Special Article

The Role of Health Information Technology on Critical Care Services in Thailand

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Health information technology (IT) has become an important part of current medical practice, especially in critical care services. One significant advance is the use of telemedicine which was initiated in Thailand nearly two decades ago. Telemedicine is also used in the intensive care unit or, what has been termed the "Tele-ICU". It has evolved as an alternate paradigm linking the intensivist and critical care specialists to critically ill patients in remote areas. In this article, the author has reviewed the evidence of health IT on critical care services in Thailand, focusing on telemedicine, as well as the concept of the 'Tele-ICU' and its challenges. These factors may assist intensivists to reach more critically ill patients in remote areas.

Keywords: *Telemedicine, Tele-ICU, Health information technology*

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Since the primary distribution of Thai intensivists work in university-based hospitals or tertiary hospitals with low physician densities (3.1 per 10,000 population)[1,2], this may lead to the difficulty of access to intensive care services for critically ill patients living in the rural areas of Thailand. Implementation of the telemedicine system, an important advance in health information technology (IT), may have an impact on Thai critically ill patients who are living in rural areas.

Evolution of health IT on medical care services

The development of long distance bidirectional communication, from the invention of the telephone (1876, Alexander Graham Bell) to the development of current, rapid wireless communication have led to advances in IT and are now available for use in medical practice. One advance in particular is telemedicine. It is implemented in a wide variety of subspecialties such as teleradiology, telepathology, teledermatology, telepsychiatry, etc. Implementation of the specialty of critical care medicine, ICU telemedicine or the 'Tele-ICU' is the exchange of medical information of critically ill patients through electronic communication which has, as mentioned previously, been in use for more than 35 years[3].

For clarification, the American Telemedicine Association defined these terms as follows[4]:

- Telemedicine is "the use of medical information exchanged from one site to another via electronic communications to improve patients' health status".

- Tele-ICU is "a collaborative, inter professional model focusing on the care of the critically ill patients using 'Tele-health' technologies".

Health IT application on medical care system and education in Thailand

In Thailand, health IT is not something new, as it has been in use for nearly two decades[5-8]. After the launching of Thailand's first communication satellite (THAICOM 1) in December of 1993, the Ministry of Public Health (MOPH) initiated a pilot telemedicine project in 1994. Its aim was to enable people in the rural communities to access urban-based, medical specialties[5]. The network consisted of a master station at the IT office of the MOPH and substations in 19 hospitals. They were interactively linked by both satellite and computer networks to health facilities throughout the country. In 1998, the installation of the equipment was completed. The intranet was connected by the UNIX gateway to a commercial service provider (WorldNet) at the speed of 1 megabyte per second (mbps) and was linked locally via the Communication Authority of Thailand (CAT) at the speed of 25 kilobytes per second (kbps). Its utilization has provided telemedicine activities such as distance learning via video-conference systems consisting of 238 non-registered walk-in lectures on medical and non-medical

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topics, and has reached a total audience of 11,622 users. There were also registered audiences for short courses in dentistry, pre-prosthetic surgery, and medical consultation.

Information exchange for medical education has also been effectively used for inter-hospital video conferences between countries. In 2001, Vincent et al[6] conducted the international distance education link between two tertiary care medical centers, the Tripler Army Medical Center (TAMC) in Honolulu and the Phramongkutklao Army Hospital in Bangkok. The audience had been principally composed of residents in internal medicine. There was a total audience of more than 1,200 doctors and 31 conferences had taken place. In the early phases, integrated services digital network (ISDN) connections (384 kbps) were used. One year later, a faster connection technology was developed. This is what is known as Intranet 2 connectivity and operates at a speed of 768 kilobytes per second (kbps). Originating from the TAMC local Hawaii Intra Network Consortium, data were sent at 45 megabits per second (Mbit/s) to Abilene, Texas, an Internet 2 network in the continental USA. Abilene was then connected to Thailand's Inter-University Network (UniNet Thailand) via an undersea fiber optic cable. This had produced a signal in Bangkok at a speed of 155 Mbit/s. However, Intranet 2 failed to demonstrate improvements in the audio's or the video's quality[7]. The authors have concluded that the 'jittery' video or video 'freezing' experienced when video conferencing over the Internet 2 connection was due to network congestion in Thailand. This was a result of the bandwidth not being in a fixed state when utilizing the system over internet protocols (IP). This was not been the case when transmitting over ISDN lines.

Telemedicine has also demonstrated its benefits on the patients' quality of their health in the rural areas. In 2004, Kulrattanamaneeporn et al studied the impact of telemedicine at AoLuk community hospital in the Krabi province in the South of Thailand. Using AoLuk community hospital as the hub, five primary care units (PCU) were connected and registered in the telemedicine program. Telemedicine can help reduce transportation inefficiencies for acutely ill patients and the developers have recommended that telemedicine should be implemented in all community hospitals with the use of PCU small-world networks (SWNs)[9]. These results are aligned to the study done by, Kost et al, which followed two years later and investigated telemedicine's integration to SWNs in Mae Hong Son Province located in the Northwest of Thailand[10]. Again, using the Mae Sarieng community hospital serving as the hub and connecting the patients in the PCUs have resulted in the improvement of timeliness and in establishing bidirectional communication between health care professionals and patients in remote areas. Additionally, telemedicine has been used to manage patients with acute cerebrovascular disease here in Thailand[11,12].

The concept of Tele-ICU

The Tele-ICU concept is to maintain standard treatments from an on-site, ICU intensivist to critically ill patients in remote areas. This allows the intensivist to reach more critically ill patients in a timely manner for continuous patient care and monitoring. Equipped with a 2-way camera, video monitors, microphones, and alarms, this allows for a high speed link between an off-site intensivist to critically ill patients in remote areas on a 24-hour a day, seven-day a week basis. The goals are to provide physicians and nurses real-time access to patient data (vital signs, laboratory values, and investigations) and provide real-time interactions with on-site personnel for the assessment of responses to therapy in a timely manner. The patients' information will be securely stored in central storage, and allow the intensivists access to the real-time patient data through a secure connection whenever access to the information is desired or necessary.

Tele-ICU characteristics

Regarding the technological aspects and standards of telemedicine[13], there has been variation in the Tele-ICU model across several studies[14-19]. In terms of the intensity of Tele-ICU coverage, some centers have used an active Tele-ICU model. This entails personnel providing continuous monitoring with computer generated alerts[14,15]. Some used a more passive model of an off-site intensivist consultation liaison[16]. In terms of the technology, some Tele-ICUs have made use of robotic technology[17,18] where a few other Tele-ICUs have used a single mobile camera[3,19] to monitor the patients in the ICU.

The impact of the Tele-ICU on patients' outcomes

Although there is no current evidence supporting of the impact of Tele-ICUs in Thailand, its potential clinical advantages are still being debated on an international level[14,15,20-22] as seen in Table 1. One observational study of an active Tele-ICU model in the USA found that the implementation of the Tele-ICU was neither associated with reduced ICU lengths of

Table 1. Evidence-based Tele-ICU studies focused on ICU length of stay (LOS) and hospital mortality

Author	ICU included and type of studies	Results	Note
Thomas et al[14]	6 ICUs (1 medical, 1 surgical, and 4 mixed ICUs) from a tertiary care teaching hospital, 2 small community hospitals, and 2 urban hospitals. Before and after the use of Tele-ICU analysis. Observational study.	No difference in overall ICU LOS and mortality. However, in the sicker patients (SAPS score >44), Tele-ICU was associated with shorter ICU LOS and improved survival.	A low percentage of attending physicians (30%) as well as mixed population of the type of ICUs may confound results.
Lilly et al[15]	7 ICUs (3 medical, 3 surgical, and 1 mixed cardiovascular ICUs) in single academic medical center. Before and after analysis. Prospective, unblinded, stepped-wedge study.	Tele-ICU reduced hospital LOS, hospital mortality, rate of ventilator-associated pneumonia, and rate of catheter related blood stream infection.	Study design was not a randomized and blinded trial. Mixed type of ICUs may confound results.
Morrison et al[20]	4 ICUs (1 medical, 1 surgical, 1 cardiac, and 1 mixed ICU) from 2 community hospitals. Observational study.	No difference in hospital LOS and mortality of the patients in both teaching and non-teaching hospitals.	Baseline overall ICU mortality was low (6.6%) and thus, possible difficulties in showing any significant survival benefits.
Rosenfeld et al[21]	A ten-bed surgical ICU in academic-affiliated community hospital. Observational time series triple cohort study.	Tele-ICU reduced ICU mortality, hospital mortality, ICU LOS, ICU complications, and ICU costs.	Reduction in mortality and hospital costs are likely the result of lower incidence of complications.
Wilcox et al[22]	Critically ill adults or children (n = 49,457). Systematic review and meta-analysis of 11 observational studies.	Compared to low-intensity passive model, either active or high-intensity passive model of Tele-ICUs had decreased hospital mortality.	Few studies of low-intensity passive model, absence of randomized trials, and using unadjusted data may exaggerate overall treatment effects.

stay nor lower hospital mortality[14]. This result is in contradiction with at least one previous study done by Lilly et al[15], a prospective study that demonstrated a mortality benefit following the implementation of the Tele-ICU. This study has shown the possibility that the Tele-ICU may improve the patients' outcomes by improving adherence to the best clinical practices in the ICU. These results are consistent with one recent meta-analysis of the Tele-ICU in 49,457 critically ill adults or children[22]. Undoubtedly, further, well designed clinical trials are needed to validate and confirm the impact of the Tele-ICU in more homogeneous ICU types (medical, surgical, or mixed ICU), ICUs of different levels (university based hospitals, community hospitals, or rural hospital ICUs) and for the reevaluation of the Tele-ICU structure.

The challenges to telemedicine in Thailand

Although telemedicine had been initiated approximately two decades ago here in Thailand[5-10], it has not been widely used in the majority of our hospitals. According to an updated database provided by the World Health Organization (WHO)[2], the barriers to implementing telemedicine in Thailand include the perceived high costs, the underdeveloped infrastructure, a lack of a framework for policies, the lack of demand by health professionals, and no nationally adopted standards. The most necessary information in the support of telemedicine's development here in Thailand is cost and cost-effectiveness. Establishing a Tele-ICU platform to support centralized ICU care is quite complicated and is hampered by the high costs related to the equipment that is necessary for use in both on-site and off-site ICUs.

Alternative procedures for telemedicine in Thailand

As evaluated from the theory and the applications of telemedicine, there are two methods for data delivery: 'real-time' or synchronous delivery and the 'store-and-forward' or asynchronous delivery[23]. Although clinical applications of asynchronous telemedicine have not received the same degree of attention as has real-time telemedicine, there is some evidence of the positive impact of asynchronous telemedicine on patients' health outcomes, the processes of their care, and access to health services and health resources[24-26]. In the past, asynchronous telemedicine had been used in specialties where the response time was not crucial. These included disciplines such as teleradiology, telepathology, and

teledermatology. Currently, with new technologies in communication and the transfer of information, asynchronous telemedicine with a shorter response time can be used in emergent and critical situations. The smart phone is one good example of asynchronous telemedicine that is nearly identical to real-time telemedicine. In Thailand, the implementation of asynchronous telemedicine has been widely used for many years in acute myocardial infarction and cerebral vascular accident (CVA) networks[11,12]. Supervision of thrombolysis and consultations for other treatments has been achieved by using this type of telemedicine system[27]. In the administration of the Tele-ICU, consultation with an asynchronous method helps provide administrative and support services when health professionals perform medical duties outside of the ICU. Nurses and junior doctors can capture and send the data from the ICU to senior or attending physicians at distant sites in various formats (e.g. audio, video, text) with the use of free applications (e.g. LINE or Skype) in smartphones. This approach is less expensive than real-time telemedicine and has been suggested for the use of Tele-ICU in developed countries. Asynchronous telemedicine is a flexible and cost-effective approach for the majority of Tele-consultation needs. Limitations of this technique were that the documentation is considered unofficial and there are possible flaws in data protection creating a problem in maintaining patient confidentiality. In our opinion, the benefits from asynchronous telemedicine may be maximized with the use of new technologies, the development of systematic protocols and proper, patient care planning.

Conclusion

Telemedicine in Thailand is not new and its use has been accepted over time. The implementation of Tele-ICU in Thailand is challenging. Asynchronous telemedicine with advances in IT will be an alternate for Tele-consultation in the ICU for middle to low income countries. Additional studies of telemedicine and the Tele-ICU in Thailand are required to determine its potential benefits in terms of ICU types, ICU levels, and Tele-ICU specific models.

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Potential conflicts of interest

None.

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บทบาทของเทคโนโลยีสารสนเทศด้านระบบสุขภาพในการดูแลผู้ป่วยวิกฤตในประเทศไทย

เพชร วัชรสินธุ์

ปัจจุบันเทคโนโลยีสารสนเทศด้านระบบสุขภาพ กลายมาเป็นส่วนสำคัญส่วนหนึ่งทางการแพทย์ รวมไปถึงการดูแลผู้ป่วยวิกฤต เทคโนโลยีสารสนเทศด้านระบบสุขภาพชนิดหนึ่ง ซึ่งนำมาใช้ในประเทศไทย เป็นระยะเวลาเกือบสองทศวรรษ และมีบทบาทมากขึ้นเรื่อย ๆ คือ โทรเวชกรรม ปัจจุบันโทรเวชกรรมถูกนำมาใช้ เพื่อช่วยในการดูแลผู้ป่วยในหออภิบาลผู้ป่วยวิกฤต บทความนี้จะได้กล่าวถึงหลักฐานเชิงประจักษ์ของการใช้เทคโนโลยีสารสนเทศด้านระบบสุขภาพของประเทศไทย โดยเฉพาะการใช้โทรเวชกรรม รวมไปถึงหลักการใช้โทรเวชกรรมในหออภิบาลผู้ป่วยหนัก ซึ่งอาจมีประโยชน์ในการช่วยให้แพทย์สาขาเวชบำบัดวิกฤตในประเทศไทย มีโอกาสเข้าถึงผู้ป่วยในพื้นที่ที่อยู่ห่างไกลมากขึ้น