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Examining the infusion of mobile technology by healthcare practitioners in a hospital setting

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Abstract While mobile Health (mHealth) holds much potential, the infusion of mHealth is still in its infancy and has yet to achieve sufficient attention in the Information Systems field. As a result, the objective of this paper is to identify the (a) determinants for successful infusion of mHealth by healthcare practitioners and (b) benefits healthcare practitioners perceive from infusing mHealth. A sequential mixed methods approach (case study and survey) is employed to achieve this objective. The study contributes to IS theory and practice by: (1) developing a model with six determinants (Availability, Self-Efficacy, Time-Criticality, Habit, Technology Trust, and Task Behaviour) and three individual performance-related benefits associated with mHealth infusion (Effectiveness, Efficiency, and Learning), (2) exploring undocumented determinants and relationships, (3) identifying conditions that both healthcare practitioners and organisations can employ to assist with mHealth infusion and (4) informing healthcare organisations and vendors as to the performance of mHealth in post-adoptive scenarios.

Keywords mHealth · Infusion · Post-adoption

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1 Introduction

The use of mobile technology in organisations has grown rapidly in the last decade. It is argued (Choi et al. 2016) that many healthcare organisations are spending vast sums of money implementing mobile health technologies (mHealth) with the expectation that users will employ the system to enhance individual performance (Devaraj and Kohli 2000; Ang et al. 2014). However, in many cases such systems are implemented without fully understanding if the proposed benefits for healthcare practitioners are realised (Black et al. 2011; Nair and Bhaskaran 2014). Many researchers (Anglada-Martinez et al. 2015; Franz-Vasdeki et al. 2015; Gagnon et al. 2016; Hamine et al. 2015; Turner et al. 2015) have documented the application of mobile technologies in a healthcare domain. However, a review of this literature revealed that these 'success' studies were primarily conducted at early stages of IT implementation. What began to emerge in the literature were studies (Cavus and Munyavi 2015; Chiu and Eysenbach 2010; Dehzad et al. 2014; Muessig et al. 2013; Nair and Bhaskaran 2014; Owen et al. 2015; Sundin et al. 2016; Tu 2015) pertaining to mHealth failure, albeit not explicitly utilising the term 'failure'.

The common argument across these studies was that mHealth often falls short of perceived expectations following adoption, thus resulting in under-utilisation and in certain cases, abandonment (Dehzad et al. 2014; Neupane et al. 2014). For the context of this study, mHealth refers to "handheld mobile device and clinical application(s) run on the device by healthcare practitioners, in a medical domain, for communication and clinical purposes" (adapted from Jarvenpaa and Lang (2005). MHealth initiatives are often implemented across varying levels of the healthcare service, namely; primary, secondary, and tertiary care (Nimkar 2016). While mHealth-related research has been examined across all three healthcare service levels, there remains few reference implementations of mHealth initiatives in a hospital setting (i.e. secondary/tertiary care) (Labrique et al. 2013; Sundin et al. 2016) thus, resulting in little empirical evidence surrounding the implied benefits of mHealth (Free et al. 2013) within a hospital context. As a result, it is important to focus on post-adoption use of mHealth in hospital settings to fully appreciate long term utilisation of these technological tools. In doing so, this will help to ensure that mHealth initiatives are scaled up and sustained in the long term. To fully obtain insights on long term utilisation, researchers need to focus specifically on post-adoption stages of mHealth implementation in hospital settings rather than treating adoption as a generic concept (O' Connor et al. 2012). If mHealth are not infused within an individual's work practice, then the technology may deliver only limited benefits. Such limited benefits may not compensate for what is usually a costly and difficult implementation process, often experienced by numerous stakeholders including patients, providers, third-party payers and governments (Nair and Bhaskaran 2014). Moreover, many healthcare organisations are receiving government funding and bonuses (e.g. via Health Information Technology and Clinical Health Act in the US) for implementing and successful utilising IT when delivering healthcare services. If the technology fails and is not used then the funding is often removed from the hospital. It is therefore important to investigate post-adoption use of mHealth to fully understand long term utilisation of these technologies. Hence, the focus of this research is to study post-adoption use of mHealth by healthcare practitioners, specifically the infusion phase, which arises several months after a technology/system is implemented.

Infusion is commonly recognised as the last phase of the Cooper and Zmud (1990) stage model of Information Technology (IT) implementation (referred to as the Technological Diffusion Model) in organisations and remains one of the least studied facets of IT post-adoption in the IS field (Hasan et al. 2016; Jasperson et al. 2005; Ng and Kim 2009; Tennant et al. 2011). In the context of this study, infusion can be identified as the extent to which individuals (i.e. healthcare practitioners) incorporate and use the IT artefact (i.e. mHealth) in a comprehensive manner. Research on individual level infusion is imperative as individuals are the primary users of the IT that underpins many organisations (Tennant et al. 2011) and it is individual infusion that is a prerequisite to organisational infusion (Peijian and Lihua 2007; Sundaram et al. 2007; Tennant et al. 2011). Analysis of the literature further reveals that infusion has primarily been investigated at an organisational level of analysis, with much less attention focused towards the individual level (Peijian and Lihua 2007). Moreover, analysis of the existing literature reveals that the majority of research on IT infusion has primarily focused on applications run on stationary desktop computers, which are different from mobile technologies (O' Connor et al. 2012). Therefore, there is a lack of a detailed understanding on the determinants of mobile infusion by individuals and subsequent performance. Also notable, analysis of the literature reveals a dearth of infusion studies conducted in the healthcare domain.

Infusing mHealth can result in potential benefits for healthcare practitioners. Research argues that IT infusion can provide numerous benefits to individual users (Cooper and Zmud 1990; Deng and Chi 2012; Fadel 2006; Sousa and Goodhue 2003; Zmud and Apple 1992). Despite the wide endorsement and support for the implementation of mHealth, Black et al. (2011) and Rahurkar et al. (2015) argue that empirical evidence surrounding the benefits of IT in health care remains to be firmly established. Although researchers (Fadel 2006; Ramamurthy et al. 2008) argue that the full benefits of mHealth can only be obtained through fully infusing mHealth, a dearth of research currently exists which examines the performance impact of mHealth infusion. Therefore, the objective of this paper is twofold: To identify the (a) determinants for successful infusion of mHealth by healthcare practitioners and (b) benefits healthcare practitioners perceive from infusing mHealth in a hospital setting.

The remainder of the paper is structured as follows: Existing literature is analysed to develop a conceptual model by which the research objective is explored. Literature pertaining to mHealth infusion is scant; therefore a preliminary model and two propositions are initially proposed (Section 2). Section 3 describes the qualitative component, allowing the researchers to refine the preliminary model developed in Section 2 and establish 9 hypotheses for further testing. Section 4 presents the quantitative methodology and findings from testing the refined model presented at the end of Section 3. Finally, this paper concludes by discussing the implications of this work for research and practice.

2 Towards a model of MHealth infusion

In this section, a conceptual model is developed to explore mHealth infusion and healthcare practitioner performance. Theorising is posited through a number of theoretical lenses in order to identify appropriate constructs with theoretical value in constructing a conceptual model to explore individual mHealth infusion.

2.1 MHealth infusion

Since the advent of 'electronic Health or eHealth' (i.e. application of IT in Healthcare), healthcare organisations are continually striving to implement new programs designed to improve patient care and support workflow activities of healthcare professionals (Safran and Goldberg 2000) vis-à-vis cloud technologies and other digital technologies. Another such venture is the implementation of mobile technology to deliver healthcare services, commonly referred to as mobile Health (mHealth). Examples of mHealth initiatives range from client education and behaviour change communication, sensors and point-of-care diagnostics, registries and vital events tracking, data collection and reporting to providing information, protocols, algorithms and checklists (cf. Labrique et al. 2013). mHealth offers both patients and healthcare practitioners the potential for flexible and mobile access to patient information quickly, efficiently and securely and/or disease management system from any location at any point in time (Kahn et al. 2010). It is inherent from the Information Systems (IS) literature that while other industries like shipping, retail, and banking have successfully transformed the way they do business through the use of IT the health care industry's use of IT has lagged (Ranallo et al. 2016). It is only nowadays that the infusion of IT, more specifically mHealth, can be truly examined.

Cooper and Zmud identify six stages of IT implementation (Cooper and Zmud 1990). Analysis of the literature pertaining to implementation of mobile technologies reveals that existing research predominately focuses on the first 5 stages (cf. O' Connor et al. 2012). Stage 6 - namely, infusion - remains one of the least studied facets of IT post adoption, not only in the mobile literature but also in the generic IS literature (Ng and Kim 2009; Tennant et al. 2011). Infusion distinguishes itself from the routinization phase of the Cooper and Zmud (1990) model by moving beyond continued use of IT to realising the full potential of IT through comprehensive and integrated use. Comprehensive and integrative use is expressed in terms of post-adoptive behaviours proposed by Hsieh and Zmud (2006). It is important to note that post-adoptive behaviours vary at different post-adoption stages of IT implementation. From a review of the literature, Hsieh and Zmud (2006) mapped IS implementation stages and post-adoptive usage behaviours and found that integrative use and exploratory use are post-adoptive behaviours depicted by individuals at an infusion phase. Integrative use refers to the configuration of workflow linkages among a set of work tasks (Saga and Zmud 1994) from utilising mHealth technologies. That is, using the content accessed through mHealth to connect or 'integrate' various tasks to achieve an overall goal (adapted from Oakley and Palvia 2012). Integrative use of mHealth can be illustrated, for example, when practitioners prioritise which patients to see first. Exploratory use captures active examination of new uses of the mHealth technology post implementation by enabling users to find novel uses of the IS within their work environment (Abdinnour-Helm and Saeed 2006; Ke et al. 2012; Liang et al. 2015). An example of exploratory use of mHealth is checking for additional functionality outside of the mainstream mandatory functionality/features (e.g. Help functionality/various healthcare applications). It is further argued that the concept of feature use is dominant at the infusion level (Oakley and Palvia 2012). Feature use refers to the most basic use of mHealth features to complete any given task (adapted from Oakley and Palvia 2012). For example, using observation charts, laboratory reports, and entering patient data etc. Therefore, in order to investigate determinants and outcomes of mHealth infusion (depicted as a second-order construct) a conceptual model is derived from the literature base and explored initially through a case study and further validated using a survey.

2.2 Determinants of mHealth infusion

Three categories (user, task and technology) with seven determinants are identified from existing literature. These seven determinants include mHealth Self-Efficacy, Technology Trust, Habit, Task Demands, Task Significance, Perceived Risk in Technology and Resource Availability. Noteworthy, however, there is limited evidence of the applicability of these determinants as they pertain to mHealth infusion. They nevertheless illustrate that three categories may affect mHealth infusion by healthcare practitioners. These three categories include user, task and technology characteristics.

(1) *User-Based Determinants:* Refer to the user's attributes (e.g. self-perception, behaviour) when interacting with mHealth technologies. A number of determinants emerged within this category including self-efficacy, technology trust and, habit. Self-efficacy is defined as the degree to which an individual's perceives his or her ability to use mHealth in the accomplishment of a task (adapted from Compeau and Higgins 1995). Technology Trust is a second order construct which depicts the degree to which an individual perceives that the mHealth is capable of facilitating tasks based on expectations of reliability and functionality (McKnight et al. 2011). Habit is defined as the extent to which an individual tends to use mHealth automatically often inferred from past experiences (Bergeron et al. 1995).

(2) *Task-Based Determinants*: Refer to the nature of the task(s) users perform (adapted from Trice and Treacy 1988). Task-based determinants identified from the literature include task demands and task significance. When IT artefacts are embedded within an individual's work practice then it must facilitate the accomplishment of tasks (H.-W. Kim et al. 2012). Building on this, task demands and task significance are selected for examination purposes within this study. Task demands refers to the procedures an individual is required to perform. As an information intensive industry, healthcare practitioners use various information regarding patient history, symptoms, functions and lifestyle; information about

diseases, diagnostic aids, drugs, and treatment methods (Kane and Luz 2009), which are all required to arrive at a diagnosis and treatment. Task significance refers to the degree to which the task is meaningful and important (Hackman and Oldham 1976).

(3) *Technology-Based Determinants:* Refer to specific features, functionality, or usability of a technology that can affect its usage by target users (Agarwal and Venkatesh 2002). Technology-based determinants identified from the literature include perceived risk in technology and resource availability. Perceived risk in technology is defined as the perceived possibility of loss or harm to patients whereby individuals believe it is unsafe to use an mHealth technology in a healthcare context (adapted from McKnight et al. 2002). Resource availability as the name suggests is defined as the perceived disposal of mHealth technology, at any given time, required by healthcare practitioners to facilitate infusion.

Table 1 provides an overview of the determinants and their relevance to mHealth Infusion and existing limitations in current literature.

As limited work has been documented on the determinants of mHealth infusion it is therefore proposed that:

P1: MHealth Infusion by healthcare practitioners is affected by user, task, and technology determinants.

2.3 Healthcare practitioner benefits from mHealth infusion

Having described the determinants which could influence a healthcare practitioners' infusion of mHealth, this section describes healthcare practitioner benefits as a result of infusing mHealth solutions into daily practice. A review of the infusion literature reveals an argument for the association between infusion and performance at a theoretical level. Researchers argue that the extent to which expected outcomes are realised from IT infusion is dependent upon IT being used in a comprehensive and integrated manner (i.e. to its fullest potential) to support higher levels of one's work practices. Moreover, Kwon and Zmud (1987, p.232) postulates that performance is largely reflected on the view of strong and weak use (this is

Table 1 Possible determinants of mHealth infusion

Category	Determinant	Relevance to mHealth infusion	Limitation
User	Self-Efficacy	Research argues that users may avoid tasks and situations (i.e. not incorporate IT into their work-practices) which they believe exceed their capabilities (Oakley and Palvia 2012)	Limited studies exist focusing on mHealth self-efficacy and its impact on infusion by medical staff in a healthcare domain.
	Technology Trust	Research argues that users may be reluctant to use some IT technologies because they may fear it will not perform reliably or possess insufficient functionality for users to perform tasks. If it is not used then it cannot be infused (Saga and Zmud 1994; Thatcher et al. 2011)	Majority of research only deals with trust relating to the individual and not the technology. Lack of empirical research on the association between technology trust and mHealth infusion.
	Habit	Research argues that habit can impact the infusion of an IT artefact (Makinen and Jaakkola 2000; Ng and Kim 2009)	Limited studies exist focusing on habit and its impact on mHealth infusion.
Task	Task Demands	Research argues that the way tasks are performed can impact the usage of a system (Saeed and Abdinnour-Helm 2008)	Limited studies exist focusing on task demands and their impact on mHealth infusion.
	Task Significance	Research argues that tasks performed in a healthcare domain are significant in nature as they can severely impact on patient outcomes (Eady et al. 2008). Content, perceived as poor quality, retrieved via mHealth may discourage users from infusing mHealth within their daily work practices.	Lack of empirical evidence examining the impact task significance has on mHealth infusion and IT infusion in general.
Technology	Perceived Risk in Technology	Research argues that perceived risk in technology can have a negative effect when using IT. Such negative outcomes may discourage healthcare practitioners from mHealth infusion.	Lack of empirical evidence on the association between perceived risk in technology and mHealth infusion.
	Resource Availability	Research argues that technological resources are required for system usage (Venkatesh et al. 2008). Without sufficient resources (i.e. mHealth) available to healthcare practitioners' infusion of same may be hindered.	Existing research primarily focuses on resources such as time, finance, IT support, etc. However, little empirical research examines the impact technological resources have on mHealth infusion by healthcare practitioners.

conceptualised in the context of this study as infusion or not). While mainstream infusion theorists have focused on organisational performance (Tanoglu and Basoglu 2006; Ramamurthy et al. 2008), individual performance impacts have gone relatively unnoticed.

Individual performance reflects individual benefits obtained from IT usage. For example, using IT has been reported to impact effectiveness, efficiency (Goodhue and Thompson 1995) and learning. Individual performance is defined in this study as "the degree to which a healthcare practitioner effectively and efficiently delivers health care services and learns through the use of mHealth." In terms of effectiveness, mHealth usage by healthcare practitioners has been reported to improve the quality of patient care by facilitating decision support and medication safety in terms of prescribing and dispensing (Prgomet et al. 2009). Effectiveness is the degree to which a given activity of a program undertaken by medical professionals (i.e. utilising mHealth) improves clinical care (O' Connor et al. 2011). O' Connor et al. (2011) defines efficiency as the degree to which a given activity or program undertaken by a medical professional (i.e. utilising mHealth) leads to a more efficient workflow. Existing research has examined the efficiency achieved by healthcare practitioners from the use of mHealth. For example, Junglas et al. (2009) found that the use of mHealth facilitated the interaction between nurses and their patients. That is, the mHealth was used as a tool to engage patients by showing the patient a scan recently taken and/or visually depicting the effectiveness of a particular medication regime. It is argued that knowledge created by one healthcare practitioner is of utmost importance to the community of healthcare practitioners in order to deliver quality of care (El Morr and Subercaze 2010; Lim et al. 2015; Peng et al. 2014). Knowledge, therefore, is of extreme importance to healthcare as the health care industry is increasingly becoming a knowledge-based community that depends critically on knowledge management activities to improve the quality of care (Hsia et al. 2006). Medical knowledge changes rapidly (Ebell 2009). Therefore, it is important that medical professionals constantly create knowledge to ensure that patient safety is not compromised. Sufficient medical knowledge may help prevent doctors from misdiagnosing an illness or prescribing medications that cause adverse drug events (Weingart et al. 2009) resulting in potential problems (S. Kim et al. 2010).

Infusing mHealth technologies can result in numerous outcomes for healthcare practitioners. Healthcare practitioner benefits are defined in terms of performance (i.e. what individual achieve from infusing mHealth technologies). Building on the overview presented above the following proposition is proposed:

> **P2**: Infusion of mHealth positively impacts healthcare practitioners' performance in terms of clinical care, workflow and learning.

Figure 1 depicts the conceptual model with independent and dependent constructs and the propositions highlighted above.

The following section describes the first phase (i.e. qualitative) of the mixed methods approach employed in this study. This section builds from the literature and assists in refining a preliminary model for exploring the infusion of mHealth by healthcare practitioners in a hospital setting.

3 Phase I: Refining the preliminary model

3.1 Methodology for phase I

In order to enhance understanding of mHealth infusion, we adopt a hermeneutic approach (Boell and Cecez-Kecmanovic 2014). Propositions are refined and hypothesis are developed through undertaking a hermeneutic cycle of analytical reading of the literature infused and refined with analysis of data collected through an exploratory case study, which are subsequently tested through a survey. Such an approach will (i) facilitate refinement of the two propositions and the conceptual model and the derivation of hypotheses via a case study and (ii) test the hypotheses and model via a survey (Section 4) to (iii) derive at a model of mHealth infusion by healthcare practitioners. The researchers applied criterion sampling, a specific type of purposeful sampling whereby the subjects

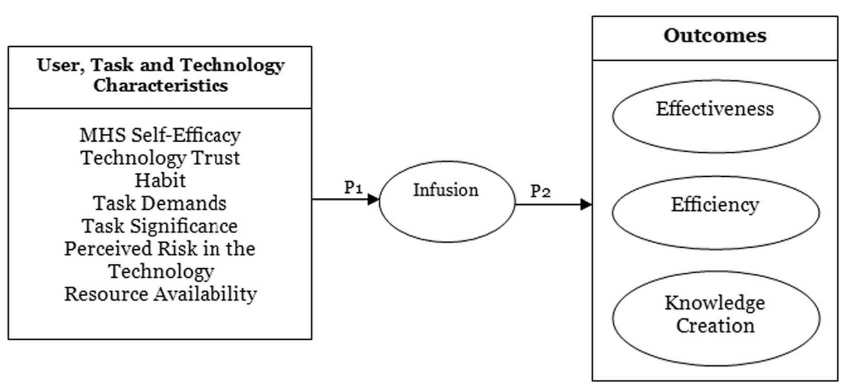

Fig. 1 Conceptual model for mHealth infusion from theory

for this study had to meet the predetermined criterion of importance stipulated by the researcher (Patton 2001). The participants of both the qualitative and quantitative components of this research were required to use any handheld mHealth tool (e.g. tablet, mobile clinical assistants, PDA, smartphone) during clinical practice, for six or more months and, as part of their daily clinical practice (e.g. looking up patient records, health status, electronic prescribing).

The case study approach is one of the most commonly used research methods in the IS field (Darke et al. 1998). It aims to obtain an in-depth understanding of the phenomenon and its context (Cavaye 1996). Case studies enable researchers to investigate pre-defined phenomena without explicit control or manipulation of any variables (Cavaye 1996; Darke et al. 1998; Yin 1994). It is indicated (Marshall and Rossman 1989) that when the state of knowledge in a field is at an early stage of investigation, a need exists for the research purpose to focus on 'discovery' and 'theory building', and be 'exploratory' in nature. For a theory building / theory-testing approach, a case study is a valid research method (Galliers 1992). The researchers selected a West Midlands hospital in the National Health Service (NHS), United Kingdom; namely, University Hospitals Birmingham, NHS Foundation Trust (UHBFT) in which to conduct the initial phase of this study. UHBFT was selected as it has been using mobile technology for more than ten years, whereby the technological tool is fully integrated within healthcare practitioners daily work practices. Over ten hours of interviews were conducted onsite with a broad spectrum of healthcare practitioners ranging from clinical lead in pharmacology, nurses, PICS (Prescribing Information and Communication System) training personnel to pharmacist technicians interviewed. Content analysis was undertaken using the three grounded theory coding techniques (open, axial and selective) proposed by Strauss and Corbin (1990) and exemplified by the research of Urquhart (2001). This resulted in the revision of the initial conceptual model derived from literature, with an extensive evidence table being presented in Table 2.

3.2 Findings from phase I

This section describes the determinants and outcomes identified during the qualitative analysis. Table 2 provides additional evidence supporting all the hypotheses.

Analysis reveals that availability of mHealth directly impacts infusion. To facilitate the demand for mHealth, University Hospitals Birmingham, NHS Foundation Trust was saturated with considerable amounts of mHealth (approximately 500 as per June, 2011 and increasing annually), which was actively in use by approximately 3500 (clinical pharmacologist) at the time of data collection. Supplying the organisation with mHealth was perceived to make the mHealth technology readily available to the end user. Yet, despite the number of mHealth implemented in the hospital, healthcare staff perceived that the availability of mHealth at their disposal was limited and this had implications for infusion. This is reflected in the statement by one nurse who stated that "*when finished with the fluid balance checks I have to return to find an available computer to enter the data scribbled down on paper*". Indeed, the rationale behind the perceived limitation of mHealth stemmed from the amount of users required to utilise and share mHealth at the point-of-care. Fifteen mHealth were assigned to most wards within the hospital, however, this number of mHealth was considered to be insufficient (as indicated by three nurses, one dietician, and two doctors) with appeals for the introduction of additional mHealth. As one nurse stated, "*I cannot explore this [mHealth] because the mHealth are in constant use by staff.*" Therefore, individual users are well equipped to utilise and embed mHealth technologies within their work practices. As a result, it is hypothesised that:

> *H1: Availability of mHealth positively impacts the infusion of mHealth by healthcare practitioners.*

Another determinant to impact mHealth infusion is that of self-efficacy. Analysis revealed that the more self-efficacious individuals are with the mHealth, the more confident they are with infusing the tool. Indeed, one nurse stated that "*You need the appropriate skill set to explore this [mHealth], otherwise people will not be enticed to investigate it.*" For instance, individuals who were self-assured about their capabilities to use mHealth were found to embrace the mHealth more when compared with people who were apprehensive (i.e. explore the mHealth tool and use the features/functionalities during clinical practice). The analysis further revealed individuals who did not fully embrace mHealth entertained serious doubts about their capabilities of exploring the mHealth and refrained from doing so. This is reflected in the comments of one nurse who stated that "*I do not have the computer skills to even know where to start.*" As a result, it is hypothesised that:

> *H2: mHealth self-efficacy impacts upon healthcare practitioners' infusion of mHealth.*

The concept of time-criticality evolved from both task demands and task significance. Time-criticality in this study refers to the willingness to use mHealth in time-critical situations (adapted from Zhang et al. 2011). Analysis revealed that time-criticality impacts individual infusion of mHealth because the decision to pursue content from mHealth is contingent on the urgency of the patient's problem. Incorporated within the mHealth (Prescribing and Information Community System [PICS]) is a Clinical Decision Support System (CDSS). The CDSS assist healthcare practitioners with decision making tasks, such as determining the diagnosis and/or treatment of a patient. The CDSS embedded within mHealth assist healthcare practitioners in selecting appropriate medication (type of drug and administration of drug) for patients and when integrated with patients' records, it assesses for any potential adverse drug events. In this case study, warning notifications/alerts were issued by PICS to healthcare practitioners when a task needed to be performed urgently. In an emergency setting, one nurse stated that "*Warning notifications via mHealth can help me prioritise which patients I attend to first.*" The most imperative alert healthcare professionals must abide by is defined as high-level. If this is presented to the user, s/he is not permitted to continue. This inevitably has an impact on how healthcare practitioners organise and prioritise which patients are to be seen and treated promptly. As a result, it is hypothesised that:

H3: The ability of mHealth to support healthcare practitioners with decision making in emergency situations positively impacts the infusion of mHealth.

Users who have been using mHealth technologies for over one year gain habits towards using mHealth technologies. The longer the length of time healthcare practitioners interact with the mHealth, the more experiences they acquire. These experiences often reflect how healthcare practitioners embed mHealth within their daily work practices. Some healthcare practitioners who have used mHealth for a long period of time use the same features consistently and become less receptive to new features. As one doctor stated "*It is easy to organise your tasks when you have been using this [mHealth] for a long time*". These habits can have an influence on infusion of mHealth technologies. As a result, it is hypothesised that:

H4: Habits formed by healthcare practitioners' impact there infusion of mHealth.

This section addresses one of the indirect determinants (Technology Trust) and its association with mHealth infusion. Firstly, technology trust was found to impact self-efficacy. Analysis revealed that some healthcare practitioners depend on the mHealth operating reliably and not undermining their efforts through unpredictable behaviour. One doctor stated that "*When this [mHealth] acts normal (so doesn't flash up technical errors or automatically switch off), I believe I am able to use the mHealth….however, I am not an IT person so when this [mHealth] does not perform reliably, I tend to abandon it*". This was primarily evident when healthcare practitioners experienced malfunctions with the mHealth (e.g. technical error messages, system freezes, etc.) and were not capable of delivering healthcare services to patients without the assistance of fellow colleagues. Contrary to this, however, is when the mHealth was behaving reliably, the majority of staff felt confident in their abilities to perform tasks using mHealth. Furthermore, individuals gain self-assurance about their ability to conduct their work when the mHealth has the necessary features and functions. When executing daily tasks, healthcare practitioners believed they had the necessary skills to accomplish these tasks. The underlying rationale for their self-assurance stemmed from the awareness that the necessary features and functions exist within the mHealth. However, practitioners acknowledged instances when they were unsure of how the task should be performed due to changes in the mHealth (i.e. features/functionality) and pursued help to overcome this obstacle. In summary, when the mHealth is perceived as being reliable and has the necessary functionality for healthcare practitioners to perform their tasks (i.e. mHealth is perceived as trustworthy) then practitioners feel confident in their ability to deliver healthcare services using mHealth. However, a pharmacist stated "*I logged into this morning and found they had made changes to the way things are entered into the system. I was unsure of how to continue so I had to find someone else to help me through the process.*" The concerns with malfunctions and changing features (i.e. mistrust of mHealth) affect the self-efficacy of some healthcare practitioners and as a result, it is hypothesised:

H5: Healthcare practitioners' ongoing trust in the mHealth technology positively impacts mHealth self-efficacy.

Analysis revealed that technology trust was found to impact time-criticality. Critical tasks (i.e. tasks which need to be performed urgently) are often performed at the point-of-care. It is clinically imperative that the mHealth does not malfunction (i.e. operate unreliably) for the simple reason that all patient data, in the context of this study, is electronically stored and healthcare practitioners cannot deliver services without access to this data. For the majority of the time the mHealth was found to operate as expected with very low unplanned downtime. This guarantees that patient data can be accessed at the point-of-care, assuming healthcare practitioners have necessary permission. Nevertheless, analysis revealed that mHealth are susceptible to some malfunctions, reflected in the statement of a nurse who complained of "*poor battery performance and instantaneous log off*". This was found to hinder individuals' willingness to use mHealth as some practitioners acknowledged resorting to Computer-On-Wheels (referred to as a 'windsurfer' within the hospital) in urgent situations. Delivering healthcare services to patients in a swift and comprehensive manner necessitates speedy access to patient information. It was therefore imperative that the mHealth encompasses the necessary functions/features to facilitate this (i.e. speedy access to patient data). The search functionality within PICS was found to be appropriate as staff could seek medical data relevant only to the patient who required immediate attention. Conversely, some functionality (i.e. relevant access and the mandatory log-in set-up) was reported to hinder the timeliness in delivering healthcare services in urgent situations as mentioned by a nurse who stated that "*In certain critical situations, I grab a windsurfer….they [windsurfer], I think are more reliable*". In summary, healthcare practitioners who perceived that the mHealth was untrustworthy in terms of reliability and functionality often resorted to the use of Computer-On-Wheels in urgent situations. As a result, it is hypothesised:

H6: Healthcare practitioners' trust in the mHealth technology positively impacts upon their willingness to use mHealth in urgent situations.

Task behaviour is deemed to be an indirect determinant of mHealth infusion by healthcare mHealth. Task behaviour refers to the activities that team members perform using mHealth to carry out a task (adapted from Chung and Guinan (1994) and derived from discussions pertaining to task demands from the initial case study). First, analysis revealed that task behaviour impacts time-criticality. In a situation where tasks have to be performed promptly (often undertaken at the point-of-care), it is imperative that any data entered into the system is complete and up-to-date. "*If all the information is on the PICS I will use it. However, I have seen one or two members of staff putting patient data on pieces of paper. In critical situations, for example, I need this information. Instead of attending to the patient I have to find that member of staff to give me that information so I don't use it [mHealth] then (Nurse 2)*". In a minority of situations, however, it was reported that this was not always the case. For the majority of the time, however, staff acknowledged that they would utilise the mHealth in urgent situations as they perceived that the documentary practices of fellow colleagues was sufficient for them to deliver healthcare services. In summary, analysis revealed that mHealth are often not used in urgent situations when healthcare practitioners retrieve the information verbally, typically as a result of poor documentary practices. Therefore, it is hypothesised:

H7: The culture surrounding data recording practices performed by team members when delivering healthcare services impacts fellow healthcare practitioners use of mHealth in urgent situations.

Analysis revealed that working as part of a team when delivering healthcare services to patients influences healthcare practitioners' mHealth behaviour (i.e. habits). It was reported by some healthcare practitioners (doctor, nurse and dietician) that their current usage of the mHealth was established based on guidance by fellow team colleagues, a point illustrated in the dietician's statement "*Initially, I was confused about how to use it [mHealth]. Getting assistance from my colleagues back then enabled me to take what they showed me and use it routinely to this day*". In some situations, simply observing how others utilise the mHealth influenced individual mHealth behaviour. Additionally, not all mHealth habitual routines were derived from working as part of a team but were formed via training programmes. Based on the analysis it is evident that habits can be influenced by various events. In a healthcare context, a number of healthcare practitioners often deliver healthcare services in collaboration. Consequently, it was determined that task behaviours of others in the team can influence one's habits. Therefore, it is hypothesised:

H8: Working as part of a team when delivering healthcare services to patients influences healthcare practitioners' mHealth behaviour.

Perceived technology risk was found to have no significant impact on infusion. Many people acknowledge that some risks exist when a system is initially implemented as "*risks are inherent within any system*" (Pharmacist 1). However, due to the maturity and stability of the current mHealth technology, many healthcare practitioners consider it safe and don't perceive any technology risk associated with mHealth infusion.

3.2.1 MHealth infusion outcomes: Revision of those developed from theory

Several categories of benefits emerged from the analysis associated with individual performance through mHealth infusion. Having a CDSS, in addition to an electronic health record, at the point-of-care helps in the decision making process. That is, CDSS often recommend diagnoses and treatments based on the data inputted by healthcare practitioners regarding patient assessment, symptoms and duration of illness. Consequently, there is a richer exchange between the practitioner and the patient as healthcare practitioners have more time listening to the patient. Furthermore, if a drug is prescribed by a healthcare practitioner and there is some danger to the patient, a warning notification is presented to the user. If healthcare practitioners do not override these notifications many people believed that, as a result, there would be a reduction in medical errors. Healthcare practitioners believed that preventive care was improved when they were prompted by reminders concerning the patient due to the notification of patients whose data is operating outside of normal ranges. This improves the delivery of healthcare services to the patient as healthcare practitioners can respond rapidly to a dangerous situation. Furthermore, tests, drug administration and vital sign checks are scheduled and completed on time due to prompts notified to the individual user once they log in. These reminders are an effective way to ensure that routine clinical care is carried out on time. Exploring knowledge creation through individual infusion of mHealth technologies was one key finding from the data analysis. The consensus

Table 2 Qualitative chain of evidence

Emergent Relationship	Evidence
Availability > Infusion	Pharmacist (1): "I have access to mHealth all the time so I open it up and roam around on it [mHealth]."
	Doctor (3): "Practitioners who don't use mHealth at the patient's bedside are not taking advantages of what the mHealth has to offer."
	Nurse (2): "I cannot explore this [mHealth] because the mHealth are in constant use by staff."
	Nurse (3): "When finished with the fluid balance checks I have to return to find an available computer to enter the data scribbled down on paper."
Self-Efficacy > Infusion	Nurse (1): "You need the appropriate skill set to explore this [mHealth], otherwise people will not be enticed to investigate it."
	Doctor (2): "My computer skills enable me to use certain features of the mHealth."
	Nurse (3): "I do not have the computer skills to even know where to start."
	Pharmacist (2): "Reviewing patient data through this [mHealth] allows me to proficiently coordinate which patients I need to see and when."
Time-criticality > Infusion	Nurse (2): "I may have to drop what I am doing and attend to a patient when warning messages appears"
	Doctor (2): "Warning notifications are issued to highlight some actions are required for patient care. Every staff member must acknowledge and ensure certain steps are undertaken. So I often use mHealth in urgent cases."
	Nurse (1): "Warning notifications via mHealth can help me prioritise which patients I attend to first."
	Doctor (1): "Tasks are organised based on the patients' health status."
	Nurse (3): "I do not play around on this [mHealth] when a task needs our immediate attention. I will attend to it."
Habit > Infusion	Clinical Pharmacologist: "If they know one particular way of getting and doing something… they will continue to use it in the same way."
	Pharmacist (1): "I have always explored the system and will continue it"
	Doctor (1): "It is easy to organise your tasks when you have been using this [mHealth] for a long time"
	Nurse (3): "I normally use the same features so I do not need to know about the other features on the mHealth."
	Doctor (2): "If you want to do something that is routine you will just sign in and go. You won't stop and have a look at what is going on."
Technology Trust > Self-Efficacy	Nurse (3): "When this breaks down [unreliable] I ring technical support as I do not know how to fix it."
	Doctor (2): "When this [mHealth] acts normal (so doesn't flash up technical errors or automatically switch off) I believe I am able to use the mHealth … however, I am not an IT person so when this [mHealth] does not perform reliably I tend to abandon it and locate one that is working."
	Dietician: "I have no problem when it comes to using it [mHealth] as, one, I believe that the data is reliable."
	Pharmacist (1): "I am self-assured in my abilities to complete a given task because I know the features required to complete the task are on the mHealth when I require them"
	Pharmacist (2): "I logged into this morning and found they had made changes to the way things are entered into the system. I was unsure of how to continue so I had to find someone else to help me through the process."
Technology Trust > Time-criticality	Pharmacist (2): "It takes time to boot up if they are switched off… when needed on demand it is important that you get one which is switched one."
	Nurse (1): "In certain situations, I grab a windsurfer… they [windsurfer], I think, are more reliable."
	Nurse (3): "I think I would rather use bits of paper as I think it [mHealth] hinders nursing care and I think it makes things less accurate and reliable."
	Doctor (3): "This facilitates for speedy search queries which are beneficial to staff when patients require attention."
	Dietician: "This is really good because it is quite easy to find all the different things that you need to find on demand."
	Pharmacist (2): "A keyboard is available with the windsurfer, which is a lot quicker to enter information that tapping. I prefer using the windsurfer when I want to get to type patient data quickly."
Task Behaviour > Time-criticality	Nurse (1): "If all the information is on the PICS I will use it. However, I have seen one or two members of staff putting patient data on pieces of paper. In critical situations, for example, I need

Table 2 (continued)

Emergent Relationship	Evidence
	this information. Instead of attending to the patient I have to find that member of staff to give me that information so I don't use it [mHealth] then".
	Clinical Pharmacologist: "PICS has been developed to minimise partiality in the data. Therefore, all healthcare practitioners who interact with a patient should provide complete and comprehensive documentation on that patient. Because of this, I would use it [mHealth] in all situations."
	Doctor (3): "In urgent cases, I am happy to use it [mHealth] because I am confident that it has all the data pertaining to the patient on it. Not only my notes but documentation from other members of staff."
Task Behaviour > Habit	Dietician: "Initially, I was confused about how to use it [mHealth]. Getting assistance from my colleagues back then enabled me to take what they showed me and use it routinely to this day."
	Nurse (2): "I found that working with other staff members that I have picked up, overtime, how they use it [mHealth] and automatically adopted the same approach."
	Doctor (3): When I first started working with the consultant a few months ago, I noticed how he was using mHealth. Since then, I took it upon myself to use it in the same way."
	Pharmacist (1): "I have a tendency to use the same features all the time because that is how I was trained."
Infusion > Performance	Clinical Pharmacologist: "Using this [mHealth] saves significant time which obviously helps us to see more patients".
	Clinical Pharmacologist: "Probably several thousand hard stopped warnings occur every year"
	Nurse (1): "If a "patient starts to deteriorate you get flag up warnings [on mHealth tool] which doctors have to acknowledge. If the patient gets really sick then the outreach nurses get an email sent to their blackberries saying that a patient has got sick."
	Nurse (2): "I don't know whether we can create knowledge but we can present knowledge to people".
	Pharmacist (1): "If people have a thirst for knowledge or a quest for knowledge then I think they will find it. They will go and read a book. I am not sure if they would get it entirely from the PICS system". Nurse (3): "I can learn about new drug interactions that I hadn't known about recently"

in the study is that knowledge can be created by healthcare practitioners; however, not necessarily through mHealth technologies. When describing knowledge many people referred to the concept of learning. That is, healthcare practitioners arguing that infusing mHealth can facilitate learning. As a result of these findings, proposition 2 (*The infusion of mHealth impacts various healthcare practitioner related outcomes*) is refined to:

> *H9: Infusion of mHealth positively impacts healthcare practitioners' performance in terms of clinical care, workflow and learning.*

In conclusion, the hermeneutical approach to infusing literature with data allowed us to test and refine the two theoretical propositions established in Section 2 into nine testable hypotheses. The next section (4) will now validate the refined model (Fig. 2).

4 Phase II: Testing the revised model

4.1 Methodology for phase II

To test the revised conceptual model a quantitative survey was subsequently employed. The online survey questionnaire was constructed using indicators already validated in existing research and derived from the qualitative analysis (Items and their description can be found in Table 3). The survey instrument was piloted in March 2012 to ensure content and construct validity. Over 20 medical experts (people who work in healthcare environments and others who actively use mHealth as part of their daily work lives) in the US and Ireland participated in the pilot study. Following this, the survey was refined before launching the survey. The data collection instrument can be found in Table 3. Data was gathered over a four month period from April 2012 to July 2012 from healthcare physicians in an acute care context within The Ottawa Hospital, Canada vis-à-vis a survey distributed by email (an URL link). The Ottawa Hospital currently has 3000 iPads, incorporating a mobile Electronic Medical Record application. No hard copies of were presented to the potential participants as all members of staff had internet access.

A total of 157 responses were obtained from various healthcare physicians via the administration of an online survey (871 physicians in total), yielding a response rate of 18%. From the 157 responses, 101 surveys were usable for data analysis. G*Power (version 3.1.2) was used to conduct power analysis and to establish whether the sample size was appropriate to reject the null hypotheses (i.e. the

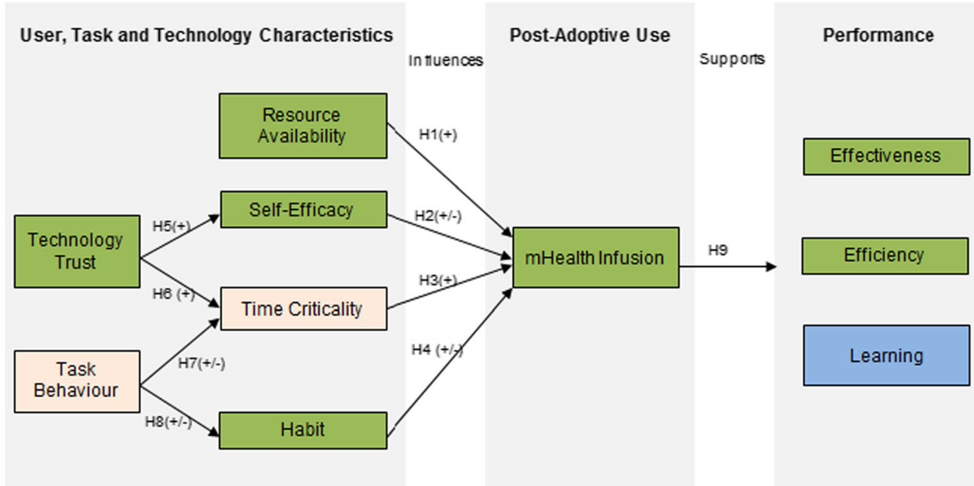

Fig. 2 Conceptual model from qualitative findings

determinants do not have an impact on infusion and subsequent individual level outcomes). Power values close to one can indicate if the null hypothesis can be rejected or not. The t-tests statistical test "Means: Difference from constant (one sample case)" was used post-hoc to determine the power (tails: two; effect size: 0.5; α err prob.: 0.05; total sample size: 101). In this research study G*Power analysis revealed a power of 0.9987202, thus this study rejects the null hypothesis. The results indicate that a sample size of 101 is more than sufficient to explain medium population effects, as per Cohen (1988).

Due to the sample size the authors employed the Partial Least Square [PLS] (Structural Equation Modelling [SEM]) approach for data analysis purposes. This approach uses component-based estimations and allows simultaneous examination of both the measurement and the structural models. The measurement (outer) model portrays the relationships between a construct and its associated variables (measurement items) whereas the structural (inner) model represents direct and indirect unobservable relationships among constructs (Diamantopoulos and Siguaw 2006; Tenenhaus et al. 2005). SmartPLS (Version 2.0.M3) was utilised to generate the statistical outputs associated with the survey data.

4.2 Findings from phase II

4.2.1 Respondent profiles

As outlined earlier the respondents were healthcare physicians, of which attending physicians and residents/fellows accounted for 53.5% ($n = 54$) and 46.5% ($n = 47$) respectively. 58.4% of the respondents were male ($n = 59$) with the remaining 51.6% representing females ($n = 42$). The age groups of the respondents varied (18–25 years, $n = 2$, 2%; 26–40 years, $n = 57$; 56.4%; 41–55 years, $n = 25$, 24.8%; 56–65 years, $n = 14$, 13.9%; >65 years, $n = 3$, 3%).

4.2.2 Hypothesis and model testing

Reliability of construct measurements was evaluated by examining the Average Variance Extracted (AVE) and Composite Reliability (CR). AVE should be equal to or exceed 0.5 (Chin 1998). AVE less than 0.5 explain more variance is due to error variance than to indicator variance. CR should be greater than the acceptable level of 0.6. Table 4 depicts that all constructs are higher than the respective AVE and CR threshold values.

Individual Reliability examines determinant loadings by specifying which part of an indicators' variance can be explained by the underlying latent variable (Chin 1998). For this research study, the threshold cut-off value for individual reliability is 0.707. Table 5 depicts the indicators higher than the 0.707 threshold. Any indicators following below this threshold were removed from the study.

The second criterion to be examined is that of validity. Latent variable cross loadings were used to assess convergent validity and discriminant validity. Convergent validity is depicted when each measurement item correlates strongly with its assumed theoretical construct, while discriminant validity is depicted when each measurement item correlates weakly with all other constructs except for the one to which it is theoretically associated (Gefen and Straub 2005). Table 4 highlights that AVE exceeds 0.5, which indicates sufficient convergent validity (each latent variable explains more than 50% of their indicator variance on average). In this study, discriminant validity was assessed following the Fornell and Larcker (1981) approach whereby the AVE of a determinant must be larger than the squared correlation of this determinant with any other determinant. If the AVE for each construct is greater than its shared variance with any other construct, discriminant validity

Table 3 Questions used for survey data collection

Construct	Item: Description
Availability (adapted from Taylor and Todd 1995)	*Avail1:* I have no difficulty findings a mHealth to use when required. *Avail2:* When providing healthcare services, availability of mHealth is not a problem. *Avail3:* There are sufficient amounts of mHealth for me to use in the department in which I am predominantly located.
Self-Efficacy (adapted from Ng and Kim 2009)	*SE1:* I have the necessary skills for using mHealth. *SE2:* I am self-assured about my capabilities to use the mHealth. *SE3:* I am confident in my ability to use the mHealth.
Time-criticality (adapted from Gebauer and Tang 2007)	*TC1:* In emergency situations, I use mHealth to access patient information. *TC2:* In urgent situations, I use mHealth to help me make clinical decisions. *TC3:* Timeliness, in terms of accessing relevant patient information through mHealth, is a critical element in urgent situations.
Habit (adapted from Limayem et al. 2007)	*Hab1:* The use of mHealth has become a habit for me. *Hab2:* Using the mHealth has become automatic to me. *Hab3:* The use of the mHealth has become a routine practice when providing healthcare services.
Technology Trust: Reliability, Functionality (Second-Order Construct)	
Reliability (adapted from McKnight et al. 2011)	*TTRel1:* The mHealth is very reliable. *TTRel2:* The mHealth is extremely dependable. *TTRel3:* The mHealth does not malfunction for me.
Functionality (adapted from McKnight et al. 2011)	*TTFun1:* The mHealth has the functionality I need. *TTFun2:* The mHealth has the features I require. *TTFun3:* The mHealth has the ability to do what I want it to do.
Task behaviour (adapted from Gebauer and Tang 2007; Pearce and Gregersen (1991)	*TB1:* I process information from many sources through mHealth. *TB2:* mHealth enable me to share patient information with other healthcare professionals. *TB3:* I require accurate information through mHealth from other healthcare professionals.
Infusion: Feature Use, Integrative Use, Exploratory Use (Second-Order Construct)	
Feature Use (adapted from Ramamurthy et al. 2008)	*InfFeat1:* I use all of the capabilities offered through mHealth. *InfFeat2:* I use most of the available features on the mHealth. *InfFeat3:* I only use a limited amount of the available features offered through mHealth.
Integrative Use (adapted from Ng and Kim 2009)	*InfInt1:* I use the data accessed through mHealth to support me when delivering healthcare services. *InfInt2:* I use the data accessed through mHealth to organise which patients I meet first. *InfInt3:* I use the data accessed through mHealth to coordinate the delivery of healthcare services.
Exploratory Use , (adapted from Saeed and Abdinnour-Helm 2008); Hsieh and Wang (2007)	*InfExp1:* I explore the features of mHealth (e.g. exploring medical reference resources). *InfExp2:* I often search for new medical/clinical information through mHealth (outside of the primary application). *InfExp3:* I use the mHealth in novel ways.
Effectiveness (adapted from Junglas et al. 2009) Katz and Rice (2009)	*Effect1:* In my experience using mHealth increases the quality of patient care. *Effect2:* Using the mHealth helps improve the diagnosis of patients. *Effect3:* Using the mHealth helps improve the treatment of patients. *Effect4:* Using the mHealth helps improve the monitoring and management of disease within the hospital.
Efficiency , (adapted from Torkzadeh and Doll 1999); DesRoches et al. (2008)	*Effic1:* Using mHealth saves me time when delivering healthcare services as information is readily available. *Effic2:* Using the mHealth makes it easier to provide healthcare services. *Effic3:* In my experience using mHealth encourages me to follow clinical guidelines/protocol. *Effic4:* The mHealth supports me in interacting with patients when they request more information.
Learning (adapted from Torkzadeh et al. 2011)	*Learn1:* Accessing medical reference resources through mHealth help me learn more about delivering healthcare services to patients *Learn2:* Intervention alerts (e.g. drug-drug, drug-allergy interactions) when using mHealth help me learn more about delivering healthcare services to patients. *Learn3:* mHealth are a convenient source of information or means of communication that assist me with medical learning.

Table 4 Internal consistency reliability test

	AVE	CR
Availability	0.683043	0.865896
Effectiveness	0.677176	0.893287
Efficiency	0.704462	0.877246
Exploratory use	0.685940	0.867575
Feature use	0.669045	0.857895
Functionality	0.762646	0.905905
Habit	0.831412	0.936686
Infusion*	0.664969	0.856085
Integrative use	0.609556	0.823586
Learning	0.689059	0.868670
Performance*	0.730723	0.856089
Reliability	0.799689	0.922894
Self-efficacy	0.835959	0.938574
Task behaviour	1.0000	1.0000
Tech. trust*	0.677311	0.90271385
Time-criticality	0.677300	0.862856

*Denotes that manual calculations were performed

is supported. Table 6 shows all constructs have sufficient discriminant validity.

The model derived from phase one presented a total of nine hypotheses that focused on the determinants which impact individual infusion of mHealth and subsequent benefits. Each structural path in the research model (Fig. 2) represents a hypothesis. The hypotheses were tested (i.e. examining strength and significance) by employing the bootstrapping re-sampling technique to calculate the corresponding t-values for each path, in order to assess the significance of path estimates. The bootstrapping procedure was undertaken using 101 cases with 1000 samples to produce stable results. The results are shown in Table 7.

In terms of the hypotheses, eight from the nine paths were significant. One path (H6: Healthcare practitioners' trust in the mHealth positively impacts upon their willingness to use mHealth in urgent situations) was not significant. The implications of the analysis is presented in Section 5, whereby the results achieved from both the qualitative and quantitative phases are synthesised and interpreted as they pertain to existing literature.

Table 5 Loading of manifest variables

Latent Variable	Item	Loading Value (λ)	Latent Variable	Item	Loading Value (λ)
Technology Trust*	Reliability	0.913	Feature Use	InfFeat1	0.769
	Functionality	0.901		InfFeat2	0.894
Reliability	TTRel1	0.901		InfFeat3	0.785
	TTRel2	0.917	Integrative Use	InfInt1	0.737
	TTRel3	0.864		InfInt2	0.761
Functionality	TTFun1	0.877		InfInt3	0.841
	TTFun2	0.908	Exploratory Use	InfExp1	0.816
	TTFun3	0.833		InfExp2	0.829
Task Behaviour	TB3	1.000		InfExp3	0.839
Availability	Avail1	0.848	Individual Performance *	Effectiveness	0.946
	Avail2	0.846		Efficiency	0.840
	Avail3	0.785		Learning	0.767
Self-Efficacy	SE1	0.889	Effectiveness	Effect1	0.800
	SE2	0.942		Effect2	0.848
	SE3	0.911		Effect3	0.871
Time-Criticality	TC1	0.856		Effect4	0.769
	TC2	0.816	Efficiency	Effic1	0.840
	TC3	0.798		Effic2	0.864
Habit	Hab1	0.912		Effic4	0.812
	Hab2	0.918	Learning	Learn1	0.899
	Hab3	0.905		Learn2	0.754
Infusion*	Feature Use	0.779		Learn3	0.830
	Integrative Use	0.821			
	Exploratory Use	0.845			

*Denotes second-order construct. Individual Reliability is assessed by examining the path coefficients between the second order latent variable to its first order latent variable (Tenenhaus et al. 2005)

Table 6 Cross construct discriminant validity

	AV	EU	EFFE	EFFI	FU	FUNC	HAB	IU	INF	LEAR	PERF	REL	SE	TC	TB	TT
AV	0.68															
EU	0.16	0.69														
EFFE	0.11	0.32	0.68													
EFFI	0.24	0.29	0.47	0.70												
FU	0.22	0.22	0.20	0.23	0.67											
FUNC	0.25	0.13	0.26	0.30	0.14	0.76										
HAB	0.23	0.33	0.37	0.52	0.22	0.35	0.83									
IU	0.19	0.31	0.39	0.35	0.22	0.31	0.23	0.61								
INF	0.29	0.71	0.44	0.44	0.61	0.28	0.39	0.67	0.67							
LEARN	0.08	0.40	0.45	0.23	0.10	0.10	0.42	0.25	0.36	0.69						
PERF	0.17	0.42	0.90	0.71	0.23	0.30	0.47	0.45	0.54	0.59	0.73					
REL	0.23	0.08	0.16	0.16	0.07	0.42	0.28	0.15	0.15	0.07	0.17	0.80				
SE	0.28	0.24	0.13	0.17	0.23	0.20	0.29	0.14	0.31	0.08	0.16	0.24	0.84			
TC	0.02	0.21	0.18	0.16	0.10	0.08	0.20	0.12	0.22	0.13	0.21	0.06	0.03	0.68		
TB	0.03	0.12	0.09	0.14	0.01	0.04	0.18	0.06	0.08	0.07	0.13	0.07	0.08	0.32	1.00	
TT	0.30	0.13	0.24	0.27	0.13	0.81	0.38	0.27	0.25	0.10	0.28	0.83	0.27	0.09	0.06	0.68

AV Availability, *EU* Exploratory Use, *EFFE* Effectiveness, *EFFI* Efficiency, *FU* Feature Use, *FUNC* Functionality, *HAB* Habit, *IU* Integrative Use, *INF* Infusion, *LEARN* Learning, *PERF* Performance, *REL* Reliability, *SE* Self-Efficacy, *TC* Time-Criticality, *TB* Task Behaviour, *TT* Technology Trust

5 Discussion

It is argued (Venkatesh et al. 2008) that availability of resources is essential for individuals to engage in a behaviour. However, the absence of sufficient resources represents a barrier to use (Taylor and Todd 1995). Typically, as a result of issues relating to cost, healthcare practitioners are required to share information systems (Daniels and Sabin 2002). This causes difficulties as users require time to exploit the systems capabilities and become more adept at discovering new uses of the systems outside of their intended use (Ng and Kim 2009). Therefore, it is imperative that healthcare organisations invest in mHealth to ensure that there are sufficient resources to facilitate infusion. This is reflected in the positive relationship between availability and mHealth infusion meaning that the higher the number of mHealth technological tools available to the end user, the greater the occurrence of mHealth infusion.

The positive association between mHealth self-efficacy and mHealth infusion revealed in this study implies that the more self-efficacious healthcare practitioners are, the more confident they are with infusing mHealth, thereby improving infusion. Therefore, when mHealth self-efficacy increases, there is a subsequent increase in mHealth infusion by healthcare practitioners. This findings corroborates the work reported by Oakley and Palvia (2012) within the infusion domain but also the work of other key researchers (Compeau and Higgins 1995; Igbaria and Iivari 1995; Saeed and Abdinnour-Helm 2008) who confirm that self-efficacy plays an important role for IT usage in the wider IS literature. As a result, training in post-adoptive scenarios is imperative to ensure that healthcare practitioners not only maintain their current skill-set, but enhance same to become more proficient with using mHealth technology. Increased competence will result in healthcare practitioners utilising mHealth at the point-of-care thus, embedding the technology within their daily work practices.

In a time-sensitive environment such as healthcare, it is crucial that healthcare practitioners deliver efficient and timely healthcare services to patients at the point-of-care. The concept of urgency has been examined in the wider IS literature in relation to IT adoption and use (Gebauer and Tang 2007; Junglas et al. 2009; Zhang et al. 2011) with Saeed and Abdinnour-Helm (2008) arguing that the way tasks are performed can impact the usage of a system. A key finding of this study, which supports the aforementioned research, is that healthcare practitioners who were willing to use mHealth in urgent situations were found to infuse the mHealth within their daily work routine. Interpreting the positive association between time-criticality and mHealth infusion means that the greater the willingness of healthcare practitioners to use mHealth in urgent situations, the greater the subsequent increase in the infusion of the technology. Based on this evidence, it is imperative that mHealth are ergonomically suitable (in terms of portability) to be utilised at the point-of-care. It must also prohibit healthcare practitioners from becoming overwhelmed with vast amounts of information.

Research also argues that habit can impact the infusion of an IT artefact (Makinen and Jaakkola 2000; Ng and Kim 2009). In order for habit to positively impact mHealth infusion,

Table 7 Path coefficients, significance levels and hypotheses outcome

Association	T Statistics	Significant (1-tailed)	Significant (2-tailed)	Hypothesis Outcome
Availability > Infusion	2.717612	$p < 0.005$	----	H1: Availability of mHealth positively impacts the infusion of mHealth by healthcare practitioners. [Supported]
Self-Efficacy > Infusion	2.383598	----	$p < 0.05$	H2: mHealth self-efficacy impacts upon healthcare practitioners' infusion of mHealth. [Supported]
Time-Criticality > Infusion	4.261993	$p < 0.0005$	----	H3: The ability of mHealth to support healthcare practitioners with decision making in emergency situations positively impacts the infusion of mHealth. [Supported]
Habit > Infusion	2.484910	----	$p < 0.01$	H4: Habits formed by healthcare practitioners' impact their infusion of mHealth. [Supported]
Tech. Trust > Self-Efficacy	5.845051	$p < 0.0005$	----	H5: Healthcare practitioners' ongoing trust in the mHealth technology positively impacts mHealth self-efficacy. [Supported]
Tech. Trust > Time-Criticality	1.841006	NS	----	H6: Healthcare practitioners' trust in mHealth positively impacts upon their willingness to use mHealth in urgent situations. [Not Supported]
Task Behaviour > Time-Criticality	5.340515	----	$p < 0.001$	H7: The culture surrounding data recording practices performed by team members when delivering healthcare services impacts fellow healthcare practitioners use of mHealth in urgent situations. [Supported]
Task Behaviour > Habit	3.545709	----	$p < 0.001$	H8: Working as part of a team when delivering healthcare services to patients influences healthcare practitioners' mHealth behaviour. [Supported]
Infusion > Performance	14.27402	$p < 0.0005$	----	H9: Infusion of mHealth positively impacts healthcare practitioners' performance in terms of clinical care, workflow and learning. [Supported]

healthcare practitioners are required to employ 'good' habitual routines from early phases of IT implementation. That is, healthcare practitioners should form habits which will facilitate infusion in earlier phases of implementation. The positive direct relationship between habit and mHealth infusion revealed in our study can be interpreted as follows: when habitual routines of healthcare practitioners increase, there is a subsequent increase in the infusion of mHealth. An explanation for this finding is that when system usage becomes repetitive and routinised, habitual routines for system usage will emerge (Garfield and Dennis 2012; Ng and Kim 2009). This often is established in the phase preceding infusion (i.e. routinization, Cooper and Zmud 1990) and continued into the infusion phase. Therefore, we corroborate existing literature on IT infusion and apply the concept of habit to the mHealth domain.

Technology trust was found to be central in explaining mHealth infusion (similar to the work of Thatcher et al. 2011). Firstly, the positive relationship between technology trust and mHealth self-efficacy shows that greater levels of trust in mHealth lead to subsequent improvements in self-efficacy levels of healthcare practitioners. This study confirms Craig et al. (2010) by showing that technology trust has an impact on self-efficacy. Users' of IT artefacts in post-adoptive scenarios can anticipate how that particular artefact will respond under different conditions (Saga and Zmud 1994). Therefore, when individuals trust the IT artefact they are aware of how the IS operates and perceive control over the technology. It is this perceived control which enables users to feel more confident in conducting tasks using the mHealth. That is, when mHealth perform in an unanticipated manner (e.g. crashes, technical issue, alterations to features/

functionality, etc.) users lose control over the technology and mistrust the technology. Therefore, trusting the technology establishes positive perceptions of one's ability to use IT artefacts in the accomplishment of a task. Secondly, the weak association between technology trust and time-criticality established in this study means that trust in technology does not impact one's willingness to use mHealth in urgent situations. A possible explanation for this finding is that users (i.e. healthcare practitioners) still have to perform tasks in urgent situations whether they trust the system or not. If healthcare practitioners withhold necessary healthcare services to patients, then detrimental consequences can occur to the extent that it can impair a patient's life and a practitioner's career. Building on this, it is important to consider both the system quality and information quality components inherent in mHealth (Chen et al. 2014). MHealth must be designed appropriately not to draw the attention away from the primary tasks (i.e. delivering healthcare services in time critical situations) of healthcare practitioner. Nilsson (2009) proposes that mHealth should present optimal information in a flexibility way, vis-à-vis reliable communication both for voice and data queries, which requires minimal effort in emergency situations. By designing non-intrusive mHealth interventions healthcare practitioners' trust in mHealth may increase resulting in their increased use of the technology in both critical and non-critical situations.

A positive relationship between task behaviour and time-criticality was found in this study. The positive relationship supports research findings by identifying that the documentary practices performed by team members, via mHealth, impacts fellow healthcare practitioners' use of the technological tool in urgent situations. This association can be interpreted as follows: the willingness to use mHealth in urgent situations increases when fellow team members have electronically documented patient data in a complete and comprehensive manner via the technological tool. Electronic documentation as a means of communication among staff in a healthcare setting is imperative as mHealth facilitates the flow of patient-related information at a workgroup level. This suggests that the information culture within an organisation appears to influence how mHealth tools are utilised in practice. That is, the values and attitudes toward information and what 'to do' and 'not to do' pertaining to information processing, publishing, and communication (Davenport and Prusak 1998) must be expressed to all team members to ensure that clinical care in urgent situations is coordinated and achieved without delay.

Task behaviour was also found to be positively associated with habit. This association corroborates and enhances existing research by highlighting that working as part of a team influences healthcare practitioners mHealth behaviour. More specifically, this finding means that habitual routines are seen to increase with higher instances of task behaviour (i.e. clinical based activities that team members perform using mHealth tools). In post-adoptive scenarios, healthcare practitioners would have frequently interacted with fellow colleagues (e.g. peers, superiors, and subordinates) and can often be influenced by the actions of those around them (Gallivan and Srite 2005). When other users in one's work group utilise the mHealth tool in certain ways, the user would assimilate the prevalent. This would shape his/her operational stance accordingly, thereby, establishing habitual routines.

The positive association between mHealth infusion and individual performance established in this study implies that as mHealth infusion increases, there are subsequent improvements in (1) delivering clinical care to patients, (2) the work flow of healthcare practitioners when delivering healthcare services and (3) learning. Based on this evidence, to obtain improvements in terms of delivering healthcare services is dependent upon the degree to which healthcare practitioners use the technology's (i.e. mHealth) features/functionality to complete any given task, the degree to which healthcare practitioners organise their work tasks to fulfil their role using the mHealth, and the degree to which healthcare practitioners actively seeks novel uses of the mHealth within their work environment. Therefore, management in healthcare organisations should promote feature use, integrative use and exploratory use of mHealth.

In the wider adoption literature researchers have found that mobile technologies impact performance of mobile workers and promote efficiency (Basole 2004; Hsiao and Chen 2012; Rossi et al. 2007). In particular, mHealth research has shown that infusion can lead to increased individual performance in terms of effectiveness, efficiency and learning (White et al. 2005). This study extends this research by quantifying the extent to which infusion impacts individual performance of healthcare practitioners in a clinical healthcare setting.

6 Conclusion

Over the last decade the provision of healthcare through the use of mHealth has become a global reality. Instant real-time access to data at the point-of-care is causing a paradigm shift in how healthcare providers deliver healthcare, making services more streamlined and cost effective. Globally mHealth is already having a significant impact but at different rates of long term usage (Jahns 2014). This argument is further reinforced by work conducted in 2013 by IMS Institute for Healthcare Informatics who analysed 43,689 mHealth apps, and argue that despite the vast number of health care applications available for download, most applications are underutilised post download (Aitken and Gauntlett 2013). If mHealth technologies are to be widely adopted and utilised on a long term continuous basis it is important the technological tools must provide value to the healthcare provider (Becker et al. 2015). For mHealth to be truly valuable, it is argued (Jasperson et al. 2005) that the technological tools be used in post-adoptive scenarios and infused within practitioners work practices. From reviewing existing literature on mHealth failures, it is evident that these technological tools are often under-utilised and/or completely abandoned following adoption and that a dearth of research exists which focuses on the infusion phase of implementation. This study seeks to address this shortcoming in the literature.

6.1 Contributions to theory

The study's findings contribute to two domains of academic research. It first contributes to the mHealth infusion literature. Contributions to mHealth infusion research include: developing a model of mHealth infusion, examining undocumented determinants and relationships, and demonstrating the benefits of mHealth infusion.

The mHealth infusion model is one of the first models to examine the determinants and outcomes of mHealth infusion. In developing the mHealth infusion model (Fig. 2), through our hermeneutical approach, we identify two previously undocumented factors, namely time criticality and task behaviour as determinants of mHealth infusion. The quantitative aspect of our study confirmed the role both play in mHealth infusion. Therefore, this study illustrates the criticality of examining the contextual landscape in which mHealth artefacts are utilised when studying infusion in a hospital setting. This study also illustrates the impact which mHealth infusion has on physician performance, specifically relating to their effectiveness, efficiency and learning.

This study also contributes to the broader IS discipline by: addressing the dearth of research on the association between infusion and outcomes, developing an infusion model for investigation in other domains thereby adding to the literature on post adoption use and associated outcomes. By empirically investigating infusion at the level of an individual, this study provides keep insights on driving adoption at an individual level and illustrates how a theory building approach can provide rich insights into an under-investigated area of existing research. Moreover, this study corroborates existing research which highlights the importance of resource availability, self-efficacy, habit, systems and content quality for IT infusion.

6.2 Implications for practice

From a practical perspective this study informs healthcare organisations and vendors as to the performance of mHealth in a healthcare organisation by clearly demonstrating that infusion leads to improvements in clinical care, workflow and individual learning. It further contributes to the practitioner community by establishing that training must be provided regularly and continues in the post-adoption phases, especially if features/functionality of mHealth changes frequently. Building from this, a dedicated team should be formulated within a healthcare organisation (consisting of both clinical and IT personnel) to promote the use of mHealth to achieve infusion. For infusion of mHealth to occur it is imperative that healthcare practitioners have access to available mHealth to gain knowledge on how to embed the technological artefact within their daily work practices. Ultimately, this might require the healthcare organisation to invest significantly in mHealth. By (1) identifying the conditions that both healthcare practitioners and organisations can employ to assist with mHealth infusion and (2) informing healthcare organisations and vendors as to the performance of mHealth models (e.g. cloud computing) in post-adoptive scenarios, hospitals can continue to avail of government funding opportunities surrounding IT within the health sector. Finally, when mHealth is infused as part of delivering healthcare services it facilitates the engagement of patients in a participatory and inclusive manner by increasing mutual dialogue and understanding in a hospital setting between healthcare practitioners and providers. This rich exchange may ultimately encourage patients to monitor and manage their own health and wellbeing using the various "quantified-self" mHealth interventions available on the marketplace (Dwivedi et al. 2016).

6.3 Study limitations

Although the research study achieved its objective, the results of this study should be interpreted in the context of its limitations. Firstly, the initial model guiding this study was derived following certain criteria (depicted in Section 2). As a result, other constructs could have been excluded from the initial model. Future research could examine additional post-adoption theories in IS research and enhance the current MHS Infusion Model to provide richer insights into the concept. Due to time constraints the survey was only implemented in one hospital. This inevitably may raise concerns regarding generalisability of the findings in this study. Future research can employ the conceptual model derived across a variety of healthcare organisations which have been utilising mHealth for an extended period of time. Additionally, in this study infusion is modelled as a second-order construct (aligning with previous research). The paths to each type of infusion (i.e. feature, integrative and exploratory use) are not examined individually which may better attest to the level of utilisation by the healthcare practitioners. Future research should delve deeper into the individual components of infusion when examining this model in other healthcare settings.

The researchers additionally call for future research to be conducted in the mHealth infusion domain focusing on different levels of analysis (e.g. organisational level, group level, inter-organisational level). A model of mHealth infusion was established in this study based on handheld mobile technologies. However, additional mobile technologies are utilised by healthcare practitioners such as mobile trolleys, sensors, and laptops. Therefore, future research should employ the model built in this study and investigate other mobile artefacts in the healthcare sector. This would allow future researchers to compare and/or contrast their findings with the findings established in this research. This study also examines mHealth at the infusion phase of implementation only. Thus, the researchers call for studies to examine the assimilation of mHealth from early phases to latter stages of implementation using a longitudinal study.

Existing mHealth research primarily explores early phases of implementation with little attention on post-adoptive scenarios. It is imperative that researchers explore the latter to ensure that mHealth interventions can be scaled up and sustained on a long term basis. Insights into understanding antecedents and outcomes of mHealth use in post-adoptive scenarios are not only of benefit to healthcare providers in developed countries but also those in resource-poor settings. The use of mHealth interventions in developing countries is currently on the rise and is dramatically changing how healthcare services are delivered to the world's poorest people. Yet, to yield the benefits offered by mHealth such technological tools must be scaled up from pilot studies and sustained on a long term basis. Therefore, more research is required around the post-adoption of mHealth by healthcare providers so that the findings and lessons learnt from such studies can be transferred and applied in a developing world context.

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