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PUBLIC ADOPTION OF TELEHEALTH TECHNOLOGY IN THAILAND

Thanarerk Thanakijsombat[1*], Veera Bhatiasevi[1], and Chavisa Suwanposri[1]
[1]Business Administration Division, Mahidol University International College, Nakhonpathom, 73170, Thailand

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ABSTRACT

This study examines key determinants and challenges in the public adoption of telehealth technology in Thailand. It aims to provide managerial implication for Thai healthcare and telecommunication policy makers in designing and planning for the nation-wide adoption of the telehealth technology, in order to remedy long-standing healthcare problems including a medical staff shortage and an inefficient care delivery. In addition, it aims to contribute to the existing telehealth technology adoption literature in the context of rural areas where environmental factors could play a major role in a successful adoption. The TOE was employed as the framework to conduct a qualitative study using an in-depth interview a 12 out of 35 Thai public primary, secondary, tertiary and specialized care centers, participated in the pilot phase of the Telehealth project which was initiated by the National Broadcasting and Telecommunication Commission (NBTC) of Thailand and the Thai Ministry of Public Health (MOPH). Findings reveal that the compatibility with disparate legacy information technology systems, the disagreement over the balance between data privacy and data usage, and the ineffectiveness in the requirement gathering process from key stakeholders are main technological barriers for adoption. Furthermore, organizational factors including the continuous infrastructure and financial supports, the work process redesigning, the digital literacy training, and the motivation schemes for a sustainable adoption are cited to be crucial determinants. Lastly, concerned policy makers need to take into consideration environmental factors including the needs for systematic collaboration among care centers at all levels, the belief in a physical meeting between care providers and receivers, and the regulatory risks related to data privacy and intellectual property rights, for a successful adoption of the telehealth technology nationwide.

Keywords: TOE, Telehealth, Telemedicine, Technology adoption

Introduction

The Fourth Industrial Revolution (Industry 4.0), similar to the revolutions that preceded it, has the potential to improve quality of life for the global population by leveraging digital technologies. In healthcare industry, the digital revolution has made possible many innovative remote healthcare services that are more efficient and more effective.

[*]corresponding author: e-mail: thanarerk.tha@mahidol.edu

In combination with modern information and communication technologies (ICTs), the digital technologies allow us to resolve the prolonged issues of poor healthcare quality and inequality. Underserved patients in remote areas where there are shortages of doctors and nurses, and those who are in needs of specialized or personalized healthcare services can all benefit from a greater accessibility provided by these emerging integrated technologies. For instance, Tortorella, Fogliatto, Mac Cawley Vergara, Vassolo, and Sawhney (2019) found that Internet of Things (IoT) is one of the most common applications in Healthcare 4.0, whereas it expands the Internet connectivity to medical tools allowing for remote monitoring and care. In addition, the concept of patient-centered healthcare is getting more attention as populations are being more familiar with individual smart devices (Redfern, 2017; Haluza & Jungwirth, 2018; Gogia, 2020). IoT devices can appear in forms of wearable smart devices and mobile applications which can be used to monitor patients' daily health behaviors and conditions for both health monitoring and risk prevention purposes outside of traditional healthcare centers (Haluza & Jungwirth, 2018).

Among all the applications of healthcare technologies, Telemedicine has been increasingly adopted globally as a solution to the healthcare issues mentioned above. Nevertheless, many developing countries often face crucial challenges in telemedicine adoption, such as the unavailability of an appropriate infrastructure, the insufficient data security system, and the lack of resources (Adelakun & Garcia, 2019; Gogia, 2020). In addition, many telehealth projects were reported to halt in the pilot stage and were unable to scale up due to many adoption barriers (Taylor, Coates, Wessels, Mountain, & Hawley, 2015; Sisk et al., 2020). In the existing literature though, only a few studies though focus on telemedicine adoption in rural areas where healthcare problems seem to be prevalent.

In Thailand, the effort to adopt appropriate technologies to provide Telemedicine services nationwide was in the form of the Telehealth project initiated by the National Broadcasting and Telecommunication Commission (NBTC) of Thailand and the Thai Ministry of Public Health (MOPH). The main purposes of the Telehealth project are to improve the accessibility and the quality of healthcare services in remote areas where there is a lack of healthcare personnel and effective medical equipment.

The Telehealth project was initially rolled out as a pilot project whereas telemedical and telecommunication devices and relevant software are procured, distributed to and installed at the facilities of 35 provincial hospitals and local public health centers in Thailand. Contingent upon the success of the pilot project, the project scope will be extended nationwide and to include healthcare services for other diseases. It is thus crucial for Thai policy makers to understand key determinants of telehealth technology adoption, especially environmental factors rarely discussed in the existing literature, based on a widely adopted technology adoption framework in order to ensure a successful adoption of the new technology. See Appendix for more details.

Objectives of the Study

The main purpose of this study is thus to examine the determinants and the challenges of the adoption of the telemedical technology as part of the NBTC and MOPH's Telehealth pilot project. The practical insights obtained from the in-depth interviews with relevant stakeholders in the sample of participating Thai provincial hospitals and local healthcare centers in the pilot project, could help ensure a successful extension of the Telehealth project to other geographical regions in Thailand, and to much needed healthcare services for other diseases. In addition, findings from this research could add to the existing literature with regard to the determinants and challenges of the adoption of telemedical technology in the rural area context.

Literature Review

Background on telemedicine

Telemedicine has emerged to improve healthcare quality and cost-effectiveness (Sanders et al., 2012), especially for the care of underserved populations where there is a physical distant between patients and professional care providers by transmitting information, such as image, voice, and health data over a device rather than moving the health professionals or patients (Lin et al., 2018; Harst, Lantzsch, & Scheibe, 2019; Gogia, 2020). The technology enables clinicians to discuss a case in a face-to-face manner over a video conference, examining the patients' conditions both from their live conditions and behaviors, and from the additional IoT devices that can monitoring patients' health data digitally, and transmitting the data for interpretation and diagnosis to the professionals (Gogia, 2020).

Telemedicine can narrow various ongoing gaps in healthcare services as its main benefit is to deliver healthcare service remotely. The problems of the shortage or immobility of the professional care providers, especially doctors, as well as the inaccessibility to healthcare services by patients who are unable to travel, could be remedied with the adoption of telemedical technology (Gogia, 2020).

Specifically, there are four types of Telemedicine classified by Gogia (2020), including real time (video conference and live diagnosis over digital equipment), store and forward (of information, including personal health data, image, and comments), tele-monitoring (medical profiles and data are obtained from the additional monitoring devices), and mobile-health, which enables possibly all of the above features on mobile devices. The current usage appears in the form of combination of all the above features. Behind these features, internet infrastructure availability with stable connectivity is required to set up the technology efficiently (Adelakun & Garcia, 2019; Gogia, 2020).

Since Noncommunicable diseases (NCDs) have been the main cause of the global death to date (Redfern, 2017), telemedical technology adoption has been frequently found to focus on the healthcare services related to chronic diseases, whereas frequent monitoring and visits are required for unserious nature of the NCD cases (Gogia, 2020). As a result, previous studies on telemedicine often focus on the medical conditions of chronic diseases, such as diabetes (Harst et al., 2019). Recently, infectious diseases are among the major drivers to increase the adoption of telemedicine in order to reduce contact between patients and professionals, thus to prevent risks of infection. The rate of telehealth use has dramatically rise in response to the COVID-19 pandemic (Sisk, 2020).

Technology adoption frameworks

Various technology adoption models have been examined in healthcare ICT and telemedicine studies. The conceptual frameworks widely used in the previous healthcare technological adoption studies include TAM: Technology Acceptance Model (Davis, Bagozzi, & Warshaw, 1989), UTAUT: Unified Theory of Acceptance and Use of Technology (Venkatesh, Morris, Davis, & Davis, 2003), TPB: Theory of Planned Behavior (Ajzen, 1991), DOI: Diffusion of Innovation (Rogers, 2003) and TOE: Technology-

Organization-Environment (Tornatzky, Fleischer, & Chakrabarti, 1990), whereas each of the frameworks provide different aspects of technology adoption in healthcare.

Harst et al. (2019) systematically and extensively reviewed previous studies with regard to end-user acceptance of telehealth adoption and reported the use of different theories in those studies. The author found TAM and UTAUT to be frequently used in the literature. TAM was reported to be presented more in the telehealth adoption studies which emphasized on professional healthcare provider aspects, while UTAUT, which differs from TAM with regard to social influence aspect, was found to be more suitable with patients' telemedicine adoption.

The TAM contains perceived ease of use and perceived usefulness as two main constructs originally. Perceived ease of use refers to the level of a person's belief that using the technology require minimum effort (Davis et al., 1989). While perceived usefulness is defined as the degree to which a person believes that using a technology will further improve the performance (Davis et al., 1989). Harst et al. (2019) mentioned that perceived usefulness is the most common significant factor that drive the telehealth adoption in care provider's perception. These TAM factors are often included other adoption frameworks.

Apart from commonly-used TAM, DOI proposed by Rogers (2003) focuses on the adopter's perceptions which affect technology diffusion process. Five general adopters' perceptions that many studies have consistently found to influence the technology adoption are Relative advantage, Compatibility, Complexity, Observability, and Trialability (Ramayah, Mohamad, Omar, Marimuthu, & Leen, 2013). Relative advantage refers to the perceived benefits over existing technology. Compatibility refers to the degree to which the adopters perceived technology to be consistent with existing values, past experiences and needs. Observability refers to the visibility of the adopted technology that others perceive. Lastly, trialability refers to the possibilities that the adopters can experiment the technology before adoption (Espadanal & Oliveira, 2012; Rogers, 2003). Compatibility is important for telehealth adoption, as evidenced in many studies regarding the telehealth adoption (Vuononvirta et al., 2011; Peeters de Veer, van der Hoek, & Francke, 2012; Taylor et al., 2015; Tsai, Cheng, Tsai, Hung, & Chen, 2019). For example, ability to share the telehealth data to existing patient record system is currently absence and become a barrier in adoption (Taylor et al., 2015). The weakness of the DOI is that it ignores the influence of the external factors (Espadanal & Oliveira, 2012; Sulaiman & Magaireah, 2014).

Unlike the aforementioned technology adoption frameworks, there is no fixed set of attributes to the TOE framework, as it can vary for different kinds of technology, making it suitable as a governing framework in which a variety of factors from other frameworks can be borrowed and integrated into. TOE focuses on technological factors, organizational factors, and environmental factors that influence technology adoption. Technological factors refer to the characteristic and usefulness of the technology that are available for adoption (Chiu, Chen & Chen, 2017). Organizational factors refer to the organizational structure, characteristics and internal matter that can support or inhibit the adoption of the technology. Environmental factors refer to the structure and characteristics of the setting, where the organization operates in, can affect the adoption of the technology (Bhatiasevi & Naglis, 2018; Espadanal & Oliveira, 2012). The framework integrates both human and non-human factors into one single model

(Wong, Leong, Hew, Tan, & Ooi, 2019). For TOE, common significant technological factors that influence health ICT adoption are data privacy and security (Sulaiman & Magaireah, 2014; Campbell et al., 2017), reliability (Sulaiman & Magaireah, 2014; Adelakun & Garcia, 2019), perceived usefulness or relative advantage (Maarop, Win, Masrom, & Hazara Singh, 2011; Campbell et al., 2017; Harst et al., 2019; Kamal, Shafiq, & Kakria, 2020), and perceived ease of use or complexity (Hu, Chau, & Sheng, 2000; Maarop et al., 2011; Campbell et al., 2017; Adelakun & Garcia, 2019; Harst et al., 2019; Kamal et al., 2020). While a common and important organizational factor is the technological readiness which include the infrastructure readiness (Marques, Oliveira, Dias, & Martins, 2011; Sulaiman & Magaireah, 2014; Adelakun & Garcia, 2019). Lastly, the common significant environmental factors from health ICT are industry competition and governmental support (Sulaiman & Magaireah, 2014; Ngongo, Ochola, Ndegwa, & Katuse, 2019).

Determinants of telehealth technology adoption

The main purpose of telemedicine projects is to make healthcare services accessible in the areas where there are scarce resources or those distanced from service points. Based on the TOE framework, the adoption of the telemedical technology in such areas are often unsuccessful due to the lack of technological resources and financial supports, as evidenced in previous studies (Adelakun & Garcia, 2019; Harst et al., 2019; Gogia, 2020; Sisk et al., 2020). As a result, technology adoption projects are usually initiated by the government, or requires its supports (Gogia, 2020; Sisk et al., 2020). Important technological resources are mainly dependent on the availability and stability of internet connectivity in the area of adoption. In countries where there is a lack of sufficient telecommunication infrastructure coverage, it is challenging to implement the technology as it relies heavily on the connectivity of internet to facilitate remote healthcare services (Adelakun & Garcia, 2019). Apart from the availability, stability, and quality of internet connection, the inability to share the data across different systems can be an important obstacle for the operators as it doubling, sometimes even tripling their responsibilities (Taylor et al., 2015). Furthermore, the maintenance of the hardware and medical devices involved in telehealth systems is required frequently, adding up more financial burden to the providers (Sisk et al., 2020).

End-user acceptance of the telehealth is another important determinant, including both providers and patients (Adelakun & Garcia, 2019; Harst et al., 2019; Sanders et al., 2012). The immediate integration of the technology can become a burden for the assigned operators to train, set up new work flows for the adoption, and become more familiar with the new routine, making it rather more complex with the newly adopted healthcare technologies (Taylor et al., 2015; Lin et al., 2018; Sanders et al., 2012). The common reasons of refusal to adoption include being discomfort with the new technology, being already occupied with current workload, and the preference of existing traditional services over the new ones (Sanders et al., 2012).

In addition, the patient's acceptance of the technology also proves to be the challenges to telehealth technology adoption. As telehealth usually supports home clinic, the acceptance of technology among patients, especially elders who may be unfamiliar to technologies, is required (Harst et al., 2019; Sanders et al., 2012). This could also be the issue that inhibit the acceptance of the users at home, as the medical devices of the telehealth may be too complex for patients' self-management (Sanders et al., 2012). In summary, the changes of patient-provider interactions that Telemedicine presents create the barriers to adoption among the users, both patients and providers (Harst et al., 2019). In this study, it is considered that the integration of various technology adoption models will best explain the telemedical technology adoption behaviors of the healthcare centers, especially at the beginning stage when an external environment for adoption can be redesigned and emerging factors can be discovered. In addition, in the context of the local healthcare system in Thai rural areas, local healthcare providers work hand-in-hand with governmental-supported village health volunteers who act both as assistant providers and care receivers, allowing them to share the perspectives of both stakeholders simultaneously for this study. TOE is thus believed to be more superior to single-stakeholder-focused frameworks such as TAM and UTAUT and to be the most suitable as the main framework to examine the determinants of technology adoption for the Telehealth project. In this study, significant determinants from previous studies, such as the perceived usefulness and the perceived ease of use from TAM, the compatibility from DOI, and other significant adoption factors mentioned in the existing literature, will be examined. Note that, in this study, the UTAUT is inapplicable since the Telehealth project does not include home-clinic application of Telemedicine. In addition, the competition construct in the TOE framework is irrelevant in this study whereas there is no competition assumed for the public project in this study.

Research Methodology

Objective

The main objective of this study is to examine potential drivers and challenges that influence and impact telemedicine technology adoption in Thai public care centers and hospitals, employing TOE as the integrated technological adoption framework.

Methodology

This study is exploratory in nature and utilizes qualitative evidence collected via semi-structure interviews. Since the NBTC and MOPH's Telehealth project is in its pilot stage with a minimal number of chosen adopters, the reliability of quantitative results would be adversely affected by low statistical power effects, and thus is inappropriate for the context in this study. Given the uncertain and intricate nature of new telemedical technology adoption, an in-depth interview deems suitable for examining the interpretations of the relevant stakeholders since it provides rich insights for exploring, identifying, and understanding viewpoints, attitudes, and influences (Healy & Perry, 2000). Furthermore, it allows for a greater control over the interview situation and provides the opportunity for making clarifications and for collecting supplementary information (Frankfort-Nachmias & Nachmias, 1996, Walsham, 1995, Hannabuss, 1996).

For an interview, to allow informants the freedom in expressing their viewpoints and give them time to prepare for the interview, they were provided with the same set of open-ended questions in advance. Interview durations varied, ranging from and minimum of 65 minutes to the maximum of 175 minutes. The interviews were all conducted in Thai, audio recorded, and translated back into English by the author during the transcription process. The original language of the transcribed data is available on request from the corresponding author.

After gathering and transcribing all the primary data from the interviews, coding was conducted to organize all the collected primary data into themes, in line with technology, organizational, and environmental contexts.

Codes were developed which provided the basis for cross-case analysis and helped identify and analyze emerging patterns of themes (Carson, Gilmore, Perry, & Gronhaug, 2001; Patton, 1990; Rao & Perry, 2003).

We believe that construct validity has been adequately addressed. First multiple sources of information were used (Yin, 1989). While interview constitute primary source of information, some of the informants provided supporting documentation which may include user manuals, traditional physical test forms, and working procedures, anonymous patient records. Furthermore, interviewees provided more information through the illustrations of both legacy and new telemedical technologies. Secondly, the informants in the sample belongs to four different levels of public health care centers, formally categorized by the Thai Ministry of Public Health, and therefore allows for different perspectives which constitutes an important of triangulation of qualitative information sources (Patton, 1990). Third, two interviewers conducted 11 of 12 interviews, and both analyzed all of them in order to reduce a potential bias which is commonly cited as a limitation of interviews (Frankfort-Nachmias & Nachmias, 1996; Yin, 1989). Finally, the chain of evidence, tracing the conclusions to the interview summary and to the interview transcripts was also maintained. These enhance the construct validity as well as the reliability of this study, thereby boosting its overall quality, according to Yin (1989).

Participants

All 35 healthcare centers included in the NBTC and MOPH's Telehealth project were approached by phone calls. Key informant representatives of these 12 centers agreed to be interviewed. The sample comprised 8 primary care hospitals (ID1-ID8), 1 district hospital (ID9), 2 provincial hospitals (ID10-ID11), and 1 specialized center (ID12). The participants for an interview are all users of the telemedical technology and may include nurses, village health volunteers, physicians and specialists, and public health technical officers, which some of them are the care center's directors. This allows for the examination of cross-communication among different levels of care providers who perform different roles and are subjected to different set of medical and ICT devices.

Results

The findings below revealed a number of contributing factors and challenges with regard to the adoption of the new telemedical system by the participating Thai medical care centers included in this study. Figure 1 summarizes these determinants using the TOE framework.

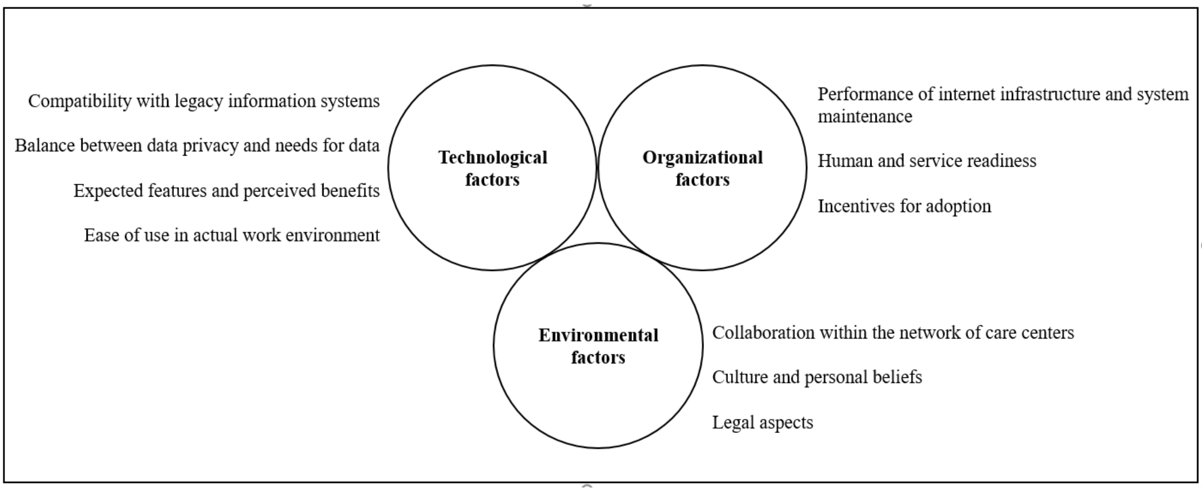

Figure 1 TOE adoption factors of the telemedical technology in the Telehealth project

Technological factors

Compatibility with legacy information systems

The majority of the respondents from the primary and secondary care centers, who play the role of front line users of the new telemedical equipment, agreed that the incompatibility between the new telemedical system and the legacy ones discouraged them from adopting the new system. The incompatibility issue seemed to hinder the ability of these users to reap expected benefits including time saving, process streamlining, and efficient nationwide healthcare service provision. For examples, the following respondents reflected on their relative experience implementing the new health system compared to the legacy information system:

"At first glance, it seems like things would be easier and faster since I can conduct KYC activity, perform and record health screening test results without the needs to manually key in data, using this new smart telemedical equipment. But, after I really used them, I felt that there was no so much difference in term of time taken to conduct these activities using the old and new systems. Also, I still needed to manually key some data items in the legacy system, namely HosXP, since some important data items, such as the diagnosis, comments or prescriptions by physicians, cannot be synced from the database of the new telemedical system (ID1)".

"Oh I think this is a big problem, there is no uniform information system across provinces in Thailand. Administrators from each tertiary care center (provincial) choose their own information system from a few choices provided by the Ministry of Public Health, which in turn will be used by all healthcare centers in that province. These alternative systems are usually incompatible with regard to features, data items, and versions. I guess it would be difficult to scale up the Telehealth project since it has to be compatible with these scattered information system and databases and the costs to do so might be so high. In that case, the features such as the teleconference for medical consultation may not work nationwide, and thus cannot help with the problem of the shortage of medical staffs in remote areas (ID9)".

Interviews with the respondents from tertiary and specialized care centers also reveal an additional evidence, added to the incompatibility issue, that the new telemedical system does not link at all to self-developed information systems and field-specific databases. For example, the new telehealth system has a feature for taking pictures of eyes, which are stored and can be shared across locations where the telehealth system is installed, but not with the main database for research and development in the field of Ophthalmology, called Vision 2020. The issue thus demotivates them to use the new telemedical system since they are unable to use collected data to improve operations or to perform specialized research.

Balance between data privacy and needs for data

Reflections with regard to data privacy reveal conflicting perspectives between respondents from primary and secondary care centers and those from tertiary and specialized care centers. While respondents from primary and secondary care centers stressed the needs to access to more data for research and management of preventive healthcare purposes (ID2, ID6, and ID9), those from higher-level care centers argued for a stricter control over the use of data, citing cases of concerns whereas "patients data was stolen by staffs and sold to insurance companies (ID11)". The latter also called for a proper data authorization and security system per international standards (ID12) across all levels of care centers, and thus expect the new telemedical system to function accordingly.

Observations of the health screening process and documents reviews at the primary care centers revealed a minimal evidence of a proper awareness and control over the privacy of patients' data including the informed consent process, password control, and real-time data backup. Nevertheless, patients who visited the primary care centers seemed to have no awareness nor concerns over possible threats of their personal data breach.

Expected features and perceived benefits

The overall theme with regard to expected features and perceived benefits by the adopter of the telemedical technology, is the lack of mutual understanding and agreements on objectives, use cases, and work procedures, between technology suppliers and end-users. This results in responses stating about missing expected features and benefits. For instances:

"Even though it looks promising, it does not help much for our routine work for walk-in patient cares. Using the telemedical system would even slow down the process of handling about 50-60 cases a day. it is better to use it case by case, not for vital sign recordings for all patients. The technology would be more helpful for the annual health screening (ID4)".

"We have health stations in each village and it would be nice if the new system can distribute EKG test results there, so that we can monitor people at risk more closely (ID1)".

"I cannot see webpages where I can print statistical reports, just like I did with the HosXP system. For HosXP, I can sort data and browse for needed data. In fact, I don't even know where the data is stored and how the data is backed up on the new system (ID9)".

"I would love to also have this kind of blood sugar testing equipment at the village health station, so that I can monitor vital signs of the people, especially the elders who cannot conveniently visit the primary care center, as often as I can (ID2)".

"For skin diseases, it is better to meet the patient in person than to look at these photographs (ID4)".

Healthcare staffs at the secondary care centers added that the new system was lacking "some crucial functions such as alerts for consultation requests, online status of care providers, and patient queuing (ID9)" as these are features that could create seamless adoption experience.

Some respondents casted doubts over the benefits to healthcare receivers including elders, those with low literacy level and those who live in remote areas. They further provided examples of cases where machines or equipment given were not needed or inappropriate, but were provided as part of the Telehealth project. One was on the case of eye chart, where a Snellen chart provided was “useless to those who cannot read (ID4)” Another instance was the response from staffs at a primary care center located near a district-level care center, questioning about the benefit of the teleconference station installed. The respondents argued that “patients prefer to see doctor in person if it is not so far (ID9)” and added that “the teleconference system would benefit more for those in remote areas (ID9)” Along the same line, some respondents indirectly implied that the teleconference system was not needed, by sharing a sufficiently satisfying experience using video call and messaging features of a popular free-of-charge mobile application, namely Line, to consult with doctors in another area.

The ability to accomplish tasks more efficiently was mentioned, by staffs at the primary care centers, as a main benefit expected when adopting a new technology. Specifically, the users expected that the telemedical system is a one-stop system equipped with features that allow them to conduct all necessary care activities. This was reported not to be the case, as users explained the needs to still manually key in some patient record items and doctors’ comments in legacy information systems, to use another isolated medication system, and to use another patient referral system, for example.

The last point worth mentioning is the trust on the new technology. Given an unclear communication with regard to the objective and the role of the Artificial Intelligence (AI) feature embedded in the ophthalmoscope, the new technology deemed insignificant to users at the secondary and tertiary care centers, who argued for more trust on ophthalmologists’ diagnosis (ID9 and ID10). Ophthalmologists who were part of the AI development team addressed the question, confirming that the purpose of the AI feature was for initial screening and should be followed by a thorough diagnosis. In the case of decision conflict between the AI and medical staffs in the screening process, the decision by human staffs should be more superior, although the AI accuracy level is greater than 95% in the test environment (ID12).

Ease of use in actual work environment

Based on the illustration and the reflection of their experience, it could be seen that participating users at all levels of care centers were quite comfortable and seemed to adapt well using the new telemedical machines and equipment. The excitement and the eagerness to learn and try could be observed. Respondents also cited the benefits of trainings and manuals provided.

Nevertheless, several respondents reported uneasiness in several instances using the new machines and equipment in the real work settings. Respondents from secondary and tertiary care centers provided insights to the issue as follows:

“Although it is not that difficult to use the new machines and equipment, it just doesn’t suit the working style here. Doctors and staffs are always on the go. They have several things to do. It is rather inconvenient to have to come here all the time. Also, the location for installing these things should be near the entrance of the hospitals since its purpose is for preliminary health screening (ID11)”.

“I know it is a web-based application and I tried to use it on my tablet, but it was not so easy to navigate and use (ID9)”.

"I prefer using my own desktop when doing teleconference. But the machine is quite old. I need another desktop camera for teleconference (ID10)".

"I tried to give a consultation using the new telemedical system, but I had to still pull up the patient's record from the current HosXP information system. The new databased did not give me historical records for the patient (ID10)".

Health care staffs and volunteers at the primary care centers also described their discomfort trying to use the new machines and equipment as part of their routine working procedure. Here are some excerpts.

"One of our main job is to visit people and give them annual health screening services at the center of the village and often their houses. These new machines are only good for people who can come here. How about elderly people? So it would be better to have something that we can use on sites and test records can be automatically upload from there, so no double work (ID3)".

"I tried the new mobile application, it is ok. I can see my test results in case I forget. But there are too many applications already. Some are from private companies and some are from the Ministry of Public Health, and now this. So sometimes I feel that it is a waste of my limited pre-paid internet connection availability (ID1)".

Organizational factors

Performance of internet infrastructure and system maintenance

The success of the telemedical technology adoption obviously lies on the stability, the reliability, the speed, and the coverage of the internet connection at care centers and local healthcare service sites. Respondents at all levels of care centers showed no concern over the above mentioned characteristics. The reason, however, was not that the internet connection was flawless, but rather that the users accepted its deficiency and were able to switch to offline mode of working. Observations during service hours at a few primary care centers confirmed that patient identification, automatic data recording, and record pulling processes were sometimes quite slow due to a low speed of internet connection, forcing the care providers to immediately switch to their normal paper-based procedure.

With regard to the potential use of the telemedical technology at the local sites in each village, volunteers and field care providers raised a strong concern over the poor performance of the free internet connection provided by the government as mentioned by a healthcare volunteer in the excerpt below.

"The Wi-Fi signal here covers only 10 to 15 meters from that box and it is rather very slow. That is why we record everything on papers and drive to deliver them to staffs at the primary care centers. For our work, we have to visit many houses where there is no internet signal. I don't want to use my mobile internet to record live data and upload it. They should also pay for my internet connection (ID2)".

Another concern from the respondents is the insufficiency of system maintenance budget and services. They raised doubts over the period and the readiness of technical services for the new machines and equipment. In addition, respondents at the primary care centers revealed their frustration for not being able to "sustainably adopt the new system (ID6 and ID8)" due to a potential cut of budget for internet connection, hardware maintenance, and software update costs.

Human and service readiness

Observations on the use of the telemedical system revealed that the teleconference service was far from being ready. This was not for the technical readiness as the reason, but due to the lack of a concrete human resource planning and a proper teleconference procedure. A respondent, who tried to initiate teleconference requests, complained about the difficulties in "knowing doctors" availability and expertise (ID4)". Another was unsure whether he should initiate a real-time request or a scheduled appointment for teleconsultation. The majority of the respondents from the tertiary and care centers hesitated to provide a clear answer on doctors' availability. This is a main hurdle to be overcome if we were to successfully solve the shortage of medical personnel problem by having the nationwide network of doctors available to provide teleconsultation services to those in remote areas.

It was also observed and responded at all levels of care centers that new or modified work procedures (ID2, ID7, ID8, ID9, ID11, and ID12) were needed to accompany the new machines and equipment, not just the "manuals for using machines and equipment (ID9 and ID10)" for a successful implementation of the telemedical system.

Respondents from a specialized care center provided an important insight with regard to the needs for a holistic training and awareness building program that include, not only how to use new machines and equipment, but also digital literacy, telemedicine, limitations of technology, and data management (ID12).

Incentives for adoption

Beside the expected intrinsic benefits in terms of time saving and a more efficient working process, as the main motivation for the adoption of the telemedical system, other forms of motivation were reported to be crucial for the adoption of the telemedical system. For instances, a few respondents at the primary care centers explained that they were motivated to actively conduct screening tests and to record results on the legacy HosXP system, since it was one of the assigned Key Performance Indexes (KPIs). They however "had no knowledge (ID1)" and "was not informed (ID7)" about such KPI for adopting the telemedical system.

Doctors at the tertiary care centers cited "complex cases (ID10)" and "severe symptoms (ID11)", usually found at the provincial-level hospitals, as desirable challenges which allow them to enhance their skills and knowledge. Visiting patients on sites or providing teleconsultation services, however, was seen as required duties without a clear incentive.

New data obtained from the telemedical system could be another form of motivation for providing teleconsultation services, cited by the specialists at a specialized care center (ID12), given that the new and the current field-specific databases were perfectly synced. More data was considered not only a KPI, but also a valuable asset for research and development.

Environmental factors

1. Collaboration within the network of care centers

Respondents, especially from primary and secondary care centers, urged for a more systematic and effective collaboration with those at higher-level care centers. The teleconference and the referral system, as parts of the telemedical system, were cited as the examples of features requiring mutual operational and human resources planning and service process redesigning, among care centers in the network. An instance was the comment provided by a respondent from a primary care center:

"The appointment and referral system on the telemedical system are useless because there is no one monitoring them online and accepting the cases (ID6)".

2. Culture and personal beliefs

Culture and personal beliefs played an unneglectable role in the success of the telemedical system adoption as evident in the case where respondents from primary care centers shared their observations on the visitors from rural areas trying the teleconference system. They stated that the patients expressed an “uneasiness (ID3)” and that they “trusted more (ID7)”, and “felt more relieved (ID8)” if they were to meet doctors in person.

Along the same line, responses from care providers through the teleconference system indicated the belief that a physical meeting was still crucial for a diagnosis to be accurate (ID1, ID7, ID9, ID11, and ID12).

3. Legal aspects

Some concerns were mentioned, by respondents from a specialized care center, with regard to the lack of regulatory risk considerations in the Telehealth project. Top among them were on the compliance with the Personal Data Protection Act (PDPA) and the intellectual property rights of the AI algorithm developed (ID12). Disputes over these issues could be to be costly for the adopters and providers of the telemedical system.

Discussion

Technological factors

In line with the findings in Maarop et al. (2011), Campbell et al. (2017), Harst et al. (2019), and Kamal et al. (2020), perceived usefulness was found to be a significant determinant of telehealth technology adoption. This could be in the forms of missing expected features e.g., the consultation request alert and the patient queuing functions as part of the teleconference system, the unavailability of equipment or shared data at the needed locations e.g., the EKG result and the blood sugar testing equipment at the village health station, and the uselessness of some equipment e.g., the Snellen chart for those who cannot read and the teleconference system installed at the primary care centers located near a district-level hospital. The insight suggests that the requirement gathering process at the beginning stage of the project may be ineffective and need to be carefully conducted using a proper software system development and stakeholder analysis processes.

Most of the respondents in this study demonstrated their satisfaction with the ease of use aspect of individual devices and system components, indicating that the ease of use or complexity is a main determinant of telehealth technology adoption, as found in Hu et al. (2000), Maarop et al. (2011), Campbell et al. (2017), Adelakun & Garcia (2019), Harst et al. (2019), and Kamal et al. (2020). This however was not the case when the new hardware and software were adopted in the actual caregiving environment. An inappropriate location for installation, an unfriendliness of the web-based application on mobile devices, too many mobile applications with a similar purpose, and the absence of a one-stop system were cited as the evidence of the unease of use in actual care settings. The finding added to the literature with regard to the definition of the ease of use as a technological factor whereas the actual work setting could greatly impact the adoption effectiveness. To remedy this problem system designers and policy makers need to ensure a thorough site survey to learn about physical constraints.

As one of the five general adopters’ perceptions proposed in the DOI framework (Rogers, 2003), the incompatibility with the legacy systems and databases was found to be another significant barrier to adoption, the finding commonly found in Vuononvirta et al. (2011), Peeters (2012), Taylor et al. (2015), and Tsai et al. (2019). The incompatibility problem was reported to be the result of the disparate information systems and databases. The responses from the adopters participated in this study indicated that the incompatibility issue led to the problems of missing perceived benefits e.g. the needs to key in data in multiple databases, and the unease of use problem. The issue calls for an extensive review of the existing technological infrastructure and risks associated with the implementation of the new system.

The disagreement among the adopters at different care center levels regarding the accessibility and sharing of medical data and patients' record revealed that data privacy was a key determinant of the telehealth adoption, in line with Sulaiman and Magaireah (2014) and Campbell et al. (2017). An insight worth mentioning from this study was the needs from the adopters for a clear and mutually accepted data privacy policy and a global-standard data management system which effectively balance between a protection of data privacy and an effective data use.

Overall, the perceived usefulness, the ease of use, the compatibility, and the data privacy as the technological factors mentioned in this study are in line with the findings in the existing literature. The importance of the observability and the trialability as the technological factors proposed by Rogers (2003), though cannot be found in this study.

Organizational factors

The findings from this study supported the common postulation by Marques et al. (2011), Sulaiman and Magaireah (2014), and Adelakun and Garcia (2019), that infrastructure readiness plays a key role in telehealth technology adoption. a key insight emerged from the adopters' responses, that the key concern was, however, not on the lack of a sufficient telecommunication infrastructure coverage, citing the reason for the flexibility to switch back to providing care offline. The main concern was rather on the long-term financial and technical supports by the government to sustainably maintain the readiness of the infrastructure and the healthcare services, consistent with the findings in the previous studies (Adelakun & Garcia, 2019; Harst et al., 2019; Gogia, 2020; Sisk et al., 2020). The policy makers and project sponsors thus should prepare the project budget which would ensure that there will be sufficient financial and technical supports in long term.

Another factor focusing on the end-user acceptance of the telehealth technology adopted was the human readiness. As revealed by the findings of this study, the requests for a clear list and schedule of available doctors who can provide teleconsultation and the needs for a better understanding with regard to the new workflows, the new equipment and systems, and the updated knowledge on digital literacy, would help end-users to be more comfort with the new technology over the traditional ones (Taylor et al., 2015; Lin et al., 2018; Sanders et al., 2012). The focus of the policy makers for this project thus should not be only on care receivers, but also care providers including doctors, nurses and supporting staffs. An effective human resource planning including recruitment and training should be among the top priorities.

Interestingly, incentive for adoption was found to be a significant organizational determinant of telehealth technology adoption in this study, despite for it having been rarely discussed in the existing literature. The care providers who participated in this study reported the needs for motivation schemes in the forms of a clear KPI assignment, an intellectual challenge, and an access to data, beyond the time and cost saving benefits as the main incentives.

Environmental factors

As mentioned in Harst et al. (2019) and Sanders et al. (2012), the acceptance of technology among patients, especially elders and those with low literacy level may be a key challenge for the adoption of telehealth technology. The personal belief of the care providers and the care receivers with regard to the trust on a physical meeting between them was reported to be a concern for adopting the new technology. A suggestion which could be made to ensure a smooth transition of adoption behavior is that a plan for dual system implementation should be put in place. This will allow adopters to have time to learn the new system while maintaining the confidence that their regular work would not be disrupted since they can always go back to adopt the legacy ones.

An additional insight from this study derived from the concerns with regard to the regulatory environment and the needs for a proper regulatory risk management. The compliance with the newly enforced regulations including the PDPA and intellectual property rights of the AI algorithm developed for the Telehealth project were cited as the instances. The concern adds to the existing literature with regard to the regulatory environment whereas people are becoming more aware of the data privacy, rights and regulations and is found to be a significant factor in this study.

Lastly, an extensive involvement and collaboration of all the project stakeholders in the whole technology adoption process was found to be a frequently mentioned need by the adopters to ensure a successful adoption of the telehealth technology, which was multi-party in nature.

Conclusion

In this study, we examined key factors and challenges of the telemedical technology adoption. Specifically, we interviewed medical staffs, administrators, and healthcare volunteers from a total of 12 out of 35 Thai primary, secondary, tertiary, and specialized care centers which participated in the pilot phase of NBTC and MOPH's Telehealth project, which employed the TOE analysis framework.

In line with the existing literature on telehealth technology adoption, we found that perceived benefit and perceived ease of use were main technological determinants for the adoption. Key challenges found were the incompatibility with the legacy information systems, the conflicting needs for data security and use, and the uneasiness for adopting the new technology, with the reason being the lack of stakeholder involvement in the system requirement gathering process.

Organizational factors also played key roles in the success of the telemedical technology adoption, whereas adopters cited a sustainable infrastructure, financial, human readiness, and motivational supports.

Lastly, the personal belief in a physical patient-provider interaction, the regulatory risk regarding data privacy and intellectual property, and the needs for a strong and committed collaboration among healthcare stakeholders, were key environmental factors and challenges to be overcome.

Recommendations

The primary aim of this research is to provide insights and considerations for successfully extending the Telehealth project nationwide. Based on the key findings in this study, we recommend policy makers and project stakeholders as follows.

First, we recommend project planners and implementers to conduct a robust information system development process with a strong involvement from key stakeholders including care receivers, care providers at all levels, project financial and infrastructure sponsors, technology creators, legal counselors, and related parties. This steps could include site survey to learn about currency infrastructure readiness, physical constraints and the nature of work. Doing so since the beginning of the project help ensure actual use cases in an actual working environment are key inputs for designing an effective system which help overcome the incompatibility, the unease of use, missing expected benefits, challenges found in this research. An effective system development process would help ensure that there is a strong collaboration in adoption, that cultural factors are taken into consideration, and that project risks are managed properly.

Secondly, plans for a strong and sustainable organizational supports including an effective and accessible internet infrastructure, ongoing financial and technical supports, trainings, human resources, and incentives for adoption should be put in place to warrant a sustainable supporting adoption environment.

Finally, policy makers and system designers must take adopters' perception and behaviors into account. Trust in the face-to-face and the legacy systems should not be undervalued but must be managed by allowing for a dual system implementation to ensure a smooth adoption of the new system. The adopters' changing awareness with regard to data privacy and the compliance to new regulation must also be addressed in the project design stage of the nationwide Telehealth adoption.

Limitations and Recommendations for Further Study

Clearly, this study is based on the Thai context. We thus accept that its external validity cannot be ensured, Consequently, our findings may not be readily generalizable beyond this study. To ensure generalizability, further research required in both other healthcare technology and other geographical contexts.

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Appendices

Purpose and scope of the telehealth project

The Telehealth project initiated by NBTC and MOPH aims to address existing main healthcare problems in Thai rural areas where populations are unable to access basic and specialized healthcare services due to the shortage of medical personals and specialists. The population to medical doctor ratio in Thailand were 1292 citizens to 1 doctor, exceeding World's Health Organization's (WHO) standard ratio of 439 citizens to 1 doctor. Specialist shortage situation in Thailand is rather worse, as one ophthalmologist is responsible for 47,900 of the population, and there are only 100 dermatologists in Thailand, excluding Bangkok.

The project also aims to address the needs to improve the quality of healthcare services related to NCDs, which considered to be the most common diseases and cause of death in Thailand. Based on the statistics provide by the Thai Ministry of Public Health in 2019, the number of patients with NCDs in Thailand has been rising, statistically 18.25 million people annually, in which the death causes by NCDs accounts for 73 percent of the total deaths in Thailand.

Specifically, the Telehealth project was initiated for population's health promotion, monitoring, and risk prevention, as well as for leveraging and extending telecommunication infrastructure to the remote area for the citizen's related use. There are 5 types of diseases targeted in the projects are diabetes, hypertension, dermatitis, eye diseases (including diabetic retinopathy, aged-related macular degeneration and glaucoma), and cardiovascular diseases.

The main deliverables of the project are the procurement and the installation of smart medical devices and software that allow for digital Know-Your-Customer (KYC) verification, medical measurements and tests, digital health data recording and reporting, system management through dashboard, AI-based diagnostic, live video conference consultation (both on the basis of live consulting based on doctor's availability and on the basis of appointment accordingly to specialists' time table), as well as, manuals and trainings for care providers.

Apart from these medical devices provided, other support devices, software, and infrastructure of the system are also installed to related care centers, namely all in one PC as the center of the system (specialized care centers are given high-spec PC for diagnosis digitally), smart ID card reader, QR code reader, fiber optic internet, private cloud storage, firewalls, uninterruptible power supply (UPS), surge protector, and teleconference devices (PC, microphone, speaker, and camera). The project provides the maintenance service for all the devices up to 5 years of usage. Nevertheless, the project enables patients to monitor their health test results from the Telehealth devices performed at any care centers real time with broad health advices for them in accordance to the results, as well as being able to message the doctor directly over the private chat feature in Telehealth platform using their smartphones.

In the pilot phase of the Telehealth project, there were a total of 35 public healthcare centers in 12 provinces from all Thai regions chosen to participate in the project. The pilot of group of healthcare centers were from all levels based on the official categorization by the Thai Ministry of Public Health including 16 primary care clusters (community level), 7 secondary care centers (district level), 9 tertiary care centers (provincial level), and 3 national specialized care centers.