scan of the extant literature was used, stakeholders were consulted and a survey conducted by colleagues at the BIHR was also used. How each of these sources was used is described in the following sections.

2.2.1.1 Initial Scan of the Literature

The relatively recent advent of smartphone apps combined with the long lead time required for publication in peer-reviewed journals meant that it

was quite difficult to locate relevant academic articles. The purpose of the scoping study was to provide information on the use of apps in healthcare, so the lines of enquiry followed reflected this focus. The researcher conducted some exploratory searches in late 2011 of relevant medical databases such as medline, but these yielded limited results. However, there is a plethora of material relating to smartphone app use in healthcare housed on specialised sites, such as Happtique, Digitalhealth.net (at the time known as e-Health insider), and imedical apps. Websites such as these tended to house material promoting the use of apps, taking for granted that apps are a positive development in healthcare. The wider literature on app use in general was not examined due to the focus of this thesis on use of apps in medicine.

From reading such websites and magazines, it became apparent that much of what had been written about apps was about the *potential* benefits and/or downsides of app use in healthcare, which were covered in Section 1.5 of the present thesis.

2.2.1.2 Stakeholder Consultation

The purpose of the stakeholder consultation was to inform not only the research questions for the scoping study but the thesis as a whole; it was important to understand what stakeholders knew about apps and their use, what concerns they had and what they would want to know about app use. Given the breadth of the topic area, the researcher decided to incorporate an element of stakeholder consultation as suggested by Arksey and O'Malley (2005). How such consultation is undertaken is not addressed in the literature but, in this thesis, consultation was conducted with the aim of helping to focus the research questions and providing an insight into what elements of app use stakeholders were interested in. The term stakeholder in this instance was applied in a very broad sense, in that not only were the views of NHS staff with a vested interest in the outcome of the research sought, but also those of researchers with relevant expertise. Asking NHS staff about their views of app use and mobile phones in general was expected to provide information that would ground the research in a real world context. When considering that one of the success criteria of the

research was the practical applicability of the findings, this incorporation of the views of practitioners was critical; increasing the relevance of the research questions has been identified as increasing the likelihood of the uptake of findings in policy and practice (Valaitis et al., 2012). The inclusion of researchers with relevant expertise as 'stakeholders' was primarily to advise on potential information sources or areas of related research.

Due to the lack of guidance in the literature, a pragmatic approach was taken to identifying relevant stakeholders. The stakeholders consulted were from three groups: managers and staff in the NHS Trust funding the work (to get both a management and a clinical perspective); researchers in the Health Informatics field; and members of the BIHR staff with an interest in health technologies. Relevant researchers were identified with the help of supervisors and informal meetings were arranged with two researchers. A similar approach was used to identify appropriate BIHR staff, and two meetings were arranged. NHS staff were identified with the help of one of the thesis supervisors who works at the BTHFT, and three meetings were arranged. These people were contacted by the supervisor mentioned by email, and the researcher followed up with a brief email containing more information about the study plans, requesting an informal meeting. Meetings were arranged with those that responded. The meetings themselves were informal, with three basic questions used to structure the conversations so that the relevant topics could be covered:

1) Are you aware of the use of apps by healthcare practitioners in your organisation?

This question was used to get an understanding of the stakeholder's knowledge of app use in healthcare, and was of most value when talking to trust employees.

2) What are your main areas of concern/hope/interest with regard to apps?

This purpose of this open question was to identify what issues relating to apps were of most interest to stakeholders

3) Are you aware of any ongoing work regarding apps?

This was mostly aimed at researchers to understand the academic landscape, but was also useful in understanding the level of Trust employees' knowledge of what was going in their organisation – for instance in relation to the Ignaz app described in the previous chapter.

These consultations or conversations were not formal interviews, with no audio recording and only basic field notes taken regarding answers to questions. The aim was to get a general view of what the stakeholders thought was important regarding apps. In order to get a patient perspective, the Patient Panel at BIHR - a small group of a patient volunteers that the BIHR work with to gain a patient perspective on ongoing research projects - were also consulted. The researcher had a short slot at what is a regular quarterly meeting, explained the purpose of the research and asked for any comments or suggestions as to what issues were of particular interest to the panel members. The meeting was not audio-recorded but, as with the other stakeholder interviews, basic field notes were taken.

As noted by others (Anderson, Allen, Peckham, & Goodwin, 2008) , one of the issues relating to the stakeholder consultation is that it often succeeds only in raising broad themes rather than specific questions, and that was true of this particular exercise. However, there was some commonality in the themes that were raised.

One particular issue is that many of the interviewees were not active users of apps, but knew of people that did use them in a healthcare context. During conversations with NHS staff, there was a shared view that there was no policy at an organisational level on the use of apps, and that this lack of strategy was more threat than opportunity – it was commonly raised that people would use the resources they saw as most useful and that it was in the hands of the users to ensure that they were referring to credible information. There was also a thread of scepticism as to the utility of apps – even those that were positive about them generally were cautious as to how widely they could or should be used. This was often coloured by previous experience of technology (particularly IT) in the workplace. Encouragingly for this thesis, there was generally a belief that apps or an

equivalent technology would probably become more widely used and that they could be beneficial.

Researchers were also generally positive about apps, and raised the issue of the impact of regulation, and whether this would stifle app development. They were also conscious of the risks of app use with regards to patient safety, and so there was an interesting tension between the need to regulate and control use whilst not stifling innovation. Patients were keen that doctors use best resources available to them. They were conscious of the fact that technology can get in the way of the doctor-patient interaction, but they felt, that as long as the doctor was explained what they were doing and were not absorbed in the technology, they would find that acceptable.

2.2.1.3 Scoping Study Research Questions

Stage 1 of the scoping study was successful in identifying some of the issues of interest to practitioners, patients and researchers, and provided some information about current usage patterns, but did not justify narrowing the scope of the review. Therefore, at this point, the Research Questions for the Scoping Study remained general in nature; the aim was to find out as much about app use from the literature as possible, and to do this the scope was kept deliberately broader than the aims of the thesis.

1. What types of study have been undertaken to investigate app usage by clinicians?
2. What is known about who is using apps and how they are being used?
3. Where are the gaps in research?
4. What theoretical frameworks and contextual factors have been considered in the study of apps?

2.2.2 Identification of papers

The initial literature search was designed to include papers that might include reference to research on app use by healthcare professionals. This was to include both apps designed specifically for use by healthcare professionals and apps designed for other purposes but that were used by

healthcare professionals as part of patient care or other service provision or delivery. Of interest to this thesis was the use of apps by any healthcare professional group as opposed to apps that are used primarily by patients. All healthcare groups were included because of the potential for shared contextual factors across groups working in similar contexts e.g. in a hospital setting. Due to the relatively small body of research available, a variety of study types that have investigated mobile phones that might have included relevant information, studies were not excluded based on their study type or design. All reported performance and outcome measures were considered. This included qualitative and quantitative data and data on both measurable impacts and staff/patient perceptions.

Literature searches were conducted on CINAHL, embase, medline and medline (in process) databases during March 2014 using search terms mobile, and *health* with associated MESH terms. After removal of duplicates, 1125 papers were put forward for abstract review.

2.2.3 Selection of papers

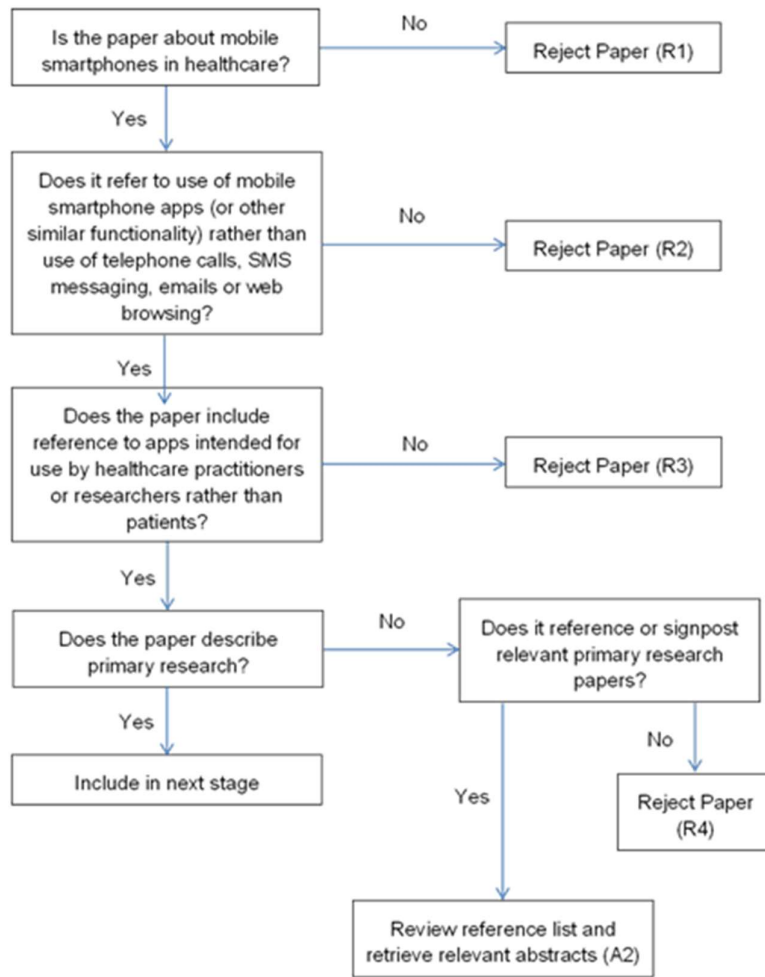
As well as needing to include relevant papers, the process for selecting papers limited the criteria to those that directly addressed the research questions. The inclusion criteria employed were very strict regarding the topic of the research – papers had to address the *use of an app* by *clinicians in healthcare settings* and had to *describe primary research*. These criteria were agreed with supervisors and developed into a process flow shown in figure 1.

The results of the initial search were then narrowed through the review of abstracts. Each abstract was double reviewed – the researcher assessed every paper for inclusion, and each of the supervisors took approximately one third of the volume, with any discrepancies discussed – where there was doubt over eligibility, the paper was included in the next stage. 305 papers were initially put forward for full paper review.

The full paper review followed a similar process, using the same criteria as the abstract review. However, after half of the papers had been reviewed, it was apparent that the level of agreement was again very high, so a pragmatic decision was made that the researcher would review the

remainder of papers. Following this stage, a total of 205 papers were put forward for data extraction.

Figure 1. Flowchart explaining selection of papers for review



2.2.4 Charting/extracting the data

A template was developed to capture data from the papers that were selected. The use of a data extraction form is common in scoping studies and serves to safeguard reliability through the provision of a framework for consistency of data extraction across papers (Levac, Colquhoun & O'Brien, 2010). In order to counter the issue of being overwhelmed with data, only data pertinent to the study aims were extracted. This included data on study design, theoretical frameworks used, findings, and explanations for findings. The data extraction was concerned with the following elements:

Purpose of study; Research design and methods; Number of participants; Study setting; Results; and an assessment of whether theory - formal or informal - was used. Using these criteria essentially acted as a form of quality assessment as the majority of papers had insufficient detail to populate the extraction sheet. For instance, insufficient description of methods or results resulted in a paper not being included in the final selection.

2.3 Results

2.3.1 Overview

Information was extracted from 73 papers. The most frequently occurring study types were those that were testing the efficacy of mobile phones and associated apps for use as medical devices (n=50). These varied from clinical trials with blinding or experiments with control groups (n=36), to proof-of-concept studies demonstrating the feasibility of using a particular app or apps(n=14). There were also surveys examining proliferation of smartphone and app use some of which included attitudes to app use (n=8). There were also case studies examining how specific apps were developed and implemented (n=2), and some that looked at the effect of introducing apps on wider programme or intervention outcomes (n=10). The ensuing sections examine the main topic areas pertinent to this thesis in more detail.

2.3.2 Types of study

2.3.2.1 App Efficacy

Fifty of the 73 studies examined the efficacy of a specific app in performing a diagnostic task. Of these studies, 14 were proof of concept studies designed to demonstrate whether particular task could be accomplished using an app or a system incorporating an app component, whilst 36 compared the efficacy of an app with an existing standard or method. In many studies, the functionality afforded by accelerometers incorporated within modern smartphones was leveraged to perform diagnostic tasks. These incorporated activities such as gait analysis (Lemoyne, Mastroianni,

Cozza, Coroian & Grundfest, 2010; Nishigushi et al., 2012), measurement of tremor (Joundi, Brittain, Jenkinson, Green & Aziz., 2011; Daneault, Carignan, Codere, Sadikot & Duval, 2013) joint flexion measurement (Jenny, 2013) and measurement of scoliosis (Franko, Bray & Newton, 2012; Izatt, Bateman & Adam, 2012; Qiao et al., 2012; Shaw, Adam, Izatt, Licina & Askin, 2012). A handful of studies added peripherals to smartphones, harnessing the computational power of smartphones to facilitate the use of apps providing diagnostically relevant information, including respiration rates (Hart, Tallevi, Wickland, Kearney & Cafazzo, 2010) and ultrasonography (Wojtczak & Bonadonna, 2010). All of these studies examined whether the app enabled a user to successfully complete a given task, or how well the outcome of app usage compared to an existing method. Some studies also compared task completion time using an app and without.

Most studies made mention of the potential advantages of mobile smartphones in general, through their portability (Lamel et al., 2012), affordability (Charani et al., 2012), convenience, and widespread use (Shin, Ro, Lee, Oh & Kim, 2012). An affordance offered by mobile smartphones that was leveraged by some of the apps examined in the studies was the presence of a camera. This was used to identify microorganisms (Bogoch et al., 2013), atrial fibrillation (Lee, Reyes, McManus, Mathias & Chon, 2012; McManus et al., 2013) as well as for the recording and transmission of medical images (Greenberg et al., 2009). This image and video capability was combined with the ability to transmit information for the purposes of remote diagnosis and interpretation. These ranged from realtime video consultations using apps such as Skype (Johnson, Meyer & Turner, 2012) or Facetime (Anderson & Jansen, 2012), to proprietary apps that securely transmitted medical images. These were most often radiological images (Ardizzone, Gambino, Genco, Pirrone & Sorce, 2009; Daemerschaelk et al., 2012; Ege et al., 2013), but in another case wounds and surgical sites were the targets (Sprigle, Nemeth & Gajjala, 2012;). These studies also examined whether a particular task was successfully completed, or compared the app use to an existing method.

2.3.2.2 Evaluation Studies

There were 11 studies that evaluated the effect of specific apps in live clinical settings. Two studies looked at specific apps designed to provide information at point of care to healthcare providers; one provided information on anti-microbial policy (Charani et al., 2013), and one on neonatal intubation (Hawkes et al., 2013). Two studies examined the impact of providing a suite of reference apps for use by clinicians (Choi et al, 2011; Hardyman et al., 2013). Such studies generally examined user reports of use through either survey or interview methods, or used automatically recorded data to understand levels of app use within the target population, as in the case of the Dr. SMARTS app at the Samsung Medical Centre (Choi et al, 2011). The exception was the neonatal intubation app, which examined whether the users had improved procedural knowledge and objectively measured performance of the task pre- and post-task completion.

A related category of studies were those that examined the effectiveness of apps for use by healthcare workers in the field, outside of clinical settings, such as in the management of mass casualty emergencies (Hudson et al, 2012), measurement and recording of malaria infection rates (Khamsiriwatchara et al, 2012) and a mother and childcare initiative (Charani et al., 2013). Such studies aimed to examine if the use of a smartphone app as part of wider system had an effect on the target measure; for instance in the example of the mass casualty emergency, the time taken for triage information to reach a central control centre during a simulation was measured using an app in comparison with traditional paper methods.

2.3.2.3 Cross-Sectional Surveys of App Usage

Five of the studies (6.9% of the total) were surveys that examined patterns of smartphone use among healthcare workers, including measurement of app use, and all of these examined attitudes to smartphone use in healthcare settings. One of the studies (Wallace, Clarke & White, 2012) also incorporated interviews in the study design to inform survey design. All of the surveys were administered at least in part online, and all

acknowledged that low response rates combined with a potential for response bias (i.e. smartphone users were seen as more likely to respond to surveys about smartphone use) limited the ability to draw wide-ranging conclusions regarding app use in the general healthcare worker population. All but one of the surveys were distributed primarily to medical students and doctors, with one being distributed to nurses (Putzer & Park, 2010).

2.3.3. Application of formal theory within studies

Most studies did not make specific mention of formal theory – of the 72 papers, only five drew on specific formal theories either in their design or as a substantive part of their discussion. Three of the studies that incorporated formal theory either had a survey or questionnaire element or were entirely based on a survey of users or potential users. Putzer and Park (2010, 2012) used the Technology Acceptance Model and Diffusion of Innovations theory in two separate surveys of doctors and nurses, whilst Wallace, Clark and White (2012) used surveys and interviews to investigate user attitudes to mobile computing in the workplace, and discussed the “Changing Location of Knowing”, referring to how practitioners can now look up information that they might have had to keep in their heads. One evaluation study incorporated formal theory regarding social processes of learning (Hardyman, Bullock, Brown, Carter-Ingram, & Stacey, 2013), and one case study utilised Information Systems theory (Andersen & Jansen, 2012). Each of these studies emphasised the user as an active party or factor in the effectiveness of mobile smartphone use.

2.3.4 Consideration of Context

Forty-three studies included some mention of contextual factors that might affect the successful use of mobile smartphone apps in healthcare settings. The only category of study types in which context was not explicitly mentioned at all was the Proof of Concept studies. A wide array of factors were discussed as potential influences on the use of apps by healthcare professionals and these categories are discussed in more detail in the following sections. What is notable is that in most cases, contextual factors are mostly mentioned in the discussion of results, as a means of explaining what might make an app more effective or be considered when

rolling out an app further. A few exceptions mentioned contextual factors in the introduction as something expected to affect the results of the study.

2.3.4.1 Implementation and Rollout Strategy

Several studies considered implementation strategy and training as particularly important in ensuring successful use of apps and incorporated it into their design, (Chihanga et al., 2012; Rajput et al., 2012).

Kaewkungwal et al (2010) highlighted the importance of training users in the use of apps, particularly where they are working in the field and might be unfamiliar with apps. This relates to the learning curve users experience when working with new apps which may limit the ability of an app to yield the expected benefits (Hawi et al., 2013; Khamsiriwatchara et al., 2012; Thomale et al., 2013). It is thus difficult to assess the utility of an app when such a curve is not accounted for in the study design.

2.3.4.2 App design

Both quality of the app design and the content held within have been shown to have some effect on medical app use. Hudson et al (2012), in a two-stage evaluation of a phone oximeter app, found that working on interface design decreased errors in usage, even when accounting for lower user familiarity with smartphones. In terms of information content, quality and trustworthiness have been suggested as key criteria that users consider when deciding to use apps (Franko, 2011; Wallace et al., 2012), with better known brands and those on the market for longer being more widely used (Franko & Tirrell, 2012). In a survey of medical students and junior doctors, relatively low ownership of medical apps compared to the relatively high ownership of smartphones was attributed to a low awareness of which apps are trustworthy (Payne et al., 2012). On a practical level, technical difficulties were seen as off-putting for app users in a Teledermatology study (Lamel et al., 2012) Power, hardware and software issues interfered with the implementation and testing of a wound measurement app (Sprigle, Nemeth, & Gajjala, 2012).

2.3.4.3 Infrastructure

The physical environment in which an app is used was highlighted as a factor in influencing app use, for instance where resources are constrained

(Rajput et al., 2012) or in rural areas where connectivity issues are more acute (Anderson, Smith, Ido, & Frankel, 2013). This connectivity issue is of particular importance for apps which rely on the retrieval of information from other systems via the internet, so a reliable and fast network connection matters (Modi et al, 2010; Noble et al 2012). It has high impact when there is a need to access hospital systems in real time (Choi et al., 2011), or to maintain communication channels for teleconsultation (Daemerschalk et al, 2012).

When using such networks to access data that may contain patient information, there is a need to ensure that the network is sufficiently secure to protect patient privacy (Doukas, Pliakas, & Maglogiannis, 2010); Patel, Dine and Asch, 2011). Within a hospital setting this is important, but arguably it is even more so when an app is used in the field, due to the risk of loss of a device (Jokela et al., 2012).

2.3.4.4 Nature of Task

The suitability of the information in an app for the job or task at hand compared to other information sources was implicated as an important factor in some studies. Hardyman *et al.* (2013), in their evaluation of the iDoc project where a suite of reference apps was given to medical students, found that the choice of information source used was dependent on the specific type of information being sought as well as level of supervision. Putzer and Park (2010, 2012) found that job relevance of information was predictive of app use. Two studies made mention of the particular suitability of an app for their intended purposes; Hawkes, Walsh, Ryan, and Dempsey (2013) described the suitability of their neonatal intubation app for enabling doctors to quickly refresh their knowledge at the bedside because of the elective nature of the procedure, and Flannigan and McAloon (2011) suggested that their paediatric intensive care app, designed to assist with medication prescribing for children, was particularly suited to the task because it was designed to be used at the bedside.

2.3.4.5 Social influences

The opinions and perceived attitudes of colleagues and patients also seem to have an influence on whether and how an app is used. In a small study

of information seeking behaviour among medical students, Khalifian and colleagues (2013) found that the perceived acceptability of phones to older doctors influenced use of apps and mobile smartphones in general, and concerns about patient perceptions also negatively influenced users' decision to use an app. However, the patients' negative affective responses can be influenced by the provision of information about why a doctor might use an app (Miller, Ziegler, Greenberg, Patel, & Carter, 2012). Such a study illustrates how contextual features are dynamic over time, both to the extent in which they influence use and are able to be influenced through consideration of how an app is used.

2.3.4.6 Individual Differences

Several studies suggested that app use and its effectiveness will vary between users, independently of the situational context within which they find themselves. Two studies by Putzer and Park with nurses and doctors respectively suggested that purely demographic characteristics were not of importance, but for doctors, level of experience was important (2010; 2012). In a large-scale survey of doctors in Academic Medical Centres across the US, Franko and Tirrell (2012) claimed to find a qualitative trend towards lower app use in more experienced doctors, supporting the idea that level of professional experience may play a role in the use of apps by doctors. In one pilot study, it was acknowledged that differences in skill level may have had an effect on propensity to use apps (Ege, Kose, Koca, Demiralp, & Basbozkurt, 2013). This suggestion is in line with the idea of the importance of learning curve.

2.4 Discussion

2.4.1 Summary of Results

The studies surveyed were primarily concerned with demonstrating the efficacy of a given app in undertaking a particular clinical task. Effectiveness studies were typically undertaken in controlled environments and, with a few notable exceptions, they did not look at use in real-life situations. As such, they did not address the decision to use an app directly, implicitly assuming perhaps that if something is shown to "work",

then individuals will use it. Many of the remaining studies were evaluations which were also primarily concerned with “if” rather than “why” questions, but the majority of these studies did examine the influence of context in some form. In each instance, the vast majority of studies were concerned with the execution of tasks, with only a few studies looking at how apps could be used to provide information at the point of care.

In terms of participants, most of the studies undertaken used doctors as participants. Some looked at other healthcare professionals, particularly in the domain of public health where field workers’ use of mobile smartphones to collect information was a prominent area of research. Where the studies were intended to determine usage patterns, the evidence points towards high smartphone ownership, with app use more prevalent among less experienced professionals.

2.4.2 Role of Context and Theory

Some studies that did incorporate context supported the idea that context plays an important part in the decision to use apps, as well as in the effectiveness of their use. Most of the useful evidence in this area came from the survey and evaluation studies. Apps which focused on task relevance and considered the interface design seemed to be more effective. A number of contextual factors seemed to be deterrents to app use, not least the relatively low awareness of specific apps that are trustworthy and safe to use as references. In general, a pattern of high smartphone use but relatively low use of apps in medicine was apparent. User characteristics (primarily in terms of level of experience) and the influence of colleagues and patients also appeared to be important.

In terms of practical issues, IT infrastructure was seen as important, particularly network connectivity and speed. The physical characteristics of the smartphone were also factors, such as screen resolution and processing speed.

2.4.3 Types of Study Undertaken

Survey studies were useful for illuminating factors that influenced decision to use an app, and provided useful information about users that seemed to

be more likely to use apps. Evaluation studies tended to focus more on the “if” rather than the “why” of use, although there was some discussion of context. However, such discussion was quite limited, making it difficult to assess the transferability of findings. Comparison, Proof of Concept and experimental studies provided good evidence of task effectiveness of specific apps, suggesting that focused studies such as these do have a role to play in building a case for app use in general.

The evaluation studies were also notable for their emphasis on real life use, which was otherwise lacking from the other studies. Some of the automated data collection of usage data was intriguing, making it possible to get objective data. Studies measuring the effectiveness of training apps were also useful for their link to outcomes outside of immediate task completion. One sizeable gap in the literature was the almost complete absence of qualitative studies – there was little emphasis on the reasoning of users and their actual experience of using apps.

2.4.4 Addressing the Research Questions

In terms of addressing the initial research objectives, this study has been successful to a point. The review of the literature suggests that apps are used in several different medical contexts and by a range of users (Question 1), and also showed that several different factors may contribute to their successful use. However, most of the material surveyed showed that very little substantive theory has been generated, and that there are significant methodological gaps in the research. Thus, in terms of understanding the key elements involved in influencing app use, the present study has shed limited light.

2.4.5 Strengths and Limitations of the Study

The limitations of scoping studies in general are addressed in section 2.1.2 of this chapter, and the present study was bound in part by these limitations, although steps were taken to address these shortcomings in the execution of the study. Although no formal quality assessment was undertaken, studies were viewed through the lens of what they would contribute to the present research – thus care was taken to assess the use

of theory in the papers reviewed, and the body of literature as a whole was assessed in terms of gaps in coverage.

To avoid being overwhelmed by the data generated from the papers reviewed, the present study focused primarily on certain aspects of the papers under study that were most pertinent to the research questions. This served to focus the analysis, but potentially at the expense of comprehensive coverage of the literature.

Another limitation of this thesis was the focus on the medical domain, which guided the choice of databases used. Although the original intention was to use a wider variety of databases that included more general references to the use of apps in information work, few databases used yielded a larger than expected number of citations to review. To keep the inquiry focused on the most relevant papers, this meant that other databases were not reviewed. As such, it could be argued that this focus on the medical literature, with its emphasis on more traditional medical research designs, meant that other research designs (such as those focusing on usability, user perceptions and so on) were under-represented in the sample retrieved.

2.4.6 Implications for the thesis

This review has established that few studies have looked at app use *in vivo* and the use of theory in the design and evaluation of apps has been limited. Contextual factors have often been used *post hoc* to account for results rather than being directly tested, with the outcome that the impact of contextual factors on app use are not well understood. Whilst many contextual factors may plausibly play a role in the adoption and effectiveness of app use, design and implementation of apps seem to be driven either by strong theory or evidence, despite their status as a complex intervention. There is evidence to suggest that apps can be useful for specific tasks under controlled conditions, but also evidence that this utility is not simply a function of the app itself, but could be affected by other factors.

The few studies that explicitly used theory in their design tended to be cross-sectional and quantitative in nature, providing reasonable evidence of

correlation between factors and use but limited evidence of causal links between these factors and app use. The implications for this thesis are that there is a clear need for research into apps that examines what factors affect their adoption and effectiveness under a range of circumstances so that the key elements of “what is important” can be understood. What is clear is that there is a growth in interest and use in apps in healthcare, and the evidential and theoretical base for understanding how to effectively and safely design, implement and use apps is not yet strong enough to guide practice. This thesis addresses these issues by taking an approach to app research that has not been taken yet, integrating in vivo empirical research with a solid theoretical base which will help to inform the implementation, design and use of apps. The following chapters describe how the researcher approached this task.

Chapter 3 – Selection of Approach

3.1 Introduction

The purpose of this chapter is to provide a rationale for the methodological approach that was taken to the primary empirical studies that constitute the main body of this thesis. At this point in the planning for the empirical stages of the thesis, the intention was still to undertake an evaluation of Ignaz, so the approach to selection of methods was primarily focused on evaluative methods. However, as the following two chapters will show, the move to an investigative approach was still guided by the foundational principles of Realist Evaluation (Pawson & Tilley, 1997), and that such an approach was justified.

The chapter begins with an outline of the research context and challenges faced, after which the idea of theory in evaluation as a methodological strategy to address the aims of the thesis is introduced. An overview of different theory-based approaches leads into a description of Realist approaches. Following this a brief description and critique of Realist ontology and epistemology and its relevance to this thesis is provided, laying the groundwork for methodological approach outlined in Chapter 4.

3. 2 Research context

This study focuses primarily on the use of apps aimed at improving the effectiveness of medical practitioners by providing information at the point of care that thereby improve quality and timeliness of patient care. Apps are designed with a purpose in mind. For instance, Ignaz, described in Chapter 1, was designed with the express purpose of providing information for a local Trust that doctors rotating between hospitals in different Trusts would require to do their job. As such, apps can be viewed as a relatively simple, single-pronged intervention. However, whilst the intervention itself is quite simple, it is being introduced into the real world healthcare environment. This environment is a complex, dynamic and open system (Westhorp, 2012); the complexity of the system refers to the number and inter-relatedness of the factors that might influence app use; dynamic refers

to the constant changes, both subtle and obvious, that occur within the setting over time; and open refers to the idea that the immediate setting will both influence and be influenced by events and factors outside of that setting. This complexity is the main reason why thinking about context as merely facilitating or blocking app use risks oversimplifying its role; rather the interplay of contextual factors is dynamic and requires careful diagnosis. As identified in Chapter 2 the potential factors that might conceivably influence app use are many and varied, such as the immediate physical environment, to the nature of the patient interaction, availability of other information or specific hospital or ward policies .

A hospital is not a closed experimental environment, where relevant confounding and influencing factors can be manipulated and controlled so that one can ascertain whether outcomes are owing solely to experimental manipulation. One might attempt to simulate an environment where relevant factors are manipulated in a controlled environment, but there is insufficient evidence to identify the most important factors, not least because of the lack of “real world” studies of app use. Thus a methodological approach is required that can take account of the range of factors that may be at work in affecting how and why apps are used in the real world.

3.2.1 Challenges faced by the present research

The preceding chapters have demonstrated that this thesis needs to overcome several challenges in order to successfully address its aims. Chapter One established that apps are an emerging phenomenon within healthcare, with many apps already in use by practising clinicians. It was also shown that the extent to which these apps are used, for what reasons, who by, and to what effect, is not well understood. Furthermore, it was argued that the lack of clearly defined policy at either a national or institutional level regarding app use means that the decision to use an app is largely an individual decision. The scoping study in Chapter Two demonstrated that whilst there is now a growing body of research into app use, it does have specific limitations; most studies were narrow in scope with regards to their focus on specific apps and comparison to existing

practice, employing little explicit theory and providing relatively little information about *in vivo* use of apps.

3.2.1.1 Absence of transferable knowledge

This state of play has implications for the present research. The lack of extant research in live settings means that little is known about the contextual factors that influence an individual's decisions to use apps in their work. The inconclusive nature of what research has been undertaken means that it is difficult to fully understand what circumstances are conducive to or inhibit app use and thus hinder efforts to generate useful information that can guide app design and implementation. As such, little transferable knowledge has been generated by research into apps in healthcare. This thesis aims to address this by utilising a theory-based approach.

3.2.1.2 The need to generate useful theory

Without solid theory from which one can generalise, the research findings run the risk of only being applicable to the specific instances studied (Walshe, 2007). For the present research to address the aforementioned lack of explanatory theory in app research, it is not enough to just incorporate some theory into the research design. It must be applied at a level that enables the transfer of knowledge across contexts. Utilising a theory-based approach has drawbacks as well as advantages, and the methodological implications described below

3.2.1.3 The need for *in vivo* data

Apps are already in use by doctors, and have been for some time (Mosa, Yoo & Sheets, 2012), reinforcing the importance of research findings being applicable to existing practice – from a practical standpoint, it would enhance the impact of the research if it were demonstrably applicable to current practice. It is thus desirable that the approach taken can incorporate at least some element of research in live settings. Such an emphasis on real world use would also impart the opportunity to look at potential real world outcomes and impacts of app use – a need identified in Chapter 2 of this thesis.

The chosen methodological approach also needs to be able to do this in a way that is open enough to allow for the investigation of multiple potentially influential contextual factors, whilst also enabling the researcher to bound the scope of the enquiry within a manageable framework. Furthermore, the research questions require data that can address issues relating to patterns of use as well as factors affecting this use, suggesting that an approach that can incorporate multiple forms of data collection would be most appropriate. For instance, understanding patterns of use will require real world data that reflects how and when doctors use apps, and also data that reflects the contexts within which this use takes place (Pawson & Tilley, 1997).

The next section addresses how incorporating the development of theory as used in an evaluative approach can address the issues raised, particularly in understanding why an app might be used differently under different circumstances by different individuals.

3.3 Theory in Evaluation

3.3.1 Evaluating Technological Interventions

Apps in use are not just software that forms part of the working environment; they are essentially a technological intervention. They are usually designed with the intention of delivering a benefit to the user. The evaluation of change programmes and interventions is challenging, and evaluation research is known to suffer from issues with inconsistency of findings, with different studies claiming different levels of success for similar interventions. As such, drawing conclusions about efficacy of a particular intervention has proved difficult (Pawson & Tilley, 1997). This is a particularly pertinent issue within healthcare research, where RCTs and experimental designs are prevalent and the widely accepted standard when it comes to 'proving' whether something works or not according to most hierarchies of evidence referred to in the literature (Walshe, 2007).

3.3.1.1 Apps as interventions

An app on its own may be considered a relatively simple intervention, but it is into a complex, uncontrolled and open healthcare system, with multiple contextual features that may influence the decision to use an app, as well as the outcomes of that use – causation is complex (Byrne, 1998). The role of context as a backdrop to a given intervention is highlighted by Blamey and Mackenzie (2007) who highlight the multifaceted nature of context and the way it operates at multiple levels. The use of level in this instance refers to whether some element of context is situated at an individual, social or organisational level, on the basis that it should not be considered as a single homogenous entity. As such, monolithic conceptions of interventions and the contexts within which they operate are unhelpful when trying to understand how or why outcomes occur.

3.3.1.2 The importance of variation in setting and intervention implementation

Walshe (2007), among others, argues that whilst these designs may be appropriate for single component interventions in tightly controlled and monitored environments, such as drug trials, they are not appropriate for more complex interventions which may have multiple interacting components and that are introduced into less controlled environments. This is owing to the level and sources of variance inherent within the type of programme being evaluated. For complex programmes or interventions, high heterogeneity may be found in the ways in which a programme is applied (through deliberate or unintentional local adaptations of the intervention) as well as the range of contexts within which it is applied. This could lead to a high variance in the outcomes. In simpler interventions introduced into controlled environments, such sources of variation are lower and, as such, the overall programme can be viewed as more homogeneous. This may partially explain why replicability of findings is so difficult in programme evaluation; if there is inherent variation in the contexts within which programmes are implemented, one cannot expect to find replications of primary outcomes. Therefore, rather than attempting to control for variation in the more heterogeneous programmes, the focus

should be on understanding this variation, as the multiple outcomes are likely to be the result of differences in context, content and application of the intervention.

Similarly, Medical Research Council (MRC) guidance on the evaluation of complex interventions discusses the need to be flexible in evaluation of such interventions, with single primary outcomes not necessarily being suitable for understanding the overall effects of a given intervention (Craig & Petticrew 2013). The MRC guidance is not without its critics, although there is some consensus regarding necessity of understanding the theory of why an intervention works; understanding these theories allows weak causal links to be identified and strengthened (Craig & Petticrew, 2013). There have been methodological attempts to reconcile the experimental, highly controlled paradigms with those that aim specifically to untangle the complexity involved in real-world evaluation, and these are discussed further on in this chapter.

3.3.1.3 Theory and transferability in this thesis

In order for the thesis to achieve its objectives, it would be useful to understand the way that apps are used in certain contexts by certain individuals (so that patterns of use are understood) and there is value in understanding why these patterns are present. For this knowledge to be transferrable outside of the present study, the formulation of sound theory is necessary. Through the development of appropriate theory, one can begin to understand why a particular intervention works for some individuals and groups in certain circumstances and not others (Pawson, 2006). Testing such theory in other settings and domains can improve the theory and demonstrate its wider applicability, giving a greater degree of confidence when using it to inform implementation and practice in the relevant field. For instance, the needs of a user in urgent care may differ to those of a user in an outpatient clinic or on an intensive care ward in terms of resources available and the immediate environment, and this may then influence how or if an app is used in those particular settings. Thus the goal is generalizability of theory that can give practical guidance rather

than empirical generalizability in terms of simply replicating findings relating to patterns of use (Walshe, 2007).

3.3.2 Middle Range Theory and the “Black Box Problem”

The term ‘theory’ can be used in an abundance of ways. It can refer to a range of conceptions, from working hypotheses, through to vague and unordered speculations to axiomatic systems of thought. When referring to theory in this thesis, the researcher is referring to logically interconnected sets of propositions from which empirical uniformities can be derived (Merton, 1949). The types of theory that operate at this level are what Merton (1949) referred to as *theories of the middle range*. Such theories are close enough to the data to explain patterns of outcomes, but are not so close as to be only particular to the specific instance or situation. Middle-range theories make use of ideas that can be generalised to a range of situations, but to a low enough level that specific predictions can be made about those instances. A middle range theory may well be congruent with a grand theory or a substantive theory, but they are essentially practical in their emphasis, with a goal of describing behaviour within a particular domain. Middle-range theory is thus an effective counter to criticisms of theory-driven research that bemoan the loss of essential practical detail due to the level of theoretical abstraction that is employed when using grander theories.

Bringing this kind of theory into the evaluation process is a potential solution to the ‘black box’ problem, where rather than just knowing the outcomes of an intervention or change programme, the research seeks to identify the “inner workings” of a programme in order to understand why it produces those outcomes – that is to fill in the “black box” between the actual inputs to an intervention and its expected outputs (Stame, 2004). A key aim of theory-driven evaluation is to unpack these programmatic black boxes so that the mechanisms that link cause and effect can be identified and used to explain why programmes work or not in different contexts for different stakeholders (Astbury & Leeuw, 2010). By developing a theory of why a programme works, it is then possible to design an evaluation based

on this theory which seeks to test the assumptions underlying the programme (Chen & Rossi, 1983).

3.3.3 Programme and Implementation Theories

Definitions of what constitutes programme theory vary between authors and methodological approaches, but can be distilled down to two types of theory. Weiss (1997) distinguishes between implementation theories and programme theories. Implementation theories are concerned with unpicking what it is about a programme that will lead to an outcome whereas programme theories can be seen as more concerned with the causal relationships within a system that lead to an outcome. Stame (2004) summarises this distinction as implementation theories being more concerned with programme activities, whilst programme theories encompass the results of and responses to these activities. In the case of this thesis, an implementation theory would relate to steps and actions taken to introduce an app (and thereby its potential affordances) into a system, whereas the programmatic theory would relate more to how introduction of an app into a system would trigger certain responses in the system - for instance through individual responses to the app being available, which would then lead to particular outcomes. Although this is a coarse distinction, it is helpful in distinguishing between types of theory-driven evaluation by virtue of the different emphases placed on the types of theory utilized in the evaluation. It is certainly a useful distinction in the context of this thesis – app adoption has been largely user-driven and only in specific cases have they been formally introduced into a clinical context, suggesting that approaches that place more emphasis on programmatic theory may have greater utility in addressing the research questions.

Blamey and Mackenzie (2007) posit that Theory of Change (Chen, 1990) approaches focus primarily on the implementation theory. They focus on building a consensual view between stakeholders of the way in which an intervention is supposed to operate. This is the form of theory that is then tested within the evaluation, and outputs relate to the effectiveness of this theory, and also to the efficacy of its operationalisation. Due to the nature and variety of the stakeholders involved, each with their own potentially

competing interests and agendas, this building of consensus can be a resource hungry process, and requires considerable investment on the part of the evaluators. The same authors suggest that Realist Evaluation (Pawson & Tilley, 1997) has a more explicit focus on uncovering the programme theory, with its focus on uncovering how contexts facilitate or alter the activation of causal mechanisms that lead to particular outcomes. This is not a clear-cut dichotomy, with both Realist and Theory of Change approaches using both types of theory, but it is an accurate description of their relative emphases.

This distinction has implications for the types of knowledge generated. Realist Evaluation aims to develop programme theories, refine them through empirical study and then test these theories in subsequent evaluations so that theories of what works for whom and how gain explanatory power in a cumulative fashion from evaluation to evaluation (Pawson & Tilley, 1997). It is questionable whether this cumulation actually occurs in practice, but there is certainly potential within the approach to achieve this (Marchal, van Belle, van Olmen, Hoérée & Kegels, 2012). Theory of Change approaches are less prescriptive about the goals of an evaluation, but it has been suggested that implementation theories found to be supported by evidence are taken as read for further evaluations rather than refined, and that subsequent evaluations focus on other implementation theories about which less is known. Again, the evidence for this occurring in practice is limited, and scepticism abounds in terms of how well developed implementation theories tend to be in practice (Blamey & MacKenzie, 2007).

3.3.4 Testing and Refining Theory

The question of knowledge cumulation is linked to the extent to which theories are built on or discarded based on empirical research. The Duhem-Quine thesis is pertinent to this point (Cooper & Blease, 2014). That is, a theory can avoid rejection even when predictions deduced from it are contradicted empirically, since the theory itself rests not on the single hypothesis deduced, but on a number of supplementary conditions. If not all of these conditions are in place for the test, then lack of empirical

support (or even a contradictory finding) may not be critical for the theory, as what has been done is essentially a partial test of the theory. In practical terms, where empirical tests take place in live settings, a partial test is often the only type possible. Thus in a theory-based evaluation, the aim is not to disprove particular theories, but to adjudicate between theories based on the partial evidence available.

This aim of adjudicating between competing theories sets expectations and limits as to what such an empirical test can achieve in terms of generating and testing theory. The resulting 'partial' theoretical knowledge is better than no knowledge at all and is a significant step on from evaluations that make binary judgments about efficacy (Pawson., 2013). Within a Theory of Change approach then, it seems difficult to progress development of a particular theory as the emphasis is likely to be on testing new implementation theories, whereas within the realm of Realist Evaluation, the goal is to build on what is known as far as is possible. The practical implications of this are that a Theory of Change approach will develop a number of potential theories, but it is not an explicit goal to develop a theory with particularly strong explanatory value. However, a Realist Evaluation approach has the goal of improving the explanatory power of a given theory or set of theories through a set of incremental steps.

3.3.5 Selection of methodological approach

The practical emphasis combined with the potential for generalisability presented by these kinds of theory-driven approaches are a good fit for this thesis. Healthcare app use is relatively unstudied in the field (see Chapter 2), and initial discussions with stakeholders (see Chapter 2) indicate a wide variation in patterns of use, and the different influences on app use. Thus, a strong case exists in favour of the use of a theory-driven approach that embraces such heterogeneity. When it comes to the choice of a specific approach, whilst implementation theory is of interest and can help inform the inquiry, the main questions of interest concern the multiple potential influences on the use of apps in the workplace i.e. understanding the programme theory. As such, with its emphasis on programme theory

rather than implementation theory, this thesis will employ a Realist Evaluation approach.

The following sections will describe the Realist approach to evaluation in more detail, and then describe how it is particularly suited to dealing with the practical issues faced by this investigation, in particular with its suitability for understanding the influence of context on patterns of outcomes and how it addresses issues of causality.

3.4 Realism and Scientific enquiry

3.4.1 Realist Philosophy

Realism is a long standing philosophical position with roots as far back as Plato that has had credence within philosophical circles for some time but up until relatively recently had not been widely utilised within evaluation research or even scientific research in general (Pawson & Tilley, 1997). Research within the social sciences has tended to be based on either constructivist accounts or, more commonly within the psychological sciences, positivist empiricism (Sayer, 2000). The form of Realism described herein refers to the idea that there is an objective reality that exists independently of our ability to perceive it, and of our theories about it (Maxwell, 2012). Reality in this sense is everything that exists, including objects seen and structures unseen interacting with each other to produce the phenomena that we can experience through our senses (Schwandt, 1997).

Over time, many different varieties of realism have emerged, with different emphases, with differing views of how well our conceptions of reality can be seen as a 'true account' of the objective reality that may exist (Sayer, 2000), but which share many of the same tenets. The 'scientific' realism (a term that is used periodically within the literature, and for the purposes of clarity will be used here) described here is based largely on the school of thought outlined by Pawson and Tilley in their 1997 book and subsequent iterations and clarifications of approach (Pawson 2006; Pawson 2013). However, the approach also draws on ideas outlined by Maxwell (2012) and Sayer (2000) as well as a range of empirical and theoretical work that

has been carried out in this relatively young tradition in evaluation science. Such a view of realism is heavily influenced by Bhaskar's writing on Critical Realism (1975), but there are notable differences in emphasis and interpretation, which Pawson documents extensively in his own writing (1997; 2006). Some of these differences will be examined in later sections, but it is worth noting that Pawson's view of Bhaskar's later writing has itself been critiqued (See Julnes, Mark & Henry, 2012, and Porter & O'Halloran, 2012), for fuller discussion of these differences and their relative importance).

3.4.2 Realist Ontology

To the realist, rather than being 'flat', as is conceived within objectivist views of the world, reality is stratified and comprises three layers; the real, the actual and the empirical (see figure 2). The empirical is the domain of experience, that which can be sensed and measured by our senses, the directly observable and, for positivist empiricists, the entirety of what can be said to exist. The domain of the actual is the domain of events that occur and whose effects are observable.

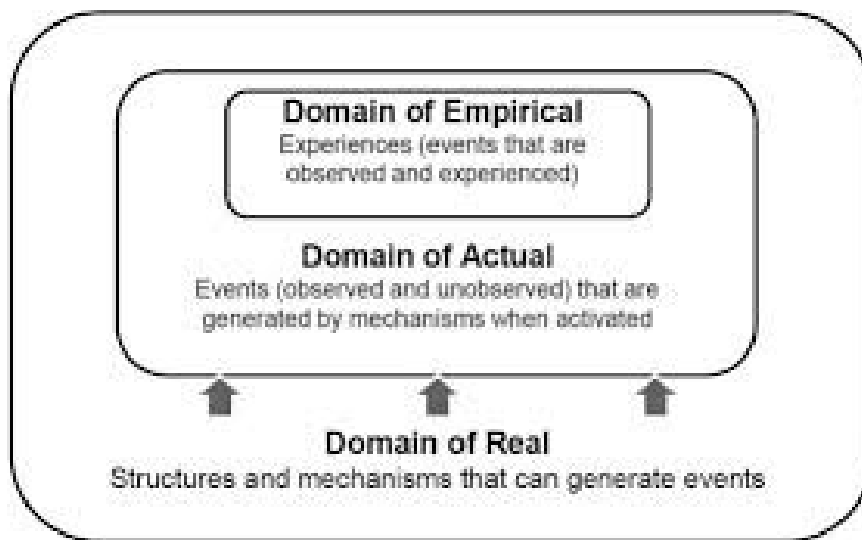


Figure 2 Bhaskar's realist conception of reality. From Mingers (2004).

As Maxwell (2012) notes, the empirical and the actual are the domains that are the usual subject of scientific enquiry, although this philosophical position may likely not be stated explicitly within a given research study.

The domain of the real refers to the idea of all that exists in the universe and encompasses those things that appear to be less tangible including social and psychological phenomena. Thus, ideas and beliefs are as real as atoms and molecules, and exist independently of our ability to observe them.

3.4.3 Scientific Realism

Scientific realism has a distinctive worldview with specific implications for the way that research is undertaken in terms of choice of methods and analysis, combining a realist ontology with a constructivist ontology (Maxwell, 2012). Whilst taking the view that there is a real world independent of our observations, perceptions and conceptions, scientific realism holds that it is only possible to understand this world using constructions derived from our own perspectives and standpoints, and that there is no one “correct” account of this real world. Such a position would probably not be seen as tenable by either side of the paradigm wars which pervaded the social sciences towards the latter part of the last century (see Shepherd & Challenger, 2013). Social constructivists who argued that there is no meaningful distinction between ontology and epistemology due to the subjective nature of reality would find the idea of there being a single objective reality, no matter how inaccessible, antithetical (e.g. Smith & Deemer 2000). Similarly, positivists would have significant issues with the idea that there is a reality that we cannot simply observe and then describe and explain, if only we could come up with the requisite techniques.

Maxwell’s apparently contradictory formulation, although controversial, has several advantages, not least in terms of its ability to accommodate contrasting worldviews into a coherent whole. Whilst in the natural sciences, many would take the view that there is an empirical, physical world that exists and is constituted of physical matter governed by universal laws which are waiting to be discovered, to the scientific realist, such a conception of reality is too narrow. For realists, reality consists of the entirety of all that exists in both the natural and social worlds, independent of our knowledge or understanding of it. So concepts like culture, beliefs and meanings seen as belonging to the “mental realm” are not simply

abstractions, but are as real as physical object (Maxwell, 2012). However, whilst part of reality, such concepts are not simply reducible to physical elements and attributable to purely neurological processes but by their very nature need to be understood and conceptualised differently. How our descriptions and explanations of these real concepts in the mental realm actually correspond with reality is less important than whether they are adequate in explaining this reality; our knowledge is transitive, whereas the objects of that knowledge are intransitive (Bhaskar, 1975).

The implications for this thesis, which seeks to explicate primarily social and psychological phenomena involved in the app use, are twofold. Firstly, apparently abstract phenomena such as ideas and beliefs exist as entities in themselves and are open to study, and secondly, whatever theories are constructed and tested do not have to be “true”, as the nature of the theorising will depend on the perspective from which it is done, and does not necessarily correspond directly to a specific real phenomenon. Thus one can justifiably refer to attitudes and beliefs towards apps as entities that are worthy of study in themselves, rather than only relying on measurable behaviours such as actual app use. Furthermore, one can talk meaningfully about these attitudes and beliefs without them needing to correspond precisely to some objective truth. Therefore, if one refers for example to substantive theory and concepts described within them (such as the Technology Acceptance Model, (Davis, 1989)), one can use these concepts without needing them to be precisely “true”. The utility they provide in describing an idea (such as an attitude or belief) is enough to justify their use because they provide a way of conceptualising an element of reality that would otherwise not be directly measurable. Measurement of these concepts allows the testing of theories empirically, and is valid provided that one remembers that they are just proxies for some other concept that exists in the realm of the real.

As such, this school of realists would reject a radical constructivist view such as that represented by Guba and Lincoln (1994) where there is no such thing as an objective reality, only an individual's constructions of their experience. Such an account would render the endeavour of generating transferable knowledge futile, since any knowledge generated would be

specific to a given individual within a given context. On the other hand, Stame (2004) argues that, rather than being relentlessly localised, a good constructivist account acknowledges that individual constructions take place within and with reference to shared institutions. These institutions themselves may be constructions, but they are shared, meaning that the knowledge gained from this kind of constructivist research does have transferable value. Maxwell's description of a constructivist ontology in realist research fits with this latter form of constructivist ontology.

3.4.4 Causal Inference in Scientific Realism

Within Scientific Realism, causation is addressed through reference to structures, powers and liabilities. Structures in the domain of the real have powers (the ability to cause changes in other structures) and liabilities (the ability to be changed), and it is interactions at this level that lead to events at the level of the actual, which in turn lead to observable phenomena in the realm of the empirical (Bhaskar, 1975). As such, Scientific Realism treats causation as a generative process rather than a successionist one. In generative causation, a causal mechanism, existing at the real level of reality, creates an outcome by one structure exerting a power on the target structure, which changes because it has particular liabilities (Maxwell, 2012). In a successionist model of causation, one thing is linked to another through a constant conjunction of events - a consistent co-occurrence of two phenomena. It is the difference between saying being admitted to hospital leads to a patient's recovery, as in a successionist model of causation, compared to being admitted to hospital leads to better monitoring of a patient's condition and more timely and accurate treatment decisions which then lead to appropriate administration of treatment that leads to an improvement in the patient's condition, as in a generative model of causation. The latter is the more complete explanation, explaining how A causes B, rather than merely saying that A leads to B temporally.

Within a positivist empiricist approach, one would only be able to make claims based on this constant conjunction model (Hume, in Maxwell, 2012), since one cannot infer anything outside of the empirical domain. Since the actual causal process or mechanism is often not directly observable, one

would have to design a protocol that allowed for the testing of whether one factor or group of factors (for instance, speed at which admitted to hospital) was likely responsible for a particular outcome (likelihood of patient recovery). If levels of the first factor correlated with a single factor, one might have a degree of confidence that one caused the other. It is this successionist causation model that is the dominant paradigm within the social sciences, and which Pawson and Tilley (1997) argue is a misunderstanding of the methods of the natural sciences.

The relevance of this distinction between generative and successionist causation becomes clearer when discussing the appropriateness of RCTs which seek to compare control and experimental interventions under controlled conditions in order to evaluate programmes. Pawson (2006) would argue that the underlying logic of RCTs is the idea of a successionist causation – by assigning treatment and control groups, the assumption is that any difference in outcome is attributable to the condition assigned. Whilst there might be a hypothesised generative causal rationale, RCTs do not directly investigate this causal pathway. When it comes to testing the efficacy of a drug, this kind of information is not necessarily important – the key issue is whether it works or not. With interventions that are reliant on voluntary (active or passive) choices from the subjects of the intervention to produce a desired outcome, a generative explanation that takes into account the role of decision-making and the factors that influence those decisions has tremendous utility because it helps to understand how people make the choices that they do and enables the manipulation of the context to make certain choices more probable.

Central to this idea is the conception of realist ontology as described in section 3.4.2. The realist conception of mental phenomena as real structures also means that they are viewed as possessing causal powers and liabilities as much as any physical object (Sayer 2000). These mental phenomena are not directly observable, but they can be described through accounts of the chain of events, and provide a means for understanding how the individual's situation influences their actions. It is this aspect of reality - the mental realm – which holds most interest for the present research. The aim is to understand the causal processes that lead to a

decision to use an app by individual practitioners - in their own minds, in their specific circumstances, in a given situation – and whether there is a patterning to these processes across individuals, situations and groups.

3.5 Criticism of the scientific realist approach

The scientific realist approach to inquiry, as championed by the likes of Pawson & Tilley (1997), and Maxwell (2012) has sometimes been accused of being vague and simply a pragmatic approach that allows for a wide range of methodological approaches. However, proponents might argue that this flexibility of approach is a strength rather a weakness, provided that data collection methods used are congruent with the research questions and theories developed. Whilst this methodological flexibility is a feature of the approach, that is not to say that every method can then be used for every question. This emphasis on pragmatic inquiry rather than prescriptive rule books has stimulated theoretical and methodological development, with conceptual tools to aid practitioners in developing and testing appropriate theory (Pawson & Tilley, 1997). As such, the methodology has a clear foundation that is defined but ever evolving.

An additional criticism is the apparent simplification of cause and effect in complex systems (Porter, 2015), where realism is accused of painting causation as a linear process, whereas in practice it is multifactorial and difficult to disentangle. This researcher believes this to be an unfair criticism; whilst the some of the conceptual tools that are used in realism appear to describe straightforward causal processes (for further discussion, see Chapter 4), they are merely simplifying for explanatory purposes, and can be applied to more complex systems (Westthorp, 2012).

3.6 Utility of Scientific Realism for the present thesis

The aims of the thesis are broad in terms of understanding patterns of app use and the factors affecting this use. However, as the scoping study in Chapter 2 showed, the extant literature hints at potential factors that might influence this use, but no single theory which adequately captures the range or scope of factors that might be involved. Therefore, the

conceptual tools and conceptions of reality afforded by Scientific realism provides a framework that is both structured enough to incorporate some of the factors that have been suggested as important in app use, but that is flexible enough to investigate the nature of the relationships between these factors and potentially elucidate other factors. As such Scientific realism is an excellent fit as an epistemological basis for the current thesis.

This section has given a brief overview of the Scientific Realist view of nature of reality and causation. In Chapter 4, the researcher will describe in more detail some of the key concepts of Scientific Realism with particular reference to their use within Realist Evaluation and Synthesis (Pawson & Tilley, 1997), and how these concepts were operationalised within the present study to meet the aims of this thesis.

Chapter 4 – Applying Realist Methodology To The Present Thesis

4.1 App Use as the Outcome of Interest

As previously described, this research evolved from an evaluation of the outcomes of app use to the investigation of app use as an outcome of interest in itself. As such, the choice of an approach designed for evaluation in a study without an evaluand may seem like an odd decision. However, having made the case for the use of Realist epistemology as the foundation of the empirical chapters in this thesis in Chapter 3, this chapter focuses on the application of this approach to the present study through application of the principles realist evaluation (Pawson and Tilley, 1997).

With hospitals being such an information-rich environment (Reddy & Dourish, 2002), understanding what “causes” the decision to use apps as source of information in comparison to other sources is an issue that is worthy of investigation. As the ensuing sections demonstrate, the key concepts of realist evaluation can be leveraged to shed light on this matter even if employed in the context of an evaluation.

4.2 Realist Evaluation in Practice

Realist Evaluation is a methodological approach which bases itself on the Scientific Realism outlined in the previous chapter, and is guided by the credo “What works, for whom, in what circumstances and why?” (Pawson & Tilley, 1997). It specifies that a generative *mechanism* (the “why” from the credo) causes an *outcome* or *outcomes*, and seeks to understand under what circumstances (or within what *context*) those outcomes are created and how. So whilst like most evaluation approaches, it is concerned with outcomes, the aim is to study how and why such outcomes come about, rather than only whether they occur.

4.2.1 Context-Mechanism-Outcome Configurations

The heuristic developed by Pawson and Tilley (1997) to operationalise this type of programme theory is the specification of Context-Mechanism-

Outcome configurations (CMOCs), represented by the formulation Context + Mechanism = Outcome.

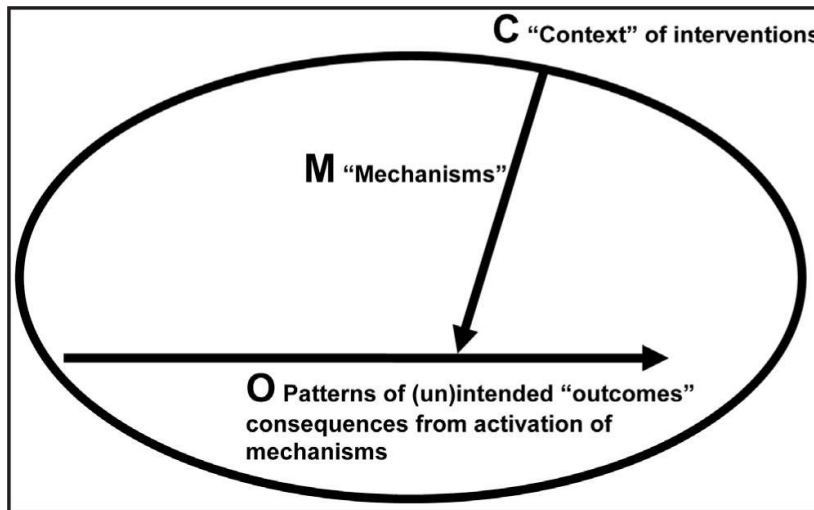


Figure 3 Context-Mechanism Outcome interaction. From Ogrinc and Batalden (2009).

By separating out the mechanism triggered by an intervention from the pre-existing context situated in the environment, the evaluator can theoretically work out how the context influences the triggering of a mechanism to produce a particular outcome. Note that the intervention or programme itself does not constitute the causal mechanism. Rather, the causal mechanism is a response by an individual or group to a change in the availability of a relevant resource that has been created by the presence of the programme or intervention.

Realist approaches theorise about the causal mechanisms that would be triggered by an intervention, identify potentially relevant contexts, and identify outcomes of interest, and then most importantly, test these theories so that the best ones can be identified. As figure 3 shows, these outcomes will include those that are both intended by an intervention and those that are unintended. By including unintended outcomes, the explanatory value of a particular theory can be tested more rigorously.

4.2.1.1 Using data to test competing theories

The following example illustrates the practical implications of using the scientific realist account of generative causation on the evaluation of an intervention. The updating of an antibiotic protocol on an organisation's

intranet page could be considered a relatively simple intervention with a straightforward programme theory – a protocol is introduced, doctors and prescribers follow the protocol, resulting in an improved adherence to antibiotic protocols. Thus, one would expect to be able to detect improved overall observed adherence to antibiotic protocols through data collected from the hospital pharmacy. Using the realist model of generative causation, we can examine how the actual mechanism at work would influence the pattern of use, and what contextual factors influence this pattern.

If the increase is attributable specifically to the introduction of the intranet page thus increasing the ability of users to access the policy and leading to an increase in adherence to the process, one would expect an increased number of page views of the relevant intranet pages by users with higher adherence to the new policy. Additional evidence for this would be a pattern relating intranet page views on a ward-by-ward basis that matches the adherence patterns in those wards. Even stronger evidence would be better adherence on wards where there is easy access to a computer. However, if the mechanism is primarily based on a general awareness of policy as a result of the updated page being briefed in staff meetings, one would not necessarily observe an increase in page views, and variation between wards may be less influenced by availability of computers but more influenced by the effectiveness of a face to face briefing. This example shows how just gathering data on outcomes would only allow one to guess as to why a policy has been more or less successful in achieving its aims in different areas; by gathering information on page views and staff briefings, one could make stronger claims about the mechanism by which the intervention best achieved its aims. This knowledge could then be applied to the way that future policy updates are rolled out.

4.2.1.2 The effect of context

The above example also illustrates how context can influence the relative success of an intervention. If the policy is not briefed effectively, one would expect only prescribers that regularly refer to the internet pages to alter their behaviour initially – therefore more confident or experienced

doctors may not alter their behaviour. If the policy is effectively cascaded (i.e. as part of an implementation plan), one would expect more widespread change in behaviour. So context in terms of existing staff behaviour and implementation methods can be seen as altering the outcome pattern- different contexts will alter the activation of the mechanism and its effects in terms of outcomes. As such, context can influence both how an intervention is implemented, and also how respondents respond to the intervention (Westhorpe 2014). This illustrates the utility of capturing multiple data points to compare theories – not only is it helpful to try and capture data from a range of situations, but it illustrates the importance of capturing information on contexts, as well as on potential mechanisms and outcomes.

4.2.1.3 Programme components, responses and causation

Another key element of Realist Evaluation that is elucidated in the example is the conceptualisation of how programmes and interventions lead to change. It is not through the programme component or intervention itself, but through the *response* to that intervention by individuals. It is through these responses to an intervention and consequent changes in reasoning that behaviour is altered and is what leads to the outcomes. Further expanding on this idea, reasoning may change in response to contextual factors other than those directly related to an intervention – a doctor may adhere to antibiotic policy more closely following an incident where they were picked up on not following the protocol in the past. This further emphasises the point of such interventions taking place in an open system – it is not possible to control everything about the situation within which an intervention may take place, as there are simply too many factors to consider (Walshe, 2007). What is necessary for enquiry is that a researcher bounds their investigation in a sensible way; given the open nature of the systems under investigation, multiple contextual factors might be seen as playing a role, but it is virtually impossible to consider absolutely everything that might influence the outcome. Perfect knowledge of the functioning of an intervention is unattainable, but by carefully selecting appropriate theory (that which seems plausible, has utility and is testable in a practical way), judicious design of data collection and careful analysis,

one can improve the understanding of how an intervention works (Pawson, 2013).

4.2.2 Implications for Data Collection

Such careful design requires a solid theoretical starting point. Thus the first step of any Realist Evaluation is the generation of programme theory (Pawson & Tilley, 1997). This is of the aforementioned middle range variety – not too high level, but not too specific to the single case. The development of such theory is discussed in more detail in Chapter 5. This theory is then turned into testable propositions, which in turn can be expressed as CMOCs. It need not be substantive in nature, but there ought to be sound practical reasons for selecting the theory. The next step is to select appropriate data collection methods to test the theory. This data collection needs to collect information that will shed light on Contexts, Mechanisms and Outcomes of interest. Due to the inaccessibility of data on mechanisms, many evaluation projects use interviews with key informants to winnow out unsuitable theories and refine the better ones (Marchal et al, 2012). Information on context can also be gathered from these interviews . Once a selection of promising candidate theories have been selected, these can be tested through empirical data collection (Pawson & Tilley, 1997). Often, contextual data will guide the sampling frame, and outcome data will be selected that is of practical concern and also helps to test the propositions at hand. This is clearly a large logistical challenge, and many realist evaluations are purely qualitative in nature (Pawson, & Manzano-Santaella, 2012). It is though, recommended that that a mix of qualitative and quantitative data collection methods are used to gather information on mechanisms, contexts and outcomes (Pawson, 2013).

Once data are collected, they are analysed so that the merits of the various candidate theories can be assessed. The outcome of such an approach is twofold. First of all, the researcher should come out with improved theories that are evidenced empirically. Secondly, and of most practical importance, is that the researcher has information that is of practical use to programme designers. Through the testing of theory, one arrives at practical

conclusions that can be used to modify, design and create new interventions that more successfully generate the desired outcomes. This, then, is the value of the realist approach – from a sound philosophical and theoretical base, practical knowledge is generated that can be transferred to other settings precisely because so much information is gathered from the study setting. The researcher can say with confidence that x causes y, and that contexts a, b, and c, have an influence on the extent to which x causes y. For the present thesis, this further illustrates the need to collect multiple sources of data to test any theories developed – it is not enough just to understand how much an app is used, but also to gather data on the processes that lead to app use so that knowledge of practical value can be generated.

4.3 Advances in Realist Methodology

Whilst the CMOC is a powerful explanatory concept that does much to guide evaluation practice, in its raw form, it can be difficult to operationalise in a research study. In particular, the distinction between mechanism and context is not always straightforward for a researcher to identify in practice (Astbury and Leeuw, 2010; Marchal et al., 2012). This difficulty is a twofold problem. In the first instance, to describe what is meant by a context is problematic because of its often vague definition (Porter & O'Halloran, 2012). Secondly, it is difficult to distinguish between what is a mechanism of action that produces an outcome that is attributable to a particular programme compared to unpicking the influence of context alone. The following sections will describe some conceptual and methodological developments that are utilised in the empirical section of this thesis.

4.3.1 Modifying the CMOC

In an attempt to unpick the distinct effect on outcomes of context and mechanism, Dalkin and colleagues (Dalkin, Greenhalgh, Jones, Cunningham & Lhussier, 2015) developed and articulated the concept of mechanism further. Building on Pawson and Tilley's (1997) description of a mechanism as comprising a changed availability of a particular *resource* due to an intervention or programme component, which leads to a *reaction*

in the target, Dalkin and colleagues explicitly disaggregate the resource and reaction elements of the mechanism to make clear how an intervention offers the resource part of the mechanism. This resource is effectively inserted into a pre-existing context. The particular combination of resource and context influences the way in which the subject reasons in relation to the resource, thus producing a particular outcome. Thus, the new formulation is as follows:

Mechanism (Resource) + Context → Mechanism (Reasoning) = Outcome

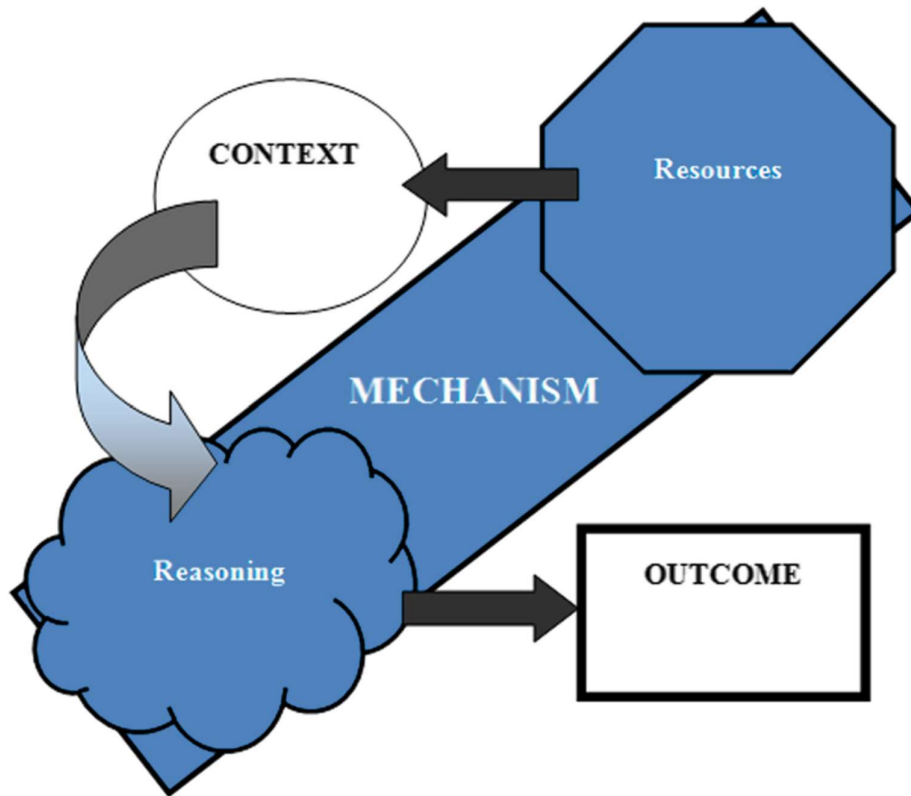


Figure 4 Amended CMO configuration. From Dalkin et al., (2015)

By formulating the CMO in this way, the effect of context on how a mechanism operates is clearer – if the resource stays the same, but the context varies, the effect on the subject's reasoning will be altered, potentially leading to a different outcome. However, it explicates the 'active ingredient' of an intervention by making clear that the resource is provided

by the intervention. The mechanism still consists of the resource and reasoning elements, but the intervening nature of the context is clearer. That is not to say that the context is a moderator in the mathematical sense of the word, but that through the interaction between resource and context, the functioning of the mechanism is somehow altered. The nature of and extent of this alteration is specific to the theory under investigation. It essentially allows us to create an idealised model of smartphone app use. Thus, we can picture the present study as follows:

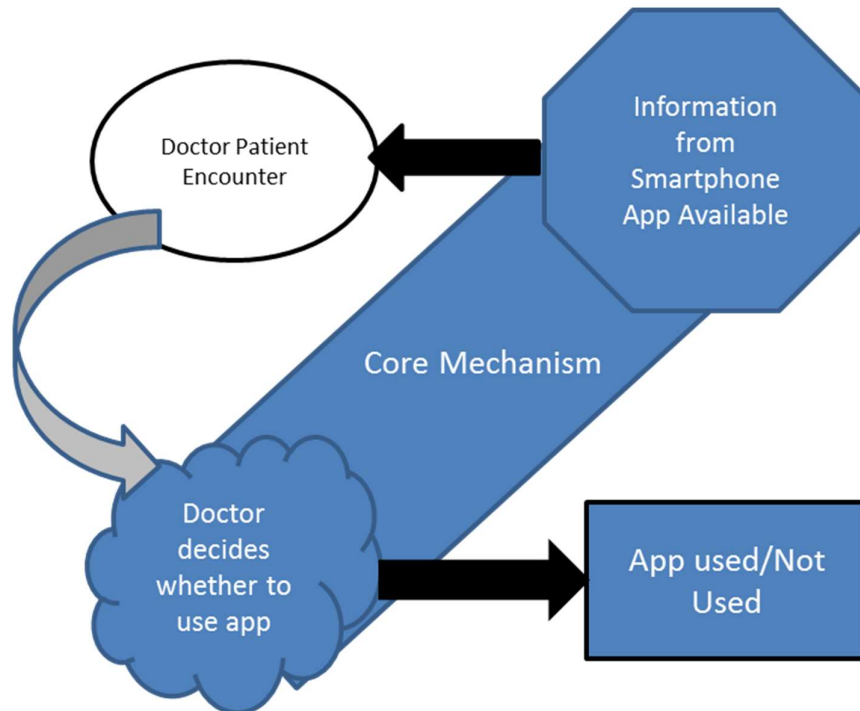


Figure 5 Core Mechanism for Decision to Use an App

Dalkin et al's (2015) formulation provides a framework that allows clearer expression of how the activation of a mechanism is influenced by a specific context, and provides a framework that enables one to identify these contextual elements. What it does not provide is a way of conceptualizing context in a way that enables understanding of how contextual elements can combine to influence the firing of a mechanism which, as has been established, occurs through the reasoning of individuals and groups. The same authors address this through their use of a "dimmer switch" analogy. Rather than a mechanism firing in a digital fashion –either on or off – it may

operate in a more analogue fashion. Thus, rather than triggering reasoning on or off, the process is more akin to a continuum of activation.

4.3.2 Distinguishing Context and Mechanism

As useful as this conceptualisation is, it does not really help to solve the aforementioned problem of clearly distinguishing what counts as a context from what counts as a mechanism. One promising avenue of inquiry is identified by Porter (2015), who in his critique of Pawson and Tilley's approach presents the idea of distinguishing between Programme Mechanisms (PM) and Contextual Mechanisms (CM). In an attempt to overcome what he describes as the "arbitrary" distinction between mechanism and context used by Pawson and Tilley (1997), Porter (2015) describes Programme mechanisms as those associated with the introduction or execution of a particular programme, whereas contextual Mechanisms are those that are already in the situation, that are "embedded in the extant social context" (p 12). This gives a clear boundary between programme or intervention mechanisms and the influence of context – contextual mechanism are already present in the situation of interest, whereas the programme mechanisms are those introduced by the programme of interest. These contextual mechanisms, like all realist mechanisms, may be latent in the situation, but the key point is that they are those that are relevant to the outcome of interest. Using the antibiotic protocol example to illustrate, a programme mechanism may be the briefing of the antibiotic protocol, whereas a contextual mechanism may be related to the propensity of an individual to refer to the intranet page for the protocol. For this conceptualisation to occur, one must view a context as constituted of multiple contextual elements, some of which may be relevant to the outcome of interest, some of which may not.

4.4. Application of Realist Evaluation to the Present thesis

There are three main stages to Realist Evaluation: 1) the elicitation and development of programme theories and the formulation of hypotheses based on CMO configurations; 2) the gathering of data on the relevant

contexts, mechanisms and outcomes from a range of sources; and 3) the use of these data to test the hypotheses.

The first stage of the Realist project is to generate programme theory. This 'surfacing' of theory uses literature and reviewing discussions with stakeholders to develop initial programme theories which are both plausible and testable. Empirical study is then used to test and refine these theories. Later chapters describe the processes and rationale behind the collection of data on mechanisms and contexts, and crucially, outcome data that will enable the testing of theory. When described in these terms, it becomes easier to see that there is no need *per se* for an evaluand, merely for there to be an outcome that can be measured (the decision to use an app) whose emergence is the potential outcome of a mechanism firing within a given set of contextual conditions.

4.5 Clarification and Operationalisation of Key Concepts

Before moving on to a detailed description of how programme theory was generated, it is worth clarifying how the concepts of context, mechanism and outcome are operationalised in this study.

4.5.1 The Operationalisation of Context in the Present Study

Context is a word that can take on multiple meanings depending on how it is used and who it is used by (Pfadenhauer et al., 2015). In this study, it is taken to mean the pre-existing conditions into which an intervention is being implemented. As such, a given context can be constituted of multiple contextual features or elements. Such contextual elements are considered real structures within a realist ontology. They are conceptualisations that convey an aspect of the underlying reality (with varying adequacy in terms of their description of that reality), and so can be construed as having their own causal powers and liabilities relating to other contextual elements and the causal mechanisms of interest. As illustrated in figure 4, these elements may exist at various levels in relation to the use of an app – they may exist at the level of the individual (e.g. attitudes towards app use), immediate doctor-patient interaction (e.g. purpose of the interaction), the physical environment (e.g. the ward within which an interaction takes place)

or specific organisational context within which that interaction takes place (e.g. organisational policy towards app use).

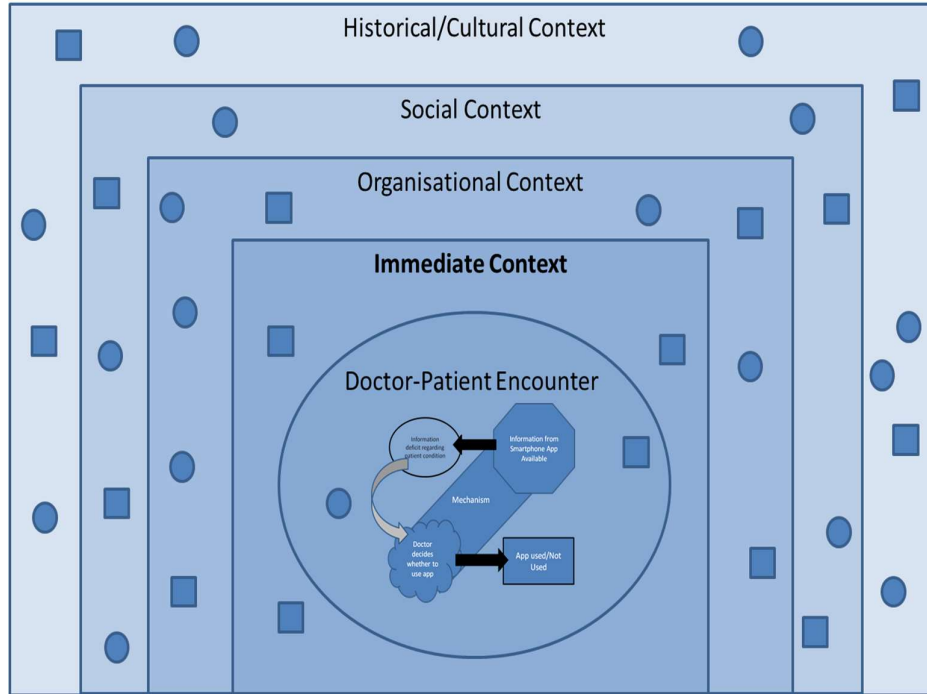


Figure 5 Layers of Context Around a Core Mechanism

4.5.2 The Concept of Mechanism in the Present Study

Much of Chapter 3 was spent describing the concept of generative causal mechanisms in scientific realism, emphasising their dynamic and active nature, with a key element being that they are only activated through the elicitation of a behavioural or cognitive reaction by an individual in response to a something in the environment. The point worth emphasising in the present study is that the focus is not only on mechanisms associated with the intervention, but also on mechanisms that might affect app use in general, and in the present study this is likely to be mechanisms arising from the context – the distinction between Programme mechanisms and Contextual mechanisms described in section 4.3.2. This comes back to the idea of understanding the causal mechanisms that lead to app use rather than understanding what specific components of an intervention lead to app use. This anchors the investigation firmly in the realm of middle-range theory, at a level of abstraction above the level of a specific app such as

Ignaz.

4.5.3 The concept of Outcome in the present study

The outcomes in this study were decisions (or not) to use apps in a particular situation. At this stage in the research design process, the outcomes of app use were also within the scope of the investigation. However, as already discussed, although such outcomes eventually fell out of scope, consideration of the perceptions of such outcomes by users did not. This was because as the study progressed, it was apparent that perceived benefits of app use were a factor that could potentially influence app use.

The consequences of deciding to use an app can be both direct and indirect. The immediate outcome is that the app would be used. Following this use, there may be a range of secondary and even tertiary outcomes. There may be an outcome associated with whether the app changed the quality or speed of care that a patient received, there may be social outcomes in terms of how colleagues and patients view the user of the app or the app itself, there may be outcomes relating to policy adherents, or key performance indicators. At this stage of the investigation, part of the task at hand was to cast the net far and wide to try and understand how or if any of these outcomes are likely to be triggered.

4.6 Programme Theory, Programme Logic and Context-Mechanism-Outcome Configurations (CMOCs)

Programme logic has a specific meaning in this study. It describes the underlying logic of why a particular intervention is expected to deliver specific benefits, and corresponds to Weiss's (1997) idea of implementation theory. Programme theory in this study refers to the causal relationships within a system that lead to an outcome, and as such is concerned not just with programme components and activities, but responses and reactions to these activities, and also takes account of contextual features. CMOCs

represent elements of the programme theory which incorporate context, mechanisms and outcomes so that the influences of different contextual elements on the activation of particular mechanisms can be evaluated and understood. CMOCs can thus be understood as a tool that aid the conceptualisation of programme theory rather than an end in themselves. The aim is ultimately to develop the overall programme theory to a point where practical knowledge can be gained and applied to real life.

Chapter 5 describes the elicitation of relevant theory for this thesis.

Chapter 6 describes the first empirical study, in which theories are refined through the use of an interview study. Chapter 7 describes a final empirical stage in which the refined theories from Chapter 6 are subject to empirical test through the use of a multi-source case study.

4.7 Framework for the Current Thesis

This thesis is built on a Scientific Realist methodology. Although ultimately the thesis is not an evaluation, this did not make a material difference to the framework employed for the empirical stage of the thesis – the overall topic (app use) stayed the same, but the line of enquiry focused in on a different outcome – rather than outcomes of interest relating to the benefits of app use, they focused on app use itself as the outcome of primary interest).

Figure 6, below, summarises the overall framework of the remainder of the thesis.

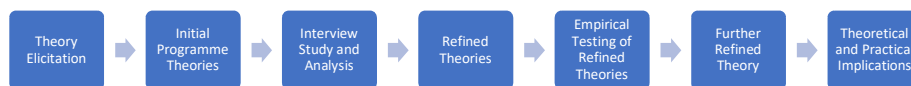


Figure 6 Theory Development to Testing in Realism

In Chapter 5, the process for eliciting theory is described. Chapter 6 describes an interview study that was used to refine these theories. The process used to test these theories is described in Chapter 7, along with the findings of this process. This progress from elicitation and refinement of theory to testing follows that described within conventional realist evaluation (Pawson & Tilley, 1997); the primary difference between the present thesis and realist evaluation is that the present thesis did not focus on the outcomes of an intervention, but rather the emergence of a specific behaviour (app use).

Chapter 5 - Eliciting the Programme Logic

In order to test a theory, it is necessary to find a theory to test. Within this thesis, the starting theories were elicited using multiple methods. The purpose of this chapter is to outline the candidate programme theories for empirical investigation, and to outline the process by which they were identified.

5.1 Theory elicitation process

5.1.1 Criteria for Development of Programme Theory

The goal of the theory elicitation stage in any realist research is to develop a suitable starting point for the investigation (Pawson & Manzano-Santaella, 2012). Any complex intervention, or even relatively simple intervention into a complex setting will have multiple potential contextual influences that may have an influence on the outcomes of interest. It is therefore impossible to specify all the ideas that go to make up a complex intervention, let alone operationalise and test them within an empirical investigation.

A criterion that was applied to selection of appropriate elements of programme theory relates to the trust-doubt ratio (Pawson, 2006). An available tactic is to trust a sizeable proportion of the programme theory whilst putting certain of its facets to the test in the expectation that knowledge of them can be revised or improved. Thus it is a case of balancing the investigation between those elements of theory that there is more reason to have confidence in compared to those elements about which investigation could yield new knowledge. Scientific enquiry never starts from scratch – as Popper wrote, ‘we simply stop when we are satisfied that they are firm enough to carry the structure, at least for the time being. So in these terms, plausibility of theory is of paramount importance.

As well as plausibility, for this study *utility* and *testability* of such theories are key considerations: *utility* in terms of how useful is it to know whether a theory provides an explanation of going on in terms of how much it is

possible to influence any of the elements involved to produce a desirable change in outcome, and *testability* with regards to how practical it is to gather data that will help to test the theories under investigation.

Although the intention with this investigation at this point was to look primarily at Ignaz, it was necessary at this point to decouple the theory development from a specific app. Realist evaluation requires the use of middle range theory, and as described in Chapter 3, such theory is abstracted from the lowest level of detail that is the domain of a specific intervention; the goal is to develop theory that could be used more generally but still is sufficiently detailed to be of practical utility. As such, when developing the programme theory, whilst Ignaz was referred to, it was not the sole focus. Rather, the general type (or family) of app to which Ignaz belonged, that with the purpose of providing reference information at the point of care, was the intended target of investigation.

5.1.2 Outline of the Theory Elicitation Process

As with many aspects of Realist Evaluation methodology, there is no single best way of generating programme theory (Pawson & Tilley, 1997) and in many Realist Evaluation studies, the process by which such theory is surfaced is not explicitly described (Pawson & Manzano-Santaella, 2012). However, there is some guidance in the literature as to what constitutes effective theory elicitation. Central to this is the idea that programmes and interventions are “theories incarnate”, in that they embody ideas and logic of why certain activities will have a particular effect (Pawson & Tilley, 1997); an intervention will have an underlying logic that may or may not be articulated explicitly. Thus, within the theory elicitation process, there should be some attempt to elucidate the programme logic behind the intervention that incorporates how outcomes are expected to be created.

Related to this point is that interventions can be viewed from a range of viewpoints, and that different stakeholders will experience the intervention from different perspectives. An evaluator cannot lay claim to possessing all wisdom when it comes to a particular intervention; evaluators may have a good overview of the programme objectives or intended outcomes, but end users are in a better position to understand the potential mechanisms at

work, with designers likely to have a good handle on various contextual factors that play a role as well as having an understanding of the programme logic. As such, the gathering of theory from a range of perspectives, from programme designers and implementers to end users and other stakeholders is held up as a good creating good programme theory (Pawson & Tilley, 1997). In this project, multiple sources of information were used in a multi-stage process to elicit potential CMOCs. Discussions with stakeholders were intended to elicit the programme logic, as well as understand some of the practical issues that might influence app use. The grey literature was expected to add further detail to the programme logic, as well as provide additional information on perceived outcomes of app use. Relevant substantive theory was searched to provide additional ideas regarding potential contextual influences.

The use of literature to identify programme theory is a feature of realist synthesis, a cousin of realist evaluation that synthesizes the evidence from a range of studies to test a theory. Rather than a new literature search, articles relating to app use identified during the scoping study (which were rarely included in the scoping study as they tended not to be empirical studies) were examined and some of the implicit programme theories were inferred. As noted by Pawson (2006), many relevant ideas can be found in discussions of the published papers. Think pieces or magazine articles were also a rich source of ideas in this study.

The use of substantive theory has also been put forward as a starting point for creating programme theories (Westhorp, 2012). Substantive theory can be useful in identifying contextual elements of a complex system that might be pertinent to a given inquiry, and they help to draw boundaries around and between these elements to enable the identification of levels of a system. They can also be helpful in identifying putative mechanisms and outcomes, and helping to link different CMOCs and elements of programme theory together into a coherent causal explanation of a system (Westhorp, 2012). In this particular study, it should be noted that they were used more as a sensitising device to aid the researcher in the identification of contextual elements rather than a direct source of programme theory. This

is because, as the scoping study showed, very little substantive theory relating to apps has been identified or tested. Thus, the emphasis in this exercise was to link grey literature with potentially relevant substantive theory to see if there is intersection between the two, which can then be used as corroboration to encourage the inclusion of a particular element into the testable programme theories for the interviews. A simple illustration of the theory elicitation process is shown in Figure 7, below

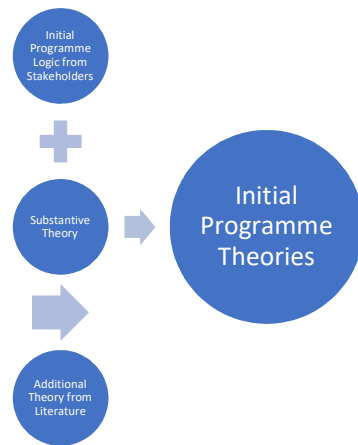


Figure 7 Information Sources for Initial Programme Theories

5.2 Elicitation of Programme Logic

5.2.1 Process for Elicitation of Programme Logic

The starting point in this study before going into detailed elicitation was to map out the initial logic of why an app would be used, and how it would lead to outcomes. In line with this reasoning, the first stage of theory elicitation was discussions with the designers of Ignaz to understand the programme logic. This initial programme logic was extracted from initial, informal discussions with app designers.

Informal discussions were held with three people involved in the development of Ignaz. The designers were also doctors themselves, who had decided to act on a need that they had identified in their own practice. This meant that when describing their programme logic, it was from the point of view of both designer and end user, but this did not mean that their

views could be taken as encompassing the full gamut of views of either group. Furthermore, the researcher had an existing working relationship with the designers as they also worked at BIHR. This relationship was seen as primarily positive, in that the respondents knew that they did not have to sell the idea of Ignaz or give an overly positive impression of the app. The main risk was that the researcher, given the pre-existing relationships and the value that they placed on these relationships, might not be as rigorous in their questioning. However, this risk was minimised through the emphasis on not using these discussions as anything more than informational – the primary purpose was to gather ideas and get a sense of how the designers saw the Ignaz app as being useful and how it would operate in practice.

These discussions were held at their place of work for the sake of convenience. They were not audio recorded and typically lasted no more than fifteen or twenty minutes. Again, the decision not to record the interviews was to encourage an informality to the discussions that would enable the informants to speak freely and share their own particular perspectives rather than feeling that they needed to toe any party line that the team had agreed on for the roll out of Ignaz. The potential loss of detail was mitigated by the fact that the researcher planned to gather information from these same respondents in the formal empirical stages of the research. The discussion was built around three open-ended questions, designed to elicit the programme theory from the designers:

- 1) Why was the app developed?
- 2) What did you expect the benefits to be?
- 3) What did you think would influence the success of the app?

There was a degree of convergence in what the designers outlined in terms of programme logic and there was a clear causal chain identified in these discussions, which is illustrated in Figure 7. The main purpose of the Ignaz app was that it put information that was either not available or only available from a limited number of sources in the palm of the doctor's hand. This formed the basis of the app's presumed utility. Once the doctor is required to execute certain tasks, it was expected that they would be able

to refer to the information on the app immediately at the point at which the need arises, leading to the outcomes that the doctor should be able to execute the action more quickly and, working on the assumption that the information in the app is accurate, should lessen the opportunity for error. In terms of the concept of mechanism, the availability of information through the app at the point of care allows a doctor to access information through app, and allows them to choose to use the app. Thus the mechanism here is a combination of the availability of the resource (the app) and the reasoning of the doctor in deciding to use the app (Dalkin et al., 2015).

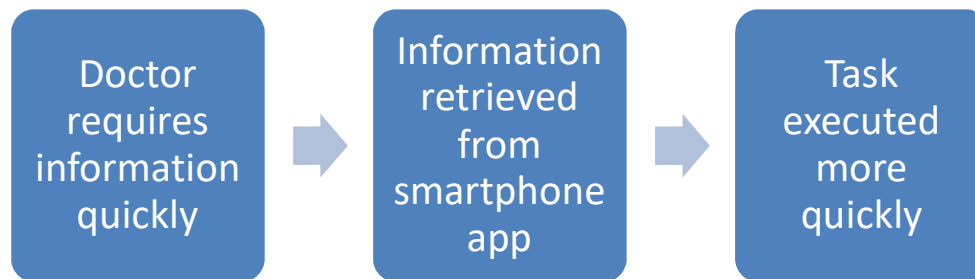


Figure 8 Simplified Programme Logic for App Use Benefits

In terms of other anticipated outcomes, easier access to relevant local policy information was also expected to lead to better adherence to those policies, for instance regarding the use of the correct antibiotic policies. Quicker and more accurate execution of tasks was expected to lead to a more efficient use of doctor's time, with the potential outcomes of more patients attended to, better overall patient care, and better objective and perceived doctor performance.

5.2.2 Causal Chain underpinning Programme Logic

Based on the conversations with stakeholders, it was possible for the researcher to construct a putative causal chain explaining how Ignaz would lead to the anticipated benefits (Pawson & Manzana-Santaella, 2013). The programme logic begins with the assumption that most doctors own smartphones and that they carry them around with them whilst going about

their duties. Smartphones have the capacity to hold smartphone apps, so a pre-condition of their use is the user having relevant apps on their phones, which requires an awareness that those apps are available and that they are useful enough to have on their phones. Then, as the user goes about their job, the app is available to use. Then, when the user is in need of information stored in the app, they will use the app to retrieve the information. This ability to retrieve information *in situ* may then have consequences in terms of the doctor's ability to complete a task quicker, with associated benefits such as increased productivity, increased ability to manage workload, and better quality of decisions.

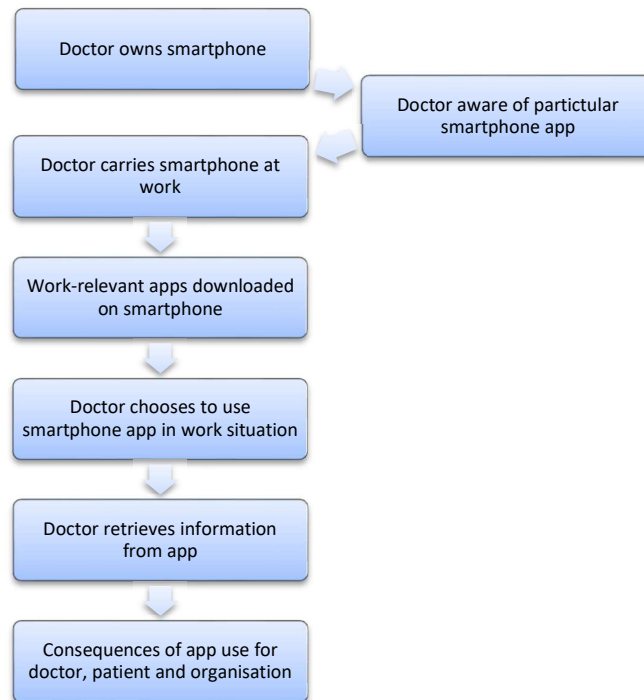


Figure 9 Proposed Causal Chain for App Use Benefits.

This description of the process in itself suggests a number of decision points in the process, where doctors have choices to make and which may be influenced by a range of contextual factors. First of all, as noted in Chapter 1, the ownership of a smartphone, whilst common, is not a given, especially given that not all doctors are necessarily issued with

smartphones. The next potential break in the chain is the decision by a doctor to carry their smartphone with them at work – again, based on surveys already reviewed in this thesis (e.g. Putzer & Park, 2010) this is not a given, and will be partially driven by whether they see their phone as a tool for work. Then there is the matter of whether a doctor will choose to download particular apps for use at work. From the conversations with stakeholders discussed in this and previous chapters, this may depend on many factors, like awareness of such apps, the capabilities of their smartphone as well as their trust in the utility and reliability of such apps. Awareness of apps may be influenced by how they are rolled out, their visibility in the appropriate software store, or through what colleagues are using.

The stakeholder conversations raised some additional interesting points. Assuming that a doctor has a smartphone at work with the appropriate apps downloaded, there are then decisions to be made about when or how such apps are used: If an issue needs to be resolved right then, or if there is a better information source, or if the patient will respond negatively. All of these considerations of the context within which the doctor is working will be taken into account, in addition to considerations of how easy it is to use such an app and whether the information from the app is trustworthy or even useful. Thus, within the implementation chain there are a myriad of possible influences that are in place before the app is even used. Then there are a series of plausible but relatively untested assumptions related to the benefits of using apps, the causal chains of which require further examination.

The discussions with app designers suggested that they were not naïve to these contextual influences, and certain contextual features were identified by the designers as potentially affecting the use of apps. For instance, the attitude of senior staff was expected to have an influence on the use of the app, with junior doctors often balancing their own clinical judgement with expectations of more experienced colleagues. Related to this, the age profile of users and their departments was expected to have an effect, with users expected to be younger than average owing to their familiarity with the technology. Whilst Ignaz was designed for use across a range of

settings, it was not anticipated that particular wards would be more or less conducive to app use. It was however thought that the implementation approach would have an effect on whether the app was downloaded and subsequently used. The developers did some informal user testing prior to roll out and usability problems were not anticipated.

Of particular interest to the app designers were those ideas that related to roll out of apps and features of apps that would make them more or less attractive to users, as well as an acknowledgement that certain environmental factors would play a role in the decision to use an app.

Bearing in mind the recommendation that different perspectives are helpful in generating programme theory, initial discussions with stakeholders held for the scoping review (see Chapter 2) were revisited for anything of interest. By and large, similar issues were raised with regards to the contextual features that would have an influence. The nuance gained from these discussions was the relatively low level of perceived use, reinforcing the researcher's belief that the app designers, although doctors themselves, were not necessarily representative of end users as a whole.

In summary, where rollout has been "successful", with high levels of visibility and buy-in, one would expect high levels of download and use. Where the app is perceived as useful and usable, one would also expect higher usage of the app. Where other information sources are readily available, one might expect lower use of the app. Where the app is widely used, one might expect higher productivity and higher adherence to policy. It is worth noting that the resource part of the mechanism in many of the above theories is essentially additional information that users can factor into their reasoning process that increases or decreases the propensity of the user to perform the outcome behaviours. It follows that for these contexts to successfully provide resources to a user, the user must have some conscious awareness of the context.

5.3 Additional literature and substantive theory

Whilst the discussions with the programme designers were useful in generating an initial sketch of the programme theory, surveying the grey

literature provides additional potential mechanisms and outcomes. . Much of this literature was identified while undertaking the scoping study described in Chapter 2, but not included within that study because it did not meet the inclusion criteria (usually the absence of empirical data). Such literature included, but was not limited to, opinion pieces on websites, articles reviewing certain types of apps, articles advocating the utility of apps within different specialties and articles cautioning against their use.

Overall, many of the ideas raised in the aforementioned discussions with stakeholders were apparent in the literature. Ownership or availability of a smartphone is an issue that would clearly affect the ability of individuals to use apps. The role of financial constraints is mentioned in the grey literature as a potential barrier to app adoption (Kahn, Yang & Kahn, 2010). In this instance, it pertains not only to the ownership of a smartphone, but also having a service plan that means that additional data download costs are not an issue.

The level of experience and confidence of doctors was also seen as likely to have an impact on their use of the app – certain individuals might prefer to refer to the app rather than asking colleagues in order to maintain an impression of high competence with colleagues. Additionally, the literature (Moore, Anderson & Cox, 2012) and stakeholder discussions highlighted the differences between different clinical groups (i.e. doctors and nurses). This issue of professional identity suggests alternative mechanisms, to do with the nature of the job role or professional function, to those already identified. While the focus of this investigation is on doctors, apps are also potentially used by other members of staff and within similar contexts, so such mechanisms are of interest to the present thesis.

The grey literature also reinforced the need to consider usability of the app, and indeed suggested alternative mechanisms. For instance, it has been suggested that poor usability could be seen not just as a barrier to use owing to the level of difficulty of use, but also by reducing the level of confidence that the user has in the information retrieved (Tsopra, Jais, Venot & Duclos (2013). This could also be a mechanism by which colleagues of the user may assess the credibility of the app, independent of

the thoughts of the user themselves, and therefore may have an indirect influence on use. Such issues may relate to the ease of retrieval of information, but also to the presentation of the retrieved information. This leads directly to questions as to the nature of the device on which Ignaz is used, with factors such as display screen size, speed of operating system and effectiveness of interface likely to play a role (Richardson et al., 2012). Such a view is congruent with the Technology Acceptance Model which has already been used on portable IT in healthcare (Yarbrough & Smith, 2007) described in the scoping study in Chapter 2, and as such seems worthy of testing.

Some of the interviewees identified issues relating to the relative supportiveness of organisational policies and procedures, a factor also identified in the literature (Phillippi & Wyatt, 2011). Such policies may not be purely IT related, but may also relate to general policies around infection control, general working practice and risk (Hamilton & Brady 2012). Such policies may even be at a ward level. Also at a ward or specialty level are factors related to the suitability of app use in certain situations. Such local level judgements might be related to perceived busyness of the ward, patient expectations or even recommendations from national bodies related to particular specialisms (Moore, Anderson & Cox, 2012).

Consideration of these organisational issues is consistent with theoretical approaches that the researcher has become more familiar with through other work. HOT-fit (Yusof et al., 2008) is a framework designed for the evaluation of health technologies, that incorporates Human, Organisational and Technological factors into its framework. . On the other hand Normalization Process Theory (NPT) (May & Finch, 2009), which has received a lot of attention within health research in recent years, suggests that uptake might be more gradual, as use of the app gradually becomes the norm. Users and groups gradually make sense of and engage with new technologies, and adapt working practices as they weigh up the costs and benefits.

With regards to additional outcomes of app use, another relevant theory from the researcher's previous work is the job demands-resources model

(Bakker & Demerouti, 2007), which suggest that the availability of additional resources (i.e. the app) should lead to improved performance and better job satisfaction and reduced stress. Furthermore, reduced experience of stress may improve the ability of doctors to learn and have positive effects on other stress-related outcomes such as fatigue, burnout and general levels of life satisfaction (Bakker & Demerouti, 2007).

In summary, the potential CMOCs, even in what is a relatively simple case, were many and varied. There are those relating to the app itself, those that relate to the nature of the devices, those that relate to formal and informal restrictions on individual use, and there are those that relate to additional outcomes. It is also apparent that many of the CMOCs suggested in the grey literature map onto substantive theory relating to the adoption of other medical technologies.

5.4 Initial Theories for Empirical Investigation

As described in Chapter 4, it is not feasible to test all possible CMOCs within a single investigation. Given the range of factors, the fragmented and competing nature of some of the theories, to attempt construction of a complete programme logic model would have been both unwieldy and not particularly helpful. Not only was there no justifiable empirical basis (at this stage) on which to select between theories, there was no evidence to even configure the theories into a putative causal model. Furthermore, attempting to configure the theories into a single causal web or pathway may at this point reduce the ability of the researcher to identify further contextual elements and mechanisms by closing off these avenues of enquiry earlier than necessary. What this meant in practice is that the initial empirical study was not to be an explicit test of the programme theories and their associated hypotheses, but an exercise in refining the propositions and understanding how they relate to each other to build a more holistic picture of the whole system, which could also bound the scope of a subsequent study.

On a theoretical level, an important implication is that wide range and type of theory elicited supports the conceptualisation of app use as actually quite

complex and operating within a complex system. Some theories operate at the level of single event, some place an emphasis on the role of the individual, some implicate immediate situational contexts and some point to social influences, whereas some point to organisation and wider cultural influences. Thus an effective evaluation would need to acknowledge this complexity and attempt to address it in some way.

A pragmatic approach was taken to the development of theory to be explored in the first study. Whilst no theories were discarded out of hand, the focus was on those ideas on which interview subjects would be able to provide insight. Thus, those theories that required quantitative data to test were rephrased to enable meaningful data to be captured from interviews, so that the “trust-doubt ratio” (Pawson, 2006) could be assessed before moving forward. The interviews would also provide some indication of what level of app use was perceived by end users, which in turn would influence the theories that would be suitable for testing in the final stage. The initial list of theories (in the form of interview schedule statements) is described below.

- 1) *Improved Performance Through Better Availability of Information:*
The app will give you the capability (Context supplying resource to mechanism) to access certain information at point of care rather than having to refer to other information sources (Mechanism – response to availability of resource) . Therefore, this will make you more able to perform your role (Outcome behaviour).
- 2) *Improved Efficiency:* The ability to access information at point of care (*Mechanism – Response to resource made available by app*) will make you more efficient overall (*Outcome behaviour*).
- 3) *Improved Compliance:* The ability to access information at point of care (*Mechanism – Resource*) will make it easier for you to comply with relevant protocols (*Mechanism – response to availability of resource*), thereby increasing your compliance to protocols overall (*Outcome behaviour*).
- 4) *Improved Wellbeing:* By allowing you to undertake your role more effectively (*Outcome of Efficiency Mechanism providing Resource*),

this reduces some forms of stress (*Secondary mechanism relating to stress reduction through reduction in perceived workload*) and therefore improve your own subjective wellbeing (*Secondary Outcome*).

- 5) *Colleague Perceptions*: Negative perceptions of an app by senior colleagues (*Context influencing response to mechanism*) will reduce your intention to use the app (*Mechanism – response to resource*), in turn leading to a reduction in use of the app (*Outcome Behaviour*)
- 6) *Patient Perceptions*: Negative perceptions of an app by patients (*Context influencing response to mechanism*) will reduce your intention to use the app in their presence (*Mechanism – response to resource*), leading to either less use overall, or use only away from patients (*Outcome Behaviour*)
- 7) *App Usability*: If an app is harder to use (*Context affecting availability of resource*), you will use it less (*Outcome behaviour*)
- 8) *App Rollout*: The way that the app is rolled out (*Context affecting availability of resource*) will impact on your willingness to use the app (*Response to availability of resource*)
- 9) *Busyness of Ward*: The busyness of a ward (*Context affecting availability of resource*) will affect the way you go about your daily tasks (*Response to availability of resource*), so busyness will affect the likelihood of you using the app in comparison to other information sources (*Outcome behaviours*)

The theories selected allow a broad coverage of the factors identified in the literature search and discussions, and should also allow for emergent factors and mechanisms to be identified. Theories 1 to 4 focus on the effects of app use, suggesting mechanisms as to how such effects would be achieved. Theories 5 and 6 explore the role of social influences, whilst Theory 7 explores the nature of the usability of an app and its affect on use. Theory 8 looks at whether how an app is rolled out plays a role in its use and Theory 9 explores the effect of immediate context on the decision to use an app.

It is worth noting that at this stage, the intention was still to do an evaluation of the benefits of app use, but as will become clearer in the next chapter, the theories were a sound starting point for the investigation into what causes app use as an outcome. The following chapter goes on to describe the empirical study that was used to refine and test these theories.

Chapter 6 – Refining the Theories

This chapter describes the first empirical study of this realist evaluation which takes the form of an interview study. In terms of the realist methodology, the purpose of this study is to move from the set of initial programme theories generated in Chapter 5 to a more fully developed set of theories that relate more specifically to the real world use of apps – that is, that are rooted in the reality within which the study is taking place. In more pragmatic terms, the purpose of this interview study is to begin to address the aims of the study – to start identifying the extent of app use within the study setting, understand which causal mechanisms are at play, what elements of context seem to be important and what outcomes are useful to measure. This chapter describes how and why data collection and analytic approaches were chosen, describes the methods used, the findings and discusses their implications.

It should be borne in mind that at this point, the empirical study was still intended to culminate in an evaluation of the Ignaz app. Therefore, the enquiry, still incorporated questions relating to the benefits of app use. However, as will become clear, the researcher anticipated that an evaluation of Ignaz alone may be problematic due to its relative newness and therefore the interviews were about app use in general.

6.1 Selection of Data Collection Methodology

The following sections give a brief justification for why the particular data collection and analysis methods used were chosen, and then moves on to describe how these were undertaken in the course of the empirical study.

6.1.1 Criteria for selection of interview type

Interviews are widely used within social science research as a method of data collection, and can vary in structure, purpose and style (Silverman, 2013). Whilst there is a difference between what people say and what they do, the aim of an interview in this realist context is to access people's perceptions of a situation rather than any hard and fast objective truth – that is, one is aiming to uncover the underlying real mental structures and

processes that may influence an individual's behaviour. That being said, one must also acknowledge that such access imparted by an interview would only be to conscious awareness of such influences, and as such, one must acknowledge such limitations, and compensate for them within the study design. As described earlier, for theory-driven evaluation approaches such as Realist Evaluation, the choice of methods is driven by the research questions rather than adhering to a specific methodological paradigm. For the present study, the interview type needed to be congruent with the research questions, and as such needed to meet a number of criteria:

- 1) Allows for the refinement of *a priori* theory
- 2) Sufficiently focused on the theories under investigation, but also flexible enough to cover novel emergent theories, i.e. capable of generating rich data
- 3) Efficient in terms of coverage – interviews were to take place in the workplace during normal working hours
- 4) Congruent with a realist methodological approach

6.1.2 Available forms of interview

Myriad forms of interview are described in the literature, and can be classified in a number of ways (Silverman, 2013), although for the purposes of this study, the initial discussion takes place with regards to level of structure. Unstructured interviews can provide rich data, but given the requirement to speak to specific theories, their reduced capacity to keep the interview “on topic” renders them less than ideal. Structured interviews have the opposite problem, in that they are easier to control from the interviewer's perspective and stay on topic, but the lack of richness of data is an issue. To actually go through the theories under investigation would require lots of questions with lots of options, and even then, would lack the ability to tap into emergent theories. Semi-structured interviews would seem to be an appropriate compromise, but there is the issue of how to ensure that the interviews cover theory sufficiently. For this reason, realist interviews were chosen.

6.1.3 Realist Interviews

Realist interviews are a form of semi-structured interview described by Pawson and Tilley (1997) with realist evaluation in mind. The realist interview follows a Teacher-Learner cycle: The interviewer explains or "teaches" their theory to the interviewee, and then asks them to give their opinion of the theory, based on their own knowledge and experience. The interviewee gives their view of the theory, refining or refuting or rejecting as per their view, essentially teaching their version of the theory to the interviewer. The interviewer then relays the new theory back to the interviewee to check their understanding of what the interviewer has said, so that the new version of the theory can be recorded faithfully. Although this can make the interview seem like the interviewer is leading the participant, it guides the interviewee to evaluate a specific theory, thus providing a form of testing. This explicit focus on theory made the choice of realist interviews a good fit for this study. Realist interviews have been used extensively within the realist literature, but as Manzano (2016) cautions, the level of success with which they have been used is variable. Following the interviews, it was anticipated that the initial list of CMO configurations would be refined; some CMOs configurations would have more evidence than others, some would be reconfigured, new contexts, mechanisms and outcomes might emerge, some might be discarded, and some would be combined to produce new configurations.

6.2 Data Collection Methods

6.2.1 Participants

Prior to the commencement of recruitment, ethical approval for the study was gained from the University of Leeds School of Psychology Ethics committee and from Bradford Teaching Hospitals Research & Development team – full NHS ethics approval was not required due to the nature of the research in that the focus was on staff rather than patients. Participants were selected using a purposeful theoretical sample (Emmel, 2013), which means the sample was deliberately rather than randomly selected, and the choice of participant was guided by the theories to be tested. This

maximised the opportunity of speaking to individuals who had exposure to apps in their working lives, with particular reference to Ignaz. As such, the interviewees were four relatively experienced doctors involved in the design and rollout of Ignaz employed by the Trust and five junior doctors (Foundation years 1 and 2) who had experience of using apps. The doctors who were involved in the design of Ignaz would have experience of using and designing the app, and would be likely to have programme theories that could be accessed by the researcher through the interview process. The junior doctors were chosen because they were part of a cohort of students from University who would have had experience of using mandatory apps during this training. Having used such apps, they were viewed as more likely to have used apps than the general population of healthcare professionals within the hospital. The logic was that such a population would have experience of using apps within the workplace, and as such would be able to provide informed feedback on the use of apps in real world practice. Using these two populations of participant meant that the researcher would have access to the programme theories in the heads of “implementers”, and would also have access to users who would provide data that could be used as evidence to evaluate the initial hypotheses. Obtaining different perspectives like this is useful within a realist study (See Chapter 3 for prior discussion).

The four more experienced doctors were recruited directly via email as the researcher already knew them. Those that replied to the email consented to be interviewed. Practical arrangements for date and time of the interview were then arranged via email and phonecall. Some of these doctors participated in the theory elicitation exercise described in Chapter 5. Whilst this might be seen as duplication, the nature of the interactions was very different – the theory elicitation conversations were informal and loosely structured, whereas realist interviews for this study were far more structured (see section 6.1.3). Two methods were used to recruit doctors in training. The first method used was through attendance at a lecture that was a part of the doctors’ training. At the end of the lecture, the researcher introduced the study, and handed out information sheets. If a candidate agreed to an interview, they either confirmed then and there or emailed the

researcher. Logistics of when the interview would take place were then confirmed with each candidate verbally or via email. Because this method only yielded a small number of interviews, additional individuals were approached on larger wards, with the permission of the ward manager on duty. Potential candidates were given an information sheet and consent form whilst the researcher explained the purpose of the interviews (See Appendix). Candidates were informed that they were free to withdraw at any time, and that their personal data would be kept anonymous and confidential – all data were handled in line with NHS Good Clinical Practice guidelines. Those that agreed to participate either emailed the researcher or verbally confirmed their willingness to take part, with logistics either arranged in person or via email.

Nine interviews were conducted, each lasting between 20 and 45 minutes.. Three participants were female, and qualification stage ranged from Foundation year 1 (FY1) to Specialist Registrar. Initially the intention was to interview more interviewees, but the extent to which themes recurred within the interviews suggested that further interviews would provide diminishing returns in terms of insight or reaching a threshold of data saturation that was sufficient for the present study (Silverman, 2013). Furthermore, this was explicitly designed as an initial exploratory study, and as such there were going to be additional opportunities to examine the refined theories in the subsequent empirical study; the purpose of this study was to create a solid foundation for that study rather than being comprehensive in and of itself.

6.2.2 Materials

The interview schedule was developed using the theories described in Chapter 5 and summarised in Table 1. All nine theories stated at the end of Chapter 5 were covered in the initial schedule, although as the interviews progressed, this number increased to 11. As well as items around the theories under investigation, the schedule incorporated a preamble explaining the purpose and format of the interview, and at the end of the interview there was the opportunity for the interviewees to respond with any additional thoughts and theories.

Table 1. Summary of Theories for Use in Interviews

<i>Theory Number</i>	<i>Theory Description</i>
1) <i>Improved Performance Through Better Availability of Information</i>	The app will give you the capability (Context supplying resource to mechanism) to access certain information at point of care rather than having to refer to other information sources (Mechanism – response to availability of resource) . Therefore, this will make you more able to perform your role (Outcome behaviour).
2) <i>Improved Efficiency:</i>	The ability to access information at point of care (<i>Mechanism – Response to resource made available by app</i>) will make you more efficient overall (<i>Outcome behaviour</i>).
3) <i>Improved Compliance:</i>	The ability to access information at point of care (<i>Mechanism – Resource</i>) will make it easier for you to comply with relevant protocols (<i>Mechanism – response to availability of resource</i>), thereby increasing your compliance to protocols overall (<i>Outcome behaviour</i>).
4) <i>Improved Wellbeing:</i>	By allowing you to undertake your role more effectively (<i>Outcome of Efficiency Mechanism providing Resource</i>), this reduces some forms of stress (<i>Secondary mechanism relating to stress reduction through reduction in perceived workload</i>) and therefore improve your own subjective wellbeing (<i>Secondary Outcome</i>).
5) <i>Colleague Perceptions</i>	: Negative perceptions of an app by senior colleagues (<i>Context influencing response to mechanism</i>) will reduce your intention to use the app (<i>Mechanism – response to resource</i>), in turn leading to a reduction in use of the app (<i>Outcome Behaviour</i>)
6) <i>Patient Perceptions:</i>	Negative perceptions of an app by patients (<i>Context influencing response to mechanism</i>) will reduce your intention to use the app in their presence (<i>Mechanism – response to resource</i>), leading to either less use overall, or use only away from patients (<i>Outcome Behaviour</i>)
7) <i>App Usability:</i>	If an app is harder to use (<i>Context affecting availability of resource</i>) , you will use it less (<i>Outcome behaviour</i>)
8) <i>App Rollout:</i>	The way that the app is rolled out (<i>Context affecting availability of resource</i>) will impact on your willingness to use the app (<i>Response to availability of resource</i>)
9) <i>Busyness of Ward</i>	The busyness of a ward (<i>Context affecting availability of resource</i>) will affect the way you go about your daily tasks (<i>Response to availability of resource</i>), so busyness will affect the likelihood of you using the app in comparison to other information sources (<i>Outcome behaviours</i>)

A copy of the final interview schedule can be found in the Appendix.

6.2.3 Procedure for data collection

All interviews were conducted on a one-to-one basis. Interviews typically took place in the hospital, in a staff room or similar room that was located in or near the ward. Each participant was asked to re-read the information sheet, and then read and sign the consent form before the interview began. The fact that the interviewee could withdraw from the interview at any time or pause because of operational requirements was stressed. The researcher then explained the format and purpose of the interview to the interviewee, with particular attention focused on the teacher-learner cycle (Pawson & Tilley, 1997). Emphasis was placed on the acceptability of differing views, with the interviewer consistently reinforcing the idea that the aim of the interview was to improve the ideas being investigated, and that the interviewees were the one with knowledge of what works and why. On a reflexive note, it was helpful that the researcher was not a medical professional. The researcher was able to convey that they were interested in why apps were being used or not, but did not have real world experience of app use in medical practice or expertise in medicine, thus privileging the view of the participant.

Follow up questions and prompts were used to elicit examples from the interviewee's own experience, as suggested by Pawson and Tilley (1997). As is common practice in qualitative interviewing, the interview schedule was used as a guide to ensure full topic coverage rather than followed sequentially so that the interview could flow more naturally between topics (Silverman, 2013). Once all the topics on the guide had been covered, the interviewer checked whether the interviewee had any further thoughts. After the interview was completed, the interviewer thanked the participant. All interviews were audio recorded and then transcribed verbatim at the earliest available opportunity.

6.3 Analytic approach

The qualitative researcher has an array of options available when it comes to textual data (Denzin, 2008). This section addresses the criteria for

selection of an appropriate method, briefly examines some of the options, and then justifies the approach chosen.

6.3.1 Criteria for selection of approach

Qualitative data analysis can be conducted for many purposes and take many forms, and unlike quantitative analysis, there is no consensus on the best way of analysing qualitative data (Denzin, 2008). The analytical methods may be informed by the research questions, the form of data collection used, epistemological concerns or even the idiosyncrasies of researcher preferences (Denzin, 2008). For the present study, the analytic approach selected must meet the following criteria:

- 1) In common with the data collection method selected, the analytic approach needs to be congruent with the research questions, and as such needs to be congruent with the data generated by the realist interviews.
- 2) In line with criterion 1, the nature of the study demands that the analytic approach is sufficiently deep to unravel some of the causal explanations at work
- 3) The approach chosen needs to be sufficiently flexible to deal with emergent themes and concepts, whilst acknowledging *a priori* theory under investigation

6.3.2 Available approaches

There are a range of approaches available, and there have been attempts to categorise these. For instance, Tesch (2013) describes three main types of analysis: those that focus on language, such as discourse analysis, symbolic interactionism and ethnomethodology; approaches that adopt a descriptive or interpretive approach which aims to reflect and report the views and culture of those studied (including the likes of life histories and classic ethnography); and those that involve theory building through approaches such as grounded theory. Such a typology indicates that the boundaries between these different forms of analysis are clearly defined, but this is not the case. It is difficult to argue for a purely descriptive analysis for instance, as there will always be an element of selection and

interpretation involved in the analytical process (Tesch, 2013). It is necessary, though, to recognise the wide diversity of approaches to qualitative analysis, and that each of the approaches is more suited to specific types of research question. The present study requires elements of theory building but also descriptive and interpretive elements to allow access to the ideas and perceptions of interviewees.

Raw qualitative data are usually voluminous and are seldom structured exactly in a form from which the researcher can draw immediate conclusions (Denzin, 2008). Even with a semi-structured interview schedule, a good interview is likely to diverge from the planned path as various topics trigger associations not anticipated in the interview schedule. As such, one of the key tasks of any analytical technique is the management of the data – sorting and organising the data into form that is readily analysable (Ritchie & Spencer, 1994). From this organised data, one can begin to connect the themes and concepts into more sophisticated frameworks which at first describe the phenomena of interest. Deeper analysis can then follow which can move into the realm of explanation, relating the data to relevant theory, and generating new insights. Ritchie and Lewis (2008) describe an analytical hierarchy, which moves from data management to descriptive accounts through to explanatory accounts. This hierarchy is not traversed in a purely linear fashion, but the researcher will move back and forth along it as the analysis progresses. This complements the view of Maxwell (2012) who describes the need to use both connecting and categorising approaches to analysis – connecting strategies where one looks for connections and relationships between elements, and categorising strategies which typically code data into discrete chunks. Essentially, a combination of the two allows the researcher to identify themes and connections between them without decontextualizing them from their source material – an important element in an approach such as realist evaluation where context is seen as an essential component of explanation. An approach that fits this way of thinking is Framework Analysis (Ritchie and Spencer, 1994), and has been used in a number of realist studies (Abyankhar et al., 2013). Consisting of five stages (Familiarisation, Identifying a thematic framework, indexing,

charting and then mapping and interpretation) , it is particularly suited to such studies as it was developed to inform policy, and thus is designed to facilitate the generation of practically applicable knowledge (Ritchie & Spencer, 1994).

Having explained the rationale behind why these data collection and analytic methods were chosen, the chapter now moves on to describe the specific methods used.

6.3.3 Procedure for Framework Analysis in this study

6.3.3.1 Familiarisation

According to Spencer and colleagues (2003), the aim of the familiarisation stage is to become familiar with the data as a whole body of material, getting a sense of the range and variety of the data. The original intention in this study was to do the initial familiarization with the data from interviews conducted with those involved in the design of Ignaz so that a clear programme logic could be developed. Although only a subset of the whole dataset, such an approach is aligned with the goal of formalising the programme theories before refining them further with users of apps. However, due to difficulties of scheduling, with some designers being interviewed later, a mix of five user and designer interviewers were used as a data familiarisation subset. In practice, this worked to the advantage of the studies, because emergent theories could then be tested with designers and users.

6.3.3.2 Identifying a thematic framework

Once selected material had been reviewed, notes generated in the familiarisation stage were reviewed to identify the key issues, concepts and themes according to which the data could be examined and referenced. This was then constructed into a framework which drew on *a priori* theories, emergent issues raised by the respondents themselves and analytic themes arising from recurrence or patterning of particular views or experiences. This was an iterative process – numerous updated versions of the framework were produced as the coding changed with rereading and reviewing of transcripts. This is the furthest point that was reached until all

interviews had been conducted. The researcher made the decision to pause the analysis at this point because this thematic framework was useful in terms of identifying emergent themes without going too far through the analysis and categorising data prematurely.

With the purpose of the study being to develop and refine CMO configurations, this identification of a thematic framework was heavily based on the *a priori* categories inherent in these configurations. That is not to say that emergent concepts and themes were not identified and used, but that these would fit primarily into a CMO framework, an approach used in other realist studies that have used framework analysis (e.g. Abhyankar et al.,2013). At this point, codes were created in Nvivo 10, a software package used for the analysis of qualitative data. The codes were based on the initial theories, plus additional codes for new themes, particularly focused on contextual elements – the relevant coding framework can be found in the appendix

6.3.3.3. Indexing

Once the index/framework was developed to a point at which the researcher had a level of confidence that it covered the main themes, it was applied to the data as a whole. This was a systematic process, with all data read and annotated according to the thematic framework, using the software to tag sections of text and link them back to the index. This was not a one-to-one mapping, with single chunks of text often containing multiple indexing references. Whilst such an approach is not always recommended, in this case it allowed the researcher to identify patterns of association. The maintenance of the CMO framework was a priority at this stage, with the categories and themes mostly grouped into references to a given context, mechanism or outcome. This process was iterative, in that the index was adjusted a number of times, with this new index applied to the data afresh to ensure that the data has been coded systematically.

6.3.3.4 Charting

Once the data had been indexed to a level where the researcher was satisfied that all of the pertinent data had been coded or attached to the relevant index nodes, the next step was to build a picture of the data as a

whole. This charting stage was important because it presented the data in a form that not only facilitated the identification of patterning of data within and across cases, but also provides a clear link to the original data source (Spencer & Ritchie, 1994). Multiple charts were devised and produced using the matrix creation functionality of the NVivo software tool (Version 11), with headings and subheadings which were drawn from a number of sources – the *a priori* research questions, the thematic framework, and according to considerations about how one might best present and write up the study findings. The primacy of the CMO framework was maintained where possible, but this was not an automatic choice -charting involves a degree of abstraction and synthesis rather than a cutting and pasting of data (Ritchie & Spencer, 1994); each indexed passage of text was distilled into a summary of the respondent's views or experiences relating to a particular index category, and entered into the corresponding cell of the appropriate chart. The headings and subheadings for a typical CMO were drawn from the relevant contexts, mechanisms and outcomes of that CMO, whilst additional matrices were created for emergent themes where not well covered by the CMO matrices. In all, 11 matrices were produced (after several iterations), each based on the 11 theories covered in the interview schedule. Potentially useful or vivid quotations were tagged using the software for later use. All of the Framework Matrices can be found in the Appendix, along with the coding framework.

The approach allowed for charts to be arranged by theme or by case/individual, but in this instance, the charts were arranged by theme – the purpose being to present the data in a form that allowed the mapping of CMOs.

6.3.3.5 Mapping and interpretation

Once charting was undertaken, the charts and notes made during the analysis to this point were analysed to look for a number of things. Different interviewees' perceptions were compared and contrasted, with patterns and connections between themes explored. Internal explanations within the data were sought and drawn out – given that one of the aims was to develop causal explanations and theories. Again, this was not a

mechanistic process, but an abductive process, requiring leaps of intuition and interpretation (Kennedy & Thornburg, 2018).

Crucial in this study was patterning of responses – that is one was looking for causal chains involving CMO configurations. The main purpose of this phase was to generate and develop the causal chains relating to CMO configurations, so the researcher was looking at how the different contexts, mechanisms and outcomes were related. Such linkages were viewed through the lens of the starting theories; which elements and linkages supported or contradicted the theories and what new ideas emerged that meant revision of the starting theories.

This analysis was facilitated by the use of separate framework matrices for each theory, which enabled the collation of all relevant coded information for a particular theory within a single table, and gave the researcher the ability to identify common threads and patterns within the data. A purely thematic approach would have made it more difficult to identify the cross-cutting patterns that occurred, with the linking together of apparently different separate contextual elements. The matrices also made it easy to track which raw data traced through to the higher level theories.

Furthermore the coding and tabulation of data illustrated commonalities and complementarity between theories, enabling the synthesis of refined theories that are discussed at the end of chapter the results section.

6.4 Results

Following a summary of findings relating to prevalence of app use, this results section is arranged by theory, with similar theories examined together. The emergent theories are then described at the end of the section. This approach was taken for the benefit of the reader in order to enhance the traceability of the theory development process, that is to make clear how the researcher moved from one set of theories to the next, using the data and analytic process to show one's working.

6.4.1 Prevalence of App use

All of those interviewed had some experience of using apps, and knew colleagues that used them, and they were not seen as exotic or extraordinary phenomena. However, regular users were in a minority of the admittedly small sample, and the most frequent user was one of the developers. Two of the junior doctors did not use any apps at all, but did use the internet on their phone. The other junior doctors did use apps occasionally, but not frequently. The apps that were named were used for specific tasks, such as looking up drug dosages.

As part of their medical education, all had used some apps because they were supplied by the medical school for administering assessments, as well as some electronic textbooks. None of the juniors continued to use these textbooks on their phone because they required a paid license. This issue of cost was raised by most of the junior doctors, and also a couple of the developers.

For two of developers, Ignaz was the only app they used on any regular basis, and amongst the junior doctors, Ignaz was not used at all – all had heard of it, but none had downloaded it. Use of Ignaz amongst participants that were not involved in its development was not apparent. There was some name recognition, in part from mentions earlier in the year, but no-one had direct experience of using it. There was agreement that it sounded like a good idea and that it might be helpful, but people either had not investigated it further, or had heard that there were glitches with it or assumed that it was no longer available to use. Developers were aware of issues with the roll out in terms of the reliability of the app, and as such were taking a cautious approach before really pushing it in the Trust where the interviews took place; they were cautious as to what the effect of a negative experience of Ignaz would be on subsequent use.

There were other practical barriers. Two female doctors mentioned the absence of pockets on clothing actually preventing them carrying their phones all of the time whilst at work. The poor quality of mobile phone signal in some areas of the hospital was also cited as an issue.

6.4.2 Availability and Utility of Information at Point of Care

- Theory 1 - The app will give you the capability to access certain information at the point of care rather than having to refer to other information sources. Therefore, this will make you more able to perform your role.

All participants agreed, in principle at least, that the main reason that apps were potentially useful was through their ability to provide information at the point of care. There was also agreement with the idea that this utility was contingent on a number of contextual factors. First of all, the app had to be sufficiently quick to use that it would not slow down the user. Tied to this idea was the need for the app to be easy to use – this would be in part down to the design of the app, but also the user's ability to use the app. Secondly, the app needed to be trustworthy in terms of the information held within it. This issue of trustworthiness was seen as particularly important by all users:

"I think yeah...the reason that I use the NICE guidelines is purely because it's the NICE guidelines, the app is by NICE, so you know it's gonna be the real deal basically, you know the...all the information's going to be accurate, but some apps you have to...you know you sometimes worry about the information's correct..." Interview J2

Visible indicators of trustworthiness were important for participants. For an app's trustworthiness to be clear, most apps that were used were either recommended by trusted colleagues, or came from recognised and trusted medical "brands", be they well known publishers or trusted public or professional bodies. Some more app savvy users did search on the app store for interesting looking apps to undertake a certain function, but this seemed a relatively rare occurrence. Fears were expressed by users that apps were not easy to validate, and that it was not easy to tell if an app was safe or not. Users did not tend to validate apps in a rigorous manner, but some informal testing was undertaken to check for usability and so on. More experienced users were able to critically examine outputs to the extent that they felt they could tell if something looked incorrect. Other heuristics users used were to do with frequency of update and whether an app was particularly unique and served a useful purpose -this information

was usually gleaned from the description given by the vendor and reviews on the store website.

These points relating to trustworthiness and usability were borne in mind by the designers of Ignaz:

“Yes, but also reassuring people that it was developed with clinical governance in mind, and within a trust structure. Reassuring them that this is a not a cowboy outfit, this comes with regional education endorsement, and support from very high up, in the shape of a postgraduate dean and the finance to back it up.” Interview D3

Ignaz was designed so that it was entirely contained on a phone, so that there was no need for an internet connection that might potentially delay the retrieval of information, thus making the app at least theoretically quicker to use. It was also developed in conjunction with Hospital Trusts so that the information held was appropriate and local to the site in which the app would be used. Furthermore, roll out materials were developed that emphasised this resulting trustworthiness.

6.4.3 Specific outcomes of app use

- Theory 2 - The ability to access information at point of care will make you more efficient overall.
- Theory 3 - The ability to access information at point of care will make it easier for you to comply with relevant protocols, thereby increasing your compliance to protocols overall.
- Theory 4 - By allowing you to undertake your role more effectively, this reduces some forms of stress and therefore improves your own subjective wellbeing.

The previous section illustrated the general point that interviewees were generally positive about apps, and the general utility of having trustworthy information available through an app at the point of care. There was, however, less agreement between the designers and the junior doctors with the idea that this access to information would have clear benefits in terms of efficiency and quality of care. On the idea of quality of care improving, whilst designers stressed the advantage of having information available at

the point of care to make the checking of information quicker, some of the junior doctors were more cautious:

“Um, I think if the app is easy to use and quick, then it can make your work more efficient. [...]the reason that I find it useful is that um, it can help me get the information I need quicker [...]I've always got my phone on me. I can be stood in the middle of the ward, I don't have to find a computer, I can just get my phone out, and if it's a...if it's a good app, I can just find the information quickly. I don't think the end outcome, other than efficiency is any different.” Interview J4

In theory they agreed that the app's portability and convenience were positive features that would help with quick checks, but they would find a way of checking when unsure regardless of whether an app was available or not. This further emphasises the belief in benefits in terms of speed as opposed to quality.

When it came to benefits to a user in terms of improved wellbeing, the developers were positive about the potential for such benefits to come to fruition. By helping a user to check facts quickly, the user would be both more efficient and have less worry about the potential for error in their previous actions. However, whilst pushing the case for this scenario, they were optimistic but realistic about the likelihood of it having a measurable material benefit on doctors' wellbeing, especially given the subjective nature of the experience of wellbeing, although it could help in some ways:

“...all medical jobs are associated with some stress. Anything which makes your job easier at the time you would hope would lessen that, but one of the other areas I think that, in terms of managing tasks as medicine becomes...erm there are certain apps and certain erm electronic aids that people are using to know that they're performing the tasks that they need to perform and able in a way to check them off. I think things like that [...] lessen some of the stress associated particularly with things like handover and handoff, where information's passing between different teams and different individuals, [...]there's potential for loss of that information or of...of...information only to be partially passed on. [...] I don't know

personally that it's changed my feelings about being stressed or not stressed, but I've certainly heard people err suggest that the use of apps has made them feel more comfortable with doing some of their stuff"

Interview D4

Juniors were equally loath to claim that apps would make a big difference to their wellbeing, with one pointing to the complexity of the overall picture when it comes to wellbeing:

"...completely depends on the quality of the app. If you're not familiar with it, you may well spend just as long by the bedside looking it up as it would be going with something you're more familiar with. But I think it's completely depends on who uses it, how familiar you are with it. Uh, I think the benefit of it, the potential benefit of making things more efficient...is...stress will be multifactoral. It will help contribute to a reduction in stress, yes, just like any other additional efficiency into the day. How big an impact? Not sure, depends on the level of intervention, or how much it's used. But yes, I would say...but like anything that increases efficiency, it would help reduce stress." Interview J5

And in simpler terms...

"Stretching things to say it reduces stress, but may be fair to say that it can make your working life a little easier - anything that makes on calls easier is a good thing." Interview J3

Overall though, there was an acknowledgement that anything that makes one's working life easier would be a positive, and that making the retrieval of information less stressful was a definite positive.

One area that seemed more promising when it came to effects of app use was through the safety net provided by having information in the palm of one's hand.

"Sometimes if you're ... like, I'll give you an example – the BNF app. If I use that, if I use the book it's the same thing, cos, you know, cos it's trustworthy. [...] it gives you confidence as well when you're prescribing, y'know, you can tell 'right, ok, this is...this is the dosage, and [...] that's the correct information. So you can quickly act upon it, and if...sometimes

when you're on nights or something, or when you're on your own, you need to do something there [...] as long as it's safe, you can initially give the treatment, then wait for the seniors and then just advise you further, but there, it's the correct procedure [...]. As long as it's safe, then, then it's fine.” Interview J2

and

“Sometimes, if you wanted to increase your clinical confidence, for example on a ward round, if your consultant has asked you to prescribe a drug dose, but you're not too sure of it, it's much easier to look it up there and then on your phone [...], not look like you're being disrespectful to your consultant and going off and checking it, but being able to say to your consultant 'oh actually the dose has changed slightly, this is the correct dose', or the 'guidelines have changed slightly, these are the correct guidelines' without having to take ten minutes off to walk away[...] So I think it would increase your confidence in doing the correct thing for your patient in those circumstances.” Interview D2

An app could then potentially give doctors the confidence to undertake tasks independently and also give one the confidence to challenge colleagues when they see something that could or should be done differently.

6.4.4 Colleague perceptions

- Theory 5 - Negative perceptions of an app by senior colleagues will reduce your intention to use the app, in turn leading to a reduction in use of the app

There was an agreement between all users that senior colleagues are key to setting the tone, norms and practices on a given ward, thus influencing how much apps are used on the ward:

“If a more senior colleague says this app's really good...again I think that's a psychological theory that you could probably apply to lots of things really. [...] someone senior saying something's good is gonna reinforce a positive mindset, equally if they were negative about something, you'd be less, probably less likely to use it. [...] for example games, if a group of people

say oh, this game's good, we can play together, then you tell the next person, again it's like the domino effect. In the same way that medical practitioners would probably...something popular or something good, would probably have an effect by spreading and multiple people using. As far as using it in an NHS type situation if it's going to be used on the ward, then obviously everyone's got to be on side for you to be able to use it" Interview J5.

The more experienced colleagues said that whilst the views of senior colleagues would not have a significant effect on their app use, it might have had a much greater effect when they were earlier in their career, a point that was backed up by some of the junior doctors.

With this in mind, it is worth noting that in the main, it was believed that most senior colleagues were happy for apps to be used, although this had not always been the case:

"Errm, you'd just get in trouble for having your phone [...], you weren't supposed to have your phone with you when you on the wards. Like, you'd just be told off, for having it on you,. And it would be seen as quite rude, disrespectful to be [...] playing on your phone really, that what it was seen as. [ok]. Cos we did used to, if we got asked questions that we didn't know, if the consultant got distracted we'd be like "let's google it quickly", and you'd look good, but you'd get in trouble for having your phone out." Interview J1

This change in attitudes over time illustrates how this element of context is not static. Over time, as apps have become more widespread, senior colleagues have been exposed to them and grown to understand their utility. This may have been through exposure from colleagues or through their own direct experience or interest. One mechanism for change appears to have been through the strategy of explaining why one has their mobile phone in their hand on the ward. Junior doctors in particular were wary of others thinking that they were using their phone for non-work activities:

"Whereas if I was to get my phone out on a ward round with a senior, even if it was looking something up, yeah I'm sure I'd be fine, and just say I'm just

looking something up, and that's become more and more accepted [...] however ultimately it's still a phone, you still could be just texting anybody, but even if you were working. And so it's just how that would come across, but that's just a widespread problem in other workplaces as well.” Interview J5

Junior doctors were especially anxious not to give any negative impression, and as such, seemed to be much more likely to ask permission or explain why they were using apps. This type of social influence seemed to have much greater impact on users than official rules and policy. This pattern was confirmed when examining the next hypothesis.

6.4.5 Patient Perceptions

- Theory 6 - Negative perceptions of an app by patients will reduce your intention to use the app in their presence, leading to either less use overall, or use only away from patients

The overriding sense that came through from the interviews is the idea that patients will, initially at least, have a negative perception of the use of mobile phones and thus apps. This preconception was arrived at less from experience in practice, but from impressions from outside of healthcare or from their own experience:

“I'm talking about senior midwifery or nursing staff who have responsibility for whole clinical areas, saying that patients can have a negative view of people using their phones in clinical areas, but...and I would probably say that's justified, and senior staff are saying y'know please be mindful of when you're using it and what you're using them for, but [...] if you're there with the patient in front of you, looking up your information relevant to you, I suspect they won't complain about that. It's when you're wondering down the corridor texting, or you're stopped in your tracks before you're going to do something clinical. You may not even be texting, you may be looking at something very relevant to do with work, maybe an email to do with work, but maybe that's when the organisation and also the patients would object.” Interview D1

There were two separate elements to the concern about patients' perceptions. A widely held view is that the user did not want to appear inexperienced in front of the patient, so the use of resources was done with caution. The second concern, which was held primarily by junior doctors interviewed, was that they did not want to appear that they were engaging in non-work activity. The two concerns seemed to link to different ameliorating strategies. One strategy was to ensure that the phone was used away from the patient where possible. For most though, it was primarily a case of ensuring that the patient understood what they were doing on their phone. It was important to prevent any negative impact on the patient's trust in them – this was not only to preserve a positive perception of them by the patient and to keep the patient comfortable, but also because of a concern that reduced trust in them may result in, for example, the patient failing to adhere to a treatment plan or ignoring their advice. One of the more senior doctors saw the use of an app as an opportunity to engage with the patient:

“I love looking at resources in front of patients, because I can tell them what I'm doing, and I can reassure that I'm looking at the latest, or checking whatever it is I'm doing so I can tailor the treatment specifically to them. [...] so if the patient comes in with a computer printout of whatever they think it is, and that sort of thing, I view that as a positive thing, because it's a great to have a meaningful conversation with the patient about their disease. And if it's the wrong information they've printed off, that's fine, because at least they've thought about it, and I can explain to them “yes, great you've looked at this but this applies to you because x, y, z, and this doesn't apply to you because k, l, m. “ Interview D3

Older patients were seen as more negative about mobile phones, and so the doctors' sensitivity was particularly high with these patients

“I guess the more elderly patients who are not familiar or um, won't be as...um, not necessarily understanding, but just won't be as aware or as familiar with the advances.” Interview J5

Despite these concerns, no participant was able to recall an incidence where they had a negative response from the patient. This is not to say

that concerns are unjustified, but does suggest a mismatch between fear and reality.

6.4.6 Usability

- Theory 7 - If an app is harder to use, you will use it less

The ease of use of an app was seen as an important component of its utility by all parties interviewed. With the general agreement that the idea of an app at the point of care being a benefit because it could provide useful information that can help with patient care, one major caveat was that this information needed to be quick and easy to obtain:

“It's got to be easy to use, or at least easy to get the hang of using so...if it was difficult to use but once you got to grips with it it was ok, and gave you the information and there was nothing better out there, then yes, that'd be ok. But yeah, for a quick reference type...that's what I would want it for, as quick reference, I want it to be quick, easy, and easy to find the information, and obviously accurate and up to date.” Interview D2

This ease and speed of use had two elements. The first element related to the apps themselves – they needed to be reasonably well designed and reliable so that information was readily available:

“...I got on this phone, I've got an app called Clip Clinica. For some things it's quite useful, but it's just got a list of...list of different conditions, and then you click on it...and then it's basically just got a guideline, and there's no way to search through that guideline – the guideline could be ten pages long. So that's not that quick to use, it's not that easy to use. Quite often it's not got the information that you want anyway, so you spend five minutes searching for something that's not there, whereas with BNF [another app] you search and if it's not there it comes up as no search results and you've only taken thirty seconds [...] to realise that you need to look somewhere else, you know.” Interview J4

This meant any app had to work when it needed to, as any kind of glitch or slow running would be irritating, lessen the user's confidence in an app and thus reduce their likelihood of even consulting it when the need arose:

"I think it's time issue main[ly]...it's the probably the time it takes. So for example, some, some of the apps will update and if you catch them at the wrong time and you've not used them in a while and they're updating, and that takes a while, then, it then becomes quicker to fall back on one of your other methods so..." Interview D1

However, some users were willing to try and get around any issues with design, or learn a more complicated app if that app had very high utility compared to other information sources, such as containing some information that was hard to find in other sources, or that made their working life a lot easier when it came to specific tasks. The key point was that it had to be worth the time and effort to learn how to use the app compared to the utility that it provided:

"Yeah, I would try and learn how to use it, if I thought it was going to be useful, I would try and learn how to use it. Depends how difficult it was going to be, because if it was, if it was so difficult that actually was making it not time effective anymore, then it would be.. not...like against the point of using. I think the easier they are the better it is, cos I suppose like...apart from having things to hand, another point of it is to make things simple as well." Interview J1

The other element related to the user's ability to use an app. Many of the participants readily acknowledged that they were not used to using their phones for this kind of activity, and thus did not feel that comfortable using apps. Thus, their knowledge of how to use an app effectively would be less than those that were more expert, and thus would lessen their likelihood of consulting an app:

" I think, errrm...yeah, if I've got more time, I'd use the BNF on the computer, just because I find it easier to use. I'm sure that if I used the phone more, that would then become a lot easier to use. I know a lot of students use the phone a lot more than I do, me personally, I need more practise." Interview J3

Thus, the subjective utility of an app was directly influenced by the app itself and also the user's ability to use the app, which would vary depending on the user's expertise; what one user found easy to use, another might

struggle to use quickly, and thus this second user was less likely to use an app in the first place. In combination with the idea that some users would need to refer to other sources of information, this suggests that junior doctors would be more likely to invest effort in learning how to use an app, as they would have a greater need to use an app more frequently than more experienced colleagues.

6.4.7 Implementation Strategy

- Theory 8 - The way that the app is rolled out will impact on your willingness to use the app

The idea that roll out would influence app use was at the forefront of developers' minds. For them, it was important for potential users to be aware of the app, its philosophy and its origins, and the app rollout was perceived to play an important role in that:

“Um. In terms of the rollout, I mean, we were, I think...the fact we had something or we were making something that we felt would make people's working lives easier or help access information more easily, has made us feel that we had to do it and roll it out and roll it out as widely as possible. In terms of how it was rolled out on a local or more regional level, or trying to roll it out, we still are. I think what's more taking more priority the sort of receiving organisations, how they want to use it and how they feel it should be used” Interview D1

There was thus recognition that the different way that Ignaz was rolled out in different Trusts had influenced uptake and subsequent usage:

“For Ignaz, it's been quite interesting, because three organisations have rolled it out completely differently. One organisation has not really advertised it, they've not really told anyone, the only people who know about it are the people that have contributed to the app itself. And unsurprisingly the uptake there has been absolutely microscopic, and they're one of our biggest trusts and they have one of the smallest total number of users. In another organisation it was done pretty much exclusively through the medical education channel. By doing it through the

medical education, it was very much targeted at pretty much only the foundation doctors, so the most junior rank of doctors. Which are, you know, a considerable group of the medical workforce, but it means that there was no planned engagement with other, more senior colleagues. And then the third organisation, they rolled it out this time at induction. This was a much [bigger] group, not just the foundation doctors, but also the other staff, support trainees and specialist trainees, so they're at registrar. And that trust has ended up with the largest numbers of trainees [using Ignaz].” Interview D3

Trusts where there had been greater Trust involvement were seen as those that were more enthusiastic about it, and this was reflected in the implementation approach; it was mentioned and demonstrated in induction for all new doctors and was spoken of positively. In contrast, Trusts where it was only mentioned as a useful aid were the ones where it was seen as less used. Central to this was the idea that it needs to be brought up repeatedly for awareness to be widespread:

“ it was kind of multi-strategy, so there was speaking to them directly as an in an audience, being available for individual uh discussions with people [...]. And then going around individual departments and speaking to individuals. And we found we didn't get all departments, but those departments that we did, uh, we got more uptake, generally, because people were able to, you know, pose questions in a more informal environment rather than emailing, [...] and we found greater engagement from that face to face [...] process. Probably [...], with some of the older medical staff, who maybe have...you know, the vast majority now have smartphones. Not massively experienced in downloading applications and the processes that are involved with it, uh, and with them, the kind of face to face and taking them through step by step if they wanted to download the app certainly helped the situation.” Interview D4

Simply raising awareness of the app's existence was seen as insufficient. This idea was reinforced by junior doctors. It was not enough to merely know that an app exists and had a certain utility, but some kind of endorsement was also seen as desirable. The source of this endorsement

was also quite important; senior colleague recommendations were almost a guarantee that an app would be looked into by a user, whilst peer recommendations would also influence whether a potential user would look into a particular app. Word of mouth was seen as a powerful motivator to use apps:

“If you got an email, you could glance through at your own leisure, but would I do it? You'd probably look at it and think 'oh I'll do that later' but probably never get around to doing it. Whereas yeah, I suppose if someone recommended me an app, someone else, like one of my colleagues or a senior recommended me an app, then I'd definitely get it.”

Interview J3

So whilst top down approaches were seen as potentially useful, the more powerful route seemed to be through direct contact with other users.

6.4.8 Ward Environment

- Theory 9 - The busyness of a ward will affect the way you go about your daily tasks, so busyness will affect the likelihood of you using the app in comparison to other information sources

The greatest impact of ward busyness was perceived to be on the availability of various information sources: on busier wards, there was more likely to be a shortage of availability of ward computers because more people would be using them. For the more experienced doctors, this was less important:

“Um, thinking of the emergency department, in the resuscitation room, where there's two computers, and all the notes that they type [...] are on the computer, so because their doctors are using computers to input their notes, it means that I can't use that same computer to look up blood results or chest x-rays quite as easily, so I might turn more towards a paper resource, [...] especially when we are busy. Um, so turning towards the app to check on the antibiotic or to find the extension number for the correct ward to transfer the patient to um, will make a difference yes.” Interview D3

The above quote illustrates the fact that more experienced doctors understood that there are other people on the ward that might need to use

the computers because there was no other way of accomplishing certain tasks, such as the typing of notes or discharge summaries. Also, there was less perceived need to look things up because of self-perceptions of confidence in their medical knowledge, and as such, less of a need to “check” their knowledge. This meant that they wouldn’t always check, even when unsure. However, for the junior doctors, a slightly lower level of confidence in their medical knowledge generally meant that they would find a way to check. This is not something they were necessarily ashamed of, as they understood that they were earlier in their career and would likely need to check less often as they got further into their career. Both groups agreed that an app or using one’s phone should be quicker, so in a busy environment, it would be preferable to using a computer. However, the extent to which a mobile was actually used was unclear – what was clear is that it wasn’t very often for most of the participants.

A factor that seemed to influence the use of apps was whether other doctors were available to consult, either in person or via bleep or phone. For junior doctors, where it was possible to consult other doctors, this would be their first port of call. Thus, when a ward was busier, more doctors were likely to be available and so this actually decreased the likelihood of an app being used:

“Yeah, I think I would, unless say you’re going round, and the person leading the round is someone who proactively or is wanting you to look stuff up, is asking you to do it, I don’t think I would routinely [use an app] if there was a group of us necessarily, unless it was a query from the senior, and you know we needed to get an answer or else. Um, if I was going around by myself, I’d probably be more likely to use, because you then don’t have anyone necessarily there and then to ask or confirm.” Interview J5

This contrasts with when the workload of the junior doctor was higher. This higher workload was likely when they were working in a situation where fewer staff were around, such as on night shifts. In these situations, apps were seen as potentially useful. This lowering of staff levels had the additional impact of reducing the demand for ward computers, meaning that these computers were more available. In these situations, whether an app

was used seemed to depend more on what the doctor was most comfortable with in terms of information seeking. It was in part dependent on the type of information required:

“Yeah, I mean, I’m thinking on the surface of it, I’m looking at this app that’s really good for looking up drugs, conditions, differentials, that sounds fantastic and obviously ideal, but I struggle to see how that would be realistic in achieving, so that’s why I said several different apps, specifically easy to use, not too in depth, more summary, more brief, looking up”
Interview J5

6.4.9 Emergent Themes

6.4.9.1 Confidence

- Theory 10 (New) - Lower confidence in own clinical judgment, more need to refer in general:

A consistent emergent theme from all of the interviews was that early career doctors would have more need to refer to external information sources than more seasoned colleagues. The more experienced doctors talked about how an app such as Ignaz would have been useful early in their careers, with this actually being one of the drivers for its inception. One of the app designers described an example of when such an app would have been useful to them as they moved from hospital to hospital as part of their early career training:

“An endoscopy can be done by a gastroenterologist, a general surgeon, or a nurse endoscopist. Um, let’s say I’m in hospital on Saturday and I’ve got a sick patient who needed an endoscopy, I know they needed an endoscopy because of x, y, and z, but I don’t know who does it. [...] And finding out who does that sort of test, and or who does things, particularly out of hours can be very time consuming. A number of phonecalls and trying to work things out. So in that sense, if you have that sort of information in the app that tells you immediately how you do this procedure here, yes it does increase efficiency. “ Interview D3

Another of the more experienced agreed that in general terms, having this type of information available to them early in their career would have been useful:

“...just thinking what I've used textbooks for in the past, or procedures, and actually going back to being a very junior doctor you would look things up like lumbar punctures and arterial blood gases [...]. Um, I wouldn't use it for things like that nowadays, just because those things have become so ingrained [...], it sounds awful, but I don't need to look those things up any more, I just know them. Whereas I do recall having to look those sort of things up when I was a house officer [FY1], and actually it would be really useful to have that sort of information, it would improve things from a procedural point of view...” Interview D2

This idea was reinforced by junior doctors, with the expectation that they would need to refer to other sources of information less as they progressed in their careers:

“I think...um...I guess I'd probably use them less, as I get further on in my career, I would have thought. Um...yeah. I'd use them less, I mean, I would hope...[laughs]” Interview J4

Though this need to refer was taken as a tacit sign of less knowledge and experience, one of the experienced doctors pointed out that there were occasions when it useful to have objective information available rather than having to exercise clinical judgment:

“... sometimes when you're more tired you'll rely on guidelines more heavily, rather than your own recall and memory. Whereas if you're in a more confident mood, you might just rely on what you know.” Interview D2

In this way, one can see that no matter the level of experience, the level of confidence in a decision was a key factor in the decision to consult an external source of information. This lower level of confidence, particularly relating to clinical matters, is more likely to occur with early career doctors than with more experienced doctors, but the nature of the job means that even experienced doctors encounter scenarios at the boundaries of their knowledge sometimes, or may need clearer evidence than their own judgment and experience provide. The experienced doctors also

acknowledged that it was more acceptable for junior doctors to be seen to refer to additional information, whereas they had to be more careful; they would have to be seen to know the majority of what they need to, and looking up information that a patient or colleague might expect them to know as a matter of course could have potentially harmful implications for their reputation.

6.4.9.2 The role of specialty

- Theory 11 (New) – The type of specialty within which one works will influence how likely one is to use an app.

An emergent theme that came through during the interviews was that of the effect of working in different specialties. In its simplest form, this was manifested in the difference between surgical and medical specialties:

“In vascular surgery, the ward rounds are very quick. Over here, in medicine, they're very long. [...] So, if you've got one or two minutes just to quickly see a patient, you don't have time to get your phone app out and just find out that information, so you have to wait until the end of the ward round. But on medicine, on medical ward rounds, because you're going through everything so thoroughly, you've got time to get your phone out, and have a look, and decide further actions and things like that so it makes a difference” Interview J2

Surgical specialties were seen as less amenable to the use of apps because of the relatively short length of time spent with the patient on rounds, reducing the time available to consult information sources in the time spent at the patient's bedside. Medical rounds involved a little more time with the patient on rounds, with more time spent gathering information.

With regards to particular medical specialties, some were seen as more prone to using apps, although this seemed to be less related to the tasks involved and more related to the “culture” within the specialty:

“Yeah I think specialties like anaesthetics will be really on board with stuff like that. [...] they love the technology side of things. And [...] the anaesthetic guys that I've met...seem to be like really look upon using the

new technology and new...and I've seen them use on ipads as well as like iphones to view apps and stuff like that” Interview J1

It was unclear from the interviews whether this difference was due to the availability of apps for a particular specialty, the preferences of doctors working in that specialty, or whether some other factor was at play. Within anaesthesiology for example, some of the junior doctors believed it was due to the attitude of users, whilst others suggested it was due to the lessened influence of another previously described contextual factor; the attitude of patients:

“Um, the difference potentially in that is the environment you're in, you're in an environment whereby you've got an anaesthetised patient after they're off to sleep, so you're not, you know, using your phone in front of uh, conscious patients, where you know, you have to then take into consideration public perception of that, whether it be positive or negative. Um, so you...the environment being different may be a factor as to why uh it seems to be generally more acceptable to do that. Or maybe not, I don't know fully the ward situation, but there's certainly no stigma attached with it in the theatre environment, and accessing mobile devices and phones to aid your practice.” Interview D4

Thus, one of the reasons for differences in specialties may be through the alteration of other contextual factors rather than as a property of the specialty itself – the effect on the decision to use an app in any given situation can be conceptualised as an indirect one rather than a direct causal relationship.

It was apparent that certain types of information were less well suited to mobile smartphones, particularly with regard to screen size. Additionally, detailed and lengthy references were seen as more cumbersome and difficult to use on a mobile screen, and a preference for using a computer with a larger screen was apparent for a number of users.

For specific information, where it was known that a particular app was available and designed for that purpose, it was favoured by users for reasons of speed and convenience.

The analysis did support a revision of the original theories under investigation. However, other factors played a role and require further discussion. Therefore the refined theories can be found in section 6.5.6 in the discussion.

6.5 Discussion

6.5.1 Summary of Theories

The data from the interviews was useful for refining and testing some of the initial ideas and theories. The first theory, that apps would enable users to access information at point of care, thus improving job performance, was partially supported. There was a general agreement that in theory apps could be useful but there were a number of caveats: an app needed to have useful enough information that was readily accessible to be of utility to the user; the app needed to be reliable and preferably be from a trusted source; and the user needed to feel that they could quickly access the information they needed. The second part of the statement, that job performance would be improved, was not supported. Whilst the developer group designed their own app, Ignaz, with the intention of making doctor's lives easier, they were loath to claim that it actually made a demonstrable difference to job performance. This reticence was reflected in the group of junior doctors, where they too believe it would be claiming too much to say that an app would have a tangible effect on job performance. Hence, there was an absence of clear support for theories two and three, that apps would improve efficiency and accuracy respectively. Hypothesis three, that apps would have a positive effect on user wellbeing, also lacked clear support, primarily because respondents saw stress and wellbeing as being multifactorial, thus making it difficult to assess the impact of using apps. That being said, there was some support for the idea that apps might contribute in some way, as anything that was seen as making the doctor's working life easier was seen as a welcome development.

Theory five, relating to the idea that a negative perception of apps by senior colleagues would lead to reduced app use, was partially supported, insofar that nearly all respondents agreed that senior colleagues played an

important role in setting norms of practice and behaviour, and that these norms were usually adhered to. Where the hypothesis lacked strong support was first, in the relative rarity of instances where a senior colleague had expressed negative views about app usage, and secondly, that those rare instances seemed to have occurred some time ago. This was reflected in interviewees' views that apps were seen as more widely accepted now than in even the relatively recent past. Theory six, relating to how patients' negative perceptions of app usage would reduce app use was more strongly supported by the data – doctors were generally wary of using apps around patients, and where they were used, they were careful to explain exactly what they were doing. The subtlety here was that there were no reported instances of a patient expressing negative views, rather that doctors assumed that there would be negative perceptions, and did not want to risk lowering the patient's confidence in them as a caregiver. This was seen as a risk not worth taking as it might have consequences for patient care.

An idea that was quite strongly supported by the interviewees was that contained in theory seven, which posited that if an app was hard to use, it would be used less. If the perceived utility of an app was high, some users were willing to spend time learning how to use it, but it would have to be worth the time invested. Theory eight was where the nature of rollout would affect the level of uptake. The evidence from the interviews only offered some support for this idea in that those involved in developing their own app considered it important. What is potentially more important is that how an individual encounters an app may play a role in whether and how they use it. Hypothesis nine related to the busyness of a ward or clinical environment affecting a decision to use an app by changing the availability of other information sources, and evidence from the interviews provided considerable support for this idea.

Two more ideas emerged as the interviews progressed. The first emergent theory was that those individuals with lower confidence would be more likely to refer to information sources including apps. This hypothesis was partially supported by the data. The second emergent theory related to

how working in a particular specialty would influence one's use of an app – an idea quite strongly supported by the data.

Additionally, the importance of other contexts that influenced app use emerged from the results. The ensuing discussion will continue by examining these important contextual elements. It will go on to elucidate the implications of the study findings for the development of the various programme theories that were under investigation in this study, discuss the implications for subsequent studies within this thesis, as well as considering the implications for practise and use of apps in clinical environments.

6.5.2. Important Contextual Factors

6.5.2.1 Utility and Usability

From the interviews, it was apparent that usability and utility of an app were important, and often linked; This conception resembles the Technology Acceptance Model (TAM) proposed by Davis (1989) and discussed in earlier in the thesis. In the TAM, perceived utility and usability are drivers that dictate whether a user adopts a particular technology. In the realist formulation described above, utility can be seen as a representation of how useful the information held in the app is, which in turn is partially dependent on its perceived trustworthiness – potentially useful information that is not perceived to be trustworthy (that is accurate and from a reliable source) is anathema to the practice of safe medicine. Information needs also to have utility; a trustworthy app that does containing information that does not have utility for the task at hand is also unlikely to be used.

This also fits with the concept of reflexive monitoring, an aspect of Normalisation Process theory (May & Finch, 2009) discussed in Chapter 5, where users actively evaluate and consider the costs and benefits of an intervention rather than passively accepting it. The following sections further illustrate the active nature of this evaluation process, and how a range of factors affect it.

6.5.2.2 Role of Individual Characteristics

The interviews illustrated how individual users may vary in how they use an app, thus leading to individual variation in how and when an app is used, with user experience and expertise influencing how they would use apps and also their decision to use apps. The interviews also showed how the career stage of a doctor was apparently related to how likely they were to refer to additional information. The putative mechanism for this was that more junior doctors were less confident due to having less experience and knowledge, and so were more likely to refer to external resources.

An additional effect of confidence that was evidenced in the data was how it moderated the effect of other influences on app use. Users who were more junior seemed to be more influenced by their perceptions of what senior colleagues and patients would think of them, and this would influence their choice of reference source.

Junior doctors were more likely to talk about using colleagues as a reference source and were generally more likely to use colleagues and other reference sources than more experienced colleagues. Experienced users were more confident in their own knowledge generally, and aware that they ought to know certain things. The exception was when it came to drawing on colleagues from other specialties – a phonecall or a face to face consult was seen as acceptable when something fell outside their domain of expertise. Thus we can consider that career stage and experience make a difference to app use – not merely at a correlational level, but through their influence on the level of confidence that a user has in their own medical knowledge. This then exerts a causal effect on whether a user feels a need to seek external references. Confidence in their own judgement, also influenced by their level of experience and career stage then influences how confident they feel in using that information source, even in the face of perceived opposition to use of that source.

6.5.2.3 Social influences and acceptability

The social acceptability of app use as described above was primarily affected by two factors – the users perception of views and use by senior colleagues, and perception of patients. The default perception in both cases was generally a cautious one – that the perception of app use would

be negative. The age of a patient was sometimes used as a heuristic to determine acceptability – older patients were seen as more likely to be uncomfortable than younger patients. Depending on the confidence level of the user, they would either avoid using an app in front of someone they perceived might have a negative response, or they would explain why they were using an app to the concerned party. From the interviews, the impression was given that certain specialties were more inclined to app use – whether this is down to culture or physical circumstance is not yet clear.

6.5.3 Prevalence of app use

Based on the interviews, the use of apps in everyday medical practice could be characterised as not unusual, but not to the extent where it was seen as “the norm”. Everyone was familiar with the concept of medical apps, how to get hold of them, and what they might be used for, but actual download and use of a range of apps was not common. This does not contradict the findings from previous surveys on app use (e.g. Moore & Jayewardene, 2014), although the frequency of use is perhaps lower than might be suggested by these surveys. This relatively low level of reported app use was not unexpected but the absence of Ignaz from the junior doctors’ accounts was a surprise, and posed particular challenges for the evaluation. Not only did the lack of use of Ignaz mean that it would be very difficult to identify instances where it would be in use, but it meant that it would be even more difficult to understand the impacts of its use. becomes almost impossible to evaluate the outcomes of app use when there are relatively few instances of its use on which to gather data.

What had become clear from the interviews was that there were a range of contextual factors and a causal chain that influenced how and when information seeking apps were used. There was enough evidence of app use, and varying patterns of app use, to suggest that keeping to a realist approach would yield useful results. If the outcome of interest was defined as app use rather than its effects, one could investigate the causal mechanisms and relevant contexts that explain why apps are used in some situations by some doctors and not in others. This approach would still have the potential to reveal valuable insights into why apps are used, what

would need to be done to encourage (or discourage) their use and what elements of the environment influence information seeking behaviour.

It was actually only after this interview study that the final decision was taken to adopt the approach outlined in Chapter 1; that of a Realist Investigation rather than an evaluation. However, as has been made clear throughout this thesis, the realist approach taken was appropriate for the questions under investigation, and only a moderate shift in focus was required. It was necessary to keep the focus on apps designed for a similar purpose, as not focusing in would result in too wide a variety of scenarios and would necessarily lead to very vague generalisations. For this reason, the focus remained on apps designed to be reference sources, so excluding those designed to take the place of another medical device, or training aids, or any of the other range of functions for which medical apps have been designed. Some minor changes were made to the research questions retrospectively, with the main change being the reduction in emphasis on outcomes of app use.

6.5.4 Benefits of app use

This study found very little evidence for the use of apps having significant impacts on clinical care. Whilst users agreed with the idea that an app in theory could be useful, there were few strong illustrative examples. General statements were made about how an app should make life easier by providing information at the point of care, thus enabling more independent decision making, but users were reluctant to say that it would have a tangible effect on their efficiency or quality of decision making. In part, this seemed to be because app use was relatively rare and when it was used, it was used for specific tasks. This absence of evidence for the outcomes of app use was interesting, and highlighted the importance of perceived benefits to user decision-making when it came to choosing an app.

6.5.5 Understanding the Implementation chain

The previous paragraphs of this discussion illustrate that the use of an app in a particular situation is really just the final decision in a causal chain, and mapping of this causal chain is a useful exercise when trying to understand

the phenomenon under study in realist evaluation (Pawson & Manzano-Santaella, 2012).

Prior to the patient encounter occurring, a user needs to be in a position to consult an app. For this to happen, they need to have the app available to them, that is, it must be downloaded on their phone. For an app to be downloaded on their phone, they need to have made a conscious decision to download it – for medical students, this might not be the case, as they might be using a phone that has been supplied by the medical education department with pre-loaded apps. For the decision to be made to download it, the user must have considered whether it might be useful to them. This decision might be based on recommendation from colleagues or professional bodies, or through their own research. At this point, depending on the user, they may or may not have made some form of informal evaluation or familiarisation with the app outside of the clinical environment. This could be seen as the distal portion of the causal chain.

Once with a patient, a range of proximal factors play their part, and the doctor will consider a number of factors and consider a number of questions: do I need to refer to additional information; if yes, what information sources are available; and what ones are most suitable for this situation. At all stages, the doctor will be considering the advantages and disadvantages of each decision, whether consciously or not. Factors such as the doctor's skills and expertise, the immediate ward environment, patient views, colleague attitudes and whether they actually have an app on their phone will all influence their decision to use an app.

This theoretical causal chain has a number of practical implications, and points to the heart of the challenge when doctors choose to use technology to assist their decisions; is this safe? The interviews suggested that there are two aspects to this – “Is the advice or treatment that I'm giving the patient accurate and safe?”, and “Is the way that I behave in front of the patient appropriate and maintaining their trust in me to the point where they feel comfortable and will follow the treatment plan?” In addition to this, doctors have to consider their role within the wider context, which involves protecting their reputation and maintaining good relationships with their

colleagues while working according to acceptable norms and behaviours – doing the “right thing” means not only being technically proficient, but acting in a way that is acceptable for their role as a doctor in a given situation. As such, decisions around whether to use an app are not matter of simply obeying official policies and protocols, or doing what is most efficient, but are subject to social norms and conventions, considerations of whether it fits with their conception of good medical practice, and maintaining appropriate relationships with their patients.

Considering the causal chain step by step, the decision to download an app depends on their awareness of an app and its reputation. Different doctors apparently have different thresholds and criteria, but the minimum for all seemed to be that the app contained data that they considered to be correct and accurate. For many, this meant using certain heuristics, such as ensuring they use only British apps (to avoid issues with conversion of measurements and to give more reassurance that the app conforms to the relevant medical standards), or only using apps from organisations that they trust, such as the British National Formulary or the relevant Royal College or Hospital trust. For some, it was enough that the app had good reviews, or that it was recommended by a trusted colleague, or they felt confident that they could assess the quality of the app by looking at how it works, testing it with some dummy searches or calculations, and checking frequency of updates.

The decision whether to use an app in a given situation only arises at a point where the doctor has a need for knowledge on a specific issue. This will not be the case with all patients, and is more likely when a doctor is working in a specialty that is either unfamiliar to them, where the specialty is very wide, or if they are at an early stage in their career. In realist language, these can be seen as contextual elements that would directly affect the *reasoning* part of the mechanism that causes the user to decide whether to use an app, through their effect on the need to refer for information.

When the need to refer does arise, the doctor needs to assess the best way of dealing with this need. If the information is required quickly, an

information source may be sought urgently, and thus needs to be available immediately. This availability will be affected by whether the doctor is working on their own – for instance on a night shift where there very few other staff, whether they are working on a ward where there is a computer available, and if they are aware of other resources available such as reference books or protocols printed out elsewhere. These contextual elements can be seen as affecting the user's perception of resource availability – not in an absolute sense, but in relation to other available sources. The viability of an app as an information source would also be affected by the type of information required – large amounts of information would be less viable using a smartphone. This perception of availability would also be influenced by how easy the user finds an app to use – the easier the user finds the app to use and obtain information from, the more viable it is a potential information source.

If the user does consider the app as an available resource that fulfils the need of providing information at the point of care, the user then has a number of other considerations that might influence their decision to use an app. They might decide that other sources, whilst not more efficient, might be more acceptable for reasons such as patient or colleague objections. Ultimately, the user must weigh the benefits of using an app in terms of convenience compared to the risks in terms of reputation and relationships with colleagues and patients.

The final implication of the consideration of this causal chain is that the core mechanism at the heart of app use is whether a doctor ultimately decides to use an app – this is the culmination of the all influences of context at different stages of the causal chain that influence the availability of an app in a given situation and the doctor's decision to use or an app in that situation. This idea is developed further during the first few sections of Chapter 7.

This conception of app use as a broadly sequential series of decisions affected by different contextual elements fits somewhere between processual theories such as NPT (May & Finch, 2009) and those that consider one-off events such as the TAM (Davis, 1999) whilst there are

existing conditions that will influence a predisposition to use an app by a given user, but that will also be influenced by immediate situational factors in the moment that the app could be used. As such, systems theories such as socio-technical systems theory (Clegg, 2000) might be useful in better understanding app use due to their inclusion of dynamic processes and static pre-conditions.

6.5.6 Refined Theories

From analysis of the interviews, it was apparent that although app use was generally viewed in positive terms, actual app use was not that common. Furthermore, the use of Ignaz specifically was quite rare. From the researcher's perspective, this made it difficult to evaluate the effects of app use. With infrequent occurrences of app use, it was not feasible to identify demi-regularities that would enable one to theorise with any confidence what effects app use had. The implication for the next stage of this thesis was that evaluation app use in terms of outcomes of that use would not be a fruitful endeavour, and that therefore that any theories to be taken forward into the next stage would necessarily exclude reference to effects of app use.

What did emerge from the analysis though, was that multiple factors were involved in the decision to use an app, and that these factors were interdependent. The analysis demonstrated that substantive "theory fragments" from the original nine theories, and new contextual elements arising from analysis of the interviews could be synthesized and provide sufficient material to investigate the equally interesting area of what causes app use by doctors in the course of their practice, thus influencing the rationale for the refining of the starting theories. This synthesis was facilitated by the framework matrices, which when viewed in combination, started to show how theory fragments from individual theories fitted together, enabling the researcher to see more clearly how different contextual elements worked together. Figure 10 illustrates this relationship.

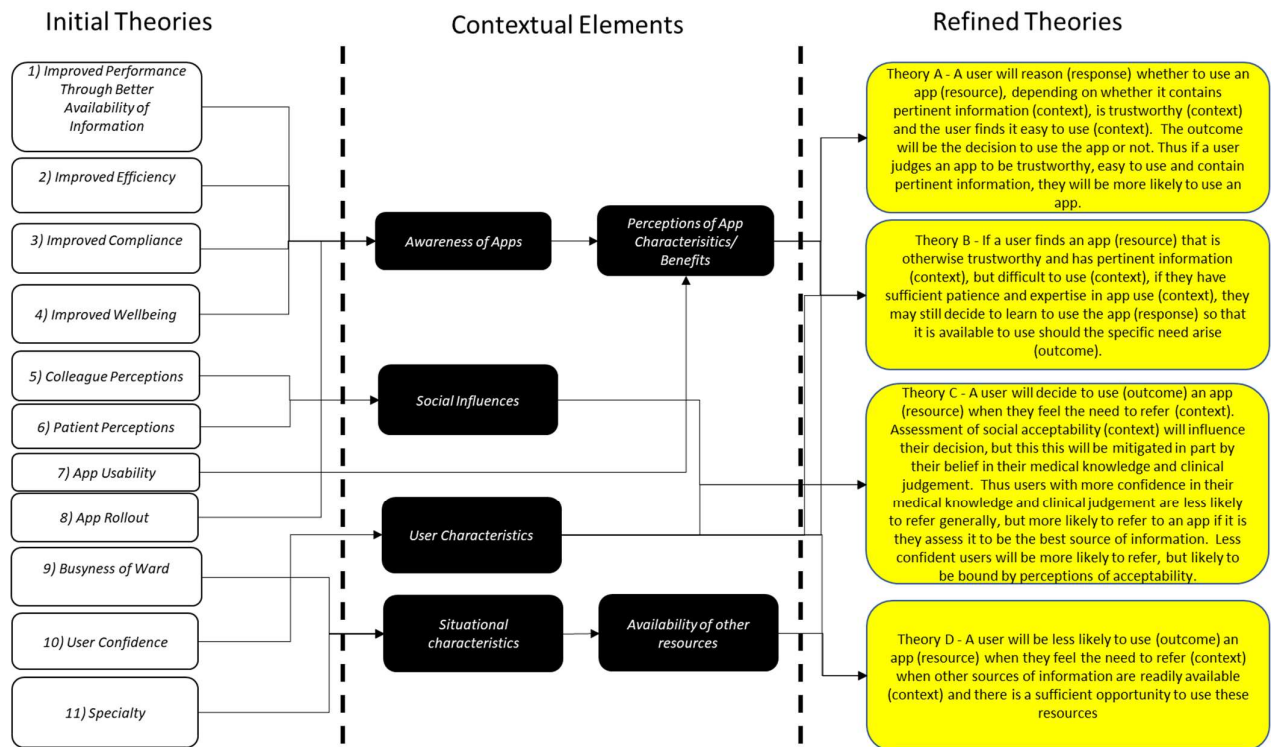


Figure 10 Refined Theories

Theories one to four, with their emphasis on the effects of app use, were deemed not suitable for further investigation in the present thesis, although relevant contexts and mechanisms within these theories were still of interest based on their prominence in the prior analysis; the ability to access information was seen as a potential motivator for app use.

Theories five and six received substantial support in terms of the importance of social factors, whilst theory seven pertaining to ease of use also shown to be relevant. Theory eight, relating to app rollout, was less important, but did drive some discussion around the importance of app awareness, whilst theory nine also touched on some emergent themes relating to situational cues that hindered or encouraged app use.

Consideration of these original theories in combination with the new contextual elements led the refinement and generation of new theories.

The interview evidence supports the idea that an app needs to be trustworthy, contain information useful for a particular task, and needs to be quick and easy to use. In this scenario, the mechanism consists of the presence of an app that is available to use (resource), with the response

being whether an individual chooses to use it. The contexts that influence the response are the app itself, which in this situation can be considered a real structure which has the properties of utility in terms of content, trustworthiness and ease of use. These properties, for most of the respondents, are essential for an app to be used. Augmenting this is a context relating to individual expertise or familiarity with a particular app. Thus a more complete realist formulation of a theory relating to specific apps would be as follows.

- Theory A - A user will reason (response) whether to use an app (resource), depending on whether it contains pertinent information (context), is trustworthy (context) and the user finds it easy to use (context). The outcome will be the decision to use the app or not. Thus if a user judges an app to be trustworthy, easy to use and contain pertinent information, they will be more likely to use an app.

This formulation makes it clear that the mere availability of an app combined with a perceived need is not enough for a user to decide to use that app. Instead, there is a need for the user to have certain beliefs about the utility, trustworthiness and usability of the app for use to be considered.

From the interviews, the most flexible facet of these factors was ease of use. The idea of an app that is harder to use lessening the likelihood of it being used sounds intuitively true. However, the interviews suggested that some individuals would invest the time in learning to use an app that was difficult to use provided it had sufficient utility. This suggests that ease of use is not a fixed property of an app, although certain design features would affect it, but that individual preferences and skills also play a role.

This supports the idea that the quality of an app is not the sole determinant of its use; that individual characteristics of a user and perhaps other factors affect a potential user's decision of whether or not to use an app in a given moment.

Thus, a variation on the previous theory statement is required:

- Theory B - If a user finds an app (resource) that is otherwise trustworthy and has pertinent information (context), but difficult to

use (context), if they have sufficient patience and expertise (context), they may still decide to learn to use the app (response) so that it is available to use should the specific need arise (outcome).

The above reflects the potential importance of a user's characteristics – not all users will have similar levels of expertise when it comes to using apps (or smartphones in general). Related to expertise was the idea of user confidence; both in their medical knowledge and confidence in their ability to make clinical decisions. The confidence in their medical knowledge was based on career stage, as was confidence in clinical decision making. However, the confidence in clinical decision making was affected by different factors, particularly the influence of colleague and patient perceptions. This interplay of confidence in decision making and social acceptability suggest a reframing of some of the earlier theories into a more coherent whole:

- Theory C - A user will decide to use (outcome) an app (resource) when they feel the need to refer (context). Assessment of social acceptability (context) will influence their decision, but this this will be mitigated in part by their belief in their medical knowledge and clinical judgement. Thus users with more confidence in their medical knowledge and clinical judgement are less likely to refer generally, but more likely to refer to an app if it is they assess it to be the best source of information. Less confident users will be more likely to refer, but likely to be bound by perceptions of acceptability.

The final theory that emerged was related to the environment within which a doctor was working, and the relative availability of other sources of information. Where there were other colleagues, easy accessibility of IT and sufficient time to leave the patient's bedside to get information, it was apparent that apps became less appealing as a source of reference of information compared to other methods. Thus:

Theory D - A user will be less likely to use (outcome) an app (resource) when they feel the need to refer (context) when other sources of information are readily available (context) and there is a sufficient opportunity to use these resources

6.5.6 Strengths and Limitations

From a starting point where the research was trying to understand which effects of app use were most supportable and what mechanisms and contexts lead to these effects, the emphasis shifted to what contexts and elements led to app use. In hindsight, this might have meant that the starting theories would have been formulated differently to reflect this effect, but in practise it did not make a huge difference to the data collection; the importance of what users believed were the benefits of app use were important contexts that contributed to opinions on the utility of apps, which in turn seemed to be context involved in their decision to use apps.

The effect on theory development was less damaging than one might imagine. From the initial data coding and interpretive stages, it was apparent that app use was less prevalent than previously thought, so that by the time it came to assembling the framework matrices and refining new theory, the researcher was able to assess which elements were most pertinent to the re-focused investigation.

With regards to the sample size, it was substantially smaller than is suggested in the literature (Manzano, 2016). But given this was an interview study with the purpose of refining rather than testing theory, it did meet the requirements in terms of providing a range of data that addressed the theories of interest. Combined with the theoretically purposive sample used to select participants, and the reasonably high level of consensus within the target sample on a range of issues, it did not greatly diminish the robustness of the study.

6.6 Conclusion

Returning to the original research questions posed in this study, the initial question of what factors affect app use suggested that a wide range of factors were influential in how an app was used. These factors tended to be based on the app itself, in terms of its perceived utility and usability.

Social factors such as senior colleague and patient views influenced when and where an app was used. Whilst specific situations, physical locations and specialties were implicated as contextual factors that would influence app use, their role was less clear based on the data in this interview study. The involvement of this multitude of factors suggests that no single substantive theory has yet been developed that can guide app research, and that perhaps use of flexible meta-theories such as socio-technical systems approaches may be of more utility in understanding the complex relationship between context and use.

Although the theories relating to factors influencing use of apps were well supported by the interviews, possibly the most important finding was that apps are not used frequently, and specifically Ignaz was not used at all frequently by interviewees other than the developers. Had Ignaz been rolled out as initially planned, this may have turned out differently, but it did confirm the idea of switching to an investigation that used realist methods rather than a realist evaluation.

Whilst demonstrating that an evaluation approach was no longer feasible, the interview study showed that the realist framework could yield useful and novel findings, particularly with elucidating a theoretical causal chain and relevant causal factors that lead to the use of apps. By understanding this causal chain one could better understand how to better design and implement apps. Furthermore, one could better understand why it might be better not to use them in certain circumstances rather than pressing on in the name of technological progress. The refined theories demonstrated the range of contextual elements involved in the decision to use an app, and how these factors do not act in isolation. The next chapter describes how this realist investigation was undertaken using the concept of a realist system, describing the logic, data collection and analysis and the findings of the investigation.

Chapter 7 – Testing the Theories

7.1. Introduction

Chapter 6 established that it would be impractical to undertake a conventional realist evaluation— there is no single intervention or family of interventions to evaluate in terms of their effectiveness. Ignaz, whilst used, is not used widely enough for its impact to be evaluated, and because roll out was delayed, one cannot evaluate the effectiveness of the roll out in terms of getting the app to be used by the target user base. The interview study did, however, affirm the utility of a realist approach in revealing the causal chains and webs involved in app use regardless of whether an evaluative approach is undertaken.

This chapter describes the rationale, process and findings of the realist investigation of app use through the refining and testing of theory relating to the use of apps developed from the interview study. Beginning with a brief recap of why evaluation was no longer an appropriate methodological approach, this chapter describes the underlying logic and the main features of the investigatory approach used. Following this the chapter will describe and unpick the theories to be tested. Subsequently, the empirical exercise is described in terms of data collection and analytic methods used, findings, and discussion of those findings.

7.1.1 Why not a realist evaluation?

The shift in approach of this study was necessitated by the delayed rollout and subsequent low use of Ignaz that was uncovered during the interview study described in Chapter 6 . This lack of a clear evaluand meant that the evaluation approach as envisaged at the conception of this thesis was no longer appropriate. If the focus were on a single app, one could look at the specific outcomes related to that app's use and use these as the primary outcomes of interest in the evaluation. Metrics could be gathered relating to these specific outcomes of use to identify demi-regularities, and the underlying theory relating to contexts and mechanisms could be tested and refined. As a result of this lack of availability of data on Ignaz, the decision was made to keep the wide scope of investigation that was used in the

interview study (with the intention of building and developing theory) to apps that are designed with the purpose of providing information to doctors at the point of care. The interview study suggested that these apps were sufficiently widely used to facilitate meaningful investigation of their use. However, this wider scope made it more difficult to trace 'line of sight' between any particular app and specific outcomes, making attribution of causality problematic – this would have been less problematic if trying to make the link between one specific app and specific theorised outcomes (i.e. use of Ignaz and increased adherence to antibiotic policy), but examining wider app use made this much more complex. There was insufficient data from the interview study to develop theory about app use leading to other outcomes, so the decision was taken to not examine outcomes of app use or theories relating to them in this final study.

What the interview study did demonstrate was that maintaining a realist-inspired approach to this final study would still be a viable option. Though not evaluating the effectiveness of the roll-out programme of Ignaz or evaluating the impact of app use, examining the causal processes leading to app use still allows the researcher to address the research questions posed at the start of the thesis in a meaningful way. The strengths of the realist evaluation approach in generating theory, testing it and in providing a framework for unpicking mechanisms of action from context, mean that, although there was not an explicit evaluation, the framework overall fits the goals of this thesis. With all of this in mind, the thesis focused on one particular outcome – the decision by a doctor to use an app.

The use of an app is measurable and detectable, and from the interviews it was apparent that there would be variation between individuals and across situations in terms of frequency and type of use. It was also apparent from the interviews that perceptions of outcomes of app use had some influence on the decision to use an app in the first place. Thus, by understanding more fully the processes leading to app use, one might also gain an insight into potential effects of such use, and how beliefs about such effects might influence app use. Effectively, the focus of the thesis was now on all steps of the implementation chain mapped in Chapter 6 except for the last one – outcomes of app use.

7.1.2 Realist systems

In a realist evaluation, one examines an intervention with the intention of identifying what works, for whom, under what circumstances and why (Pawson and Tilley, 1997). One looks at the components of the intervention, identifies potential mechanisms that it would activate and then looks at the outcomes that might arise as a result of the intervention, both intended and otherwise. In the present thesis, there is no single intervention to be evaluated as such, but the thrust of the thesis is still about discovering the how, what, when and why of app use in clinical settings. The issue then arises as to how one needs to modify one's approach to investigate this effectively.

Consider the choice to use an app as an outcome (O). This outcome will have been triggered by a mechanism, which is encapsulated in the decision of a user to use an app - the mechanism resides within the mind of the user. Within the paradigm of Context-Mechanism-Outcome put forward by Pawson and Tilley (1997), context (C) will influence the mechanism (M) that, directly or indirectly, leads to this choice being made. Despite the decision being a conscious one, the actor may not be aware of all of the influences on that decision.

Such voluntary decisions can occur without the presence of a specific intervention – in the health arena, people stop smoking without a specific targeted programme, people lose weight for health reasons without outside assistance from a programme, and doctors use apps without being told to. Counter to this, there are many people that do not choose to stop smoking, lose weight, or use apps. From a realist perspective, understanding what it is both within the individual and the situations that they are in that lead to these decisions means learning more about the realist system within which they are situated. That is, understanding what the mechanisms are that lead to these voluntary decisions, and understanding how context influences these mechanisms. As described in Chapter 3, Dalkin et al's (2015) explicit disaggregation of a mechanism comprises resources that elicit a response in the user that leads to an outcome. Therefore, context must act in some way on the mechanism of interest to influence the

outcome. The question of how context actually influences a mechanism needs addressing here, as it is not explicitly dealt with in the literature – many studies use concrete examples of contextual factors influencing the activation of a mechanism, but the general process of how this occurs is rarely elucidated.

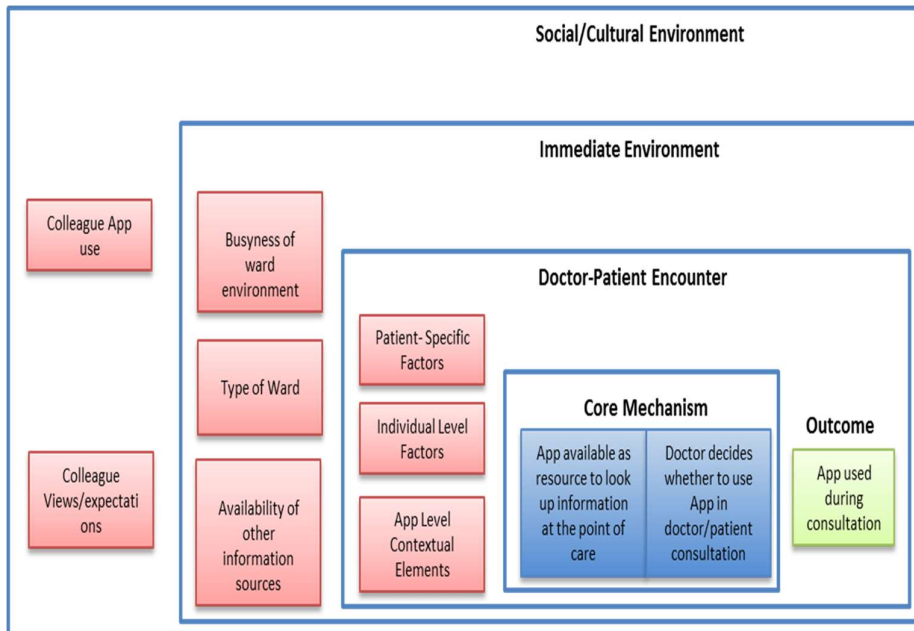


Figure 11 Contextual elements relating to the core mechanism

If one returns for a moment to the description of reality as conceived by realists as described in Chapter 3; it consists of all things that exist, structures with powers and liabilities that are on either the real, actual or empirical planes. Context is not a single, monolithic structure – the term in this scenario is a ‘catch-all’ for the environment within which a mechanism is fired - but consists of multiple structures. These structures can be conceived as elements of the overall context, or *contextual elements*. Each of these elements is a real structure, whether they are a belief held by an individual, physical feature of the environment or perceived behavioural norm. If one thinks about these contextual elements as structures that have specific properties, causal powers to influence other structures and liabilities that mean that they can be influenced by other structures, then

one can begin to conceive as to how they influence the activation of a causal mechanism that leads to an outcome. Figure 11, though not exhaustive, illustrates how this idea pertains to the current thesis.

There are contextual elements that reside at the level of the particular doctor-patient encounter: those within the individual, relating to their existing beliefs, thoughts, and capabilities relating to the particular behaviour; those relating to the patient; and those relating to the app available to use. There is the immediate physical environment, which may comprise the specific type of ward, availability of other information sources and the busyness of the ward at that time. Then there is the socio-cultural environment, relating to the perception of what others believe and how they behave. An additional complexity may be through the addition of a temporal dimension – for instance, an individual's lack of awareness of apps might have precluded them from downloading an app that might be of use. One can move up through levels like layers of an onion, through the organisational environment and societal environment, right up to the national and global environment.

7.1.3 Core mechanisms

At the heart of all of this is the idea of a *Core Mechanism* which represents the decision to use an app. Using Dalkin et al.'s (2015) disaggregation of mechanism, this comprises the presence of a resource (an app) and the response of a user to that resource (a reasoning process) which leads to the decision or not to use an app (Fig 12).

A contextual element may influence the resource hypothesised in the mechanism by changing its nature or availability by exerting its own powers on the liabilities of the target resource or responses, which are themselves real structures. This action can be described as a *contextual mechanism* – the causal means by which contextual elements act on the core mechanism that leads to the outcome of interest (through their action on the resource or response components of the core mechanism). For instance, poor mobile phone reception in a particular room (poor mobile phone reception being a contextual element) may reduce the availability of a mobile phone app that is reliant on retrieving data from the network. A

contextual element may also affect the response in the mind of the subject – it may alter the reasoning by changing the beliefs of the user, alter the perception of the behavioural choices available or may even physically alter the behavioural options available. For instance, the presence of a computer on the ward might be preferable as a source of information compared to a mobile phone for some doctors.

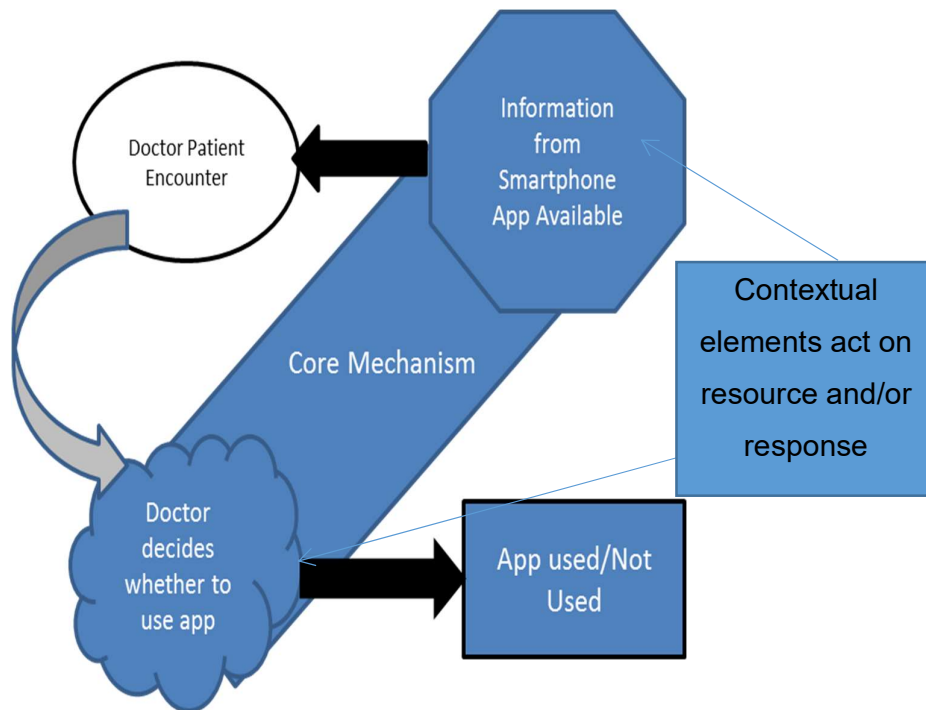


Figure 12 Contextual elements acting on the core mechanism

Contextual elements may also influence each other, either at the same level or at other levels, thus altering how another contextual element acts on the core mechanism. The way in which they influence the outcome is through a causal chain, or more accurately, a causal web. Thus, the realist system of interest is that in which the relevant resources exist and exert an influence on the outcome of interest through their action on the core mechanism that causes that outcome. This realist causal chain maps onto the implementation or causal chain described in chapter 6.

One feature of this realist conception of the combination of context-mechanism-outcome is that the context is a construction of the researcher's view of how an individual constructs their own context. It is not an empirical

reality that is directly observable as might be viewed by more positivist research, but an acknowledged “best guess” on the available evidence, (Maxwell, 2012). Thus different elements of context may be more salient to different individuals and exert different influences, explaining in part the differential effects and also the variation in reasoning processes that individuals might employ. Having described what the researcher means by a realist system, it is now necessary to describe the implications of this for the present empirical investigation.

7.1.4 Realist investigation in a realist system

With the change from realist evaluation to investigation, the emphasis shifts. Rather than theorising and testing how a given intervention leads to a particular outcome, it is taken as a given that the core mechanism, that which encapsulates the decision of a user to use an app, is what leads to app use. The focus then is on how context influences the activation of this mechanism. One moves from testing overall CMOCs configurations to identifying candidate contextual elements and theorising about the nature of their associated mechanisms that act on the core mechanism that produces an outcome. As with the interview study in the previous chapter, one must select the most appropriate theories to investigate and test, and so similar criteria are applied to their selection. The difference here is that theory fragments relating to particular contextual elements and their effect on the core mechanism are the focus of inquiry.

Relating these ideas back to the current thesis on app use, it is clear that contextual elements do not all operate in the same way. Some may be dichotomous in nature – thus the Senior Colleagues’ attitude may be positive or negative, there may be an information deficit or not requiring the use of additional information or not. On the other hand, some elements may operate on more of a sliding scale – the doctor’s level of confidence, or the time available for the encounter. Thus, contextual influences can be seen as operating in a manner congruent with the dimmer switch analogy used by Dalkin et al (2015), in that the supportive and hindering influences combine to ultimately determine whether a user chooses to use an app in a given situation. However, it is not practical for a lone researcher to map

every possible permutation and combination of contextual elements that might have an influence. Instead the task of the researcher, through review of the literature and other inquiry, is to identify pertinent theories that specify which contextual factors are of interest, how they may be involved and thus give a group of theories which can be examined empirically, as in Realist Evaluation (Pawson & Tilley, 1997). In the present research, part of this task has already been done through the interview study, but there are implications for the aims of this empirical study, which are reflected in the research questions addressed by this next study.

7.1.5 Research Questions

- 1) Discover to what extent apps are used by doctors in live settings, and identify patterns of use related to users across different contexts.
- 2) Identify which types of apps are used most extensively
- 3) Identify the key causal mechanisms that lead to app use
- 4) Identify relevant contextual elements and how they:
 - a) Influence the firing of key mechanisms identified
 - b) Influence the response of users when those mechanisms are fired
- 5) Use the information gathered on contexts, mechanisms and outcomes to generate better theory relating to the use of apps by doctors, and apply

The purpose of this study was to provide answers to the overall thesis objectives outlined at the end of Chapter 1. The gathering of primary data on the patterns of app use among doctors in live settings would address Objectives 1 and 2, and led to the first research question for this study:

1. What are the patterns of app use amongst doctors at different career stages and within different settings and specialities?

Objectives 3 and 4, relating to the understanding of relevant causal mechanisms and contexts that influenced their activation also needed addressing, and led to the following questions:

2. What are the contextual elements that affect the use of apps by doctors in healthcare settings, and what are the causal mechanisms by which they exert their influence?

3. How do these contextual elements interact to influence app use by doctors?

By answering these questions, one is in a position to better address Objective 5, which related to generate better theory relating to app use. The present study addresses these questions using the realist approach described in section 7.1. For this approach to be employed, it is first necessary to specify theories for testing and refining. Theories to be tested are described below.

7.2 Selection of Theory

The theories selected for the current study emerged from the interview study and are summarised in Section 6.4.10. The theories selected focus primarily on use as the outcome of interest, and interim outcomes that lead to this decision to use. They are more complex than for the interview study owing to their combinatorial nature, where numerous contextual factors are posited as contributing to the outcomes described. Unlike for the interview study, the theories relate primarily to contextual mechanisms. The contextual elements of interest arising from the interview study and their implications for the middle-range theory to be tested are discussed in more detail below.

Theory A - A user will reason (response) whether to use an app (resource), depending on whether it contains pertinent information (context), is trustworthy (context) and the user finds it easy to use (context). The outcome will be the decision to use the app or not. Thus if a user judges an app to be trustworthy, easy to use and contain pertinent information, they will be more likely to use an app.

The core mechanism of a user choosing to use an app in the light of its ability is posited as being affected by a number of contextual elements. Regarding the app itself, the (perceived) utility of the information held within the app itself is seen as affecting the decision to use the app. This

information is not intrinsically useful or not, but is contingent on the information needs of the situation. Therefore, the first proposition is as follows:

- a) Apps will be used when the information held within them is seen as useful for a patient encounter

The trustworthiness of the app is based on the perception of the user, and the ease of use is based on the perception of the user as well, although this perception may be affected by the objective usability of the app in terms of design. In an empirical test, one would expect “road-tested” apps to be used, and users to be proficient in their use, rather than figuring out how to use an app in front of the patient or even on the ward. This leads to the following two propositions

- b) Only apps that are seen as trustworthy will be used in the context of a patient encounter
- c) Apps that are perceived as easy to use will be used in the context of a patient encounter

Theory B - If a user finds an app (resource) that is otherwise trustworthy and has pertinent information (context), but difficult to use (context), if they have sufficient patience and expertise in app use (context), they may still decide to learn to use the app (response) so that it is available to use should the specific need arise (outcome).

In addition to the propositions above, this theory brings in the idea of user expertise with apps as a characteristic of importance. One would expect users who have a higher degree of confidence in the use of apps to use more apps than those that do not. In empirical testing, one would expect to find evidence of users with more confidence both in apps and their own confidence in ability to use apps to use a wider range of apps and to use them in a wider range of situations, leading to the following propositions:

- d) Users with a higher degree of expertise and confidence in app use will be able to use a wider range of apps than users with less expertise

- e) Users with a higher degree of expertise and confidence in app use will use apps in a wider range of situations than users with less expertise

Theory C - A user will decide to use (outcome) an app (resource) when they feel the need to refer (context). Assessment of social acceptability (context) will influence their decision, but this this will be mitigated in part by their belief in their medical knowledge and clinical judgement. Thus users with more confidence in their medical knowledge and clinical judgement are less likely to refer generally, but more likely to refer to an app if it is they assess it to be the best source of information. Less confident users will be more likely to refer, but likely to be bound by perceptions of acceptability.

The role of user characteristics in terms of confidence in their medical knowledge and professional judgment are prominent in this theory. The role of social acceptability of app use is also important; when testing theory, one would look for empirical evidence that highlighted the role of perceptions of social acceptability, and user confidence, leading to the following propositions:

- f) Users who believe that senior colleagues approve of app use will be more likely to use an app in a given situation
- g) Users who are more confident in their medical knowledge are less likely to refer to external information sources in general

Theory D - A user will be less likely to use (outcome) an app (resource) when they feel the need to refer (context) when other sources of information are readily available (context) and there is a sufficient opportunity to use these resources

The role of physical working environment comes to the fore in this theory. The availability of other sources of information is important; during theory testing, one would expect to find different patterns of use across wards and specialties, a view reflected in the following propositions:

h) A user will be less likely to use an app in a ward where other sources of information, such as colleagues or other IT, are readily available

i) Non-app users will be more likely to use other sources of information than non-app users.

Each of the theories described above takes a particular form – under a particular condition (i.e. in the presence of certain contextual elements), a particular outcome or outcome pattern will occur owing to the influence on the core mechanism specified, and so essentially conforms to the Context-Mechanism-Outcome configuration that is employed within Realist Evaluation. Compared to the interview study, there are fewer theories but they are more complex. The formulations are more specific in terms of how contextual elements are posited as either influencing the reasoning of an individual (in this case, the reasoning of an individual with regard to whether or not to use an app to obtain relevant information), or the availability of the resource (availability of the information provided by an app). Having elucidated the theory to be tested in the empirical study, the following section discusses the methodological implications for data collection and analysis.

7.3 Method

From the range of theories and propositions described in the previous section, it is apparent that a variety of data need to be collected. Data need to be collected on a variety of contextual elements, and additional information needs to be collected on relevant outcomes.

7.3.1 Methodological approach

The opportunity to use an app arises as a result of an information need generated by a doctor-patient encounter. Any such encounter is embedded within a particular ward or clinic, in a specific physical environment, within the specific hospital and healthcare organisation, and as such is subject to the contextual elements that constitute these settings. For the outcome elements of the theories, it was necessary to obtain data on real world use

to meaningfully test these elements of the theories. Likewise, it was necessary to gather real data on contextual elements to test the contextual elements of the theories from real world settings. Objective data on outcomes and contextual elements would provide partial evidence of mechanisms, since particular outcome patterns would be expected based on the activation of a specified mechanism. Mechanisms are by their nature in the realm of what is real, and so are not necessarily directly observable (Sayer, 2000), but insights can be gained into such mechanisms by individuals reporting their accounts of their decision-making processes (Maxwell, 2012). Thus, the interview study described in Chapter 5 was useful in gathering information on potential mechanisms. Whilst the extent to which such accounts are *post-hoc* explanations of decisions made, rather than direct reflections of the reality of the decision-making process, is a matter of debate. Such insight is useful as evidence for the existence of potential mechanisms, and serves as corroborative evidence as to what causal processes contribute to decisions made (Pawson, 2013).

To evaluate the theories under investigation, the researcher chose methods that reflected the need to gather outcome data and understand decision-making processes, whilst also gathering information on contextual elements that were deemed pertinent to the enquiry. Furthermore, to counter the “relentless localism” of purely qualitative approaches (Maxwell, 2012), methods were required that could reflect the variety of different contextual influences to which doctors are subject. To this end, a two-pronged approach was employed. An observational study was used to gather information on actual use of apps by doctors, wherein individual doctors were shadowed whilst going about their duties on shift, with the researcher recording their activities in relation to information-seeking behaviour, whilst simultaneously gathering information on the context in which such behaviour was taking place. It was important to gather data on information-seeking behaviour in general in order to understand the circumstances under which apps were chosen as the appropriate reference source compared to other sources of information. Observational studies also give the researcher the opportunity to question the subject as to why a particular decision was taken (often very soon after that decision was taken) and as

such obtain some insight into the reasoning behind those decisions, thus providing some illumination into the causal mechanisms at work.

To complement the observations, a questionnaire survey was devised by the researcher and administered to doctors across the organisation. The intention behind the survey was to gather data from a larger sample on individuals' perceptions of factors that affected their app use at work, thus partially addressing issues relating to representativeness of data from the necessarily small sample used in the observational study. The following sections describe the data collection design and procedures in more detail, beginning with the survey study. This multi-method approach is in line with the philosophy of realist approaches in that it seeks to gather whatever data are available to test the theories of interest (Pawson & Tilley, 1997).

Prior to the recruitment of participants for the survey and observations, ethical approval was sought and received from the University of Leeds School of Psychology Research Ethics Committee, and from Bradford Research and Development Office – full NHS ethics approval was not required due to the nature of the research undertaken because the focus was once again on staff rather than patients.

7.3.2 Quantitative Survey

The interview study described in Chapter 6 had the purpose of eliciting and refining theories and was not explicitly focused on quantification of app use or the associated contextual elements. The interviews employed purposive sampling to elicit and refine theories, but to test the theories a more systematic approach was required, hence the rationale for a quantitative survey, which aimed to:

- Identify demi-regularities - find the groups of people and settings (i.e. relevant contextual elements) in which apps seem to be used more, as well as those for which app usage appears to be lower
- Formally test the candidate theories that emerged from the interview study through the use of basic descriptive and inferential statistics.

The following sections describe the methods used to undertake this survey

7.3.2.1 Participant recruitment and selection

A total of 212 surveys were distributed across a single large NHS Teaching Hospital Trust in the North of England, with the researcher attempting to recruit from all wards on the site. 82 surveys were returned to the researcher, providing a response rate of 39.2%.

7.3.2.2 Materials

The survey items were constructed by the researcher based on the theories under test, and the rationale for the items based on the theories under test. The first part of the survey collected demographic and career information relating to specialty and career level. The second part collected information of app use – types of app, frequency of use and information gathered on career stage, specialty, nature of work and usage patterns; this was the section of the survey that would provide information on the Outcome of interest, namely whether apps were used. The third section of the survey focused on beliefs about the utility of apps – an important contextual element based on the interview study. The fourth section was focused on factors that participants believed influenced their use of apps, and measurement of the extent of that influence. The items were kept specific to particular contexts relating to app use. Items were mostly closed response (Yes/No) or Likert scale items indicating level of agreement or disagreement, or frequency of use. Free text items were included to allow participants the opportunity to elaborate on their answers to the closed response items if they so wished. The survey was designed to be as short as possible, the rationale being that individuals would be more likely to fill in a shorter survey. A copy of the survey is included in Appendix.

7.3.2.3 Procedure

Recruitment was initially through email approaches to heads of department to seek permission to distribute questionnaires to staff members. When permission was granted, the researcher liaised with individual specialties and wards to find the optimal method of distributing the questionnaire. The decision was taken to distribute paper copies rather than by email, as initial inquiries indicated that emails would likely be ignored, and as noted in the introductory chapter of this thesis, previous survey studies have suggested

that respondents would be more likely to be smartphone users than the general population. The survey was distributed by one of two methods – doctors' pigeon holes, with return envelopes attached, and in person on wards. In all cases, the survey was distributed with a comprehensive information sheet that informed participants as to the purpose of the survey, the researcher's contact information, the anonymity of their responses, and the purely voluntary nature of their participation. A tear off sheet was added to the survey which gave participants the opportunity to volunteer for the observation study.

7.3.3 Observational Study

7.3.3.1 Setting

The study was undertaken primarily in four wards in the same Teaching Hospital Trust as the survey. The aim was to undertake observations in wards that varied in terms of important contextual elements; for instance, wards which were known to have a high patient turnover and variety of medical presentations were approached, as were wards that had high levels of medical specialism with lower patient turnover. These contextual elements were viewed as important because, based on the interview study described in Chapter 6, they would affect other contextual elements such as the relative availability of external sources of reference information. The four wards, which were all medical rather than surgical, in which the doctors were observed are described below.

- Ward A: A small ward (fewer than 20 beds) with relatively low turnover of in-patients who typically stayed more than one night and each had individual rooms. Patients with acute and chronic conditions were treated on the ward. In terms of contextual elements of interest, there was a low volume of patients at any one time and patient encounters were usually unhurried, with relatively few doctors on the ward at any one time and thus fewer colleagues with which to consult. Ward rounds took place every day. The range of conditions being treated was specialised, potentially reducing the breadth but not depth of knowledge. There was also relatively easy access to IT (four desktop computers, three of which

were in a side room); the pace at which decisions needed to be reached was potentially slower.

- Ward B: Renal Ward: Larger than Ward A, with slightly higher turnover of patients, but still relatively specialised with relatively long patient encounters, and ward rounds taking place daily. Most patient beds were in the main ward area, with a few in individual rooms. Several desktop computers scattered around the ward plus three in the doctor's room. There were also two Computers-on-Wheels (COWs). The general pace of work was higher, and there were more doctors on the ward than Ward A
- Ward C: Accident and Emergency department. Very high turnover of patients, with relatively short patient encounters. The range of conditions being assessed and treated was extremely high. There were six desktop computers around the ward, and a very high number of doctors and other medical staff around the ward. The pace of work was very high. Patients were situated in cubicles in the ward area.
- Ward D: Medical Assessment Unit (MAU): Larger area than Ward C, with patients in cubicles and beds across two adjacent ward areas. Like Ward C, a high variety of conditions being treated, but with slightly longer patient encounters, and ward rounds taking place. Multiple desktop computers were located around the ward, and COWs also available. There were generally fewer doctors per bed than Ward C. Patient turnover was more rapid than in Wards A and B, but slower than in C .

Each of the wards described were typically staffed by a mixture of consultants, registrars and foundation year doctors during normal working hours (between 8 am and 6pm). During evenings and night shifts, consultants were not generally on the ward but were available on call. There were fewer doctors at this time of day, with doctors assigned either to Wards C and D specifically, or to cover across multiple inpatient wards within the hospital.

The varied nature of the observations made it possible to observe the effects of different contextual factors – for instance, rounds typically had relatively short patient interactions and were focused on information gathering, whilst individual observations tended to be more task-focused and provided the opportunity to observe in more detail how doctors gathered information in a range of scenarios. Clinics, on the other hand, were private and unhurried and had a computer available in sight of the patient.

7.3.3.2 Participants

The recruitment of participants, as with study settings, was primarily guided by theoretical considerations (Emmel, 2013) to ensure that a wide range of contextual elements were observed.

Consultants across the Trust were emailed to request permission to approach doctors on their wards for the purposes of this observational study. Only four consultants responded, but these contacts were deemed sufficient to fulfil the purposes of the study because the wards represented sufficient variation in busyness and specialism to satisfy the need of varied context. Once access to the ward had been agreed, the researcher attended the ward and approached individual doctors, explaining the purpose of the study. An information sheet was given to those that expressed an interest in the study. Some doctors agreed to take part immediately, in which instance the researcher arranged a convenient time and place to observe them. Others were then recruited on subsequent visits to the wards in question. A total of 19 observations were mainly undertaken across the four wards – the exception being certain periods in MAU when sometimes doctors were covering multiple wards on late or night shifts, and one observation that was excluded from analysis because it turned out to be a meeting rather than an observable interaction involving patients. In addition, doctors at different career stages were observed, under a range of circumstances; during ward rounds, in clinic and undergoing regular duties, as well as on shifts at different times of day to account for varying levels of busyness, support and availability of other resources. The list of observations is shown in Table 2.

The type of observation varied in terms of the activities being undertaken. Ward rounds typically included a group of three to five doctors, usually led by a consultant with registrars and junior doctors in attendance. The rounds aimed to go around all of the patients on a ward, assessing their condition and gathering information so that a course of action could be agreed and undertaken later in the day. Typically these actions were undertaken by more junior doctors, who would record activities in a book or on a piece of paper.

Two weekly rounds were observed, and these involved larger meetings with most of the doctors from a particular specialty and other colleagues involved in the care of patients of these wards, such as doctors from other specialties, nurses and allied health professionals. These were held in large rooms, with a computer and projector, with patient details on the screen as they were discussed. Typically, the actions agreed were about more significant decisions about patient courses of treatment.

Individual observations were usually spent shadowing a single doctor as they went about their duties for the day, and there was typically more opportunity to speak to doctors and get their views while they were walking between tasks. These tasks were usually based on that day's rounds, but also involved making decisions based on situations that came up as the day progressed. On later shifts, the workload was less based on pre-planned actions than on dealing with situations that occurred as the day progressed, such as admitting and assessing new patients, or dealing with emergencies. Two clinics were observed, and these involved a single doctor in a room with a desk and a computer seeing patients that had come in for scheduled appointments.

Table 2. List of Observations Undertaken

Observation	Career Stage	Ward/Specialty	Type	Shift	Date
1	Registrar	A&E	Solo	Day	19/08/2015
2	Multi	n/a	n/a	n/a	21/08/2015
3	Multi	Renal	Rounds	Day	24/08/2015
4	Foundation	Renal	Solo	Day	24/08/2015
5	Multi	Haematology	Rounds	Day	25/08/2015
6	Foundation	Haematology	Solo	Day	27/08/2015
7	Foundation	Renal	Solo	Day	27/08/2015
8	Consultant	Haematology	Clinic	Clinic	03/09/2015
9	Foundation	Haematology	Solo	Day	03/09/2015
10	Foundation	Renal	Solo	Late	03/09/2015
11	Registrar	Renal	Clinic	Day	08/09/2015
12	Multi	MAU	Rounds	Day	11/09/2015
13	Multi	Renal	Rounds	Day	18/09/2015
14	Foundation	Renal	Solo	Day	21/09/2015
15	Multi	Haematology	Rounds	Day	22/09/2015
16	Registrar	MAU	Solo	Night	23/09/2015
17	Registrar	MAU	Solo	Night	24/09/2015
18	Foundation	A&E	Solo	Day	28/09/2015
19	Foundation	A&E	Solo	Day	30/09/2015

7.3.3.3 Materials

An observation template was drawn up prior to observations taking place to ensure pertinent information was captured – doctor career stage, type of shift, and specialty. The template operated as an aide memoire to the researcher undertaking the observation. Notes were taken using pen and paper, as the use of recording equipment was seen as likely to reduce the access of the researcher to doctor-patient encounters owing to concerns about privacy. An example of an observation write up can be found in the appendix.

7.3.3.4 Procedure

During recruitment, and prior to each observation, the researcher made clear that participation was voluntary, that patient information was not going to be recorded, and that even if they did consent to participate, they could withdraw at any time during the observation and up to a week afterwards. In addition, the researcher emphasised their own lack of medical knowledge, that they would not be evaluating job performance, and that they would not be interrupting patient care. As an additional reassurance. Also, given the nature of the study focus on app use and the attached risk of demand characteristics, the researcher made it clear that they wished to observe normal medical practice, and that it was just as important to understand why apps were not used as it was to understand why they might be used. Such steps were taken to ensure that the researcher minimised their impact on doctor behaviour, so that the participant was as unaffected as possible.

During the observations, the researcher followed proceedings as a non-participant observer. Records were made with a pen and notepad, with the time, date, setting and type of observation recorded, as well as relevant participant details. The researcher took note of the activities that took place, recording the time of occurrence and nature of the activity in note form. Given the nature of the study and the focus on the use of apps as a source of information, particular emphasis was placed on the recording of *Information-Seeking Events*. These were any occasion when the participant or participants looked up information – this could be information

about the patient specifically, referring to guidelines or referring to colleagues. Initial discussions with patients, such as taking patient histories, were typically not coded as information-seeking events. A summary of the types of information seeking events is discussed in the results section of this chapter. At opportune moments during observation periods i.e. when walking between beds or wards, or whilst waiting for systems to load, the researcher took the opportunity to ask clarification questions and also about attitudes to app use and information seeking in general.

7.3.4 Analytic Approach

Observations were typed up into a template for ease of comparison and analysis. The researcher coded the data using NVivo software (Version 11). Each observation was categorised according to where it was undertaken, the type of observation (clinic, rounds, solo observation or other meeting) and the career stage of the participant. Information-seeking events were coded and categorised according to how they were undertaken by the doctors concerned. Other information gleaned from discussions during the observation and other context-relevant information was coded by contextual element using thematic analysis (Braun & Clarke, 2006). The quantitative data obtained relating to category of observation and information seeking events was then transferred to SPSS version 11 for analysis. The contextual element information was used to situate the quantitative data in terms of the hypotheses under test.

7.4 Results

This section is organised with reference to relevant outcomes and contextual factors. Following an outline of the overall outcome patterns, and reporting of results relating to different contextual factors, the implications of these data are to the theories under test. The section concludes with a series of refined theories that are supported by the available evidence.

7.4.1 Patterns of App Use

From the 82 surveys returned, 58 (70.7 %) stated that they used apps as part of their practice. The respondents were split quite evenly across career stage (30.49% consultant, 34.15% registrar and 35.37% foundation), and their respective usage of apps is recorded in Table 1.

Inspection of the usage rates reported suggests that there was a trend towards registrars being more likely to use apps than other groups, but a chi-square goodness of fit test was undertaken to see whether any professional groups was more likely than the others to use apps but fell short of significance, $\chi^2(2, N= 82) = 5.181, p=0.075$.

Table 3 Proportion of Doctors who use Apps by Career Stage

<i>Career Stage</i>	<i>Mobile App Use (%)</i>		<i>Total</i>
	<i>No</i>	<i>Yes</i>	
Consultant	8 (32.0)	17 (68.0)	25
Foundation	12 (41.4)	17 (58.6)	29
Registrar	4 (14.3)	24 (85.7)	28
Total	24 (29.3)	58 (70.7)	82

The observation study showed a slightly different picture, a summary of which is shown in Table 2. A total of 270 information seeking events were observed during the 18 observation periods (totalling 42.65 hours) described, of which 187 related to the patient and their condition, 55 related to medical reference, 24 related to other care-related information (such as where certain materials were kept or bed availability on other wards) and three related to finding out how to contact a particular colleague. Within these events, mobile smartphones were used as the reference source on eight occasions, and only two of these occasions was an app used – on the other six occasions, smartphones were used to access websites. On one occasion, the doctor used it to calculate a risk score for a particular medical condition (Observation 12). On the other occasion (Observation 17), the generic calculator app on the phone was used to quickly work out a drug dose. One specific occasion when apps did come up that was not used for information seeking was when the users showed a junior colleague that they had created database of information to which they could refer to if they needed to rather than actually referring to it themselves

(Observation 1). It may be worth noting that all three users were registrars working in the broader specialties, but with such a small sample, it seems unwise to take this as representative of all app use. Internet mobile phone use was typically to check the name of a test, or to look up a description of a condition.

Table 4 Summary of Information Seeking Events Observed

Information Seeking Behaviour	Number of Events (%)
Info about patient	187 (69.3)
<i>Info from colleague</i>	40 (14.8)
<i>Info from Computer - hospital systems</i>	82 (30.4)
<i>Info from Computer - internet</i>	2 (0.7)
<i>Info from Patient</i>	8 (3.0)
<i>Info from Patient notes</i>	55 (20.4)
Medical Info	55 (20.4)
<i>Info from book or similar reference</i>	9 (3.3)
<i>Info from colleague</i>	28 (10.4)
<i>Info from computer - internet</i>	10 (3.7)
<i>Info from mobile phone - app</i>	2 (0.7)
<i>Info from mobile phone - internet</i>	6 (2.2)
Other care information	24 (8.9)
Contacting colleague	3 (1.1)
Total Information Seeking Events	270

The types and frequency of apps used by survey respondents is shown in Table 3. Of the 82 survey respondents, 58 (70.7%) said that they used apps. Of the apps used, the most frequent type was the use of research

sources, followed by logbooks , clinical decision tools and textbooks. Just over a third of respondents used Ignaz and quarter of respondents claimed to use patient records.

Table 5 Type and Frequency of App Use by Survey Respondents

Type of App	Frequency of Use						Total Users
	Never	< Once a month	Once per month	Once Per Week	Most Days	At Least Daily	
Textbook	36 (43.90)	12 (14.63)	5 (6.10)	6 (7.32)	7 (8.54)	16 (19.51)	48 (56.10)
Research	26.0 (31.71)	11.0 (13.41)	13.0 (15.85)	12.0 (14.63)	9.0 (10.98)	11.0 (13.41)	56 (68.29)
Clinical Decision	32 (39.02)	14 (17.07)	4 (4.88)	16 (19.51)	6 (7.32)	10 (12.20)	50 (60.98)
Logbook	28 (34.15)	9 (10.98)	11 (13.41)	6 (7.32)	10 (12.20)	18 (21.95)	54 (65.85)
Patient Records	61 (74.39)	1 (1.22)	1 (1.22)	0 (0)	1 (1.22)	18 (21.95)	21 (25.61)
Ignaz	52 (63.41)	7 (8.54)	1 (1.22)	3 (3.66)	2 (2.44)	17 (20.73)	30 (36.59)
Other Apps	61 (74.39)	2 (2.44)	2 (2.44)	1 (1.22)	3 (3.66)	13 (15.85)	21 (25.61)

Inspection of the free text sections of the survey suggested that there was some ambiguity in the classification of apps, and it was also clear that some respondents regarded the use of smartphones at all was using an app – for instance, the use of SMS messaging and the internet was seen by some respondents as app use. Overall, the pattern of use was quite infrequent for the majority of respondents, with the majority reporting that they used apps less than once a day, but it was striking that around one fifth of respondents were fairly consistent in saying that they used apps daily. This suggests that there are a substantial minority of doctors that are regular users of apps, whilst the majority of others are infrequent users.

It was not possible to analyse the information provided by respondents on specialty because of the inconsistent level of reporting – some answered at the level of “surgery” whilst others recorded a specific department such as anaesthesia. However, the data suggest that a wide range of specialisms were included within the sample.

Taken together, these data suggest that app use is not seen as especially unusual, but it is not a common occurrence. There are a small proportion of regular users who seem to regard it as a regular part of their toolkit.

What the data do not describe is the situations and the reasons for which apps are used.

7.4.2 Theory Testing

7.4.2.1 Theory 1 – The Role of app properties

Theory 1 - A user will reason (response) whether to use an app (resource), depending on whether it contains pertinent information (context), is trustworthy (context) and the user finds it easy to use (context). The outcome will be the decision to use the app or not. Thus if a user judges an app to be trustworthy, easy to use and contain pertinent information, they will be more likely to use an app.

- a) Apps will be used when the information held within them is seen as useful for a patient encounter

Using the survey data, an independent-samples t-test was conducted to compare perceived utility of apps between users and non-users of apps.

This test was used despite the unequal sample sizes in favour of a non-parametric test because it does not perform worse than those tests under these conditions (Zimmerman, 1987). There was a highly significant difference in the scores for users ($M=5.19.2$, $SD=1.48$) and non-users ($M=3.53$, $SD=1.95$); $t(75)=3.916$, $p < 0.001$. This suggests that users of apps believe them to be significantly more useful than non-users.

The observation data adds some detail to this idea. A registrar on MAU (Observation 17) said that they were useful for calculating risk scores, but that they could also use a desktop pc for that. Bearing in mind that this is one of the few people that had been observed using an app, this supports the idea that simply having the right information in an app is not sufficient. Other contextual factors will play a role. One of the doctors mentioned that they would be in favour of apps if there were any useful ones (Observation 6), which suggests both that there is a market for apps that users would find useful, but that not everyone is aware of what apps are available. This absence of awareness of apps was apparent throughout the observations, with very few of the doctors being aware of more than one or two apps aside from those used in their training. This lack of awareness of specific useful apps was a recurring theme.

- b) Only apps that are seen as trustworthy will be used in the context of a patient of a patient encounter

This was not addressed directly in the survey, but it there was evidence from the observation studies. The BNF app was given as an example of a trustworthy app that many users had used on previous occasions (Observations 4 and 8) or had witnessed other using it (Observations 12 and 16). Other examples of when apps were used as trustworthy and therefore used was in the context of apps introduced by specific hospital trusts, such as a doctor's handbook (Observation 4) or when an app for taking patient observations was introduced at another hospital (Observation 19).

An example of an app that was not fully trusted was Ignaz, since users expressed a concern that it was not fully up to date (Observations 3 and 4).

The view of the registrar who had their own note-taking app (Observation 1) summarised the importance of trustworthiness – it was the reason that they did not use the app store, because they believed that there were as many bad apps as good.

- c) Apps that are perceived as easy to use will be used in the context of a patient encounter

From the survey, perceptions of how easy an app was to use were compared between app users and non-app users using an independent samples t-test. There was a highly significant difference in the scores for users ($M=5.19.2$, $SD=1.48$) and non-users ($M=3.53$, $SD=1.95$); $t(75)=2.995$, $p = 0.004$, supporting the idea that app users were more likely to find apps easy to use than non- users. This is not a direct test of the theory in that there is no differentiation between apps that are easy to use and those that are not. However, it does provide one half of the story, because usability will be a function of what the user finds easy and what is inherently easy to do.

From the observation study, there was little or no reference to ease of use, and specifically no mention that they were difficult to use in and of themselves. This contrasts with the interview study, where ease of use came up as an important factor when choosing to use apps

The evidence for Theory 1 overall is interesting. No one part was ruled out as playing a role in the decision to use an app, with utility and ease of use coming across as very important based on the survey, and trustworthiness and utility emerging as key contextual factors from the observation data. Ease of use was not directly relatable to a specific app though, so based on that, a slight rewording of this theory is in order to reflect its non-specificity to a specific app.

Theory 1 (revised) - A user will reason (response) whether to use apps (resource), depending on whether they contain pertinent information (context), are trustworthy (context) and the user finds them easy to use

(context). The outcome will be the decision to use an app or not. Thus if a user judges apps to be trustworthy, easy to use and contain pertinent information, they will be more likely to use apps.

7.4.2.2 Theory 2 – Expertise and Confidence

Theory 2 - If a user finds an app (resource) that is otherwise trustworthy and has pertinent information (context), but difficult to use (context), if they have sufficient patience and expertise (context), they may still decide to learn to use the app (response) so that it is available to use should the specific need arise (outcome).

- d) Users with a higher degree of expertise and confidence will be able to use a wider range of apps with than users with less expertise
- e) Users with a higher degree of expertise and confidence will use apps in a wider range of situations than users with less expertise

Due to the absence of evidence for app use in the observation study, this is a difficult theory to test. However, within the survey, there were a few items that relate to this idea of confidence. An independent samples t-test was used to measure differences in comfort downloading and using apps between users and non-users. There was a highly significant difference in the scores for users ($M=5.67.2$, $SD=1.33$) and non-users ($M=3.80$, $SD=2.02$); $t(76)=4.719$, $p < 0.001$. This suggests that app users are much more comfortable downloading and using apps than non-users.

The other relevant piece of data from the survey is from the frequency of use described in section 7.4.1. There appeared to be a proportion of users who used apps daily – this ties in with there being a group of users who use a range of apps.

When it comes to assessing this theory, the lack of evidence from the observation study is a hindrance. There is some evidence that confidence is important, and that confident users use more apps, but not enough to suggest that this leads to a change in approach compared to other users. A better supported idea relates to confidence leading to increased expertise and therefore wider use of apps.

Theory 2 (revised) - If a user finds an app (resource) that is otherwise trustworthy and has pertinent information (context), but difficult to use (context), they are more likely to develop expertise(response leading to resource) in use of that app if they are confident in using apps in general (resource), so that said app is available to use should the specific need arise (outcome).

7.4.2.3 Theory 3 – Social Influences and Confidence

Theory 3 - A user will decide to use (outcome) an app (resource) when they feel the need to refer (context), and are confident that an app is the appropriate reference source (response). The appropriateness of an app will be determined by the type of information deficit (context), assessment of social acceptability (context) and the availability of other appropriate information sources. Thus users with more confidence in their medical knowledge and clinical judgement are less likely to refer generally, but more likely to refer to an app if it is they assess it to be the best source of information. Less confident users will be more likely to refer, but likely to be bound by perceptions of acceptability.

- f) Users who believe that senior colleagues approve of app use will be more likely to use an app in a given situation

From the survey data, the influence of peer and senior colleague views can be assessed. First of all, an independent samples t-test was undertaken to compare whether there was a difference in whether app users and non-users believed they were influenced by senior colleagues' views of app use within their specialty. This item was reverse coded on data entry due to the phrasing of the questionnaire item (see Appendix). There was no significant difference in the scores for users ($M=3.40$, $SD=1.94$) and non-users ($M=3.59$, $SD=1.82$); $t(77)=0.391$, $p=0.697$. This suggests that app users were no more likely than non-users to be influenced by the approval of app use by senior colleagues within their specialty.

The same test was used to see if perceptions of active encouragement of app use by colleagues were different between users and non-users. There

was a significant difference in the scores for users ($M=4.07$, $SD=1.41$) and non-users ($M=3.10$, $SD=1.74$); $t(73)=2.489$, $p = 0.015$. This suggests that app users were more likely than non-users that senior colleagues encouraged app use. These two results together appear to suggest that although senior colleagues views did not matter, app users were more likely to believe that those same colleagues encouraged app used.

The same tests were carried out regarding colleagues outside the specialty of the respondents. With regards to whether perceptions of the views of colleagues outside their specialty influenced their own use of apps, an independent samples t-test was undertaken to see if this varied between users and non-users. There was a no significant difference in the scores for users ($M=3.32$, $SD=1.91$) and non-users ($M=2.59$, $SD=1.62$); $t(76)=1.573$, $p=0.120$. This suggests that there was no difference between app users and non-users as to how affected they were by whether senior colleagues outside their specialty approved of app use or not. With regards to whether senior colleague encouragement to use apps outside their specialty varied between users and non-users, there was no significant difference in the scores for users ($M=3.82$, $SD=1.53$) and non-users ($M=3.33$, $SD=1.56$); $t(75)=1.515$, $p = 0.134$. This suggests that app users were no more likely than non-users to believe that senior colleagues outside their specialty approved of app use. Taken together, these results suggest that the attitudes of senior colleagues outside of their specialty make no difference to whether someone uses apps.

From the observation study, it was apparent that views varied as to what senior colleagues actually thought, and whether this affected participants' views on apps in general. On the one hand, the doctor observed in Observation 18 did not believe that colleagues (or patients) would mind if smartphones were used "*because everyone uses them*". Whereas some were uncomfortable using a phone in front of a consultant unless they were able to explain what they were doing because it would be hard to tell exactly what they were doing (Observation 14) or because it would look unprofessional (Observation 6). At the heart of this idea is that it is hard to

tell when a phone is being used for work purposes – from the viewer’s perspective, someone typing on their phone could be just as easily sending a text as looking up an important piece of information.

g) Users who are more confident in their medical knowledge are less likely to refer to external information sources in general

Using the survey data, an independent samples t-test was used to measure whether there was a difference between users and non-users in their need to refer to external sources of information. This item was used as a proxy for confidence in their own medical knowledge. There was a highly significant difference in the scores for users ($M=2.35$, $SD=1.61$) and non-users ($M=2.72$, $SD=1.59$); $t(79)=0.958$, $p = 0.341$. This suggests there was no difference in need to refer between users and non-users, which in this case is taken as an indication that there is no difference in confidence in medical knowledge.

From the observation study, there was little evidence either way with regards to confidence. During the observations, it was apparent that most people were more interested in finding the right answer than appearing not to know the answer. The only times that this appeared to matter is when in front of a patient, which is discussed in section 7.4.3.3.

When assessing this theory, it is apparent that there is no evidence of a link between confidence in medical knowledge and clinical judgment and immunity to influence of colleague perceptions when it comes to app use. The single most important context within this theory appears to be whether the senior colleague encourages app use. It may be that absence of information about colleague views is seemingly taken as tacit disapproval of app use – it has to be stated or seen to be believed. An appropriate reframing of this statement is purely in terms of social influence:

Theory 3 (revised)- A user will decide to use (outcome) an app (resource) when they feel the need to refer (context). Assessment of social acceptability (context) will influence their decision may influence this decision, but the absence of information of this factor is taken as

disapproval of app use. Thus users who do not believe senior colleagues approve of app use will be less likely to use an app (Outcome).

7.4.2.4 Theory 4 – Availability of Other Information

Theory 4- A user will be less likely to use (outcome) an app (resource) when they feel the need to refer (context) when other sources of information are readily available (context) and there is a sufficient opportunity to use these resources

h) A user will be less likely to use an app in a ward where other sources of information, such as colleagues or other IT, are readily available

An independent samples t-test was used to measure differences in availability of other IT on wards for between users and non-users. There was a highly significant difference in the scores for users ($M=5.67.2$, $SD=1.33$) and non-users ($M=3.45$, $SD=1.94$); $t(78)=2.283$, $p = 0.025$. This indicates that users of apps were more likely than non-users to work on wards where there were computers available.

i) Non-app users will be more likely to use other sources of information than non-app users.

An independent samples t-test was used to measure differences in preferences of other sources of information between app users and non-users. This item was reverse coded on data entry. There was a highly significant difference in the scores for users ($M=4.40$, $SD=1.57$) and non-users ($M=3.09$, $SD=1.90$); $t(78)=3.136$, $p = 0.002$. This indicates that users of apps were less likely than non-users to choose other information sources.

Given the unexpected nature of the statistical test to on proposition i), where app users were more likely to work on wards when other information sources were available, it is worth considering the data from the observation study regarding other information sources as a whole. The general trend in this population on mostly non-app users was that most people did not feel that there was a need for more information sources

when computers were available and easy to use (Observation 11,14, 8). However, the researcher observed that even on wards with lots of computers, these were often in use and there was a queue. This was potentially because the wards with more computers tended to have more staff on them. A potential explanation for the result of the statistical test on i) is that on the more “computerised” wards, the norm is to look up information for oneself, so when a computer is not available, an app is a viable alternative.

This notion has more support when one considers that the preferred source of information was often other doctors. When unsure about what to do about a patient, doctors tended to prefer to contact senior colleagues (Observations 9 and 16). As the participant in Observation 18 observed, more senior colleagues are likely to have “*seen it all before*”, with the additional benefit that they can use it as an opportunity to keep colleagues updated. One factor that influenced choice of information source was the type of information required, which is discussed in more detail in section 7.4.3.2.

When evaluating this theory, it is worth considering the fact that presence of another source of information does not mean that it is available. However, it may be indicative of what sources of information are acceptable – if a computer is acceptable, so is a phone. As such, this theory is not so much changed as augmented:

Theory 4 (revised)- A user will be less likely to use (outcome) an app (resource) when they feel the need to refer (context) when other sources of information are readily available (context) and there is a sufficient opportunity to use these resources. The type of resource available will be chosen based on the norms of the environment, so in IT-rich environments, it is more likely that a smartphone app is used (outcome) when that other IT is unavailable (resource).

7.4.3 Other Important Contexts

The observation study yielded a lot of useful information about the potential impact of other factors on app use. The main features are described in the following sections.

7.4.3.1 Awareness and Use of Medical Apps

Despite the very infrequent absence of app use directly observed by the researcher, it was apparent that all observation participants were aware of the presence and use of apps by colleagues, with many having experience of having used them during training or in previous placements.

Through discussions with participants, it was apparent that many were aware of the use of apps in medicine through their own direct experience or observation. Many of the junior doctors had used apps during their training because they had been issued with phones that had training materials provided by their home university. Many of the juniors had also used specific apps in the recent past – the BNF app was particularly widely known - but very few still used it. This was in part because they knew that it could be provided for free, and they did not want to pay for it. Other reasons for not using apps included forgetting login passwords, or just not getting around to downloading it again.

A foundation year doctor in A&E said that the hospital at which they had done their previous placement introduced an app for recording patient observations (Observation 19). All staff were given a phone with pre-loaded apps, and everyone could access it from on-site. This suggests that having the equipment as standard issue was a powerful influence – not only did people have an app in their hands, but there was clear organisational endorsement of that specific app. The participant also added that “patients initially thought staff were messing about on their phones but once knew what it was about were fine with it.”

There were numerous examples during the observations of participants describing having heard of other doctors using apps, or seen them being used by other colleagues. A quick exchange with a ward sister during the observations illustrated this:

Sister: “Bet they’re using them all the time”

Researcher: “Not really...”

Sister: “Well it depends what they’re doing”

7.4.3.2 Type of Information Needed

This characterised a recurring theme from the observations; that app use was by no means unusual, it was not seen as a negative concept, but it also was highly contingent on the type of task being undertaken. One of the registrars (Observation 15) whilst working on the renal ward had used the BNF (British National Formulary) app quite a lot the day before, but this was on a busier day than the day of observation. This appeared to be because they could not locate the BNF book quickly and they were locked out of the PC on the ward, suggesting that the app was not their first choice. This suggests that app awareness or even owning an app was insufficient on its own to prompt a decision to use it.

A consultant working with a foundation year doctor being observed, upon being told about the purpose of this research, showed the researcher an iPad with apps on that they said they used in their practice. They did not use phone apps because they *“didn’t have a good enough phone”* (Observation 18), highlighting the importance of having the right hardware, and that not everyone had this.

Although there was a general awareness of apps, not all participants were aware of specific apps (other than the BNF app). One foundation year doctor in Haematology stated that they would be in favour of apps if there were any useful ones and that *“it would be good for getting contact numbers because switchboard takes ages and that’s the only way to get numbers”*(Observation 6). Such a statement supports the idea that there are certain types of information for which an app would be considered especially apt.

With reference to Ignaz specifically, many of the participants had heard of it, but were wary of using it because of fears that it was not up to date (e.g. Observation 4), or that only part of it was up to date (Observation 3).

In terms of actual app use, this was observed on two occasions. A registrar in A & E had a note-taking app which they used to collate and organise a range of miscellaneous notes on protocols, procedures and other useful information for their own reference (Observation 1). What is interesting

about this particular app is that the doctor in question had created and organised specific information that they found useful to keep on a smartphone, thereby ensuring that the app held information that they would find useful. Furthermore, they had organised the information in such a way that they knew they would be able to retrieve it. By design, the user knew what information was held in the app and that it was useful information, reflecting the importance of the right type of information being available in an app. The information was also organised according to the user's idiosyncrasies, so one could question whether another user would find that doctor's information store as easy to use as they did. The context within this was observed was when they were showing a foundation year colleague the app and recommending that they adopt something similar so that they would have a reference source of their own. The participant did not actually use the app to find information for themselves in this instance, further demonstrating the rarity of app use for information seeking at the point of care.

7.4.3.3 Influence of Patient Views

There was a general wariness of using apps in front of patients, something that seemed almost institutional, and not restricted to this hospital. The doctor observed in Observation 1, who was an app user, recounted how a previous hospital had tried to ban the use of smartphones for fear of patient complaints. This wariness is sometimes borne of experience, as in the doctor in Observation 15 – they remembered that whilst on rotation at another hospital where nurses took down patient observations on iPhones and a few patients thought the nurses were playing on their phones. It was not uncommon for participants to share this belief that patients would not be able to tell what was being done (Observations 4, 7, 9 and 17).

Some participants took the opposite view, where because smartphones were so widespread, patients would be perfectly accepting (Observations 1 and 18), and some acknowledged that the act of explaining what one was doing would resolve any issues (Observations 16 and 17). There is, though, little doubt that fear of negative perceptions from patients was a powerful contextual factor in influencing the decision to use an app.

7.5 Discussion

7.5.1 Summary of Theory Testing

Theory A related to the properties of a given app and how they would affect decisions to use them. There was good evidence for most elements of the theory, with trustworthiness, utility and usability coming across as important. However, the evidence suggested that rather than being desirable characteristics, they were essential characteristics of an app, allowing for the generalisation of the theory to apps in general.

The lack of observation of app use *in vivo* hindered examination of Theory B, which related to user confidence and expertise in relation to app use. However, the idea that confidence drove the development of expertise rather than vice versa was more supportable with the available evidence from the survey study.

Theory C examined the link between confidence in clinical judgment and its link to social influences. However, it was apparent from the available evidence that there was insufficient evidence to support this link. There did seem to be support for the idea that in terms of social influence, implicit or explicit encouragement was required to displace the perception of apps as not acceptable.

Theory D, relating to the availability of other information sources, provided a fascinating insight under testing. The evidence helped distinguish between presence of other information sources in the form of IT, compared to actual availability. This brought to the fore the idea that a technological environment can be a helpful context for encouraging app use.

7.5.2 Key Findings

At first examination, the observations and survey appear to be in conflict. The survey appeared to suggest that app use was reasonably commonplace, but the observations did not support this. This may in part be owing to the nature of the recruitment. The surveys were dropped in

pigeonholes and handed out, and typically the researcher was not present when a participant decided to participate. Thus, it may have been slightly biased towards people that were already interested in apps. The observations were typically done on the ward, and participants had to give a direct yes/no answer to the researcher. This meant that their participation had less to do with their interest in apps, and more to do with their willingness to be followed around whilst doing their jobs. On closer inspection of the survey results, the relative rarity of app use observed was not unexpected. Although the proportion of users saying they used apps was quite high, the frequency of use was not. Additionally, the survey did not explicitly ask about use in front of patients, and educational apps were among the most popular.

There were larger differences between users and non-users in terms of attitudes rather than between specialisms or career stages. People were either aware of apps or they were not. As with the interview study, there was agreement with the general principle that apps can be useful, but the level of awareness of specific apps was low – a point borne out by the observation study. Registrars were more likely to use an app than other groups. Combined with the similarity of attitudes towards apps between groups, this suggests that registrars were more immune to the influence of other contextual factors. A potential explanation for this is that they were likely to be engaged in mobile phone use than older colleagues, but that they had more confidence in their judgment than their less experienced colleagues. Evidence for this was not borne out in the observation study, mostly owing to the relatively few occurrences of app use in total.

It appeared from the observation study that it simply did not occur to most participants to go to an app as a point of reference while at the point of care. The immediate context had limited effect in stimulating app use, with people relying on tried and trusted forms of reference. Users preferred using sources they knew, whether it was consultants/more experienced colleagues, or hospital and trust information systems. A pertinent point is that much of the information being sought was specific to the patient, or based primarily on the patient's information.

The majority of apps that people knew about did not contain pertinent knowledge, at least not in a quickly accessible way. Many of the points of information that were sought pertained to a specific patient – this was particularly true at times when individuals were looking through patient notes, or at a computer in general – and they typically sought specific results and patient histories. The study also raised the importance of awareness of apps, the specific information required, and the influence of perceived patient attitudes.

This final study enabled the creation of a theoretical framework, which is described in the final chapter of this thesis. Discussion of limitations, implications for future research and practice are described in that same chapter.

7.5.3 Strengths and Limitations

The survey study and the observations were designed to complement each other; the observations provided depth whilst collecting objective data on actual app use, whilst the survey provided breadth, but relied on self-reported data. Both collected outcome data, but the survey suffered from the clear limitation that outcomes were self-reported, and that the survey sample itself was relatively self-selecting – staff that filled in the survey were skewed towards those that did use apps and the data did suggest that these people were over-represented in the sample.

Another potential limitation of the survey was the relatively small sample size – although the response rate was not low, it was not high enough to perform multi-variate analyses. In combination with the decision to keep contextual elements separate within the survey separate, this meant that the testing of theories that combined several contextual elements was not as rigorous as would have been possible with a larger sample size. That being said, the general trends within the survey data largely supported the data collected from the observations.

The observation data itself provided some snippets of insight, but the quantitative analysis of information-seeking events was far more useful than the qualitative data. What qualitative data was there yielded some snippets of information, but the thematic analysis was superseded by the

quantitative analysis. It did provide some snippets of insight that reinforced much of what was surfaced during the interview study, and actually provided the best evidence regarding real app use.

The low prevalence of app use observed and the similarity of factors that seemed influence the decision to use an app across participants in different contexts was quite striking, suggesting that more observations in this specific Trust would probably have yielded similar patterns.

7.6 Conclusion

This study addressed overall aims of the thesis reasonably successfully. In terms of identifying patterns of app use, it appears that these patterns are mostly at the level of the individual, in terms of confidence and propensity to use apps. However, there are contextual factors that appear to play a role, which addresses the two other questions, relating to the important contextual elements and the interactions between them. The nature of availability of information sources within particular settings is important, with a seemingly technological bent being conducive to app use. In terms of user confidence, there is a fine balance between confidence to seek information in the way that is most effective and the need to refer to information, which appear to be largely at an individual level, although most likely found whilst a doctor at the career stage of registrar. In general, the study confirmed the idea of a core mechanism, and illustrated how different contextual elements influence each other and the core mechanism.

Chapter 8 - General Discussion

This thesis aimed to understand more about app use by doctors, A scoping review of the literature was undertaken and concluded that the existing knowledge base was not strong, with specific gaps around understanding the extent to which apps were used in real-life settings, the effects of such use and what factors had an influence on app use. Following the elicitation of theory from relevant grey literature, an interview study was undertaken which suggested that the original plan of a realist evaluation of the Ignaz app would not be feasible. However, the decision was taken to continue using a realist approach and adapt it to the more general purpose of investigating the realist system involved in app use, the main difference being that the thesis refocused on the decision to use apps as the outcome of interest, rather than looking at the impact of such use. This change in focus resulted in a much more fruitful investigation. The final empirical study used a mixed-methods approach to gather data that could be used to test theories that would shed light on the research aims.

This discussion chapter begins by with an assessment of how successful the thesis was in achieving its goals. It then goes on to describe the key findings, framing these in terms of a theoretical model of app use in secondary healthcare. The discussion then moves on to the theoretical and practical implications of the findings, Strengths and limitations of the approach are discussed, and the thesis concludes with a set of recommendations for the implementation and use of apps in secondary healthcare.

8.1 Thesis Aims and Objectives

The thesis was successful in addressing its aims, undoubtedly benefiting from the decision to focus on a single outcome of app use rather than trying to investigate multiple more distal outcomes.

- 1) Discover to what extent apps are used by doctors in live settings, and identify patterns of use related to users across different contexts.

Chapter 7 showed that most doctors are aware that apps are used by many people, and that they are now part of the medical landscape. However, it also showed that their use is relatively limited, particularly in front of patients. It seems that there is a significant minority of doctors who are more likely to use apps, who are confident in their use, and that use them when they deem it appropriate as opposed to their main source of information. The research was only undertaken within a single trust within which the culture and practice did not seem particularly “app friendly”. As such, it should not be taken as representative of healthcare across the United Kingdom, particularly given that the research was conducted in the mid-2010’s in a fast-moving area. However, the fact that the research was conducted in a large hospital should be granted some weight.

2) Identify which types of apps are used most extensively

The survey study in Chapter 7 established that research sources, log books, clinical decision tools and text books were the most used sources. Most of these have the purposes of providing information to the user. The utility of these apps was not established during this thesis.

3) Identify the key causal mechanisms that lead to app use

The core mechanism is essentially the result of a reasoning process by which a doctor assesses whether an app is the right source of information for the situation. There are multiple contextual factors that influence this outcome.

4) Identify relevant contextual elements and how they:

- a) Influence the firing of key mechanisms identified
- b) Influence the response of users when those mechanisms are fired

Taken together, these were the aims that examined what contexts were relevant. This thesis has examined and outlined a number of contextual elements that influence the use of apps, and these are outlined in the proposed theoretical model.

5) Use the information gathered on contexts, mechanisms and outcomes to generate better theory relating to the use of apps by doctors, and apply this learning to generate guidance for the design, implementation and use of apps by doctors.

Based on the findings of the empirical work, this thesis makes a number of recommendations to that will aid the design, implementation and use of apps by doctors further on in this discussion.

8.2. Key Findings

The scoping study, although working with a relatively small body of literature was useful in setting the agenda for this research. It was useful for identifying gaps in the research regarding neglected methods, small number of in vivo studies, and the relatively light touch of theory. It also did provide some evidence of the efficacy of apps in specific situations for specific purposes.

The interview study was useful in establishing the general workings of the core mechanism, which relied on the simple idea of a reasoning process in the mind of the user. It also identified important contextual elements, such as the influence of colleagues and patients and immediate situation.

The final empirical study identified usage patterns and was a good test of the relevant theories. It came up with some surprising ideas, such as nuances relating to the availability of other information sources, and confirmed some other elements of theory relating to the role of awareness and individual confidence in app use.

8.3 Theoretical Framework

The study overall, through the testing of the theories in Chapter 7, enabled the creation of a theoretical framework for app use in secondary healthcare. Having framed the thesis around the idea that the core mechanism at work is the decision of the doctor to use an app or not in a given situation, the thesis succeeded in elucidating many of the contextual elements that affect

that decision. What is apparent is that different factors operate at different points in the causal chain.

The start of the chain is the availability of apps that fulfil a need. This would require an investment of time by developers in analysing the market and understanding what clinicians need. For this investment of time to be worth it for developers, they need to be sufficiently confident that there is an appetite for more apps. Once the app is available, then a doctor needs to be aware of the app and its utility. The contextual elements at this point are those that affect awareness. On an individual level, this would require active scanning of relevant publications and marketplaces, which current app enthusiasts are more likely to do. At a wider level, this would require raising the profile of their offering, which would likely involve active marketing of an app to healthcare providers and professional bodies who would need to be convinced of the benefit of an app. In this way, the contextual elements are partially dictated by the current contextual situation: until benefits of app use to an organisation or individual are demonstrated, the development and raising of awareness are likely to be more difficult.

At the point at which a doctor is deciding whether to download an app(s), they need to have decided whether this will be a useful part of their toolkit. At this point in the chain, their views will be shaped by the culture of where they work, which is largely set by senior colleagues, but also by the technological stance of the hospital; where the use of information technology is seen as more usual, the likelihood of a user seeking out apps is higher. The individual-level context in this instance is the user attitude towards apps – those that are already convinced of the benefit of app use to them personally are more likely to try an app they are unfamiliar with because of their confidence in apps and in their capacity to use them. At this stage, the practicalities of whether an app is affordable to the user comes into play – they will make a cost-benefit calculation based on their own specific circumstance. It is worth noting that if someone believes that they could get something for free, or has done in the past, they are less willing to pay for it.

The next stage of the implementation chain is largely a practical one, and relates to the ability of the doctor to have their phone with them. Contexts such as acceptability of carrying a smartphone around the hospital environment will affect this, but also seemingly trivial practicalities of having pockets in which to keep a phone will also be a factor.

The final stage of the chain is the decision to use an app in a particular situation. The key contexts in this instance are the type of information required, and the perceived acceptability of using an app in that situation. If the information can be obtained via an app more easily or conveniently than other sources, than it is more likely to be used – this is a combination of the utility and usability of the app, which maps onto Davis's TAM (1989). Acceptability is more a function of the situational context, and such a conception is more in line with system's theories such as Socio-Technical Theory (Clegg, 2000). Elements of the process by which the acceptability is changed are akin to the processes described in NPT(May & Finch, 2009).

By conceptualising the processes involved in app use in this way, one can draw out the key contextual factors and where they act. Key at the start of the process is Awareness of app(s) and ultimately impacts on the availability of the resource in the core mechanism. From the decision to download onwards, confidence in one's ability to effectively use app(s) is critical, and will affect the both the reasoning element of the core mechanism. At the final stage, perceived usability and acceptability are critical, but contingent on the specific situation, all of which act on the reasoning element of the core mechanisms. Each of these contexts are changeable and dynamic over time.

8.4 Strengths and Limitations of the Thesis

The thesis changed from an evaluation to investigation ostensibly because it was apparent that Ignaz was not used widely enough to be able to evaluate the effects of its use. However, the seeds of this change were sown much earlier on the research and this change in emphasis turned out

to be a strength of this thesis, as this breadth of focus meant that the questions being asked were more broadly applicable to apps as a whole, and allowed the investigation of different contextual factors. The change in emphasis actually enabled the thesis to better address the research questions. However, trying to investigate so many contextual factors limited the extent to which the impact of any individual contextual factor could be explored in depth. A theoretical framework was created based on empirical evidence, but the range of contexts combined with limited evidence of app use means that further testing and refinement of this framework is desirable.

Realist evaluation (and by implication, any study using realist methods) is labour and data intensive (Pawson & Tilley, 1997), making it challenging for a lone researcher to complete a thorough investigation particularly as “typical” evaluation will be conducted by a team of researchers. Whilst the methodology was adapted to compensate for this lower level of resource, the nature of the questions faced meant that less data were gathered than might be possible with a team of researchers, and this lessens the strength of the findings. Despite this, the thesis suffers less from a paucity of data than it might due to the broad nature of the questions addressed and range of methods used – the breadth of data gathered was enough to address the research questions

The purpose of the interview study was to develop and refine some pre-existing ideas rather than test them out. As such, a theoretically purposive sample was used to try and maximise the probability that a user would have experience of apps in some way. While the small number of interviews could be considered a limitation of this study, after nine interviews, it was apparent that similar explanations were coming from most of the participants, so that saturation had been reached. This implies that, for the purposes of that stage of the thesis, it was sufficiently large to develop the theories under investigation.

The research design of the final empirical study was also not perfect – cross-sectional surveys and observations are less than ideal for understanding and interpreting causal relationships because they are

snapshots in time. Time constraints and pragmatic considerations did influence this design, but it must be acknowledged that this weakens the inferential power of the study. However, the employment of realist methods did allow for causal inference when addressing the research questions.

A strength and limitation of the study was the decision to collect data at a single hospital site. This potentially limits the generalisability of the findings, a critique that is often aimed at qualitative research by those of a more quantitative or positivist bent. Counter to this is the limitation of variation in the setting – keeping some element of context constant allowed one to better observe the differences between individuals and groups in the same setting.

The analytic approach used also addresses this transferability issue through conceptualisation of contextual elements that, whilst intrinsic and specific to specific settings, are abstracted to a level where their influence can be understood across settings. Rather than trying to find exact matches of contexts across settings for replication, one can identify the relevant elements within different settings and see if theoretical predictions arising from these combinations of contexts hold true. Indeed, the analysis itself demonstrates that by understanding how specific contextual elements affect each other, one can begin to make predictions about what might occur in a variety of settings – this in itself is a real strength of realist approach to research (Pawson, 2013).

The aim was to refine and develop theory, and at most, was intended to find which ideas “hold water” and tally with real world experience of users. So whilst the study can’ not be said to have offered unequivocal results regarding app use, this was not the point of the thesis - the study achieved this objective and succeeded in providing considerable evidence for the involvement of numerous contextual factors in a doctor’s decision to use an app. .

8.5 Areas for future research

This thesis was successful in outlining the importance of specific contextual elements, more so in outlining a framework within which these contextual

elements could be tested. Many of the apparent limitations of the current research in themselves suggest potentially fruitful avenues for further research. Realist investigations should be undertaken within a wider range of settings, particularly those in which contextual elements are more varied. Based on this study, it would certainly be expected that hospitals with a higher investment in IT, in more modern buildings, would be more likely to have higher incidence of app use.

Smaller scale, focused evaluations of specific apps would yield useful outcomes in terms of testing elements of the putative theoretical framework put forward in this thesis. It is not necessary to test the whole framework, but larger data sets focused on specific elements would be useful validation exercises. By cumulating evidence in this way (Pawson & Tilley, 1997), the framework could be refined and become more useful in a practical sense. Ideally, such evaluations would also assess outcomes, so that practical information could be generated that can influence decisions on when and where apps may prove to be useful in medical practice.

There is still a pressing need to evaluate *in vivo* use of apps. Until more users are convinced of the potential utility of apps, it is difficult to see how their adoption will become more widespread within a community where so much practice is evidence-based.. The incorporation of qualitative as well as quantitative data in such case studies will allow further testing of mechanisms put forward by this thesis that explain why particular outcomes occur (Keen & Packwood, 1995)

8.6 Practical Recommendations

8.6.1 Potential uses of apps in secondary healthcare

Although this study was primarily concerned with the factors affecting the use of apps and how this knowledge could be employed, the observations gave the researcher the opportunity to see how apps could be of benefit to clinicians

Given that most of the information-seeking behaviour observed was pertaining to patient data, making patient data accessible via mobile apps

would probably have a significant effect on whether people used them, and based on the observations, would potentially save a great deal of time. Time was lost waiting for availability of desktop PCs, colleagues and also just looking for patient notes.

At the present time, it appears that specific mobile apps may be useful in specific circumstances, rather than as a catch-all portable information source that can fulfil all the informational needs at point of care.

Doubtless, as technology develops further, they will be refined and eventually outstripped by emerging technologies. The key for such technologies is to focus on what specific purposes they can fulfil and then concentrate on fulfilling these purposes in a way that is sufficiently trustworthy, effortless and unobtrusive so as not to interfere with the doctor's relationship with their patient. In this way, app use – and future forms technological support for doctors – could eventually become normalised. Developers should also develop apps specifically for use in particular situations, rather than digitising existing knowledge repositories. Emphasis should be placed on simple search functions, speed of operation and reliability and stability of function rather than multiplicity of features – focusing on using the assets of phones as additional, portable information sources that can deal with specific types of information deficits rather than trying to fully match the functionality of a computer.

8.6.2 Raising Awareness of Apps

It is the belief of this researcher that apps could be a useful addition to the doctor's toolkit, as an additional source of information that could be used in specific circumstances. If one did want to increase the usage of apps by doctors, awareness of what apps might be useful is a priority. Given that one of the biggest single factors that seems to inhibit app use is a lack of knowledge of trustworthy apps, NHS Trusts could raise awareness amongst their employees of apps they know to be safe and reliable sources of information. Based on this interview study alone, a number of steps could be taken to encourage the use of apps by doctors. NHS Trusts could raise awareness amongst their employees of apps they know to be safe and reliable sources of information. These could include measures such as

posting notices in hospital buildings advertising “good” apps, briefings to staff members in team and ward meetings, as well as including them in resources provided to new employees as part of induction. Email could be used to send links to appropriate apps, but as the interviews demonstrated, these should only be used in combination with other modes of communication, as otherwise they are likely to be ignored. For an app such as Ignaz, use of launch events would be particularly appropriate as such apps are endorsed by a given Trust if they have taken the decision to be involved.

Royal colleges could also play a part by reviewing particular apps for a given specialty through their publications and other communications with members. could be taken by employers. For instance, issuing smartphones pre-loaded with appropriate apps to employees would show explicit endorsement of their use. Such devices could be “locked down” or restricted to limit personal use. This would not only ameliorate practical issues of knowing what apps to use and having hardware to use them on, but would also indicate the Trust policy on app use, which is currently either unclear or poorly communicated. Clarification and communication of Trust policy in this regard is essential.

8.6.3 Increasing Acceptability of Apps

At the time at which the research was undertaken, app use appeared to be at the stage where, for the majority of users, it needed to be clearly acceptable. The use of apps is still a relatively novel practice, and as such is something requires signalling as acceptable practice. This would give colleagues a clearer indication of whether app use is acceptable, and under what circumstances. Putting notices on wards to notify patients that use of phones by doctors is part of medical practice would also go some way to communicating why smartphones are in use on the ward, and also help less confident colleagues to feel less inhibited in using such resources. Doctors should be encouraged to explain to patients why they are using their phone to ensure that the patient-doctor interaction is not unnecessarily disrupted.

Such steps would be warranted for a small number of apps initially, specifically those that have demonstrable utility, such as the BNF, approved protocols and other similar apps. There should be a route put in place, whereby doctors can recommend apps to be put on a list of approved apps – given the lack of accreditation available for apps, this should require a review board to assess them. This could in practice be a small group of doctors who pilot the app's use in their own practice for a fixed period of time and then approve or reject the application.

It was noteworthy that there were very specific instances in which app use was deemed suitable; the situational requirements were such that the information had to be objective, available and digestible quickly. And to use an app, the app needs to be the preferred source compared to the multiple other sources of data. Trusts and developers could work together develop apps specifically for use in particular situations, rather than digitising existing knowledge repositories. Emphasis should be placed on simple search functions, speed of operation and reliability and stability of function rather than multiplicity of features – focusing on using the assets of phones as additional, portable information sources that can deal with specific types of information deficits rather than trying to fully match the functionality of a computer.

These could include measures such as posting notices in hospital buildings advertising “good” apps, briefings to staff members in team and ward meetings, as well as including them in resources provided to new employees as part of induction. Email could be used to send links to appropriate apps, but as the interviews demonstrated, these should only be used in combination with other modes of communication, as otherwise they are likely to be ignored. For an app such as Ignaz, use of launch events would be particularly appropriate as such apps are endorsed by a given Trust if they have taken the decision to be involved. Professional bodies could also play a part by reviewing particular apps for a given specialty through their publications and other communications with members.

In addition, the publication and dissemination of more research that can provide evidence of the utility of apps would be a powerful tool in promoting

their use, particularly with to a population who base much of their practise on research-based evidence.

8.7 Contribution of this thesis

This thesis contributed in two important ways. With regards to app use, it identified a framework through which the impact of different contextual elements could be linked to specific steps of the implementation chain. The use of an implementation chain in conjunction with these contextual elements has the potential to be a powerful approach, particularly in areas where there is little substantive research and there is a need to build a theoretical framework within which meaningful empirical work can take place. The research's employment of a theory-based approach in app research is relatively novel, and gives a basis for the transferability of findings across different situations. This approach may lend itself particularly well in areas of emerging or technological innovation.

However, the main contribution of this thesis has been methodological. Previously, the conception of Realism put forward by Pawson and Tilley (1997) had been applied to the synthesis of literature (Pawson, 2006) and the evaluation of programmes and interventions. This thesis has used Realism as an investigative framework into the phenomenon of app use by doctors. This has been done by focusing enquiry on the Realist system that influences the voluntary use of apps by doctors rather than examining the programmes and activities leading to the introduction of apps into the healthcare system.. The research successfully operationalised the theoretical concepts involved in realist evaluation into a different context, and suggests that realist investigation should be considered as a worthy addition to the realist armoury.

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Appendix 1 – Scoping Study Data Collection Template - Headings

Title and Author

Brief description of study aims

Brief description of app

Methods/Type of study

Study population and design

Study Setting

Brief description of findings

Use of theory/influencing factors

Study type

Formal theory

Context

Appendix 2 – Interview Study Materials

Appendix 2.1 Interview Topic Schedule

Interview Topic Schedule

Summary of method

Interviews will be semi-structured and follow the format of a realist interview. That is, rather than a conventional interview where the researcher asks questions to gather data from the subjects and keeps their own theories “hidden”, the aim is to co-create data. The researcher “teaches” the subject their theory or theories, and the subject then gives their view of that theory with reference to their own experience. This “teacher-learner cycle” therefore creates a situation where the researcher’s initial theory can be explicitly refined, falsified, validated or supplemented by the participant. The interviewer attempts to formalise the interviewee’s theories based on the new information, and the interviewee then comments on the theories to confirm or correct the interviewer’s rephrasing. As such, the participant helps the interviewer to revise and develop their theory. These revised theories are then taken into subsequent interviews for further refinement. See Nanninga and Glebbeek (2011) for an example of how this technique has been employed.

Interview process and questions

1. Explain nature of study (in conjunction with information sheet where not already provided):
 - The present study is concerned with the use of particular types of Mobile Smartphone Applications in healthcare settings. Interviews will be undertaken with both users and designers of the type of app (as well as implementation managers) in question in order to maximize the range of perspectives used to refine the candidate theories. The designers and implementation managers themselves are medical doctors and as such may be able to offer insight from their own practice. The candidate theories themselves have been developed on the back of a review of relevant literature.
2. Obtain written consent using consent form (where not obtained previously)
3. Pass the theory summary sheet to the interview and explain overall nature of the interview:
 - The interview may differ in form from previous interviews that participants have been involved in
 - The main difference is in the way that the questions are asked, and in the role that the participant plays. The questions will be in the form of theories (ideas) that the researcher describes and the participant comments on, using their own experience to refine or modify. The researcher will then “play

back” the modified theory (idea) and use probes to further refine the participant’s understanding.

- The theories will include elements of contexts, mechanisms and outcomes. The contexts refer to the situation or environment (both physical and social) in which the phenomenon of interest occurs. Mechanisms refer to the causal chain through which that phenomenon occurs, with the outcomes referring primarily to the consequences of said mechanism being triggered.
- An example would be a match lighting gunpowder. The context might be the environmental conditions (atmospheric humidity, for instance). The mechanism would be the chemical reaction that would cause the match to light the gunpowder, and the outcome would be the gunpowder igniting or not. So the mechanism would only be triggered under right contextual conditions.

First the interviewer will ask some general questions about the interviewee’s role and their experience of Mobile Smartphone Applications (from this point, they will be referred to as Apps), specifically those that are used as reference tools during patient care. The discussion will then move on to discussion of the relevant theory. The specific questions may vary depending on the role (user, developer or both)

4. Initial questions:

- a. What is your role
- b. (If a practitioner) - Have you ever used an App as part of your practice?
- c. (If a programme designer) – How do you intend your app to be used as part of practice?

5. Main Interview Questions

Effect of App use on effectiveness through provision of information at point of care

The logic behind the introduction of new technology such as MSAs is *often to improve your ability to do your job by providing you with the information you need at point of care*. Does this tally with your experience?

- Probes
 - o If yes, could you give me an example of this?
 - o What would you have done if you hadn’t had the MSA available?
 - o How dependent is this on the availability of other information sources?
 - o If no, how do you get the information you need when you don’t know the answer?
 - o What makes these other options more attractive?

Benefits of App Use

There are a number of theoretical benefits related to app use. One of the main ones is that apps lead to *increased efficiency due to the availability of information*. Does this ring true at all?

- Probes

- If yes, can you give me an example of this?
- Has it made a difference to your overall effectiveness?
- Have there been any knock-on effects of this?
- Do other colleagues feel the same way?

Another benefit that has been put forward is *increased compliance with recommended procedures (due to availability of protocols)*. Are there any examples you have from your own experience that fit with this idea?

- Probes

- Are there other sources of information that you prefer to use to ensure that you are compliant?
- How trustworthy is the information you get from the app?

There is some literature that suggests that apps can help users to undertake their role more effectively, leading to improved feelings of wellbeing. Does this tally with your experience?

- Probes

- If yes, can you give me an example of this?
- Does this hold true for other pieces of equipment or kit that you use as well?
- Does using the app make you feel more or less competent in your role, or is that something you don't really see as having an influence?

Influence of other people's views

Some of the theories on the introduction of technology, such as MSAs, talks about the impact of what other people think or do. Some theories talk about other people's attitudes in terms of their acceptance of technology, as influencing other users. *For instance, if senior colleagues have negative views of an app, it might reduce your intention to use the app, or even stop you using it altogether.* Is this something that fits with your experience?

- Probes

- How did your colleague express their approval or disapproval?
- Did they actively condone or prohibit the use of the app?
- What consequences did you anticipate if you went against what your senior colleague thought?
- Are certain individuals, or types of individuals, more influential than others?
- If no, what does influence your decision to use an MSA in a particular situation?
- Do you change the way you use the app when different people are present?
- Does the positive perception of an app by colleagues make you more likely to use it?

Another suggestion is that patients might not view use of an app favourably, so doctors are more reluctant to use the app in front of them. Do patient views influence your use of apps?

- Probes
 - o Can you give me an example of this?
 - o Why do you think [they] have that view?
 - o How does [their] view influences yours?

Ease of use of apps

Much theory emphasizes the importance of the usability of technology. By usability, I'm referring generally to how easy it is to get the information you need out of the app. *So if an app is harder to use, this will make the app less likely to be used.* Does this fit with your experience?

- Probes
 - o Can you give me an example when it was difficult to use the app in a particular situation?
 - o How did this affect your ability to take care of the patient?
 - o Are there any steps you take to improve the usability of an app, i.e. do you practice using it outside of a live environment?
 - o Are there particular things that make it difficult to use an app?

Roll out Strategy and awareness of apps

It could be argued that the way that a technology is rolled out to different users has an effect on whether they use it or not. *For instance, receiving an email from the IT department saying you could use an app may be less effective than someone coming in to show you how to use an app.* Is this something that you have experience of?

- Probes
 - o How do you think the way you found out about the app affected the way you used it?
 - o Why did you decide to roll out the app in that way (for those involved in app development and rollout)
 - o What effect do you think this had on download rates and app usage? (for those involved in app development and usage)

Role of specific settings

Some theories suggest that the way you go about your tasks will change depending on your workload. *In these cases, it may be more convenient to use different methods of finding information depending on how busy the ward is, such as ward computers or asking colleagues.* Do you find that how busy the work environment is has an effect on the way you search out information?

- Probes
 - o If yes, can you give me an example of this?
 - o What were the reasons for your choice of information source?
 - o Do you find that you check information less at busy times?

6. Is there anything regarding your use of apps that we haven't covered? In particular, are there any other factors that affect your decision to use them or how you use them?

7. Thank the interviewee for their time, and leave contact details for any subsequent queries:
Email: psdj@leeds.ac.uk
Telephone: 07968 443189

References

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Appendix 2.2. Example Interview Transcript

M: Have you used apps in your own practice in the past?

I: Yes

M: What kind of thing?

I: If this counts, the medical school app to help us do assessments. We used those in fourth and fifth year. I've had the BNF on my phone before, and I've had um the Oxford Handbook on my phone.

M: Ok

I: They're the ones I've used over the years.

M: How about whilst you've been a foundation year.

I: Erm, BNF app, and I use other peoples as such. If other people have the apps, I'll...I don't actually have a lot on my phone. I'm generally not very good with apps in general, I don't have a great variety of apps, but I know when I do my anaesthetics placement for example, lots of anaesthetists have apps, so I'd use theirs, and see what they...work out drug doses, yeah, things like that.

M: Ok, so coming onto more theory type questions now. One of the main sort of arguments for the use of new technology like apps is to improve your ability to do your job, by providing you with the information you need to do your job by providing you with the information you need at the point of care. Does this tally with your experience?

I: Yes.

M: Yeah? Can you give me an example?

I: Um, look at the dose of something? [yeah]. There, you know it's there and then you can check. Um, clarify contraindication on a drug, clarify the usage of a drug, clarify, uh presenting complaints of a condition. It's a good recap.

M: Sorry?

I: It's a good recap.

M: It's a good recap, ok. Would you ever tend to use it for um brand new information, or would it be for checking stuff that you already knew?

I: I think generally it tends to be checking, I'd say, but then again if there's some rare condition that you've never heard about, then yeah, it would be new information really.

M: Ok, so in terms of other benefits, I mean, one of the things that it improves, is that it makes things faster. Is that something actually that does hold true for you, or is that not always the case.

I: Oh yeah definitely. You've got your phone in your pocket, you've not books around you, so yeah.

M: Ok so if you didn't have the phone, what other sources of information would you be using?

I: Internet, on google, um on my phone or on a computer, asking colleagues, trying to find a book, um Oxford handbooks, probably, but in practice you just don't have time to.

M: Um, so what do you do on those situations where...

I: I used to carry around a book, an oxford handbook when I started, and since I can't even manage to keep a water bottle with me, there's no chance I could keep a book with me, so...

M: Yeah? So, what do you do when you haven't got that information available to you then, either because you don't have the app on your phone or...what course of action do you end up having to take?

I: Um, go and ask somebody. Go get someone senior, go it from a senior or google.

M: Yeah? Would google normally be through the ward computer.

I: Probably on my phone, if I could [yeah] yeah.

M: Ok, one of the issues actually that got mentioned by someone, is that they don't have pockets, so they don't actually have anyway to...

I: It is bad. For a female, yeah definitely, hence I've got this skirt, it's got a pocket, it is hard. When you've got scrubs, I wear trousers a lot for that reason. Consultants like have a band to carry a phone in, which I'd love to have, but I think it looks a bit pretentious for an F1 to have band with a phone in, that's the only thing [laughs]

[interview paused]

M: Unpause. Some general chat...

M: So, um one of the other things, with overall effectiveness is that having the app is quicker...

I: Yeah

M: Yeah? Is that...

I: Definitely

M: What about in terms of improving your accuracy of the information...

I: Yeah.

M: Have you got an example?

I: Umm, I can use the BNF as well, you know what the BNF is, don't you? Yeah, I can use that example again. Ummmm, medicines, I know anaesthetists use it to check doses of things sometimes. So that's just an extra double check. Um....

M: Have you ever had a situation where you were pretty sure what the answer was, and if you'd had your phone with you, you would have checked it, but you didn't have your phone with you.

I: If I'm I'm ever not sure, if there's ever any doubt, depends what it is, if it's a prescription, I'd always double check. There's certain things, depending on the situation, that I'd always...if there's any element of doubt I'd always get checked
5:50.

M: Ok, cos, following on from that, where, where there's doubt, you would check yeah? So um, one of the knock on, knock on effects has been suggested, that if you're doing things quicker and you're more accurate, your overall sort of wellbeing is better as well, so you're anxious and that kind of thing. Does that hold true, or is that just overstressing things slightly?

I: I think there's lots of other things that make me anxious. But um, yeah I suppose if I knew how to use the things...knew how to use the apps, I think that's a barrier for me, I don't know how to access the best ones, I forget my password when I put it into iTunes and then I kind of give up. I think that's a big barrier for me.

M: Oh right ok

I: But I suppose if I knew, if I knew...a lot of ... if I had a lot of apps on my phone, then yeah, I suppose it does, it does make your life easier. Probably a bit of a stretch to say it makes you less anxious, but yeah, anything that makes on calls easier is better.

M: Why did you mention on calls specifically?

I: Just because your so busy.

[brief pause]

M:Um,so it's a bit of a stretch make you less anxious, but it would be handy to have maybe.

I: Yeah, definitely

M: Um...

I: I mentioned on calls because on calls are so busy. Like on a day, you're busy, you've got jobs constantly, but when you're on call, you're just horrendously busy. You're so busy, you don't have time to do anything. You've got to be in ten places at once.

M: Right, ok, so, um...one of the things that's been put forward about apps, and one of the advantages is that when it's busy, they're really good to have and to refer to. Does that hold true?

I: Yeah, I'd agree.

M: And they're particularly useful in that sort of situation.

I: Yeah.

M: When you've got more time to look something up, if that ever happens, do you have preferred information sources that you use other than apps or your phone?

I: I think, errrr...yeah, if I've got more time, I'd use the BNF on the computer, just because I find it easier to use. I'm sure that if I used the phone more, that would then become a lot easier to use. I know a lot of students use the phone a lot more than I do, me personally, I need more practise.

M: Ok. So, coming back to the usability thing. So, usability is...it's been put forward as quite a big barrier to...not just by you, now, but generally, it's like, if something's hard to use people don't use it. Or is it a case of, something is very useful, but it's hard to use, so...I'm going to figure out how to use it, or find a workaround or something. Which better describes it.

I: Um, I think...I know there will be a point where I use it more often, I'd just manage to find my way around it, I suppose.

M: Yeah?

I: Yeah. I think I...it could help me a lot more, but then there are just so many things I've got to do, right now [laughing]. Maybe that's one of the things I've got to uh, sort out.

M: Ok. So one of the things...there are a number of things that have been put forward as influencing um...the type of...whether you would use an app or not. We've talked about like the busyness type thing, and usability. What about the particular type of specialty you're in, would that make a difference.

I: Definitely, yeah.

M: In what way?

I: Well surgeons, um, don't really use apps, they do very quick ward rounds and spend the time in theatre, so they wouldn't really look at apps um...if there was

some apps, which I'm sure there are, which would help to search for evidence based literature, then they'd probably use that, that would be a useful app for them. Whereas medics spend a lot more time on the ward, dealing with conditions, dealing with drugs, so they'd use it more for those reasons.

M: Right, ok. Excellent.

I: But anaesthetists, like I said before, doses, drug doses.

M: They keep coming up!

I: Yeah, they do. Cos if you talk, talk to an anaesthetist, they have loads of apps on their phone, if you found one of the anaesthetists.

M: Yeah, what to do with?

I: To do with um...cos they do with um...cos they do, like, children, loads of different calculations for child doses of different drugs, anaesthetic drugs, everything's really different depending on your weight, your height, erm...different issues like that, it's just about checking.

M: Um, in terms of other types of influence on whether you use them or not, one things that's come up a bit more often is the idea of other people's influence. So for instance, if a senior colleague's view of apps is either positive or negative, that would have an influence [yeah definitely, definitely]. Have you got any examples?

I: Ummm, my colleague [name], he uses his phone quite a lot, and I see him using it and I think 'ah, I could use mine more'.

M: Have you ever had the inverse? Where you've been told to put your phone away, or have you ever seen it happen to anyone else?

I: Well, um, sometimes patients don't know what you're doing with your phone, so there is a bit of err 'he's talking...she's talking to me but she's looking on her phone, it doesn't seem like you're very engaging with the patient does it so...

M: Is that your perception, or something that was pointed out to you, or has a patient actually...

I: That's my perception

M: Have you ever seen a situation where a patient's actually shown either discomfort or um, made it known that they're not happy in some way...

I: No, I don't think so, not that I can point out, no.

M: Have you um, ever had a situation where a colleague's done that, sort of pointed out that you're on the phone, or that you shouldn't be on the phone.

I: Uh, as a student, [yeah?], um been bollocked a couple of times by um, teachers for you know, having some ward-based teaching, 'you're on your phone' and then

yeah, I remember making a remark once, yes

M: Were you actually doing work, or were you just...

I: It was my friend, that...they were actually checking something

M: Work-related?

I: Yeah

M: Did they try and explain it or did the teacher just...

I: No, don't think so.

M: It was just 'put your phone away'...

I: Yeah.

M: Ok, so um...are certain individuals more influential than others in your choice as to whether you've got your phone out? Is it more...are patients more important than colleagues, is it senior colleagues, is it peers? Would they make more of a difference?

I: I think it just depends on the job that you're doing, more than anything.

M: In what way?

I: So, like I was saying basically, on here, um, not many people use their phone's, so that would get you out of the habit maybe. When I do my anaesthetics placement, lots of people use them. So yeah I suppose you are influenced

M: Right so um, are there certain situations where you would be more or less likely to use them...

I: Yeah, and I think generally... I suppose that's not really massively the case...to a certain degree.

M: Right, we talked about...of the apps that you do use, how did you get on to using them.

I: Through medical school. Cos they gave us iphones in the 4th year. So they put on their website some suggestions, and they gave us um, oxford handbook for free as an app so you could download it, and instructions on how to download it, so just an idiot proof guide on how to put it on your phone, so I did that. And then, I think the same with BNF, um, but I lost my own phone after that and then didn't re-put that one back. You got a license for some of them like the um, oxford handbook one, you've got to pay for a license for that so....

M: Do you actually have any apps now, or is it only the BNF one?

I: Let me see...um....yeah in terms of medical apps, yes. That is the only one.

M: And you do use that quite a bit

I: Yeah.

M: Um, have you ever had apps your phone, or seen a situation where a colleague's had apps on their phone, where they haven't been sure as to the trustworthiness of it.

I: Um, no, I don't think so, because you can trust the BNF. You can trust certain names I suppose, I suppose that's the case.

M: Do you actively seek...have you ever had a situation, or know of colleagues having a situation where they've actively sought out apps that they're looking for them cold, sort of thing?

I: What do you mean?

M: Uh, so for instance, um, [pause due to interruption]

M: Sorry, what I was trying to describe was um, for instance, in a previous interview, someone had said that when they were going on a medical on call, they had a look on the iTunes store for some potential apps sort of thing, so do you ever see that sort of thing

I: No. I think that's a good idea, but no, I've not done that.

M: Right. So um, cos what I was trying to see was whether you've had a situation really where you've had an app on your phone and...

I: Not trusted the information?

M: Yeah

I: I haven't personally, and I haven't heard of anyone else no.

M: Right so, we've talked about that and that....so in terms of your own sort of use of apps...what are the main barriers for you in terms of using apps

I: Um, finding them and putting them on in a place...remembering to do it in a place where I've got wifi.

M: Yeah

I: Um, remembering my password for iTunes, which I know sounds ridiculous...

M: no, it doesn't...

I: But I've replaced lots of phones, and I keep on forgetting the password. Um, and...um...what else? Knowing which ones to use I suppose.

M: Ok, in terms of your own confidence as a practitioner, do you think you would, um, have a different need for apps at a later stage in your career?

I: Yes, I hope to do anaesthetics [laughs], so yeah.

M: Ok, and do you think you...your reasons for choosing...cos it doesn't sound like, and I might...tell me me if I am putting words in your mouth here, that there are any particular constraints on whether you would use them or not, other than sort of, your own sort of having to put them on sort of thing, so it's not a situation where the environment isn't conducive to you using them if you need to, that kind of thing.

I: Other than the things we mentioned before – having a phone that you can carry around with you, um...um...and not being...doing it directly in front of a patient's view, I suppose are the only things, but they're easy to get around.

M: Ok, I think the...we've got a couple more sets of questions so...regarding how you become aware of apps, would it be more if someone emailed with a list of apps, or would it be more effective if someone came around and showed you.

I: Um, probably both, um, if you wanted to know which ones...I suppose logistically just trying to meet up with someone in the time that you're free it'd be difficult. If you got an email, you could glance through at your own leisure, but would I do it? You'd probably look at it and think 'oh I'll do that later' but probably never get around to doing it. Whereas yeah, I suppose if someone recommended me an app, someone else, like one of my colleagues or a senior recommended me an app, then I'd definitely get it.

M: Yeah?

I: Yeah

M: Ok, so, um...in terms of cost, is that a barrier to your use of apps.

I: Yeah, yeah. If somethings going to be too expensive, then yeah, definitely.

[interesting]

M: But with regards to cost, not just talking about in terms of the cost of the app, but do you need to have...make sure you have a particularly up to scratch phone, cos someone's mentioned that their previous phone was pretty terrible, so there's no point downloading apps, so is that sort of thing a consideration.

I: Right, well I've got a [iphone] 4, I've got an iPhone 4, so as far as I'm aware, you can get the majority of things on a four that you can get on a 5 or a 5S as far as I'm aware, so...don't think so.

M: Right, ok, cool. Right, so, uh...I think we've actually managed to cover most of the schedule. Is there anything else that we've not really talked about that you thought would come up when we've been talking about apps.

I: Uh, I don't know to the degree of illegitimate apps as such, I don't know how, you know, if that's the case, people putting unsafe um information on apps that you know aren't checked any actual trustworthy body, I don't know how much that goes on.. I'm sure it does, I don't know. Um, I'd like to use apps more, in a way where I don't have to, you know...if I was recommended apps by other people, that'd be really helpful...um...uh, I feel I'm not getting enough out of my phone as it is, I feel like I've got a good phone and I don't use it enough, and I think apps is one way around that...yeah I think that's it.

Appendix 2.3 Interview Study Coding Framework

App Level Contexts

- General Limitations of apps

- Perceived Utility

- Trustworthiness

- Usability

Implementation

Individual Level Contexts

- Confidence

 - In own clinical judgement in light of others

 - Less need to refer to app

- Technological Knowledge

Organisational Level Contexts

- Organisational Norms

- Organisational Policy

Other Information sources

- Availability

- Reasons for choice

- Types

Other Local Environment Contexts

- Availability of other information sources

- Busyness of environment

- Specialism

Practicalities

- Carrying a mobile

- Cost

Technological issues

Social Context (Local)

Acceptability

Attitudes

Other People's perceptions

Other Colleagues

Patients

Senior Colleagues

Peer App Use

Senior Colleague App Use

Shared cognition

Type of information

Finding out about apps

Outcomes of App Use

Doctor Wellbeing CMOC

Increased Compliance CMOC

Increased Efficiency CMOC

Other consequences

Other personal consequences

Patient Outcomes CMOCs

Strategies to facilitate use

Explaining use to others

Testing out apps

Use of App CMOC

Use of App - Mechanisms

Use of App - Outcomes

Appendix 2.4 Framework Matrices

CMO 1 –

	A : App Level Contexts	B : General Limitations of apps	C : Perceived Utility	D : Trustworthiness	E : Usability	F : Reasons for choice	G : Increased Efficiency CMOC
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<p>1 : Interview D1</p>			<p>Non-medical apps useful for speeding and making more accurate judgments in specific situations - basically about computational power at point of care.</p> <p>Useful as a reminder or a check rather than for brand new information</p> <p>Basic belief that ignaz will be useful</p>	<p>Trustworthiness is important. Don't necessarily do a lot to verify trustworthiness, but stick to trusted 'brands'. Assume that the app is as reliable as the paper copy - but paper can be fallible too. When using something very novel, try to check that it tallies with existing methods.</p> <p>Stopped using apps in the past. Sometimes wonder whether some have been updated when they should have been.</p>	<p>Usability important in terms of an app needing to be quick to use to be of benefit.</p> <p>User has some knowledge of what is good and bad in terms of usability, so notices when things aren't right.</p>		<p>Quicker than looking at the BNF book, for example.</p> <p>Usually quicker than other information sources because you have it with you</p> <p>Useful for non-medical information i.e. phone lists, that one might have difficulty memorizing, or might take up cognitive capacity</p> <p>Quicker than going away to check stuff, so made them personally quicker.</p> <p>If something takes too long to update and that delays use, then that negates the efficiency gains.</p>
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<p>2 : Interview D2</p>			<p>Initial thing that they are useful shortcuts, but information may not be validated.</p> <p>Non-medical app use highlighted (and non-app use). Having info at point of care is the main selling point. Useful for information that is hard to retain/detailed.</p>	<p>Slight anxiety about lack of validation of some apps - lead to stopping use.</p> <p>If believe that an app is validated, would override colleague concerns, but a lack of validation would stop use.</p> <p>Stopped others using apps when noticed inaccuracies.</p> <p>No strict validation, but maintains vigilance i.e. notices that some figures were wrong. Also, informal testing indicated that different inputs gave similar outputs where they shouldn't.</p>	<p>Don't mind if it's a little tricky to use to get the hang of, but ultimately needs to be worth the effort in terms of time saved, and info would need to be accurate and up to date.</p>	<p>Perceived risk of not checking - for instance when checking a drug dose, if you're quite sure and the margin for error is quite large, then you might not check.</p> <p>Busyness is really important.</p>	<p>Use the camera etc to photograph tables of useful info that would be difficult to memorize rather than apps. Point is that having the info at touch of a button at point of care is useful.</p> <p>Saves time, and time is money.</p> <p>Having it at point of care</p> <p>Talks about how it would save time if additional data were available, such as test results etc.</p> <p>Quicker to use something purpose built for searching rather than a book</p> <p>Reducing time a single interaction allows time to see more patients.</p>
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<p>3 : Interview D3</p>			<p>Useless if there's no useful content</p> <p>Importance of letting potential users know about potential utility, and having authoritative sources reinforcing that</p> <p>One of selling points of ignaz is the localised, relevant information</p>	<p>Wouldn't use Wikipedia as as ource of information. Rely on resources that are "trusted".</p> <p>Ability to say app was developed in conjunction with a trust was powerful, as was ability to say it had been developed by end users</p> <p>Powerful to be able to reassure users that had been developed with clinical governance in mind. "Not a cowboy outfit", within a trust structure and with authoratitive backing</p>	<p>Importance of user experience and functionality.</p> <p>Not much you can do a mobile phone in terms of functionality that you can't do elsewhere</p> <p>Some websites not designed for mobile use - important to take that into account in terms of usability</p>	<p>Printed materials can be out of date, but prior to app, sometimes they were the only resource available</p> <p>App preferable to website as don't need to rely on internet connection</p> <p>Not having to rely on accessibility of other resources</p> <p>Depends on task and location i.e. ward - what is quickest under what circumstance</p> <p>Ward computers not always accessible because of shared logins</p> <p>If know where to get the info online, phone might be quickest(not necessarily an app though)</p> <p>Some resources not easy to access on a mobile</p>	<p>Aim of ignaz is to put the info in the palm of your hand</p> <p>When moving around lots of sites, local policies will vary, and so will how things are done in one place compared to another</p> <p>Not much done to measure increase in efficiency</p> <p>Quicker to check an app than waiting for ward computers to come free</p>
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4 : Interview D4			Aim behind introducing it is around information at point of care. Important to make the information fully available, i.e. not reliant on internet connection	Information needs to be trustworthy. Accreditation is a tricky issue - seems to have been shied away from. Current rating systems are pretty limited, and it needs addressing. But also need to balance with a system that won't stifle app development.	Would probably go off an app if it was difficult to use, and use alternatives, and might be difficult to get the users back. Failure to deliver on expectations.	Amount of time available, compared to speed of finding the information out. Hard to use other sources such as switchboard because it's hard to get through (particularly at peak times) Put off by usability issues or "bugyness". Has information that can be accessed elsewhere.	Mostly anecdotal evidence from colleagues that it makes it quicker to look up phone evidence. Needs verification. Useful for effective task management?
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<p>5 : Interview J1</p>			<p>Useful due to speed in comparison to paper sources i.e. BNF</p>	<p>Has some concerns about whether guidelines are correct, but gets around this by making sure they use apps from reputable sources.</p>	<p>Would try and learn to use it if they thought it was going to be useful, but only if they thought it would save time. Also makes the point that needs ultimately to be simple to use as well as putting things in your hand.</p>	<p>More efficient than hunting around the ward for a book</p> <p>When appropriate app not available, have just used internet, or intranet.</p> <p>When don't know a colleague, first instinct is to ask them for info rather than using own phone</p> <p>However, phone is much easier than carrying multiple books around</p> <p>If you've got more time and space, using a computer is more comfortable, but if you're busy, use the phone if you can.</p>	<p>Quicker using a search function than looking for a book and then looking it up in that book</p> <p>You can use the phone on the move, whilst walking between wards etc.</p> <p>Finding the same info that you would have to look for anyway but in a quicker way.</p>
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<p>6 : Interview J2</p>			<p>Useful when you need to know something at that second, whether it's just general management or an emergency.</p> <p>Beneficial in that can know whether it's up to date or not.</p> <p>Minor problems with reliability can be overlooked if it can be fixed and the app is useful.</p> <p>Cost can prevent some useful resources being utilised - especially stuff that didn't cost at a different point in one's career because it had been provided already.</p>	<p>Only uses apps from reputable sources. Would use some that have been recommended by senior colleagues. Wouldn't use apps that weren't tried and tested.</p> <p>Upside of apps is that the good ones are updated regularly, so enhances trustworthiness - perhaps over other sources?</p> <p>Would question something that hadn't been updated in a decent length of time i.e. a year.</p>	<p>Had problems with an app that kept crashing, but simply reinstalled it - it was a good app. Minor niggles are fine, but bigger issues would prevent full adoption.</p>	<p>Know that can access the most appropriate information on a computer</p> <p>Apps tend to be quicker to access because of the search functions available.</p>	<p>Useful for when you need to know something that will affect the immediate management of the patient.</p> <p>Would save a lot of time when having to travel around the hospital to look at scans.</p> <p>Allows you to do things when you're on your own i.e. on nights that ordinarily you would have to wait for seniors. As long as it's safe.</p>
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7 : Interview J3			Useful in particular specialties for specific purposes i.e. anaesthetics for calculating drug doses	Rarely come across untrustworthy apps, but don't use many and only use previously trusted ones. Limited knowledge of unsafe apps and would like to be recommended some good apps.	If it's something that is useful and desirable to use often, then would figure out how to use it.	Can't keep book with at all times Always check info when unsure, particularly where one knows it matters Find the computer easier to use, but sure that phone would be easier to use if used it more. Know others that use phone more.	Good for checking info that you're not sure of, for instance contra-indications of drugs - a good recap Faster than books because tend to have phone on their person. Useful in on calls because things move so fast, and because such a range of situations (and therefore specialties?)
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<p>8 : Interview J4</p>		<p>Limited in the information that they can provide</p> <p>Internet in general can be better for some specific information</p> <p>Not good for long guidelines</p>	<p>Use as a reference from time to time</p> <p>How it looks and description, professionalism - tied to trustworthiness in some ways</p>	<p>Goes with ones that the brand is known</p> <p>Uses other ones that are for other trusts, but with caution</p> <p>Avoids non-UK apps as aware that different.</p> <p>Lots of little judgments without being conscious of- how it looks, ease of use, professionalism</p>	<p>Search functions particularly useful</p> <p>Poorly designed apps not used i.e. Clip Clinica</p> <p>Usability important to utility</p> <p>Having to repeatedly enter passwords whenever it is used can be tiresome.</p>	<p>Best way for particular tasks.</p>	<p>Useful because can find information needed quicker. Otherwise no effect on other outcomes really.</p>
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<p>9 : Interview J5</p>		<p>Easier to look at multiple resources on a computer than a phone screen</p> <p>App isn't necessarily a definitive resource. Not great for text heavy info.</p> <p>Better when dealing with less in depth information, and when not trying to do too much. Not realistic to expect an app to do too much.</p>	<p>When searching for apps on the app store, look for ones that seem useful. Look at how rated, description of what it does, or recommendations from others.</p> <p>Needs to not be trying to do too much, easy to use, and better for specific info/functions - multifunctional not overly useful.</p> <p>Perceived utility would potentially outweigh issues with usability, but usability is integral to the actual utility</p> <p>Ignaz potentially useful</p>	<p>Tend to rely on known textbooks etc as a sign of trustworthiness - sources or names that are already trusted</p>	<p>If you're not used to it, can be harder to use and ultimately frustrating</p> <p>Not great generally for looking through very text heavy material</p> <p>Is very important - is part of the point of an app existing</p> <p>Has been put off a particular app in the past because it was too "in depth"</p>	<p>If the info needed was on the phone, and it was a well designed app, would probably use it for convenience.</p>	<p>Having the resource close by and portable.</p> <p>Depends on quality of app - if find it difficult to navigate, won't save time necessarily.</p> <p>Also depends on what you're looking up. BNF for instance is much quicker because of the search function etc. Needs to be something quite quick to look up.</p>
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CMO 2 –

	A : General Limitations of apps	B : Perceived Utility	C : Trustworthiness	D : Usability	E : Increased Compliance CMOc
1 : Interview D1		<p>Non-medical apps useful for speeding and making more accurate judgments in specific situations - basically about computational power at point of care.</p> <p>Useful as a reminder or a check rather than for brand new information</p> <p>Basic belief that Ignaz will be useful</p>	<p>Trustworthiness is important. Don't necessarily do a lot to verify trustworthiness, but stick to trusted 'brands'. Assume that the app is as reliable as the paper copy - but paper can be fallible too. When using something very novel, try to check that it tallies with existing methods.</p> <p>Stopped using apps in the past. Sometimes wonder whether some have been updated when they should have been.</p>	<p>Usability important in terms of an app needing to be quick to use to be of benefit.</p> <p>User has some knowledge of what is good and bad in terms of usability, so notices when things aren't right.</p>	<p>Makes it easier to just do the checker step</p> <p>Can be an additional reassurance</p>
2 : Interview D2		<p>Initial thing that they are useful shortcuts, but information may not be validated.</p> <p>Non-medical app use highlighted (and non-app use). Having info at point of care is the main selling point. Useful for information that is hard to retain/detailed.</p>	<p>Slight anxiety about lack of validation of some apps - lead to stopping use.</p> <p>If believe that an app is validated, would override colleague concerns, but a lack of validation would stop use.</p> <p>Stopped others using apps when noticed inaccuracies.</p>	<p>Don't mind if it's a little tricky to use to get the hang of, but ultimately needs to be worth the effort in terms of time saved, and info would need to be accurate and up to date.</p>	<p>Believe that it increases accuracy because more likely to use guidelines etc. if they are to hand.</p> <p>Useful for early career doctors - having to look up a lot of new procedures, so much easier if it's to hand.</p>

			No strict validation, but maintains vigilance i.e. notices that some figures were wrong. Also, informal testing indicated that different inputs gave similar outputs where they shouldn't.		
3 : Interview D3		Useless if there's no useful content Importance of letting potential users know about potential utility, and having authoritative sources reinforcing that One of selling points of ignaz is the localised, relevant information	Wouldn't use Wikipedia as as source of information. Rely on resources that are "trusted". Ability to say app was developed in conjunction with a trust was powerful, as was ability to say it had been developed by end users Powerful to be able to reassure users that had been developed with clinical governance in mind. "Not a cowboy outfit", within a trust structure and with authoritative backing	Importance of user experience and functionality. Not much you can do a mobile phone in terms of functionality that you can't do elsewhere Some websites not designed for mobile use - important to take that into account in terms of usability	Helps a lot with antibiotic policies

<p>4 : Interview D4</p>		<p>Aim behind introducing it is around information at point of care. Important to make the information fully available, i.e. not reliant on internet connection</p>	<p>Information needs to be trustworthy. Accreditation is a tricky issue - seems to have been shied away from. Current rating systems are pretty limited, and it needs addressing. But also need to balance with a system that won't stifle app development.</p>	<p>Would probably go off an app if it was difficult to use, and use alternatives, and might be difficult to get the users back. Failure to deliver on expectations.</p>	<p>Wasn't the original idea as wasn't going to have a lot of clinical information, but now it's got antibiotic guidelines in, the thinking is that it will make a difference. Needs verification i.e. through pharmacy department.</p>
<p>5 : Interview J1</p>		<p>Useful due to speed in comparison to paper sources i.e. BNF</p>	<p>Has some concerns about whether guidelines are correct, but gets around this by making sure they use apps from reputable sources.</p>	<p>Would try and learn to use it if they thought it was going to be useful, but only if they thought it would save time. Also makes the point that needs ultimately to be simple to use as well as putting things in your hand.</p>	<p>Always look at the guidelines anyway (because so junior), but having them to hand may help to challenge other colleagues to ensure guidelines followed - more experienced colleagues may be inclined go with the experience.</p>
<p>6 : Interview J2</p>		<p>Useful when you need to know something at that second, whether it's just general management or an emergency. Beneficial in that can know</p>	<p>Only uses apps from reputable sources. Would use some that have been recommended by senior colleagues. Wouldn't use apps that weren't tried and tested.</p>	<p>Had problems with an app that kept crashing, but simply reinstalled it - it was a good app. Minor niggles are fine, but bigger issues would prevent full adoption.</p>	<p>Not necessarily- only use apps that trust anyway.</p>

		<p>whether it's up to date or not.</p> <p>Minor problems with reliability can be overlooked if it can be fixed and the app is useful.</p> <p>Cost can prevent some useful resources being utilised - especially stuff that didn't cost at a different point in one's career because it had been provided already.</p>	<p>Upside of apps is that the good ones are updated regularly, so enhances trustworthiness - perhaps over other sources?</p> <p>Would question something that hadn't been updated in a decent length of time i.e. a year.</p>		
7 : Interview J3		<p>Useful in particular specialties for specific purposes i.e. anaesthetics for calculating drug doses</p>	<p>Rarely come across untrustworthy apps, but don't use many and only use previously trusted ones.</p> <p>Limited knowledge of unsafe apps and would like to be recommended some good apps.</p>	<p>If it's something that is useful and desirable to use often, then would figure out how to use it.</p>	<p>Good as an extra check - more senior colleagues have used it in the past.</p>
8 : Interview J4	<p>Limited in the information that they can provide</p> <p>Internet in general can be better for some specific information</p>	<p>Use as a reference from time to time</p> <p>How it looks and description, professionalism - tied to trustworthiness in some ways</p>	<p>Goes with ones that the brand is known</p> <p>Uses other ones that are for other trusts, but with caution</p> <p>Avoids non-UK apps as aware</p>	<p>Search functions particularly useful</p> <p>Poorly designed apps not used i.e. Clip Clinica</p> <p>Usability important to utility</p>	<p>Always look things up if unsure anyway, so no real effect on compliance.</p>

	Not good for long guidelines		that different. Lots of little judgments without being conscious of- how it looks, ease of use, professionalism	Having to repeatedly enter passwords whenever it is used can be tiresome.	
9 : Interview J5	Easier to look at multiple resources on a computer than a phone screen App isn't necessarily a definitive resource. Not great for text heavy info. Better when dealing with less in depth information, and when not trying to do too much. Not realistic to expect an app to do too much.	When searching for apps on the app store, look for ones that seem useful. Look at how rated, description of what it does, or recommendations from others. Needs to not be trying to do too much, easy to use, and better for specific info/functions - multifunctional not overly useful. Perceived utility would potentially outweigh issues with usability, but usability is integral to the actual utility Ignaz potentially useful	Tend to rely on known textbooks etc as a sign of trustworthiness - sources or names that are already trusted	If you're not used to it, can be harder to use and ultimately frustrating Not great generally for looking through very text heavy material Is very important - is part of the point of an app existing Has been put off a particular app in the past because it was too "in depth"	Potentially yes, but it depends on the quality of the information in the app and who it's provided by. Prefer looking at guidelines on the computer

CMO 3 –

	A : Doctor Wellbeing CMOC	B : Other consequences	C : Other personal consequences	D : Use of App - Mechanisms	E : Use of App - Outcomes
1 : Interview D1	When on a busy clinic, can help you work through quicker and also check information. This lowers the stress of trying to get through all patients, but also of wondering whether you've given the right information.	The need to have the phone with makes it an expectation to then have the phone with you and on at all times when on duty.	No expectation of serious negative personal consequences in terms of reputation Personal effects can be quite subjective, as people will use it for their own purposes and in their own way.	Allows one to access info that would otherwise have to keep in head. Means that don't have to get anyone else to do it, or find another way to do it.	
2 : Interview D2	Helps to build confidence because of the safety net that having the information available gives you Having info at point of care allows you to get things done there and then, and so prevents frustration. Prevents worry later by allowing the looking up of information at the time it's needed because it's quicker, and it allows one to justify reasoning behind a particular patient care decision.	Means can spend more time with patients. More tools available to interact with them e.g. blood tests. Could potentially show them data they want to know about straight away rather than going to look them up quite well.	Can build up confidence on the job - can look information that one is unsure of. Particularly when been asked to do a task by a consultant or other senior colleague. Helps to hide the fact that one doesn't know something that maybe you should - reputational protection Keep on top of patient lists and prevents one becoming frustrated or frazzled.	Makes it easier having info at the touch of a button, rather than having to access info from a computer that could take ages to find or wait for Eases frustrations being able to do it then and there - otherwise it might not be done at all because can't get around to it due to tiredness or busyness Emails from IT don't work- junior docs don't particularly read email. Needs leadership from the top, seniors using it, pressure from below. There actually being a need for it. Need	Eases frustration being able to check it then and there, rather than not having the time to double check later on

				changes depending what level/group you're in.	
3 : Interview D3			Risk of patient confidence being undermined, but can deal with this through explaining what you're doing. Gives confidence to challenge colleagues because have the evidence to hand Pride in having being involved in the development in something that's made a difference		Haven't measured outcomes of ignaz

4 : Interview D4	<p>Can be useful for reducing some stressors by making some pinchpoints more efficient i.e. hand over/hand off, as well as easing the mental load associated with keeping a task list in one's head.</p> <p>Personal experience is that it's not made that much difference though others have suggested that it makes them feel more comfortable.</p>				
5 : Interview J1	<p>A lot of stress is to do with time management and so if they save time they can be helpful.</p>	<p>Having the info there may reduce the need to know things, thus making you less of an "expert". Element of deskilling?</p> <p>Might be useful for unusual diagnoses, but also may mean that identify horses as zebras, and thus do more investigations than necessary.</p>			

<p>6 : Interview J2</p>		<p>More phone chargers would be needed</p> <p>Because having phone on you may be more acceptable, may result in phones being used more for personal use as when looking things up, may discover that have several messages etc.</p>	<p>Can feel more confidence in taking actions independently.</p>	<p>Useful for getting on the spot information of certain types - going to find a book or internet search, that's a delay. But if you've got the phone in your pocket, can just get info then.</p> <p>As long as it's safe, it's fine. Can trust things like the BNF app. Means you can act quickly, particularly when you're on your own e.g. nights, starting off the treatment rather than waiting for seniors.</p>	
<p>7 : Interview J3</p>	<p>Stretching things to say it reduces stress, but may be fair to say that it can make your working life a little easier - anything that makes on calls easier is a good thing.</p>				
<p>8 : Interview J4</p>	<p>Stressful not being able to get info that's needed quickly, and apps can help resolve that.</p>		<p>Very stressful not being able get info that's needed quickly, so helpful if an app can do that for you. Makes you less frustrated and thus reduce stress levels.</p>	<p>Use BNF app rather than paper version</p>	

9 : Interview J5	Stress is multifactorial, so it may have an effect because it makes you more efficient, but not necessarily a large effect because it's just one of many things that can make you more efficient.				
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CMO 4 –

	A : Acceptability	B : Attitudes	C : Senior Colleagues	D : Senior Colleague App Use	E : Other consequences	F : Other personal consequences	G : Use of App - Mechanisms	H : Use of App - Outcomes
1 : Interview D1	Computers are accepted in the clinical environment, so why not mobile phones? Slightly different electronic medium rather than a complete change	Senior staff reminding individuals to be mindful of patient views. Those staff speculating (albeit maybe with some basis) about patient views More likely to have issues when it appears you're doing something non-clinical. Not always obvious when you're doing something work related because using an app not associated with medicine for work purposes i.e. checking	Would be more reserved about using around senior colleagues if they had a negative view, but those individuals seem to be in a minority now. Positive perceptions of colleagues wouldn't necessarily change whether it was used, but it might mean it was used in a more open manner		The need to have the phone with makes it an expectation to then have the phone with you and on at all times when on duty.	No expectation of serious negative personal consequences in terms of reputation Personal effects can be quite subjective, as people will use it for their own purposes and in their own way.	Allows one to access info that would otherwise have to keep in head. Means that don't have to get anyone else to do it, or find another way to do it.	

		Whatsapp regarding scheduling etc.						
2 : Interview D2		Senior's views alone wouldn't stop it being used - but if the view was based on the lack of evidence of utility or reliability, then it would be considered.	Senior's views alone wouldn't stop it being used - but if the view was based on the lack of evidence of utility or reliability, then it would be considered. Although maybe would be more discreet in how it was used if a senior disapproved. Need to be mindful of not shoving it in colleagues faces, but can be a good tool. Consultants generally becoming more	Some use them, and this give tacit permission, even positive reinforcement.	Means can spend more time with patients. More tools available to interact with them e.g. blood tests. Could potentially show them data they want to know about straight away rather than going to look them up quite well.	Can build up confidence on the job - can look information that one is unsure of. Particularly when been asked to do a task by a consultant or other senior colleague. Helps to hide the fact that one doesn't know something that maybe you should - reputational protection Keep on top of patient lists and prevents one becoming frustrated or frazzled.	Makes it easier having info at the touch of a button, rather than having to access info from a computer that could take ages to find or wait for Eases frustrations being able to do it then and there - otherwise it might not be done at all because can't get around to it due to tiredness or busyness Emails from IT don't work- junior docs don't particularly read email. Needs leadership from the top, seniors using it, pressure from below. There actually	Eases frustration being able to check it then and there, rather than not having the time to double check later on

			open minded. Don't want to admit that don't know something to a consultant (only some).				being a need for it. Need changes depending what level/group you're in.	
3 : Interview D3	Explaining helps others accept the app use - both colleagues and patients Less acceptable in paediatrics - less capability to explain due to patient's limited vocab Is a way of justifying decisions to self and others		Advocate of the app, and make a point of letting senior colleagues know that they're using it. Feels "protected" by relative seniority within own specialty, so no qualms about being transparent Feels need to be able to back up own decisions with evidence of following guidelines, so willing to challenge. More a personal trait			Risk of patient confidence being undermined, but can deal with this through explaining what you're doing. Gives confidence to challenge colleagues because have the evidence to hand Pride in having being involved in the development in something that's made a difference		Haven't measured outcomes of ignaz

			than a learned behaviour.					
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<p>4 : Interview D4</p>		<p>Not actually heard of it happening</p> <p>But if it did, would make you think twice about using</p> <p>As a junior, the effect would probably be stronger</p>	<p>Make you think twice if a consultant objected, but don't know if completely put off if you felt there was benefit to it. Might use it out of their sight. The leadership will always have some sort of effect.</p> <p>In anaesthetics, the consultants all use apps, and they seem to encourage their use, so is seen as acceptable</p>	<p>In anaesthetics, consultants all use apps.</p>				
<p>5 : Interview J1</p>	<p>Everyone seems to carry them all the time. Phones used to contact doctors more than beeps.</p> <p>Would expect</p>	<p>Could be seen as double standards with nurses not being allowed phones on them.</p> <p>Attitudes can change, for instance a</p>	<p>Used to get in trouble for having phones on you, but it's changed now.</p> <p>If they didn't want you to use</p>	<p>In current environment, all the consultants use apps. Not ture of all environments. As such, they kind of expect you to have the</p>	<p>Having the info there may reduce the need to know things, thus making you less of an "expert". Element of deskilling?</p>			

	<p>ward leadership team to make their thoughts clear, on current ward it's acceptable.</p> <p>Depends on how it's portrayed or explained (colleagues and patients).</p> <p>Still an assumption that when you're on your phone, that you might be doing personal stuff - phones not part of the medical landscape yet.</p> <p>Consultants set the tone, even if they don't discover the app as such.</p> <p>Might bring</p>	<p>consultant might be against app use until maybe a more junior colleague shows them the utility of a given app.</p> <p>These can be expressed through whether they're actively encouraged.</p>	<p>it now, they would tell you.</p>	<p>info on your phone.</p> <p>Used to have to be very careful of having your phone on you, but now not so much.</p>	<p>Might be useful for unusual diagnoses, but also may mean that identify horses as zebras, and thus do more investigations than necessary.</p>			
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	back ideas from conferences and the like, making certain things more acceptable.							
6 : Interview J2			Example of being told to put phone away on a ward round by the consultant, but explained afterwards and the consultant was fine with it.		<p>More phone chargers would be needed</p> <p>Because having phone on you may be more acceptable, may result in phones being used more for personal use as when looking things up, may discover that have several messages etc.</p>	Can feel more confidence in taking actions independently.	<p>Useful for getting on the spot information of certain types - going to find a book or internet search, that's a delay. But if you've got the phone in your pocket, can just get info then.</p> <p>As long as it's safe, it's fine. Can trust things like the BNF app. Means you can act quickly, particularly when you're on your own e.g. nights, starting off the treatment rather than waiting for seniors.</p>	

7 : Interview J3			Got "bollocked" a couple of times as a student. Didn't bother trying to explain afterwards.	If senior colleagues recommended, then would use more				
8 : Interview J4	It's a given that people use their phones in a hospital. Don't know what the org policy is, but seeing consultants using it seems to be an endorsement.		If a senior colleague expressed disapproval, then probably wouldn't use it. Generally though, seniors quite happy for you to use it on the ward round etc. But you do need to be open about why you're using it. Never had a consultant take issue with that in those circumstances. Take a lead from consultants. Regardless of	Senior colleagues need to refer less.		Very stressful not being able get info that's needed quickly, so helpful if an app can do that for you. Makes you less frustrated and thus reduce stress levels.	Use BNF app rather than paper version	

			own views, if a consultant said not to use it, you wouldn't use it, but never had that happen.					
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9 : Interview J5	Need to be conscious, like in any workplace, that people may assume that phone is being used for personal reasons. Therefore, always feel the need to explain why being used. Could eventually just become commonplace, in which case it will be come the accepted thing.		If a senior says something's good, then that would lead to you doing something about it, equally so if they were negative about it. Applies to things other than medical apps too.					
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CMO 5

	A : Reasons for choice	B : Specialism	C : Patients	D : Other consequences	E : Patient Outcomes CMOCs	F : Explaining use to others
1 : Interview D1		Not really used too much in their specialism, but some calculator type apps may be useful in other areas	<p>Patients may prefer you to use conventional methods i.e. calendar instead of a phone.</p> <p>Need to be mindful of directing sufficient attention to the patient rather than the phone, but that's the same as with a computer in the GP room.</p> <p>Sometimes staff make presumptions about patient views.</p>	The need to have the phone with you makes it an expectation to then have the phone with you and on at all times when on duty.		<p>When a student, always told about the potential for the computer to be the third person in the room. Important to explain, and it can be a useful tool for showing the patient what you're doing. Breaks down barriers, and patients don't express discomfort. Also gives reassurance that you've worked the date out correctly. Aids in the communication process</p> <p>Whilst you might be doing something important and relevant, unless you explain to patients or other people, they might not know that.</p>
2 : Interview D2	Perceived risk of not checking - for instance when checking a drug dose, if you're quite sure and the margin for	Know their own specialism well, so don't usually need to look it up and don't have a phone app. If	Need to explain why something is being looked up to the patient. - make clear why you're doing what	Means can spend more time with patients. More tools available to interact with them e.g. blood tests. Could	Allows you to have information on hand with which to challenge senior colleagues, which	Would explain to a patient what they were looking up, and that it was safe and legitimate - comes from own

	<p>error is quite large, then you might not check.</p> <p>Busyness is really important.</p>	<p>really need to look something up, will use a computer.</p>	<p>you're doing, and that it's quicker than looking for a text book.</p> <p>Concern that if you look stuff up in front of them, that the patient may lose confidence in you.</p> <p>Juniors concerned that patients think they're on facebook etc.</p> <p>Patients becoming more accepting that handheld technology is useful and that it's not being abused.</p> <p>Patient discomfort would be expressed through body language or worse not expressed.</p> <p>May lead to consequences for patient care. - rare for this to happen, particularly with explanation</p>	<p>potentially show them data they want to know about straight away rather than going to look them up quite well.</p>	<p>may enhance patient safety in certain situations.</p> <p>If a patient disliked the use of an app, they might not object directly, but it might lead them to trust the physician, or disengage from the service or stop following the treatment plan.</p> <p>Allows the physician to spend more time focused on the patient</p> <p>By removing frustrations etc., would lead to physician being better able to look after patient needs.</p>	<p>experience when a child patient. Worry that patients would lose faith in you as a doctor.</p> <p>Juniors wary of using in front of a patient because maybe assumption that doing non work stuff. But general acceptance that it's not being used for stuff like that.</p> <p>Would be hesitant to use in front of patients, and would explain what doing and why, and make sure it didn't spoil doctor/patient relationship</p> <p>Also have to be wary of patient's relatives - even when sat at a desk, you can see relatives giving you evil looks.</p> <p>Have to deal with the perception that not doing anything useful unless you're face to face with the patient</p>
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			Worry about relative's perceptions			
3 : Interview D3	<p>Printed materials can be out of date, but prior to app, sometimes they were the only resource available</p> <p>App preferable to website as don't need to rely on internet connection</p> <p>Not having to rely on accessibility of other resources</p> <p>Depends on task and location i.e. ward - what is quickest under what circumstance</p> <p>Ward computers not always accessible because of shared logins</p> <p>If know where to get the info online, phone might be quickest(not</p>	<p>In particular specialism, some patients unconscious, so negates the impact of their views of apps</p> <p>Relative seniority in their own specialism</p> <p>Certain environments (which might be more associated with specific specialties) might alter the availability of other information sources</p>	<p>Could be used in front of a patient, but a lot of the time, when extra resources are referred to, it's done away from the patient. So wouldn't necessarily expect it to be used in front of a patient.</p> <p>Likes using resources in front of a patient, can give the angle that personalising the care.</p> <p>A lot patients are unconscious because of the nature of the specialty.</p> <p>Understand why a patient might be wary if looking up something basic, but more acceptable when it's something unusual or non-routine. Don't want the patient to lose faith</p>		<p>Can affect patient care through providing on the spot information</p> <p>Encourages adherence to antibiotic protocols</p> <p>Material information whilst in transit has been helpful</p>	<p>Can use it to counter info that the patient has printed out, and is a tool to communicate with them and personalise care</p> <p>Make it clear that using for the sufficiently complex info so that trust is not undermined.</p> <p>Not had negative responses, but tend to explain. Doesn't mean the patient isn't feeling wary.</p> <p>Tend to speak up and explain to colleagues why using, sometimes using it to find out information and thus demonstrate utility.</p>

	<p>necessarily an app though)</p> <p>Some resources not easy to access on a mobile</p>		<p>Could undermine patient's view of competence, but if it's sufficiently relevant to them personally, happy to talk with them about it.</p> <p>Patients haven't registered negative responses, but it could be that they haven't voiced them</p> <p>Paediatrics - wouldn't necessarily use in front a patient because they may not have capacity to understand why you're using it. And have to be sensitive to parents, who want you to be paying attention to their child. Haven't used in a paediatric setting</p> <p>Other groups of professionals may not feel they can get away with it.</p>			
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<p>4 : Interview D4</p>	<p>Amount of time available, compared to speed of finding the information out.</p> <p>Hard to use other sources such as switchboard because it's hard to get through (particularly at peak times)</p> <p>Put off by usability issues or "buggyness". Has information that can be accessed elsewhere.</p>	<p>Popular in anaesthetics. May in part be due to culture, or types of available. May also be to do with the fact that patients are unlikely to object due to their being asleep.</p> <p>In particular specialties, no stigma at all. But again, may be due to the patients being less aware of what's going on, so lower impact of patient perceptions.</p>	<p>Anaesthetized patients don't really mind...</p> <p>Need to take into account public perception</p> <p>Environment may play arole.</p> <p>Haven't really used much in a clinical environment, so no examples.</p>			<p>Combats the preconception that when doctors on phone, not for clinical reasons. Patients want to be included in the conversation.</p>
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<p>5 : Interview J1</p>	<p>More efficient than hunting around the ward for a book</p> <p>When appropriate app not available, have just used internet, or intranet.</p> <p>When don't know a colleague, first instinct is to ask them for info rather than using own phone</p> <p>However, phone is much easier than carrying multiple books around</p> <p>If you've got more time and space, using a computer is more comfortable, but if you're busy, use the phone if you can.</p>	<p>Can depend on the behaviour of consultants - some wards, all of the consultants use them.</p> <p>Anaesthetics just love apps, on board with the technology side of things.</p> <p>Don't think there'd be time in surgery. More time on medical ward rounds because you have longer to spend with each patient.</p> <p>Be good if there was a list of apps for each specialty.</p>	<p>Depends how it's explained to them.</p> <p>Particularly conscious of elderly patients.</p>	<p>Having the info there may reduce the need to know things, thus making you less of an "expert". Element of deskilling?</p> <p>Might be useful for unusual diagnoses, but also may mean that identify horses as zebras, and thus do more investigations than necessary.</p>	<p>Because it allows one to look up information very easily, it may flag up a rare cause for a disorder. If correct, this would be helpful. If not, could lead to unnecessary tests or delay in correct diagnosis.</p>	
<p>6 : Interview J2</p>	<p>Know that can access the most appropriate information on a computer</p> <p>Apps tend to be quicker</p>	<p>In vascular, they have a COW so that makes it quite easy.</p> <p>Less time in surgery</p>	<p>Only use the mobile in front of a patient because need to know it there and then, but if it can wait a while, won't use it in front of</p>	<p>More phone chargers would be needed</p> <p>Because having phone on you may be more acceptable, may result</p>	<p>Enabled fast look up of a drug dosage to help a fitting patient.</p> <p>Can help make faster decisions to enable</p>	<p>Younger patients tend to understand why, but older patients may need explaining to. When consultants use in front of patients, they tend to</p>

	to access because of the search functions available.	than medical, so don't go as far in depth.	<p>patients.</p> <p>Need to explain why using to patients, particularly elderly ones.</p> <p>Also true of colleagues (not the elderly bit)</p>	in phones being used more for personal use as when looking things up, may discover that have several messages etc.	better patient management	<p>explain why they're using it and that they're not just texting someone.</p> <p>Once got told off by a consultant for looking something up during a ward round because they thought it was texting, but explained afterwards and it was all right.</p> <p>As long as you explain to patients and colleagues, they accept it, but without the explanation, there is preconception that it's not for work stuff.</p> <p>With their own students, can't tell exactly what they're doing unless stood next to them. But can get a sense by the way that they're looking at it whether using it for work tasks.</p>
7 : Interview J3	<p>Can't keep book with at all times</p> <p>Always check info when</p>	Not really useful for surgeons - ward rounds are too quick.	Perception that patients will be sceptical, but not had any direct experience			Once got a bollocking from the consultant during a round, but didn't

	<p>unsure, particularly where one knows it matters</p> <p>Find the computer easier to use, but sure that phone would be easier to use if used it more. Know others that use phone more.</p>	<p>Anaesthetists often use them, as an example, so perhaps specialism does make a difference.</p>	<p>of a patient showing discomfort with it.</p> <p>Avoid doing it in front of patients really.</p>			<p>bother to explain and just put it away.</p>
<p>8 : Interview J4</p>	<p>Best way for particular tasks.</p>	<p>No big difference between surgery and medicine, except wouldn't get phone out in theatre</p>	<p>Use in front of patients but always explain when getting it out. Otherwise it would look unprofessional. Particularly with older patients.</p> <p>No one's ever taken issue with it, and never had funny looks or anything.</p> <p>Assumption about older patients is brought in from other settings, like on the bus, and what they say in other settings.</p>			<p>As long as you explain why you're using it to colleagues/consultants, haven't had an issue with it. But feel that there is a preconception that it displays a kind of disinterest unless explained.</p> <p>Always explain to patients, as can look unprofessional if you don't. Phones have a social connotation, particularly with older patients, who may not appreciate that have medical apps.</p> <p>Always explain straight away, but unsure</p>

						whether would get funny looks if they didn't.
9 : Interview J5	If the info needed was on the phone, and it was a well designed app, would probably use it for convenience.	Go into depth more in medicine, so more likely to look stuff up and check it.	Had a patient just commenting that they were on their phone, but then explained why. Tend now to explain why using phone. Unsure of the patient's interpretation. Assumption that more elderly patients would be less familiar.			<p>Problem in most workplaces, if you have your phone out it looks like non-work. Sure it'd be fine if got it out in front of a senior if explained what was doing. Ipads might look more professional.</p> <p>Had slight reaction from patients saying, oh, you're on your phone. However, it's fine if explained. That's just part of modern medicine. Otherwise, there might be that preconception of it being non-work, or suspecting as such.</p> <p>More elderly patients may be unfamiliar, but then again, it might just become the norm. But need to be wary at the moment.</p>

CM) 6

	A : Organisational Norms	B : Organisational Policy	C : Specialism	D : Other Colleagues	E : Peer App Use	F : Senior Colleague App Use	G : Shared cognition	H : Type of information
1 : Interview D1	<p>If it becomes the norm to use phones for communication purposes, becomes more likely that they are accepted.</p> <p>Highlights divide between doctors and nurses - nurses not allowed their phones on the wards, whereas doctors need to be contacted. In part influenced by doctor's need to move between wards and nurses tending to be based on a single ward.</p> <p>Generally low resistance to docs</p>	<p>Not issued with a bleep, so expectation is that phones carried with them.</p> <p>Roll out influenced by how receiving organisations want to use it - implies that they have responsibility to remove barriers.</p> <p>Unclear on whether there is a policy, but this may be because of a lack of clear communication of what the policy is. Likens it to a</p>	<p>Not really used too much in their specialism, but some calculator type apps may be useful in other areas</p>	<p>If they're perceived as being validated, might be seen as more acceptable.</p>	<p>Can be hard to differentiate whether being used for work purposes or not</p>			

	having phones with them.	dress code - as much about norms as official policy.						
2 : Interview D2			Know their own specialism well, so don't usually need to look it up and don't have a phone app. If really need to look something up, will use a computer.			Some use them, and this give tacit permission, even positive reinforcement.		
3 : Interview D3		Follow national rather than organisational policy because know it's evidence-based Antibiotic stewardship very much on an organisational basis Different organisations gone about roll out in different	In particular specialism, some patients unconscious, so negates the impact of their views of apps Relative seniority in their own specialism Certain environments (which might be more associated with specific specialties) might alter the availability	Seniority means that feel comfortable using it whatever other colleagues are doing Other colleagues don't really influence own app use as foremost is own need to be able to justify	Acknowledges that own experience may vary from colleagues. Different rules for nurses and doctors - may in part be driven by nature of work.			Needs to be for justifiable information in the patients i.e. not basic stuff that they would assume you should know as routine Could serve to undermine your credibility in the patient's eyes if too simple Useful for referring to protocols, and demonstrating this to others.

		ways with differing results	of other information sources	decisions. Role as an advocate is key				Content of app needs to be worthwhile, even if the platform is great Certain environments, app may be the fastest way to accomplish a task, whereas in other areas this might not be the case
4 : Interview D4			Popular in anaesthetics. May in part be due to culture, or types of available. May also be to do with the fact that patients are unlikely to object due to their being asleep. In particular specialties, no stigma at all. But again, may be due to the patients being less aware of what's going on, so lower impact of patient perceptions.			In anaesthetics, consultants all use apps.	Still comes down to individual actions, so if a piece of info needs looking up, such as a protocol, it will be. But will bounce ideas off team members. Example would be that agreed that guidelines should be followed,	Whilst teams may make a collective decision to take a course of action, it will be down to an individual to execute that particular decision. Teams may not have the protocol in their head, so may need to look it up specifically, and Ignaz is designed for that.

							so need to look up those guidelines.	
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<p>5 : Interview J1</p>			<p>Can depend on the behaviour of consultants - some wards, all of the consultants use them.</p> <p>Anaesthetics just love apps, on board with the technology side of things.</p> <p>Don't think there'd be time in surgery. More time on medical ward rounds because you have longer to spend with each patient.</p> <p>Be good if there was a list of apps for each specialty.</p>	<p>Juniors can play a role in introducing novel apps into the environment.</p>	<p>Can't think of a situation where told not to use it.</p>	<p>In current environment, all the consultants use apps. Not ture of all environments. As such, they kind of expect you to have the info on your phone.</p> <p>Used to have to be very careful of having your phone on you, but now not so much.</p>	<p>Don't download apps often because a lot of other people have them, so don't need to look it up themselves.</p> <p>Also don't always download stuff because only on a placement for a short time</p> <p>Even when a student, didn't always use it, would ask others how to make things happen.</p>	<p>Calculation apps etc are useful, but you don't want apps to stop you thinking - not sure if diagnosis apps are necessarily a good thing</p>
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<p>6 : Interview J2</p>			<p>In vascular, they have a COW so that makes it quite easy.</p> <p>Less time in surgery than medical, so don't go as far in depth.</p>	<p>Tend to explain why they're using it. Now, when med students have their phones out, tend to assume that if they're just having a quick check, that it's for personal stuff, whereas for longer periods, more of an assumption that it's work related.</p>				<p>Only use it when absolutely need to know the information there and then. If the answer can wait, then use the internet or use the phone away from the bedside</p> <p>With surgery, don't have as long with the patient, whereas tend to have a bit longer with the medical ones. So don't have time to look stuff up then and there with surgery.</p>
<p>7 : Interview J3</p>			<p>Not really useful for surgeons - ward rounds are too quick.</p> <p>Anaesthetists often use them, as an example, so perhaps specialism does make a difference.</p>		<p>Sees a colleague using it more, and thinks then that maybe they can use it more.</p> <p>Depends on what your colleagues in the immediate environment are</p>	<p>If senior colleagues recommended, then would use more</p>		<p>Tend to use it for checking rather than brand new information, but if it's for something completely novel, then might look it up.</p> <p>If ever in any doubt about something</p>

					doing. If was enthusiastically recommended an app, then would definitely download.			critical, i.e. a prescription, will always check it.
8 : Interview J4	Normal for phones to be used in a hospital Consultants have more latitude than juniors Senior colleagues set the tone of what is acceptable and what isn't	Unaware of any particular policies	No big difference between surgery and medicine, except wouldn't get phone out in theatre		Junior doctors more clued up on what apps are good, because they've grown up with them. Also younger colleagues have more need to refer to apps for guidelines.	Senior colleagues need to refer less.		Tend to look up stuff on the internet because apps are limited in scope and quite general. They're pretty good for telling you the type of medication, for instance, but not necessarily the dose. Generally think the internet is better for more specific information, and is easier.

<p>9 : Interview J5</p>	<p>If someone senior says it's good, more likely to use it. Similar for anything really.</p>	<p>Only policy that aware of is that not supposed to use in A & E. And sometimes used it discreetly anyway if the need arose.</p>	<p>Go into depth more in medicine, so more likely to look stuff up and check it.</p>		<p>Positive feedback tends to people getting the app in question</p>		<p>Less likely to look stuff up in a group, unless actively encouraged to do so. MOre likely to look stuff up on your own.</p>	<p>Apps good when you have a clearer idea of what it is you need to find, whereas internet better for multiple tabs, particularly on a larger screen.</p> <p>Apps often basically electronic versions of books</p> <p>Apps can be useful for guidelines, but it's not necessarily first choice. Ipads have been used elsewhere.</p> <p>More likely to use on own rather than in a group, because can ask other colleagues, unless actually asked to look something up by a senior, because no-one else to refer to</p> <p>App is quicker than book when you know what you're looking for. Familiarity with</p>
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									the app is helpful, even more helpful if it's from a reputable source.
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CMO 7

	A : Confidence	B : In own clinical judgement in light of others	C : Less need to refer to app	D : Acceptability	E : Attitudes	F : Other People's perceptions	G : Other Colleagues	H : Patients	I : Senior Colleagues	J : Peer App Use	K : Senior Colleague App Use
1 : Interview D1	As a junior, you'd be more likely to be influenced by the opinions of senior colleagues and patients. Or even just your perceptions of their opinions.			Computers are accepted in the clinical environment, so why not mobile phones? Slightly different electronic medium rather than a complete change	Senior staff reminding individuals to be mindful of patient views. Those staff speculating (albeit maybe with some basis) about patient views More likely to have issues when it appears you're doing something non-	If can show that app has a use e.g. can produce a queried piece of info, could help to win over sceptics. Although never had a very negative experience, always aware of what others might think. Would theoretically be beholden to what seniors said could be done, but never actually	If they're perceived as being validated, might be seen as more acceptable.	Patients may prefer you to use conventional methods i.e. calendar instead of a phone. Need to be mindful of directing sufficient attention to the patient rather than the phone, but that's the same as with a computer in the GP room. Sometimes staff make presumptions	Would be more reserved about using around senior colleagues if they had a negative view, but those individuals seem to be in a minority now. Positive perceptions of colleagues wouldn't necessarily change whether it was used, but it might	Can be hard to differentiate whether being used for work purposes or not	

					<p>clinical.</p> <p>Not always obvious when you're doing something work related because using an app not associated with medicine for work purposes i.e. checking Whatsapp regarding scheduling etc.</p>	<p>had a negative experience</p> <p>When a junior, might be more wary of what you think seniors may think. So projecting perceptions.</p> <p>Acceptability to patients might be higher than thought because smartphones so widely used generally.</p>		<p>about patient views.</p>	<p>mean it was used in a more open manner</p>		
2 : Intervi ew D2	<p>Helps to build your confidence because of the safety net of having the information</p>				<p>Senior's views alone wouldn't stop it being used - but if the view was</p>			<p>Need to explain why something is being looked up to the patient. - make clear why you're doing what you're</p>	<p>Senior's views alone wouldn't stop it being used - but if the view was based on the lack of</p>		<p>Some use them, and this give tacit permission, even positive</p>

<p>available.</p> <p>When you're tired/less confident, more likely to rely on guidelines than your own clinical judgement</p> <p>So can be down to how feeling on the day (trait vs mood)</p> <p>Gives confidence to challenge others due to safety net</p> <p>Confidence to use despite what other people think, if believe it to have utility. Would be</p>					<p>based on the lack of evidence of utility or reliability, then it would be considered</p>			<p>doing, and that it's quicker than looking for a text book.</p> <p>Concern that if you look stuff up in front of them, that the patient may lose confidence in you.</p> <p>Juniors concerned that patients think they're on facebook etc.</p> <p>Patients becoming more accepting that handheld technology is useful and that it's not being abused.</p> <p>Patient discomfort would be expressed</p>	<p>evidence of utility or reliability, then it would be considered.</p> <p>Although maybe would be more discreet in how it was used if a senior disapproved.</p> <p>Need to be mindful of not shoving it in colleagues faces, but can be a good tool.</p> <p>Consultants generally becoming more open minded.</p>		<p>reinforcement.</p>
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	<p>discreet about it though.</p> <p>Don't rely on them so much because more confidence in clinical judgement</p>						<p>through body language or worse not expressed.</p> <p>May lead to consequences for patient care. - rare for this to happen, particularly with explanation</p> <p>Worry about relative's perceptions</p>	<p>Don't want to admit that don't know something to a consultant (only some).</p>		
3 : Interview D3	<p>Sees self as advocate for apps.</p> <p>Relatively senior in their specialty, and no qualms in using apps in front of others</p>	<p>Confidence to explain to the patient and have a conversation about why they're using the app</p> <p>Personalit</p>		<p>Explaining helps others accept the app use - both colleagues and patients</p> <p>Less acceptable in paediatrics - less</p>			<p>Seniority means that feel comfortable using it whatever other colleagues are</p>	<p>Could be used in front of a patient, but a lot of the time, when extra resources are referred to, it's done away from the patient. So wouldn't necessarily expect it to be used in front of a patient.</p>	<p>Advocate of the app, and make a point of letting senior colleagues know that they're using it. Feels "protected" by relative seniority within own specialty, so no qualms</p>	<p>Acknowledges that own experience may vary from colleagues.</p> <p>Different rules for nurses and doctors - may in part be driven</p>

		<p>y trait - has to be able to justify why doing something, and willing to point out if they think someone's doing something wrong</p> <p>Personal responsibility for patient - advocacy - even when not primary carer</p> <p>Clear identification with doing the right thing for the</p>		<p>capability to explain due to patient's limited vocab</p> <p>Is a way of justifying decisions to self and others</p>			<p>doing</p> <p>Other colleagues don't really influence own app use as foremost is own need to be able to justify decisions.</p> <p>Role as an advocate is key</p>	<p>Likes using resources in front of a patient, can give the angle that personalising the care.</p> <p>A lot patients are unconscious because of the nature of the specialty.</p> <p>Understand why a patient might be wary if looking up something basic, but more acceptable when it's something unusual or non-routine. Don't want the patient to lose faith</p>	<p>about being transparent</p> <p>Feels need to be able to back up own decisions with evidence of following guidelines, so willing to challenge. More a personal trait than a learned behaviour.</p>	<p>by nature of work.</p>	
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		patient and using the app to support this						Could undermine patient's view of competence, but if it's sufficiently relevant to them personally, happy to talk with them about it.			
								Patients haven't registered negative responses, but it could be that they haven't voiced them			
								Paediatrics - wouldn't necessarily use in front a patient because they may not have capacity to understand why you're			

								<p>using it. And have to be sensitive to parents, who want you to be paying attention to their child. Haven't used in a paediatric setting</p> <p>Other groups of professionals may not feel they can get away with it.</p>			
4 : Interview D4	<p>Leadership is important, and it would definitely influence whether you used it. However, would still have own opinion of efficacy, and as such, may still use it. Other</p>	<p>When a junior, would take senior colleagues views very seriously.</p>			<p>Not actually heard of it happening</p> <p>But if it did, would make you think twice about using</p> <p>As a junior, the effect would</p>	<p>If patient's said it, then you would take it on board. Have spoken to some patients, and generally they were ok as long as they were included in the conversation.</p>		<p>Anaesthetized patients don't really mind...</p> <p>Need to take into account public perception</p> <p>Environment may play a role.</p> <p>Haven't really used much in a clinical</p>	<p>Make you think twice if a consultant objected, but don't know if completely put off if you felt there was benefit to it. Might use it out of their sight. The leadership</p>		<p>In anaesthetics, consultants all use apps.</p>

	people's views would still have an influence though.				probably be stronger			environment, so no examples.	will always have some sort of effect. In anaesthetics, the consultants all use apps, and they seem to encourage their use, so is seen as acceptable		
5 : Interview J1		Believe patients would see junior members of staff as more likely not to use it for work. Would feel more confident in setting norms	When more senior, have more experience and knowledge, and therefore don't need to refer, or feel the need to be so	Everyone seems to carry them all the time. Phones used to contact doctors more than bleeps. Would expect ward leadership	Could be seen as double standards with nurses not being allowed phones on them. Attitudes can change, for instance a consultant might be		Juniors can play a role in introducing novel apps into the environment .	Depends how it's explained to them. Particularly conscious of elderly patients.	Used to get in trouble for having phones on you, but it's changed now. If they didn't want you to use it now, they would tell you.	Can't think of a situation where told not to use it.	In current environment, all the consultants use apps. Not sure of all environments. As such, they kind of expect you to have the info on your phone.

		when in a more senior role.	guideline driven.	team to make their thoughts clear, on current ward it's acceptable. Depends on how it's portrayed or explained (colleagues and patients). Still an assumption that when you're on your phone, that you might be doing personal stuff - phones not part of the medical landscape yet.	against app use until maybe a more junior colleague shows them the utility of a given app. These can be expressed through whether they're actively encouraged.						Used to have to be very careful of having your phone on you, but now not so much.
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				<p>Consultants set the tone, even if they don't discover the app as such.</p> <p>Might bring back ideas from conferences and the like, making certain things more acceptable.</p>							
6 : Interview J2		<p>Feel less confident of using apps in front of people that haven't explicitly or implicitly</p>	<p>Seniors have more knowledge and don't need to refer to as much. Juniors need to</p>				<p>Tend to explain why they're using it. Now, when med studen</p>	<p>Only use the mobile in front of a patient because need to know it there and then, but if it can wait a while, won't use it in front of patients.</p>	<p>Example of being told to put phone away on a ward round by the consultant, but explained afterwards and the</p>		

		said that it is ok to.	refer more at their career stage				ts have their phones out, tend to assume that if they're just having a quick check, that it's for personal stuff, whereas for longer periods, more of an assumption that it's work	Need to explain why using to patients, particularly elderly ones. Also true of colleagues (not the elderly bit)	consultant was fine with it.		
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							related				
7 : Interview J3			<p>Always check information when in doubt</p> <p>Expect to use them differently in future career (in anaesthetics) because they're more widely used there.</p>					<p>Perception that patients will be sceptical, but not had any direct experience of a patient showing discomfort with it.</p> <p>Avoid doing it in front of patients really.</p>	<p>Got "bollocked" a couple of times as a student. Didn't bother trying to explain afterwards.</p>	<p>Sees a colleague using it more, and thinks then that maybe they can use it more.</p> <p>Depends on what your colleagues in the immediate environment are doing.</p> <p>If was enthusiastically recommended an app, then would definitely download.</p>	<p>If senior colleagues recommended, then would use more</p>

<p>8 : Intervi ew J4</p>		<p>Uses regardless of setting if it's the best way of doing a task</p>	<p>Seniors know the guidelines so don't need to refer to apps as much</p> <p>Expects to use them less as career progresses</p>	<p>It's a given that people use their phones in a hospital. Don't know what the org policy is, but seeing consultants using it seems to be an endorsement.</p>				<p>Use in front of patients but always explain when getting it out. Otherwise it would look unprofessional. Particularly with older patients.</p> <p>No one's ever taken issue with it, and never had funny looks or anything.</p> <p>Assumption about older patients is brought in from other settings, like on the bus, and what they say in other settings.</p>	<p>If a senior colleague expressed disapproval, then probably wouldn't use it.</p> <p>Generally though, seniors quite happy for you to use it on the ward round etc. But you do need to be open about why you're using it. Never had a consultant take issue with that in those circumstances.</p> <p>Take a lead from consultants.</p>	<p>Junior doctors more clued up on what apps are good, because they've grown up with them.</p> <p>Also younger colleagues have more need to refer to apps for guidelines.</p>	<p>Senior colleagues need to refer less.</p>
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									Regardless of own views, if a consultant said not to use it, you wouldn't use it, but never had that happen.		
9 : Interview J5			More open to other sources of information when early career, particularly because it's so accessible . Nice to have a safety net. Less requirement as have more familiarity with	Need to be conscious, like in any workplace, that people may assume that phone is being used for personal reasons. Therefore, always feel the need to explain why being used. Could eventually		Never had someone say that a particular app is rubbish that has caused them to stop using it, but has responded to positive recommendations i.e. BNF		Had a patient just commenting that they were on their phone, but then explained why. Tend now to explain why using phone. Unsure of the patient's interpretation. Assumption that more elderly patients would be less familiar.	If a senior says something's good, then that would lead to you doing something about it, equally so if they were negative about it. Applies to things other than medical apps too.	Positive feedback tends to people getting the app in question	

			guidelines etc. Mostly juniors using reference e.g. ignaz.	just become commonpl ace, in which case it will be come the accepted thing.							
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CMO 8

	A : General Limitations of apps	B : Perceived Utility	C : Trustworthiness	D : Usability	E : Technological Knowledge	F : Availability	G : Reasons for choice	H : Types
1 : Interview D1		<p>Non-medical apps useful for speeding and making more accurate judgments in specific situations - basically about computational power at point of care.</p> <p>Useful as a reminder or a check rather than for brand new information</p> <p>Basic belief that ignaz will be useful</p>	<p>Trustworthiness is important. Don't necessarily do a lot to verify trustworthiness, but stick to trusted 'brands'. Assume that the app is as reliable as the paper copy - but paper can be fallible too. When using something very novel, try to check that it tallies with existing methods.</p> <p>Stopped using apps in the past. Sometimes wonder whether some have been updated when they should have been.</p>	<p>Usability important in terms of an app needing to be quick to use to be of benefit.</p> <p>User has some knowledge of what is good and bad in terms of usability, so notices when things aren't right.</p>	<p>Technical knowledge influences views of usability and suitability</p>			

<p>2 : Intervi ew D2</p>		<p>Initial thing that they are useful shortcuts, but information may not be validated.</p> <p>Non-medical app use highlighted (and non-app use). Having info at point of care is the main selling point. Useful for information that is hard to retain/detailed.</p>	<p>Slight anxiety about lack of validation of some apps - lead to stopping use.</p> <p>If believe that an app is validated, would override colleague concerns, but a lack of validation would stop use.</p> <p>Stopped others using apps when noticed inaccuracies.</p> <p>No strict validation, but maintains vigilance i.e. notices that some figures were wrong. Also, informal testing indicated that different inputs gave similar outputs where they shouldn't.</p>	<p>Don't mind if it's a little tricky to use to get the hang of, but ultimately needs to be worth the effort in terms of time saved, and info would need to be accurate and up to date.</p>		<p>Even if the ward computer is available, rarely have the time to look up things on it. Even if it is preferable.</p>	<p>Perceived risk of not checking - for instance when checking a drug dose, if you're quite sure and the margin for error is quite large, then you might not check.</p> <p>Busyness is really important.</p>	
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<p>3 : Intervi ew D3</p>		<p>Useless if there's no useful content</p> <p>Importance of letting potential users know about potential utility, and having authoritative sources reinforcing that</p> <p>One of selling points of ignaz is the localised, relevant information</p>	<p>Wouldn't use Wikipedia as as source of information. Rely on resources that are "trusted".</p> <p>Ability to say app was developed in conjunction with a trust was powerful, as was ability to say it had been developed by end users</p> <p>Powerful to be able to reassure users that had been developed with clinical governance in mind. "Not a cowboy outfit", within a trust structure and with authoritative backing</p>	<p>Importance of user experience and functionality.</p> <p>Not much you can do a mobile phone in terms of functionality that you can't do elsewhere</p> <p>Some websites not designed for mobile use - important to take that into account in terms of usability</p>	<p>Advocate for the app</p> <p>Some are early adopters, some take as a point of pride that not up on tech or with the latest smartphone</p>	<p>Resources not always available (or not consulted) in front of the patient</p> <p>Use information available at the time to justify a decision, but many of the printed sources risk being out of date</p> <p>Don't like having to rely on something being open in order to access the resource</p> <p>Sometimes have to use workarounds to get the required information i.e. not the mobile site</p>	<p>Printed materials can be out of date, but prior to app, sometimes they were the only resource available</p> <p>App preferable to website as don't need to rely on internet connection</p> <p>Not having to rely on accessibility of other resources</p> <p>Depends on task and location i.e. ward - what is quickest under what circumstance</p> <p>Ward computers not always accessible because of shared logins</p> <p>If know where to</p>	<p>Availability of ward computers is difficult</p> <p>Some websites not optimised for mobiles</p>
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							<p>get the info online, phone might be quickest(not necessarily an app though)</p> <p>Some resources not easy to access on a mobile</p>	
4 : Interview D4		<p>Aim behind introducing it is around information at point of care. Important to make the information fully available, i.e. not reliant on internet connection</p>	<p>Information needs to be trustworthy.</p> <p>Accreditation is a tricky issue - seems to have been shielded away from. Current rating systems are pretty limited, and it needs addressing. But also need to balance with a system that won't stifle app development.</p>	<p>Would probably go off an app if it was difficult to use, and use alternatives, and might be difficult to get the users back. Failure to deliver on expectations.</p>	<p>Don't use other medical apps, but possesses the technological knowhow.</p> <p>When rolling out, being on hand to help people with less tech savviness helps with initial adoption. Particularly true of older medical staff.</p>		<p>Amount of time available, compared to speed of finding the information out.</p> <p>Hard to use other sources such as switchboard because it's hard to get through (particularly at peak times)</p> <p>Put off by usability issues or "buggyness". Has information that can be accessed elsewhere.</p>	

<p>5 : Intervi ew J1</p>		<p>Useful due to speed in comparison to paper sources i.e. BNF</p>	<p>Has some concerns about whether guidelines are correct, but gets around this by making sure they use apps from reputable sources.</p>	<p>Would try and learn to use it if they thought it was going to be useful, but only if they thought it would save time. Also makes the point that needs ultimately to be simple to use as well as putting things in your hand.</p>	<p>Not particularly good with technology (self-described), and gets help from partner when using apps.</p> <p>Other colleagues have the apps anyway.</p> <p>No strong incentive to download unless in specific specialties, and is partly driven by expectation of future need.</p>	<p>Have the option of using the COW on that particular ward but often use the phone</p>	<p>More efficient than hunting around the ward for a book</p> <p>When appropriate app not available, have just used internet, or intranet.</p> <p>When don't know a colleague, first instinct is to ask them for info rather than using own phone</p> <p>However, phone is much easier than carrying multiple books around</p> <p>If you've got more time and space, using a computer is more comfortable, but if you're busy,</p>	<p>Can often ask a more senior colleague (SHO or reg)</p>
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							use the phone if you can.	
6 : Intervi ew J2		<p>Useful when you need to know something at that second, whether it's just general management or an emergency.</p> <p>Beneficial in that can know whether it's up to date or not.</p> <p>Minor problems with reliability can be overlooked if it can be fixed and the app is useful.</p> <p>Cost can prevent some useful resources being utilised - especially stuff that didn't cost at a different point in one's career because it had</p>	<p>Only uses apps from reputable sources. Would use some that have been recommended by senior colleagues. Wouldn't use apps that weren't tried and tested.</p> <p>Upside of apps is that the good ones are updated regularly, so enhances trustworthiness - perhaps over other sources?</p> <p>Would question something that hadn't been updated in a decent length of time i.e. a year.</p>	<p>Had problems with an app that kept crashing, but simply reinstalled it - it was a good app. Minor niggles are fine, but bigger issues would prevent full adoption.</p>		<p>Type of information available on the intranet is local to the trust - not always the case with apps - so the specific information is not available</p>	<p>Know that can access the most appropriate information on a computer</p> <p>Apps tend to be quicker to access because of the search functions available.</p>	

		been provided already.						
7 : Interview J3		Useful in particular specialties for specific purposes i.e. anaesthetics for calculating drug doses	Rarely come across untrustworthy apps, but don't use many and only use previously trusted ones. Limited knowledge of unsafe apps and would like to be recommended some good apps.	If it's something that is useful and desirable to use often, then would figure out how to use it.	Not very good with apps Not in the habit of keeping up to date on itunes so keep forgetting password - makes it more hassle Lack of familiarity with phone as opposed to computer - feel that increased use would make it easier Practical technology barriers - wifi, remembering passwords	When phone not available, would use internet, or try and find a book. Problem with carrying a book around is that it's bulky and easy to leave somewhere. If phone not available, may also ask someone	Can't keep book with at all times Always check info when unsure, particularly where one knows it matters Find the computer easier to use, but sure that phone would be easier to use if used it more. Know others that use phone more.	
8 : Interview J4	Limited in the information that they can provide Internet in general can be better for some	Use as a reference from time to time How it looks and description, professionalism -	Goes with ones that the brand is known Uses other ones that are for other trusts, but with	Search functions particularly useful Poorly designed apps not used i.e. Clip Clinica		Phone is there and available, so if the app is easy and quick to use, will use it.	Best way for particular tasks.	Computer if phone not available

	specific information Not good for long guidelines	tied to trustworthiness in some ways	caution Avoids non-UK apps as aware that different. Lots of little judgments without being conscious of- how it looks, ease of use, professionalism	Usability important to utility Having to repeatedly enter passwords whenever it is used can be tiresome.				
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<p>9 : Interview J5</p>	<p>Easier to look at multiple resources on a computer than a phone screen</p> <p>App isn't necessarily a definitive resource. Not great for text heavy info.</p> <p>Better when dealing with less in depth information, and when not trying to do too much. Not realistic to expect an app to do too much.</p>	<p>When searching for apps on the app store, look for ones that seem useful. Look at how rated, description of what it does, or recommendation s from others.</p> <p>Needs to not be trying to do too much, easy to use, and better for specific info/functions - multifunctional not overly useful.</p> <p>Perceived utility would potentially outweigh issues with usability, but usability is integral to the actual utility</p> <p>Ignaz potentially useful</p>	<p>Tend to rely on known textbooks etc as a sign of trustworthiness - sources or names that are already trusted</p>	<p>If you're not used to it, can be harder to use and ultimately frustrating</p> <p>Not great generally for looking through very text heavy material</p> <p>Is very important - is part of the point of an app existing</p> <p>Has been put off a particular app in the past because it was too "in depth"</p>		<p>Phone screen not ideal</p>	<p>If the info needed was on the phone, and it was a well designed app, would probably use it for convenience.</p>	
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CMO 9

	A : Implementati on	B : Organisa tional Level Contexts	C : Organisational Norms	D : Organisational Policy	E : Availability	F : Availability of other information sources	G : Finding out about apps	H : Use of App - Mechanisms	I : Use of App - Outcomes
1 : Interview D1	<p>Intended to make it available to as many people as possible. Need to take account of how receiving organisations want to use it. and what info they want to put on there.</p> <p>Nobody doubts the place of computers in the work area - not trying to reinvent the wheel</p>		<p>If it becomes the norm to use phones for communication purposes, becomes more likely that they are accepted.</p> <p>Highlights divide between doctors and nurses - nurses not allowed their phones on the wards, whereas doctors need to be contacted. In part influenced by doctor's need to move between wards and nurses tending to be based on a single ward.</p> <p>Generally low resistance to docs</p>	<p>Not issued with a bleep, so expectation is that phones carried with them.</p> <p>Roll out influenced by how receiving organisations want to use it - implies that they have responsibility to remove barriers.</p> <p>Unclear on whether there is a policy, but this may be because of a lack of clear communication of what the</p>		<p>1When have the option, would use a screen for large blocks of prose</p>		<p>Allows one to access info that would otherwise have to keep in head. Means that don't have to get anyone else to do it, or find another way to do it.</p>	

			having phones with them.	policy is. Likens it to a dress code - as much about norms as official policy.					
2 : Interview D2	No-one ever quite as aware as you think they are about the availability of these things. No matter how much you're told that people are sick of hearing about these things, there are still people that don't know.				Even if the ward computer is available, rarely have the time to look up things on it. Even if it is preferable.	Can be hard to locate a spare computer, and then time consuming to locate information on the intranet. Can use books, but can be quite hard to find, and may not be fully up to date (depending on version). Some sites available, but wikipedia and google may not be that reliable - have to use judgment to assess whether it's a good source.	Emails from an IT department don't work - Juniors don't particularly read through them. Needs leadership from the top, and a real clinical need. That need changes depending on your clinical group. Junior doctors discover apps themselves and share it with you. Sometimes seek out apps on the app	Makes it easier having info at the touch of a button, rather than having to access info from a computer that could take ages to find or wait for Eases frustrations being able to do it then and there - otherwise it might not be done at all because can't get around to it due to tiredness or busyness Emails from IT don't work- junior docs don't particularly read email. Needs leadership from the top, seniors using it, pressure from	Eases frustration being able to check it then and there, rather than not having the time to double check later on

						<p>Can seek info from other specialists or senior colleagues.</p> <p>Need to assess risk of not checking at all - some decisions lower risk.</p>	<p>store if there's a clinical need to do something unfamiliar</p>	<p>below. There actually being a need for it. Need changes depending what level/group you're in.</p>	
3 : Interview D3	<p>Three orgs rolled out differently. One didn't advertise it and the uptake has been low. Another went through medical education channel and targeted at FY, and no engagement with other colleagues. Third rolled it out through</p>			<p>Follow national rather than organisational policy because know it's evidence-based</p> <p>Antibiotic stewardship very much on an organisational basis</p> <p>Different organisations gone about roll out in different ways with differing results</p>	<p>Resources not always available (or not consulted) in front of the patient</p> <p>Use information available at the time to justify a decision, but many of the printed sources risk being out of date</p>	<p>Not necessarily a replacement, but an alternative or complementary. One that is cheaper for the trusts involved.</p> <p>Even when asking other people, they won't necessarily know the answer</p> <p>Can be labour intensive/a long process to find</p>	<p>Usually find out from other people, whether because someone's using it or is aware of functionality. Sometimes search for something with a particular functionality.</p>		<p>Haven't measured outcomes of ignaz</p>

<p>induction for all new starters, and with support from infection prevention team. So people knew it was available and had trusted information and had good uptake.</p> <p>Implementation not done as well as would have liked, not really worked with comms teams. Although been a blessing because of the teething problems.</p> <p>Planning on giving trusts a communicatio</p>				<p>Don't like having to rely on something being open in order to access the resource</p> <p>Sometimes have to use workarounds to get the required information i.e. not the mobile site</p>	<p>the person who knows</p> <p>Lots of other resources used by people, but often used away from the patient</p> <p>In A&E for instance, lots of other people use ward computers for input, so not available to look up info</p> <p>Login practices mean that can't always access ward computers anyway</p>			
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	n package to support launch								
4 : Interview D4	Multi-strategy approach to rollout - speaking to people directly, being available for individuals, and going around individual departments. Didn't get around all departments, but found that higher uptake in the ones that got to, because people were able to ask questions. Particularly true of older staff, who had less experience of apps.					<p>App as a quicker alternative than phonelines/swit chboard or intranet.</p> <p>Believe people can access info more quickly on that than the intranet, but needs verifying</p> <p>Sometimes need the actual guideline, so team knowledge is not enough.</p> <p>Familiarity with a screen etc. may encourage people to use that.</p>			

5 : Interview J1					Have the option of using the COW on that particular ward but often use the phone	Not easier using a book, so would choose to use phones. May depend on who you're working with - can be easier just to ask a colleague if you know them.	A list from the hospital would be good, because would know that they've all been ok'd. Better still if when you went to a new area, consultant told you what apps were useful, then you would know they're being backed, and you're more inclined to download them because you they're really useful.		
6 : Interview J2					Type of information available on the intranet is local to the trust - not always	Particularly useful if you're on your own e.g. on nights Some other resources are		Useful for getting on the spot information of certain types - going to find a book or internet search, that's a delay. But	

					the case with apps - so the specific information is not available	really useful, and Oxford handbooks are on some of the trolleys. However, apps are quicker.		if you've got the phone in your pocket, can just get info then. As long as it's safe, it's fine. Can trust things like the BNF app. Means you can act quickly, particularly when you're on your own e.g. nights, starting off the treatment rather than waiting for seniors.	
7 : Interview J3	If you got an email you could look at it at leisure, but may never get around to it. Personal touch harder to arrange, but if someone recommended an app, would probably get				When phone not available, would use internet, or try and find a book. Problem with carrying a book around is that it's bulky and easy to leave somewhere.	Books aren't available often	Medical school let them know about apps, suggested some and put some on the iPhone. Some of them need licenses. Don't really use the iPhone store to search for apps, but not		

	around to downloading it.				If phone not available, may also ask someone		averse to the idea.		
8 : Interview J4			Normal for phones to be used in a hospital Consultants have more latitude than juniors Senior colleagues set the tone of what is acceptable and what isn't	Unaware of any particular policies	Phone is there and available, so if the app is easy and quick to use, will use it.	Other trusted sources for particular things e.g. electrolyte imbalances on the intranet Tend to ask the senior if they're there. They have the scope to act outside of guidelines where appropriate.	Mostly through word of mouth, but can look on app store. Junior docs more clued up on which apps are good than the seniors. Tend to be people that have grown up with apps, and have are inexperienced enough to find them useful. Seniors don't tend to need to refer to guidelines as often	Use BNF app rather than paper version	
9 : Interview J5	Ignaz mentioned at the start of the year, and		If someone senior says it's good, more likely to use it.	Only policy that aware of is that not supposed to use in A & E.	Phone screen not ideal	Portability of app makes it easier to use between wards.	Told about them by the university. Otherwise not		

	seems a useful resource, but not really mentioned much since.		Similar for anything really.	And sometimes used it discreetly anyway if the need arose.		Internet easier for multiple information sources, so use computer for that kind of thing. When other people are around, less likely to use	that widespread. Will look up stuff on the app store - lots of them on the app store, some of which wouldn't have thought of. When hear something positive about an app, will proactively look it up and download.		
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CMO 10 - Confidence

	A : Confidence	B : In own clinical judgement in light of others	C : Less need to refer to app	D : Technological Knowledge	E : Carrying a mobile	F : Technological issues	G : Testing out apps
1 : Interview D1	As a junior, you'd be more likely to be influenced by the opinions of senior colleagues and patients. Or even just your perceptions of their opinions.			Technical knowledge influences views of usability and suitability			Tally with what is already known If heard about one, tend to download at home where have a wifi connection, have a play around with it and see whether you think it will be helpful, but not with a specific perception of must check before use. Really using to see if it will be helpful, and do that at home.
2 : Interview D2	Helps to build your confidence because of the safety net of having the information available. When you're tired/less confident, more likely to rely				As a girl, often don't have pockets so don't have mobile phone on me.		Found an app that didn't seem to be trustworthy - put in different parameters and came out with the same answer, and knew this shouldn't happen.

	<p>on guidelines than your own clinical judgement So can be down to how feeling on the day (trait vs mood)</p> <p>Gives confidence to challenge others due to safety net</p> <p>Confidence to use despite what other people think, if believe it to have utility. Would be discreet about it though.</p> <p>Don't rely on them so much because more confidence in clinical judgement</p>						<p>Don't spend a lot of time familiarizing with apps, generally they're quite easy to use. Otherwise don't really bother with the app.</p>
3 : Interview D3	<p>Sees self as advocate for apps.</p> <p>Relatively senior in their specialty, and no qualms in using apps in front of others</p>	<p>Confidence to explain to the patient and have a conversation about why they're using the app</p> <p>Personality trait - has to be able to</p>		<p>Advocate for the app</p> <p>Some are early adopters, some take as a point of pride that not up on tech or with the latest smartphone</p>		<p>Teething problems with ignaz, first part of the year has been about developing to the capability that hoped it would reach in the first place.</p>	

		<p>justify why doing something, and willing to point out if they think someone's doing something wrong</p> <p>Personal responsibility for patient - advocacy - even when not primary carer</p> <p>Clear identification with doing the right thing for the patient and using the app to support this</p>				<p>If an app has unique functionality, would try to work around the technical issues.</p> <p>Some people don't have smartphones</p> <p>Creating content on an app can be quite time consuming, but once it's done, it's just a matter of keeping it updated</p> <p>People need to be informed as to how to obtain an app</p> <p>Small user base has been helpful because there have been problems with app functionality</p>	
4 : Interview D4	<p>Leadership is important, and it would definitely influence whether you used it. However, would still have own opinion of efficacy, and as</p>	<p>When a junior, would take senior colleagues views very seriously.</p>		<p>Don't use other medical apps, but possesses the technological knowhow.</p> <p>When rolling out, being on hand to</p>		<p>If it's cached data, don't need a connection. But if in a communication blackspot, should still be able to use it. So needing to access a connection would</p>	<p>People don't really test out the validity of apps, or are unaware that the info might be invalid</p> <p>There are sites where users have</p>

	such, may still use it. Other people's views would still have an influence though.			help people with less tech savviness helps with initial adoption. Particularly true of older medical staff.		be problematic - having local data gets around that limitation. Would probably be less likely to use an app with technical issues, backed up by users' experience with ignaz. It's put people off using it altogether. May be different if it had unique functionality	rubber stamped apps, but not sure how much they can be trusted because don't necessarily know the process used. E.g. NHS choices. Self validation not great, probably need to do an RCT or something. People tend to base it on what others have said to them, and their own experiences. Had issues with some other apps where don't trust the information in them.
5 : Interview w J1		Believe patients would see junior members of staff as more likely not to use it for work. Would feel more confident in setting norms when in a more senior role.	When more senior, have more experience and knowledge, and therefore don't need to refer, or feel the need to be so guideline driven.	Not particularly good with technology (self-described), and gets help from partner when using apps. Other colleagues have the apps anyway.	Used to be told off for having your phone on the ward. It was useful for finding stuff out, but used to use it surreptitiously because could get in trouble.		Standard ones given out by the uni. If on a train for a long time, would go through and use them, and see if it seemed useful, deleting the ones that didn't seem to work well.

				No strong incentive to download unless in specific specialties, and is partly driven by expectation of future need.			Would be a worry if the guidelines on an app weren't right, so tend to just go for ones from reputable sources. e.g. Heart Foundation
6 : Interview w J2		Feel less confident of using apps in front of people that haven't explicitly or implicitly said that it is ok to.	Seniors have more knowledge and don't need to refer to as much. Juniors need to refer more at their career stage			Used them more as a med student when had an iPhone. Previous phone wasn't that quick, so some things would run really slowly, so didn't use them much in the previous year. But now have a better phone, so use them more.	Just wouldn't trust an app unless you knew it was from correct sources
7 : Interview w J3			Always check information when in doubt Expect to use them differently in future career (in anaesthetics) because they're more widely used there.	Not very good with apps Not in the habit of keeping up to date on itunes so keep forgetting password - makes it more hassle Lack of familiarity with phone as	MOre likely to have your phone in your pocket than books on you Is a problem for girls when don't have pockets - when wearing scrubs, wear trousers for that reason. Consultants have a	Keep forgetting iTunes password, so that's a practical difficulty when trying to get hold of apps Need to remember when have wifi to find and put apps on the phone. And whenever get a new	

				<p>opposed to computer - feel that increased use would make it easier</p> <p>Practical technology barriers - wifi, remembering passwords</p>	<p>band to carry a phone in, but a bit pretentious for an F1.</p>	<p>phone, having to remember iTunes password. That and knowing which ones to use.</p> <p>Current phone not a barrier, seems to be good enough.</p>	
8 : Interview J4		<p>Uses regardless of setting if it's the best way of doing a task</p>	<p>Seniors know the guidelines so don't need to refer to apps as much</p> <p>Expects to use them less as career progresses</p>		<p>It's not that apps are better intrinsically, but that always have a phone on me</p>		<p>Look at the blurb, avoid american ones, download it and have run through to see if it's useful. If it seems it, would keep hold of it. Then try it out at work, is quite trial and error, just get a feel for it.</p>
9 : Interview J5			<p>More open to other sources of information when early career, particularly because it's so accessible. Nice to have a safety net. Less requirement as have more familiarity with guidelines etc.</p>		<p>Proximity and transportability of a phone make it useful, can use it between wards. Can be helpful at point of care. Doesn't mean wouldn't use a computer.</p>		<p>Have to go off reviews, summary of what it does, or what other people have said. You don't really know how good it is, unlike a book which you can flick through.</p> <p>ONce downloaded, would have a quick</p>

			Mostly juniors using reference e.g. ignaz.				look at it, look at the interface and how you could use it. Would then only use it if it cropped up.
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CMO 11

	A : General Limitations of apps	B : Availability of other information sources	C : Busyness of environment	D : Specialism
1 : Interview D1		<p>1When have the option, would use a screen for large blocks of prose</p>	<p>Whilst using a computer screen may be preferable, can have a knock on effect on queues to use the machine for people that don't have an option.</p> <p>Don't have the luxury of time to read reams of pages</p> <p>Check for info less at busy times generally</p>	<p>Not really used too much in their specialism, but some calculator type apps may be useful in other areas</p>
2 : Interview D2		<p>Can be hard to locate a spare computer, and then time consuming to locate information on the intranet.</p> <p>Can use books, but can be quite hard to find, and may not be fully up to date (depending on version).</p> <p>Some sites available, but wikipedia and google may not be that reliable - have to use judgment to assess whether it's a good source.</p> <p>Can seek info from other specialists or senior colleagues.</p>	<p>Prefer to use ward computer if there is the time, but rarely the case</p> <p>App handy in time-pressured situations.</p>	<p>Know their own specialism well, so don't usually need to look it up and don't have a phone app. If really need to look something up, will use a computer.</p>

		Need to assess risk of not checking at all - some decisions lower risk.		
3 : Interview D3		<p>Not necessarily a replacement, but an alternative or complementary. One that is cheaper for the trusts involved.</p> <p>Even when asking other people, they won't necessarily know the answer</p> <p>Can be labour intensive/a long process to find the person who knows</p> <p>Lots of other resources used by people, but often used away from the patient</p> <p>In A&E for instance, lots of other people use ward computers for input, so not available to look up info</p> <p>Login practices mean that can't always access ward computers anyway</p>	<p>Lots of other people using shared resources such as ward computers when ward is busy</p> <p>Different circumstances vary how easy it is undertake a particular task</p>	<p>In particular specialism, some patients unconscious, so negates the impact of their views of apps</p> <p>Relative seniority in their own specialism</p> <p>Certain environments (which might be more associated with specific specialties) might alter the availability of other information sources</p>
4 : Interview D4		<p>App as an quicker alternative than phonelines/switchboard or intranet.</p> <p>Believe people can access info more quickly on that than the intranet,</p>	<p>Sometimes it may be too busy to get your phone out, but counterargument is that when information needs to be checked, really need to do something.</p>	<p>Popular in anaesthetics. May in part be due to culture, or types of available. May also be to do with the fact that patients are unlikely to object due to their being asleep.</p>

		<p>but needs verifying</p> <p>Sometimes need the actual guideline, so team knowledge is not enough.</p> <p>Familiarity with a screen etc. may encourage people to use that.</p>	<p>Quite often in busy environments, other sources aren't available either i.e. ward computers.</p> <p>If it's quiet, some people will prefer to access a screen.</p>	<p>In particular specialties, no stigma at all. But again, may be due to the patients being less aware of what's going on, so lower impact of patient perceptions.</p>
<p>5 : Interview J1</p>		<p>Not easier using a book, so would choose to use phones.</p> <p>May depend on who you're working with - can be easier just to ask a colleague if you know them.</p>	<p>Prefer to use a computer if you've got the time, but phone is convenient because you can use it on the move.</p>	<p>Can depend on the behaviour of consultants - some wards, all of the consultants use them.</p> <p>Anaesthetics just love apps, on board with the technology side of things.</p> <p>Don't think there'd be time in surgery. More time on medical ward rounds because you have longer to spend with each patient.</p> <p>Be good if there was a list of apps for each specialty.</p>

<p>6 : Interview J2</p>		<p>Particularly useful if you're on your own e.g. on nights</p> <p>Some other resources are really useful, and Oxford handbooks are on some of the trolleys. However, apps are quicker.</p>		<p>In vascular, they have a COW so that makes it quite easy.</p> <p>Less time in surgery than medical, so don't go as far in depth.</p>
<p>7 : Interview J3</p>		<p>Books aren't available often</p>	<p>On calls really busy. covering lots of places, so app is useful.</p> <p>Find the BNF on the computer easier to use than the phone.</p>	<p>Not really useful for surgeons - ward rounds are too quick.</p> <p>Anaesthetists often use them, as an example, so perhaps specialism does make a difference.</p>
<p>8 : Interview J4</p>	<p>Limited in the information that they can provide</p> <p>Internet in general can be better for some specific information</p> <p>Not good for long guidelines</p>	<p>Other trusted sources for particular things e.g. electrolyte imbalances on the intranet</p> <p>Tend to ask the senior if they're there. They have the scope to act outside of guidelines where appropriate.</p>	<p>Doesn't affect whether it would be used or not - best tool for the task would be used.</p>	<p>No big difference between surgery and medicine, except wouldn't get phone out in theatre</p>

<p>9 : Interview J5</p>	<p>Easier to look at multiple resources on a computer than a phone screen</p> <p>App isn't necessarily a definitive resource. Not great for text heavy info.</p> <p>Better when dealing with less in depth information, and when not trying to do too much. Not realistic to expect an app to do too much.</p>	<p>Portability of app makes it easier to use between wards.</p> <p>Internet easier for multiple information sources, so use computer for that kind of thing.</p> <p>When other people are around, less likely to use</p>		<p>Go into depth more in medicine, so more likely to look stuff up and check it.</p>
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Appendix 3 - Example Observation Template Write Up

Observation Number: 14
Date and Time: 21/09/2015 2000
Specialty: AMU
Participant Information: F2
Background Information: Late shift, on call cover on this ward. Current specialism is Ward 6
Observation Data: 2005 – Handover room. One doctor explaining handover cases to another, who is writing down notes. Someone's bleeps goes, appears to be a test bleep. Another doctor comes in and explains other available cover. 2 doctors handing over to 3. Appears to be first night shift for a few, some discussions about the quality of staff they'll be working with. 2011 – Finished handover, walk to main ward and go to nurses station. Talking to nurse, six doctors and a sister at the station. Talking to nurse about workload, and doctors divvying up workload between them. Sits down at computer and looks up guidelines on intranet. Discussing case with other doctors. One of the doctors asks whether UP2DATE is on the computer – no time to answer. Other doc asks about a particular computer. Doctor puts smartcard into computer, looks up patient. Then logs into another computer which has lists of patients. Asks a sister where a patient from the notes is on the ward. Another doc asks about another patient. Goes to get notes from another bay and gets a form. Sits at station. Updating notes onto another sheet. 2022 – Looking through notes. Logs into another system, looks at test results. Now discussing with another doctor. Checking to see if a test has come back. Tries ringing and doesn't get through. Doctor explains what test they're waiting for. Puts notes back in folder and takes folder back to where they got it. Goes back to computer w/ patient spreadsheet, takes two off. Quick general conversation with another doctor. Briefly pop to nurses station on other ward, go to other handover room after getting notes. Puts stickers on new notes pages, now reading through notes on the clerking form. Another patient's notes are mixed in. 2034 – Logs into system. Trying to log into ICE – looks at blood test results, and looks at CT scan report. Nothing abnormal. Uses smartcard to look on GP records. Puts sticker on notes, fills in top of notes form and heads back to original ward.

2040 – briefly goes to get something out of bag in locker room. When comes back doc answers red phone which is ringing (casualty referrals). Takes down details on preform. Finishes on phone. Discusses another case with another doc – giving some advice. Three doctors, a sister and a nurse at the station. Telling other docs about a case she has, talking about lack of clarity of care pathways. Gives mixed up notes to sister and other notes to another nurse. Adds casualty notes to board whilst telling sister about the cases. Ringing reg to ask if patient can stay in cos family are not comfortable with her going home. Looking on computer, can't find what she's looking for. Quickly checks with sister to see if beds available – there aren't. Hangs up phone. Now ringing referring reg to see what can be done 2055. Another doc asks for opinion on scan. Compare earlier and current scans, now looking at notes for that patients. Further discussion ensues. Returns to putting patient on board. Goes back to other ward, and tells sister about patient that's just been admitted. Goes in w/ patient for who she was looking at notes 2100. Patient recounts history, doc asks questions to clarify. Asks lots of questions about history. Leaves cubicle and goes to get equipment for physical exam – searches both wards 2115. Finds reg and discusses, asking for advice. Asks about a particular drug. Someone comes by having got equipment needed. Goes back in room patient to do physical exam. Asking about pain rating. Explain outcome of physical exam to patient. Comes out. 2130 – Discusses further with reg. Goes back to original ward. Sister asks about casualty referral, doc explains situation. Another doctor asks for advice. She tells them to look in BNF, but can't locate it. Other doc goes to look for it. Continues discussion with sister. Now sits at computer and logs into ICE, gets patient number off sister. Rings to bleep another doc. Updates paper notes. Sister asks doc to do another task – doctor notes down to do it on another piece of paper. Phone rings, continues to document. Reg comes over to have a quick chat. Other doc comes back, still can't find BNF. Takes phone call from another doc. Another doc comes and asks doc to do something. Somoen asks for x-ray contacts. Other doc comes back, has found info from somewhere. Doc continues on notes. Gets asked about casualty referral by doc that's coming to see her. Now updating drug chard. Logs back in using smart card. Discussing processual issue. Getting drug history off system. Sister tells about another case
Observation concludes at 10pm...

Other useful information: Quick comment – glad not on ward cover, much more manic. Much more support when on MAU. Doctor trained at another medical school to the local one. Has friends that do use apps, but find that it's just easier to use a computer because there are loads around.

Appendix 4 – Survey Questionnaire

Doctor's Use of Medical Smartphone

Apps

This questionnaire asks about your views on the use of mobile smartphone applications or 'apps' in healthcare with particular reference to your role as a doctor. The information that you provide in this questionnaire will help to identify current patterns of use and also some of the factors that affect the use of apps by doctors. The findings from this study will be published in a PhD thesis, and may be used to inform policy on app use and also to inform the future development and roll out of apps in healthcare. This study has been approved by the University of Leeds IPS Research Ethics Committee (ref no: 15-0124; date approved: 24-Apr-2015).

Your answers are important. Any information you provide will not be shared with anyone and your responses will be confidential. Please complete each question, your opinions are important. The questionnaire should take no longer than 5 minutes to complete. Please return your questionnaire to Dharsh Jayewardene (PhD Student) in the addressed envelope provided. Further information about this study can be found in the attached information sheet.

About You

Q1. Role/Career Stage Foundation Registrar
Consultant

Q2. Length of time since receiving medical degree _____ Years _____
Months

Q3. Length of time in current specialty _____ Years _____
Months

Q4. Current Specialty -

Q5. Would you describe your role as:

Mainly based in one ward Yes No

Based in more than ward within a single specialty Yes No

Based across numerous wards across multiple specialties Yes No

Q6. Please list in the space below the main wards you work in:

Your Current Use

Q7. Do you use medical smartphone apps in your practice? Yes No

Q8. If yes, how often do you use the following different types of medical smartphone applications to inform your practice?

	At Least Daily	Most Days	Once Per Week	Once Per Month	Less than Once per Month	Never
a)Text book/Guidelines/Formulary	1	2	3	4	5	6
b) Research	1	2	3	4	5	6
c) Clinical Decision Tool/Clinical Calculator	1	2	3	4	5	6
d) Learning Logbook/Educational Tool	1	2	3	4	5	6

e) Patient records	1	2	3	4	5	6
f) Ignaz	1	2	3	4	5	6
g) Other	1	2	3	4	5	6
h) Please list any apps you use :						

Your Views on Apps

Q 9. Please indicate the extent to which you agree with the following statements, by circling one of the seven alternatives (where **1 = Strongly Disagree** and **7 = Strongly Agree**).

a) Using mobile smartphone apps improves my performance in my job	1	2	3	4	5	6	7
b) Using mobile smartphone apps increases my productivity	1	2	3	4	5	6	7
c) Using mobile smartphone apps enhances my effectiveness in my job	1	2	3	4	5	6	7
d) I find mobile smartphone apps useful in my job	1	2	3	4	5	6	7
e) I find mobile smartphone apps to be easy to use	1	2	3	4	5	6	7
f) I find it easy to get mobile smartphone apps to do what I want to do	1	2	3	4	5	6	7
g) I am comfortable downloading and using apps on my phone for use in my role	1	2	3	4	5	6	7

Using Apps in the Workplace

Q10. Please indicate the extent to which you agree with the following statements, by circling one of the seven alternatives (where **1 = strongly disagree** and **7 = strongly agree**).

a) I rarely need to refer to any information sources when treating patients	1	2	3	4	5	6	7
b) Given the choice, I would use other sources of information (i.e. colleagues, textbooks or ward computers) rather than referring to a mobile smartphone app at point of care	1	2	3	4	5	6	7
c) A ward computer or Computer-On-Wheels is generally available at or near the point of care should I need to look up any information	1	2	3	4	5	6	7
d) I draw on the resources I need to make decisions purely based on the needs of the patient, rather than the needs of where I am working or who I am working with	1	2	3	4	5	6	7
e) The views of senior colleagues within my specialty do not influence my use of mobile smartphone apps at the point of care	1	2	3	4	5	6	7
f) Senior colleagues within my specialty generally encourage the use of mobile smartphone apps at the point of care	1	2	3	4	5	6	7
g) Many senior colleagues within my specialty use smartphone apps	1	2	3	4	5	6	7
h) The views of senior colleagues outside of my specialty do not influence my use of mobile smartphone apps at the point of care	1	2	3	4	5	6	7
i) Senior colleagues outside of my specialty generally encourage the use of mobile smartphone apps at the point of care	1	2	3	4	5	6	7
j) Many senior colleagues outside of my specialty use smartphone apps	1	2	3	4	5	6	7
k) The views of peers do not influence my use of mobile smartphone apps	1	2	3	4	5	6	7
l) Many of my peers use mobile smartphone apps at the point of care	1	2	3	4	5	6	7
m) I feel comfortable using mobile smartphone apps in front of patients	1	2	3	4	5	6	7
n) A patient's view of mobile smartphone apps does not affect my decision to use an app (although I may explain why I am using it)	1	2	3	4	5	6	7

Q11. If you have any comments about this questionnaire or the use of mobile smartphone applications in general, then please write them below:

Please return your questionnaire to Dharsh Jayewardene in the envelope provided

Thank you for your participation

Would you be willing to be contacted by Dharsh Jayewardene about another study exploring the use of mobile smartphone apps in clinical practice? Ticking "Yes" does not oblige you to take part in subsequent studies.

Yes No

If Yes, please provide details on which you may be contacted below:

Name
(optional): _____

Email address and/or phone
number: _____