Understanding Factors Influencing Adoption of Mobile Devices in Telehealth: A Quantitative Study

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1. INTRODUCTION

Globally, the impact of mobile devices has improved the healthcare environment and they will continue to take centre stage into the future. Using mobile devices, data can be communicated easily between Health Care Professionals (HCPs) and patients. Patient data can automatically be collected, transmitted, aggregated with other physiological data, analysed, stored, and presented as actionable information (Klonoff, 2013). Expert health professionals can use this actionable information to communicate with the patient and make diagnoses, treatment and recommendations to emergency doctors at other sites. Furthermore, primary care physicians can access specialists for consultation and diagnosis at any time using mobile devices. Mobile devices can also be used to manage patients' particular medical conditions and health risk factors (Deng et al., 2013). Using real-time video-based virtual consults, people can access their health information and consult doctors in an emergency through mobile devices (Zangbar et al., 2014). Moreover, mobile devices have the potential to reduce the inefficient use of resources in the health domain. It is predicted that, worldwide, there will be a net shortage of 15 million healthcare workers by the end of 2030; a shortage which can be better managed using mobile devices (Singh and Sullivan, 2011). Mobile devices are also used in emergency responses, short message services (SMS), paging, automated sensing, mobile applications, media capabilities and video conferencing in healthcare (Eskinder et al., 2016). These services are reducing the unnecessary hospitalisation of patients. In addition, administrative tasks, documentation, decision-making and educating health staff can be accomplished using mobile devices (Croll et al., 2012). Along with these advantages, several health applications can be used on mobile devices. Some of these applications include as stethoscopes, sleep structure analysers, cardiac analysis systems, mental health trackers, Parkinson's disease trackers and trackers for monitoring the physiological signs of patients (Bort-Roig et al., 2014). These applications are helping health professionals and patients in various ways. An application `NumaStatus' can be downloaded to a mobile device and used for patient dose report generation and communication anywhere in the health facility (Tangorra, 2015). 'Resolution Software' is a U.S. Food and Drug Administration (FDA) class II cleared solution and can be used in validated mobile devices for diagnosis and providing seamless image access across multiple departments (Tangorra, 2015). Thus, it can be seen that the use of mobile devices in healthcare has great potential.

Although the use of mobile devices in healthcare is contributing to managing the health of people in various ways, their adoption in this domain is slow (Wu et al., 2011, Nour et al., 2015, Slaper and Conkol, 2014, Milward et al., 2015, Alaiad and Zhou, 2014). Most of the mobile device-based projects in healthcare are implemented on a pilot or trial basis and the adoption of these projects remains unknown or limited (Lu and Wu, 2015, Willcox et al., 2015, Hebden et al., 2014, Clarke et al., 2014). In the health environment, mobile devices are mainly used for calling, text messaging, medication reminders, reminder emails, maintaining health diaries and symptom tracking (Muralidharan et al., 2017, Tian et al., 2017, Wu et al., 2017, Oliver-Williams et al., 2017). Even though the use of mobile devices has great potential in remote monitoring and Tele-consultation (Chow et al., 2015, Rahman et al., 2017), their use in these activities is limited. Therefore, this research study is designed to understand the adoption of mobile devices by HCPs in the Telehealth environment.

2. LITERATURE REVIEW

Previous studies have explored many factors explaining technology adoption from the Individual, Technological and Usage contexts and the most common factors found are: Intention, Self-efficacy, Social influences, Relative advantages, Compatibility, Complexity, Design and technical concerns, Privacy and security. These factors may be used in this research study. However, they may not fully explain mobile device adoption as these were only explored in countries such as USA, UK, Canada, New Zealand, Taiwan, Korea, Pakistan, Bangladesh, India and the Netherlands (Wang et al., 2010, Bradford et al., 2014, Deng et al., 2013, Daim et al., 2013). Further, these studies were conducted for various types of technologies such as Telehealth, e-health and m-health and not specifically for explaining the adoption of mobile devices. Mobile device adoption research studies are limited and applied to mobile devices that are now obsolete (Yangil and Chen, 2007). As mobile devices are a part of m-health, the literature review has also been conducted to gain insights into the adoption factors associated with m-health. The factors associated with m-health adoption have been identified through research focussed on non-Australian healthcare contexts such as those in South-East Asia, Turkey, America, Europe, Western Pacific, Africa, Canada and UK (Sezgin et al., 2016). These research studies in non-Australian healthcare contexts can provide an idea of how mobile devices are adopted in healthcare but may not be fully relevant for exploring the adoption of technology in the Australian healthcare context because of obvious differences between difference in the countries' healthcare contexts. Furthermore, previous research studies into the adoption of m-health may not be fully applicable to the context of this research study context because m-health includes various components such as application software used in mobile devices, which are not within the scope of this study. In the Australian healthcare context, only a few studies have been conducted to explain the factors influencing the adoption of various types of technologies from the individual HCP's perspective (Tiong et al., 2006, Hafeez-Baig and Gururajan, 2010, Tsai and Kong, 2013). As with the international research outlined above, these studies alone may be insufficient to understand the adoption factors of mobile devices in this research study context due to their wider scope and the technology studied being obsolete (Tsai and Kong, 2013, Tiong et al., 2006, Hafeez-Baig and Gururajan, 2010). It is hoped that the above examples justify the importance of conducting this research study.

3. METHODS

In this research study, the data was collected using both online and paper based surveys because these techniques are suitable in the health domain to collect data according to the convenience of the participants and are also used by previous researchers. Surveys collected using these techniques were further analysed using exploratory factor analysis because by using this particular type of analysis the main factors can be extracted from a large number of factors (Yangil and Chen, 2007, Wu et al., 2007, Kim et al., 2007, Wu et al., 2011, Sanders et al., 2012, Singh et al., 2012, Deng et al., 2013, Thomas et al., 2014). A detailed description of the survey questionnaire, process of data collection and data analysis are explained further.

The survey instrument is designed using an extensive process of four phases (themes and factors selection, items creation, items refinement and item testing). The instrument in this study consists of two parts. Part 1 contains sixty-nine questions used to measure the fourteen factors proposed to influence mobile device adoption in healthcare. Multi-items (4-7 items) were used to measure each factor. A five-point Likert scale from strongly disagree to strongly agree was used to measure the items which were considered from previous HIT adoption studies and conducting exploratory study. Part 2 contained eleven socio-demographic factors about each respondent such as age, gender job experience and mobile device use experience which were considered according to the suitability of this research study.

The survey was conducted from December 2016 to February 2017. Healthcare professionals involved or familiar with the provision of Telehealth services in Australia participated in the survey. The sample was conveniently selected using those who work in the regional health facilities in Queensland, including HCPs such as nurses and physicians. The response rate in this research study was 9%. In this research, a total of 1500 surveys were distributed to HCPs. Of these, 135 responses were received. However, due to unforeseen events occurring during data collection, only 39 responses were used for the purposes of statistical testing.

3.1 Data analysis

The descriptive analysis indicated that of the 39 respondents, 74.4 % were females and 25.6% were males, and most were young (less than 40 years of age) nurses. All participants had differing levels of experience working in healthcare ranging from less than 5 years to greater than 25 years. The data indicated that most HCPs had some experience with mobile device usage in their daily routine and some of them (17 participants) were also using them in the Telehealth environment.

The missing values analysis pattern for surveys showed a range of missing values from 2.6% to 5.1% which was considered completely random because the missing values were independent of each other. However, the results of inter-item correlation indicated that ten factors needed to adjust their items for further data analysis to occur because Cronbach's Alpha value improved when certain items were considered for deletion. Cronbach's Alpha is used to test the scale's reliability as it is widely used to estimate the internal reliability of multi-items scale and its value of 0.7 and higher is considered acceptable. In this research, the Cronbach's Alpha value was ≥ 0.7 which was acceptable. The number of items considered for deletion from the survey are mentioned in Table 1 last column.

Table 1: Cronbach's alpha before and after deletion of lowest rank item

Constructs	Number of items	Cronbach's alpha before deletion of any item	Items considered for deletion	Cronbach's alpha after deletion of some items	Items deleted before conducting
Intention	5	.900	IN2	.906	IN2
Self-efficacy	4	.706	SE3	.774	SE1-SE4
Functional features	6	.891	FF1	.898	FF1
Complexity	5	.760	CX5	.794	CX5
Social influences	5	.772	SI5	.875	SI5
Compatibility	5	.814	CP1	.807 Alpha value	-----
Relative advantages	4	.911	RA3	.919	RA1-RA4
Training	5	.808	TR4	.802 Alpha value	-----
Management support	4	.904	MS2	.907	MS1-MS4
Network coverage	5	.674	NS5	.877	NS5
Privacy and security	7	.849	PS1	.930	PS1
Resource issues	5	.934	RS1	.927 Alpha value	-------
Trialability	5	.819	TR5	.852	TR5
Demographic factors	4	.700	DC1	.716	DC1-DC4

These items were: IN2, SE1-SE4, FF1, CX5, SI5, RA1-RA4, MS1-MS4, NS5, PS1, TR5 and DC1-DC4. This deletion indicated that four constructs (Self-efficacy, Relative advantages, Management support and Demographic factors) were removed before conducting the first EFA. Also, one item from each of the six factors (Intention, Functional features, Social influences, Network coverage, Privacy and security and Triability) was removed before the first EFA. Thus, in the first EFA ten factors with 45 items were loaded.

A rule of thumb, Eigen values > 1 was used to determine the number of factors from EFA. Principal Component Analysis (PCA) was used for extraction and orthogonal rotation varimax, rather than promax rotation, was used to derive non-correlated factors. The results of the EFA are presented in the next section.

4. RESULTS

In the first run of EFA, from 69 items, 45 variables/items were factored using Eigenvalues >1. The 45 items were those items for which the inter-item correlation (Cronbach's Alpha) was ≥ 0.7 and a minimum of four items represented a construct. The SPSS rotated component matrix for the first EFA results indicated that a possible eleven factors could be extracted from 45 variables/items. This factor analysis solution indicated that there were some items, which were not loading properly or loading twice. For example, the items for the compatibility factors were not making a proper component. Such types of items were removed and EFA was conducted again. The second factor analysis was carried out using the remaining 34 items to evaluate the component identified in the first EFA. The rotated factor structure indicated that nine possible factors could be extracted from a second EFA. However, the rotated factor structure showed that some of the items were not loading properly with the nine components or loading more than one component. Therefore, these items were deleted and EFA was re-run. In the final EFA solution, six items/variables were removed and the remaining 21 items/variables were factored using Eigenvalues >1. The rotated component matrix represented in Table 2 indicated that six possible factors could be extracted.

Table 2: Rotated component matrix for the Final EFA

No	Items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
1.	Q52PS Secure transmission of patient data needs to be assured before I would use mobile devices in the Telehealth context.	.872					
2.	Q53PS Patients need to have appropriate location privacy assured before using mobile devices in the Telehealth context.	.898					
3.	Q54PS Privacy is ensured while providing patient care before using mobile devices in the Telehealth context.	.878					
4.	Q55PS The privacy of patient's data needs to be assured before using mobile devices in the Telehealth context.	.798					
5.	Q11FF Battery backup of mobile devices such as smart phones and tablets is adequate for use in Telehealth.		.813				
6.	Q12FF Data storage of mobile devices such as smart phones and tablets is adequate for use in Telehealth.		.880				
7.	Q13FF Sound quality of mobile devices such as smart phones and tablets is adequate for use in Telehealth.		.797				
8.	Q14FF Image quality of mobile devices such as smart phones and tablets is adequate for use in Telehealth.		.760				
9.	Q1IN I intend to increase my use of mobile devices in Telehealth.			.689			
10.	Q3IN I intend to use mobile devices in the Telehealth context, if required by my health facility.			.869			
11.	Q4IN I intend to use mobile devices in the Telehealth context to improve my work processes and outcome.			.847			
12.	Q5IN I intend to use mobile devices to make more efficient use of my time.			.855			
13.	Q61TRI I would use mobile devices on a trial basis prior to embedding into normal clinical practices.				.799		
14.	Q62TRI I would use mobile devices in the Telehealth context if these were available for a certain time period so I could become familiar with their use before the actual use.				.885		
15.	Q63TRI I would try out certain features of mobile devices prior to embedding into clinical practices.				.909		
16.	Q64TRI I need time to be allocated to trialling the mobile devices so I can understand how to use them in the Telehealth environment.				.569		
17.	Q45NC Network reception is good in my health facility to support the use of mobile devices in the Telehealth environment.					.927	

No	Items	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Factor 6
18.	Q46NC Network coverage in remote area for Telehealth is adequate for the effective use of mobile devices.					.848	
19.	Q47NC Network coverage in my Telehealth environment is available anytime and anywhere to support the use of mobile devices.					.886	
20.	Q37TR Using mobile devices in the Telehealth require regular information sessions to update my knowledge.						.787
21.	Q38TR Using mobile devices in the Telehealth context requires printed manuals to support my learning.						.891
22.	Q39TR Using mobile devices in the Telehealth context require video clips to help me to refresh my knowledge.						.786
	Extraction Method: Principal Component Analysis. Rotation Method: Varimax with Kaiser Normalization. Rotation converged in 6 iterations.						

All the items in this factor solution were loading properly on their relevant factor. Therefore, this factor solution was considered the final solution for EFA.

The final exploratory factor analysis solution accounted for 82.42% of the total variance in the data as shown in Table 3.

Table 3: Cumulative frequency for the final EFA

Components	Cumulative frequency (for six factors)
Privacy and security	33.839
Functional features	47.778
Intention	60.403
Trialability	69.031
Network coverage	76.866
Training	82.428
Note: Percentage of variance for each factor is calculated by subtracting the values of cumulative frequency of each factor from their previous factor.	

The first factor, which accounted for 33.8% of the variance was Privacy and security. In this factor, high factor loading (0.7-0.8) of four items was found. Factor loading is the correlation of a variable with a factor. A loading of 0.3 or more is considered to be meaningful. These items were: 1. Security of patient data, 2. Location privacy, 3. Privacy of patient care, 4. Privacy of patient data necessary. The second factor which explained 13.9% of the total variance was Functional features. High factor loading of four items: 1. Battery backup, 2. Data storage, 3. Sound quality and 4. Image quality was observed. The third factor described 12.6% of the total variance and this factor was Intention which was characterised by the following four items: 1. Intended to increase use of mobile devices, 2. Intended to use mobile devices, 3. If required by health facility, 4. Intended to improve work processes and outcome using mobile devices and intended to make more efficient use of time using mobile devices. The fourth factor which accounted for 8.6% of the total variance was Trialability, characterised by the following four items: 1. Requires trialabiltiy before embedding mobile devices in normal clinical environment, 2. Trialability to become familiar with the devices, 3. Trialability to use features and 4. Trialability to understand how to use mobile devices in Telehealth. The fifth factor which accounted for 7.8% of the total variance was Network coverage, characterised by three items: 1. Network reception is good in my health facility, 2. Network coverage in remote area for Telehealth is adequate and 3. Network coverage in my Telehealth environment is available anytime and anywhere, and labelled as network coverage. The last and the sixth factor which explained 5.5% of the total variance was Training, characterised by the following three items: 1. Requires regular information sessions, 2. Requires printed manuals and 3. Requires video clips.

5. CONCLUSION

This research study examined mobile device adoption by HCPs in the Telehealth environment. In this research study six factors are established as the key factors explaining the adoption of mobile devices in Telehealth. These six factors are: 1. Intention, 2. Functional features, 3. Trialabiliy, 4. Network coverage, 5. Privacy and security and 6. Training. A detailed discussion on these factors is provided further.

The First factor demonstrated in this research is Intention. The role of Intention as a dependent factors has been well established in the HIT adoption literature (Tavares and Oliveira, 2017). The HIT adoption literature suggests that successful adoption and use of technology needs user intention to adopt technology (Lyzwinski et al., 2017). The findings from this research study also demonstrate that HCPs Intention to use mobile devices is an important factor for understanding adoption of mobile devices to improve the quality of care in Telehealth environment. The finding is consistent with previous HIT adoption literature (Tavares and Oliveira, 2017). The insight gained from this factor can contribute to the theory and directly benefit the decision maker who implement technology in the Telehealth environment. To accelerate adoption of mobile devices in Telehealth, decision makers should strongly support and encourage their staff to adopt mobile devices in Telehealth.

The second factor highlighted in this research study is Functional features. The HIT literature suggests that design and technical concerns such as screen size, touch screen, keyboards, a lack of printing options, inability to view certain websites (visual quality) and file format are some of the features which limit the use of technology in healthcare (Gagnon et al., 2016). In this study's scientific evidences indicates that the Functional features: battery life, data storage, weight and sound quality are the most significant features for their adoption in Telehealth. The information on these factors is limited in the previous HIT adoption literature. This research study reveals that for effective Telehealth sessions battery backup and data storage capacity should last for at least one shift and sound and image and sound quality should be clear enough to understand. The finding of this factor suggests that developers should carefully explore the importance of Functional features from HCPs' perspectives for their adoption in Telehealth. Also, the top level of management and decision makers involved in the formulation and implementation of mobile devices in Telehealth should consider mobile device features carefully before implementing these devices in the Telehealth context.

The Third factor emphasized in this research study is Trialability. In the HIT adoption literature, Trialability is an important factor explaining the adoption of technology in healthcare (Lin and Bautista, 2017). Consistently, this research study confirmed that for using mobile devices in the Telehealth environment, HCPs require Trialability so that they can obtain the knowledge necessary to become familiar with mobile device usage. In the trial environment they need to learn how to use mobile devices as well as try some features before embedding them into their normal clinical practices. This finding suggests that trial time and environment before using such technology in the Telehealth is necessary and may be provided by the management of the health facility.

The Fourth factor recognised in this research study is Network coverage. Limited literature indicates network coverage to be a challenge for the use of technology in the Australian healthcare context (Parliamentary Committees, 2014). This research study also confirmed that a good Network coverage is required in the health facility to effectively use mobile devices in the Telehealth context. The finding of this factor suggests that the top level of management and decision makers involved in the implementation of mobile devices in Telehealth should consider carefully network services providers before implementing these devices in the Telehealth context.

The Fifth factor confirmed is Privacy and security. The literature suggests that Privacy and security issues such as authentication, anonymity, authorization, access control, accountability, location privacy, data security and integrity may inhibit technology adoption in healthcare (Premarathne et al., 2015, Htat et al., 2017). This research study also confirms Privacy and security as an important factor explaining the adoption of mobile devices, and indicates that the major concern in Privacy and security are: security of patient data, location privacy, patient care privacy and privacy of patient data. This finding suggests that policy makers and managers should consider these privacy and security concerns carefully. Policy makers should refine policies and procedures by ensuring the privacy and security of patient data and care while using such technology. In the health facilities where mobile devices need to be used in Telehealth sessions, managers can recommend a separate location to maintain privacy of patient care and consultation.

The Sixth factor established is Training. The literature indicates that training is important to improve the health professionals' technological abilities and effective use of technology-based interventions (Agarwal et al., 2015, Lyngstad et al., 2015). Consistent with previous HIT adoption literature, this research study also suggests that Training is an important factor in explaining mobile device adoption in Telehealth. This research also reveals that HCPs like to obtain regular training in printed and electronic form (video clips).

6. LIMITATIONS AND FUTURE WORK

Using quantitative approach, this paper has provided evidences for the six factors (1. Intention, 2. Functional features, 3. Trialability, 4. Network coverage, 5. Privacy and security and 6.) Training) for understanding the adoption of mobile devices in the Telehealth environment. These factors contributed to the HIT adoption literature and also have some practical recommendations for technology developers, management staff, decision maker and policy maker. However, these factors for mobile device adoption in Telehealth were obtained in the regional areas of Queensland, Australia, the generalisation of these findings should be made with caution for other states of Australia and countries. Further investigation may look into other states of Australian health context and different countries' health context.

ACKNOWLEDGE

This research study is supported by the Gold Coast Human Research Ethics Committee, Research Governance Officer Darling Heights Hospital and Health Services and University of Queensland Human Research Ethics Committee.

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