Journal of Theoretical and Applied Information Technology
30th April 2018. Vol.96. No 8

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

HUMAN FACTORS FOR IOT SERVICES UTILIZATION FOR HEALTH INFORMATION EXCHANGE

[1]MOHAMMED AHMED DAUWED; JAMAIAH YAHAYA; ZULKEFLI MANSOR; ABDUL RAZAK HAMDAN

Faculty of Information Science and Technology

Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia.

Corresponding author email: [1]mohalyasari@gmail.com

ABSTRACT

Currently, the exchange of patient information continues to be a challenge. The growing demand for health care makes it necessary to enhance the exchange of health-related information efficiently. IoT makes data available easily to exchange health-related information for health professionals'. Internet of Things (IoT) services can improve the quality of life and help health care professionals in their decision-making. Health records can be exchanged easily through the IoT network. The IoT is growing technology to integrate all smart devices, resources, and systems to discover drugs, treatments, and health records of patients in one network. Despite the advantages of this technology, there are a lot of challenges facing the healthcare organizations to utilize it especially in the context of developing countries. As such, the researchers carried out the literature survey for the related information in order to investigate the current issues and the factors that affect medical professionals and IT practitioners in order to use IoT in health information exchange. The purpose of this study is to help researchers and practitioners to develop the models for utilizing the IoT in health information exchange among healthcare providers. The researchers found the main critical factors to be, intention to use, user satisfaction, collaboration environment, trust, efforts, and service quality, which must be taken into consideration. From the review, a number of critical factors were found to be essential in the utilization of IoT.

Keywords: *Internet of Things; Health Information Exchange, Healthcare System; Utilization IoT; Human Factors.*

1. INTRODUCTION

Before using any new system, its elements must be carefully studied to ensure its success. In addition, the success of any system must be achievable by all individuals. Therefore, the successful utilization of IoT in the healthcare system is based on the behavior of the users.

The Health information exchange can be defined as a system to exchange health information among health organizations and medical professionals as well as patients. This system can improve patient care coordination, reduce the medical errors, increase the efficiency of care, save time, decrease the duplication test, allow physicians, nurses, and health care staff to access and share clinical data, and provide more health care for patients [1], [2]. The electronic exchange of documents I such as clinical summaries, laboratory, radiology reports, imaging reports, pathology reports, may enhance patient safety and enhance the efficiency of care [1], [3]. Some patients have difficult describing clearly the physical problem to physicians or nurses. For example, a nurse may have difficulties understanding the stroke-related aphasia, and language issue [3]. Therefore, there are different reasons for using health information exchange system.

To increase the efficiency and quality of healthcare, the healthcare resources must be made available and authenticated on [4]. In this digital era, the electronic health record has become important for patients and medical staff. Most of the hospitals have patient records although there are some that are still paper-based, especially those in developing countries [5]. Some studies have reported on the lack of use of new trend technology such as IoT, Cloud computing, and radio-frequency identification (RFID) to provide easy monitoring of patient state and access to relevant patient health information, thus presenting physicians and nurses with the challenge or difficult information access and exchange. Of patients' information among the

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

organizations to enhance the quality of care [3], [6], [7].

The IoT technology is a new trend technology that can be utilized in the healthcare sector to improve the healthcare quality, organizational performance, and healthcare society in general. The idea to use IoT in healthcare is to facilitate the exchange of data between organizations as well as between medical staff and patients automatically without need for personal involvement. The IoT concept was first proposed by Kevin Ashton in 1999, and described as a uniquely identifiable interoperable system that connected objects through RFID technology [2], [8]–[10]. The access through the Internet is important to exchange medical data. The concept of IoT is reflected in the way several things or objects preserve their presence and are a connected set for anyone, anywhere, anytime, any media, and any network as illustrated in figure 1.

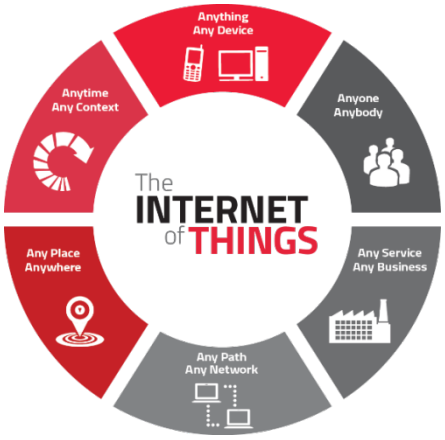

Figure 1. The environment of IoT services

The benefits of IoT include providing information in real time of patients' health state and making available information to doctors who are assisting in the treatment of a patient [4]. IoT facilitates communication forms to expand from human-human to human-thing and thing-thing (also from machine-to-machine [8]. This technology provides the capability to integrate a large number of devices to store and exchange the health-related information in real time to all physicians involved in a particular case [4], [11]. In addition, IoT can smoothen and speed up the workflow and motivate the medical staff to engage with the health information system [12], [13].

The main objective of using IoT for health information exchange is to integrate and unify the communications and systems in the healthcare environment. Hence, it is possible to have full control of and provide access from the system to other linked systems and make available ubiquitous communication and computing for the purpose of defining a new generation of assistance in health service [14]. The practical advantages in the design of the Internet of Things (IoT) technologies include the ability to encourage the development of the smart systems to support and improve the processes related to biomedical and healthcare. Moreover, monitoring patients for physiological parameters in real-time for early detection of clinical deterioration, automatic people identification and tracking through biomedical devices in smart hospitals, and drug-patient associations are some examples for further investigation [15].

Figure 2 illustrates how this technological innovation in healthcare will appear in a typical IoT process in practice in smart hospitals. A patient with an emergency case will have a wearable device that detects the nearest emergency department in a hospital to deliver the required services. The emergency department when detecting a patient within an emergency case, links the ambulance care to send the care services. The ambulance care will have detection that, when arrived, links the bio-bank of patient information to a secure cloud, which stores their electronic health record vitals and lab results, as well as medical and prescription histories. This process can assist health medical staff to know the patient status in a fast, easy, and effective way.

The health information system is mostly designed to store, enter, receive, and exchange health information. The system increases the number of devices and mobility of information to support health professionals in their consultations. This study was motivated by the gap in the literature indicating there are several issues in healthcare information exchange such as, the incapability of the clinical centers, especially with the perceived need for early detection of specific aspects is considered [16]. Moreover, there is the concern of interoperability raised between the systems of various smart electronic devices [5].

ISSN: 1992-8645 E-ISSN: 1817-3195

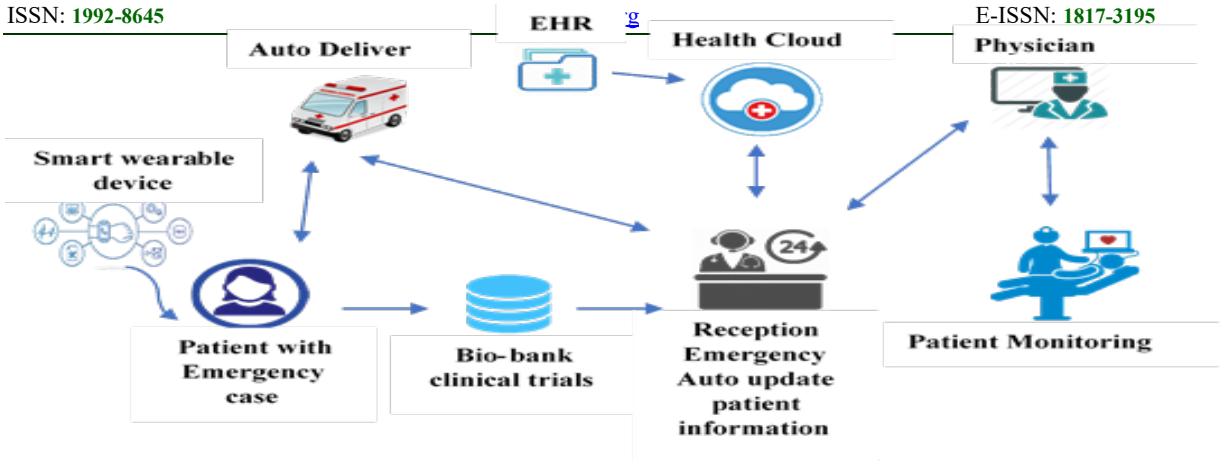

Figure 2: An illustration of how this innovation in healthcare will appear in a typical IoT process in smart hospital, in practice

Some people need continuous monitoring and care like children and chronic decrease sufferers, which adds to the overloaded issue of health information while many hospitals today work over capacity. The elderly and disabled people are important challenges in their society and need more monitoring of their physical activity and health care especially in developing countries. Many studies have dedicated efforts to develop the IoT technology and smart devices to help especially elderly and disabled patients in their health monitoring and physical activity primarily because most of them live alone who at home [17].

Nevertheless, the number of devices connected and advances in technology make it challenging to work on reach agreements. There is an increase in the number of applications which preclude uniform infrastructure with fragmented architectures, incoherent unifying concepts and hence, have little reuse potential. Current use cases for the future IoT are typically based on pre-agreements of the various devices to exchange information and to act upon this information [18].

The primary motivation of this study is to perform the utilization of IoT services in health care system to facilitate exchange the patient information between the healthcare providers and hospitals. Therefore, this study focuses on addressing the difficulties and factors that could affect the use of the Internet of Things (IoT) for health information exchange in order to obtain and exchange the patient records among most of the hospitals and healthcare providers with patients to be more effective and appropriate.

2. MATERIALS AND METHODS

A literature survey was conducted in this study in order to obtain and verify the related information on the research topic. The objective of this paper was to investigate the related factors for physicians and health professionals to successful utilize the IoT for health information exchange. This study could help researchers and practitioners to develop the utilization of the Internet of Things in health information exchange between healthcare providers. The guideline of this study proposed reviewing most of previous studies on factors that have an effect on the people who work in healthcare providers such as hospitals and clinics in sharing healthcare information for practical and medical histories of the patients to help in the decision making. Following the review, the authors proposed the Internet of Things technology for the exchange of healthcare information among different healthcare providers in line with the facilities mentioned above.

In general, this study aimed to answers to the following question: "What are the individual factors that have an effect on the use of IoT services for health information exchange?" The review was performed based on multiple databases to minimize the omission of relevant studies. The selected articles were based on the following search criteria such as: All articles should be written and published in English language journals during the period from 2003 till 2017, at a time when the IoT technology was considered new. The selected articles were also those that focused on the health information exchange through IoT successfully implemented in the healthcare sector. Further, the articles were those targeted at clinicians and medical provider groups because this current stuffy does not focus only on physicians or nurses.

Journal of Theoretical and Applied Information Technology
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ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

Through the years 2003-2011 there were limited articles published whereas from 2012-2016 the number of articles published on exchange of health data information using information technologies showed a significant increase. However, there was still scant research done specifically on the use of IoT in healthcare. Figure 3 shows the distribution of articles by year.

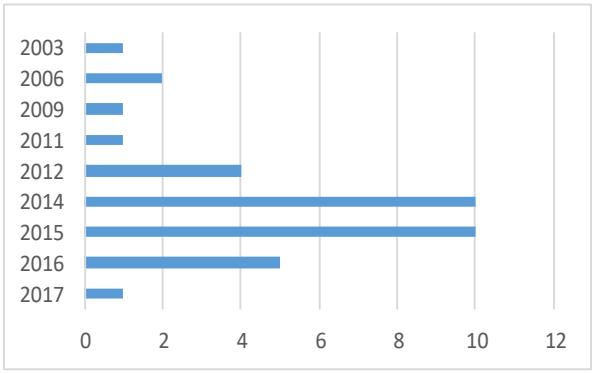

Figure 3: Distribution of articles according to year

The studies were classified according to the country of research, and it was found that the majority of case studies focused on the United State, with six articles while two articles focused on Canada and three focused on Iran while there were two each for Iraq and Taiwan. One was a case study focused on Indonesia and one on Texas, while 16 did not specify any country in terms of frequency. Figure 4 shows the distribution of articles according to country.

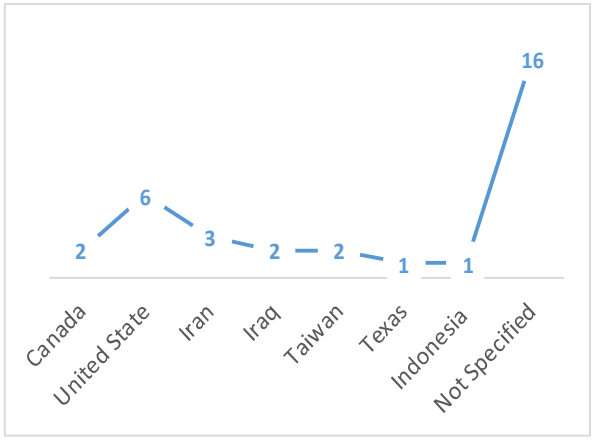

Figure 4: Distribution of articles according to country

2.1 Human Factors

Following the literature review it was found that there are some factors which had an effect on the medical professionals and IT practitioners to use IoT for health information exchange among multiple stakeholders. The researchers concluded that there were six factors based on the review of the literature that were effective. Table 1. shows the frequency of selected factors that were identified in the literature.

Table 1: The frequency of factors

Factor	Resources
Intention to use	[13], [3], [14], [9], [10], [19], [20], [21], [22], [23], [24], [25].
User Satisfaction	[10], [22], [23], [24], [26], [27], [14].
Collaboration environment	[6], [2], [14], [16], [18], [23], [28], [29], [30], [26], [31], [32], [27], [33].
Trust	[6], [3], [11], [16], [18], [20], [24], [29], [26], [31], [34], [35], [36], [32], [37], [25], [33], [38], [39], [40].
Efforts	[3], [2], [14], [10], [19], [21], [23], [24], [29], [33], [40].
Service Quality	[3], [7], [11], [16], [18], [22], [23], [26], [34], [41], [40].

2.1.1 Intention to use

Intention to use s can be defined is a prediction of the intention to use a system [13]. Actual user interaction with the system is perceived for different types of user behavior to use the system with details. A complex pattern targets the kinds of information used [6], [19]. Jain et al. [9], explain the intention and adoption behaviors of the end users toward technologies in the healthcare sector, in which users who have high behavior of intention to use are more likely to adopt the new technology [9]. Nikolaou et al. (2006) reported the important system design for data exchange must be considered a quality of information and beliefs about the work environment, which leads to specific intentions. These factors can directly affect the users intention [20]. Therefore, the use of such technology in the healthcare system needs to overcome the issue of acceptance of the user. The actual intention usage of IoT for health information exchange from the health care providers can affect the endorsement to use the IoT services [21].

K. M. Unertl et. al. (2012) reported that most of the understanding of intention behavior of medical staff to use such technology to exchange health information is important for diagnosis and

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

treatment of a patient, because it is difficult to fully comprehend implications accurately based solely on an observation [3]. The different types of user behaviors depend on what already exists and vary among jobs, organizations, and time within a single health information exchange system. For example, repeated searching is the most common in hospital settings, and uncommon in Emergency Departments (EDs). Furthermore, In the United States, study has found that there are two behaviors of usage including nurse-based and physician-based, where the nurses are more likely to use the health information exchange technology in order to facilitate the retrieval of recent hospitalization data, while the physicians are more likely to opt for open-ended usage [6]. Therefore, the intention to use IoT based healthcare system is related to facilities provided for the user [6], [14].

According to framework of Delone et al. [22] the intention to actually use a system belongs to behavior and this factor has the effect of system quality and affects the success of the system [23]. Moreover, in another study in Taiwan, it was found that high user intention influenced the successful use of the system [9].

2.1.2 User satisfaction

User satisfaction has been reported for different levels. High level of satisfaction from nurses and physicians is related to a number of factors, such as usability, reliability, and support provided when problems occur. Medium level also is for nurses and doctors, and administrative staff who are moderately satisfied with the EHR. Low satisfaction is concerned about usability and is less positive toward the system, and low experiences with EPR system. Moreover, nurses indicated low satisfaction when the EPR system did not meet clinician needs [23].

Low expectation includes the usefulness in system [3]. Prior experience in computer use contributes to different concerns such as time taken and care quality that affects the usage of the new system. Privacy is a major concern of users, computer self-efficacy is associated with beliefs and behavior toward computer usage and it influences the usage of computer technology, which has been proven to be a strong indicator of the attitude toward information technology (IT) acceptance in hospitals [10], [24].

2.1.3 Collaboration environment

According to Ahmed and Yasin [28], there are many requirements for a cooperation environment, such as the cooperation between physicians' activities, collaboration between physicians in the treatment of patients, information sharing, and collaboration in resources as well as tasks scheduling. The Electronic Health Record system has been created to achieve communication, and integration with the physicians. Nguyen et al. (2015) found that the EHR system was well communicated, and integrated with physicians outside but still the cooperation based on the system was quite difficult [23]. In addition, the cooperation among physicians is important to improve their skills and provide best medical services to citizens.

Evidence from studies shows that 97% of the physicians' agreements on the collaboration environment can lead to improve the physician's skills and enhance the quality of healthcare services which leads hospitals to become more reliable [23]. Therefore, the use on such a system with the advanced technology can help them to communicate with each other more easily and efficiently.

However, communication is one of the challenges to overcome to achieve a suitable environment for the collaboration among health care providers and physicians. The complexity of the data flow and information management requirements however still needs to be addressed [29]. For example, EHR have built-in logic to avoid the duplicated results, but if, these cancellations are not properly communicated through the system the staff may have to remove the duplications manually. The laboratory may need to implement duplicates in order to compare the results [30]. Improve the care coordination and communication within the many clinicians and care team can increase the quality of care, reduce the medication, minimize the error, and improve the follow-up result [23]. Moreover, good collaboration between the users and technicians in providing technical support and advice could ensure full use and success of the healthcare system [29].

2.1.4 Trust

This factor plays an important role in management of IoT technology for reliable data fusion and mining, and enhanced user privacy and security [20]. Otherwise, help the medical professional to overcome perceptions of uncertainty and risk and engage user acceptance and use of IoT services and application [26]. There are many aspects of trust such as trust in the HIE partners, lack of trust in a patient's narrative, and other involved issues of trusting patients [6]. Some physicians are skeptical about the trustworthiness of the exchange access

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

way because they do not trust or cannot fully decipher the information from the patients as it, may be unreliable due to poor recall by the patients. One ambulatory physician stated, "It's not that I don't trust them, it's just that maybe the patient doesn't know or maybe doesn't have a high medical literacy" [3]. Trust in the privacy and security aspects of the exchange of health data is also important. These aspects could provide more satisfaction for both physicians and patients [42]. Inadequate and poor quality training has been linked to poor utilization of EHR also; and lack of efficiency can lead to failure to reach the full potential use of EHRs and hamper progress [34]. The IoT technology can provide a high degree of monitoring and smartness can lead to higher trust in utilizing medical data based on IoT-based healthcare system [42]. Moreover, IoT will pose several new problems concerning issues related to efficient utilization of resources in low-powered resource constrained objects [35].

Barriers associated with interpersonal processes include a lack of accessibility to collaborating partners in other organizations, different views of what is considered relevant information and a lack of confidence in the information received from others, as well as the fact that others feel they do not trust the information that is sent [36]. Because it is difficult to agree across several institutional health providers on sharing the information, the EHR enables access to trust among the medical staff, but full success is still difficult to achieve satisfactory information mobility. The goal therefore is to use the patient central of EPR to manage the patient information and control the medical data for it to be more trusted by medical staff. In another study, protected and sensitive information is made easy and natural for exchange while the smart objective communicates on behalf of users/organizations with services they can trust, while trust has to be a part of the design of IoT and must be built in [32], [37].

Trust in communication devices is a requirement when dealing with personal information. This very sensitive information must be protected and allow the authorized person to maintain the privacy. The channel must also be able to guarantee delivery of the health information every time. However, communication technology has different requirements for emergency situations when there is a need for patient health information [11]. In the USA and Europe, studies have expressed concerns about the misuse of the information transfer via smart technology [32]. Low trust of the information transfer may lead to low adoption of new technology [25]. Therefore, to meet individuals' trust in using IoT technology, there is need to maintain the privacy and security of the patient information via the IoT network.

2.1.5 Efforts

There are several programs that offer incentives for users to adopt the new technology to promote health information exchange. These programs focus on user efforts to exchange the electronic records. This is because the efforts of users play an important role in using the system and making the data available [29]. Therefore, understanding the efforts of different kinds of users for health information exchange can make it more useful. Furthermore, the need for various roles to provide a range of functionality and different approaches to data with different levels must be addressed [3].

Medical errors are the common problem for most countries. During the recording in health documentation mistakes may occur or the documentation may be unclear pertaining to drug prescriptions. Therefore, the different studies proposed the healthcare systems to overcome the medical errors. The benefits of IoT for the healthcare system can increase user efforts to use it. The medical staff believe the exchange of health information based on new technology reduces the error rate by approximately 50 to 70%. Moreover, most of the medical errors from the aspect of delivered healthcare system affect the patient care, as these errors usually occur due to workload, fatigue of medical staff, and miscommunication of patients' information [14]. Therefore, if the IoT-based healthcare system can minimize the medical errors, users will be encouraged to use the system.

Many of the clinicians prefer using paper-based documentation, but several studies have found that electronic documentation has a positive effect of the physicians as it will reduce reliance on memory to retrieve written documentation of patient's data [23]. The most difficult to change are the various groups of stakeholders such as employers, players, and providers, who have to assess the several services within the health information exchange to improve healthcare quality, efficiency and safety of individuals. The various stakeholders have a positive effect on efforts for improvement of the health information exchange [27], [33], [43]. These stakeholders may include hospitals, nursing facilities, clinics, private physicians' offices, pharmacies, laboratories, radiology facilities, health departments, and possibly the patients themselves.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

2.1.6 Service Quality

The main goal of health information exchange is to share the electronic patient information to improve the care quality and enhance the efficiency of healthcare. The reduction in medical errors is linked to increased care quality by enhancing the coordination and communication between the stakeholders [23]. Improving the quality of services makes the healthcare more efficient by increasing the ability of access to research providers with up-to-date knowledge of the medical histories, including recent laboratory tests and imaging procedures that help to reduce medical errors [3], [5], [6], [41].

Furthermore, service quality is an essential requirement in order to be able to use personal health devices to cover the needs of the patient particularly in an emergency situation [11]. In this way, the Internet of Things makes available resources and services for the user through the communication channel based on the user needs. Advanced technologies such as IoT can provide better healthcare services to benefit users and at the same time save costs [38].

The IoT service quality will have a great impact on user acceptance if the network and application can be fully provided and trusted [26]. Delone and McLean (2003) reported that the quality of services, system quality and information quality are associated with actual use and user satisfaction to ensure the success of the system [22]. Therefore, to make the IoT health system more usable there is a need to develop a design based on user requirements. Researchers think IoT will eliminate the problem of duplicated images [6].

4. RESULTS AND DISCUSSION

The goal of the present study was to investigate the current issues and the factors that affect medical professionals and IT practitioners in the use of IoT in the healthcare context. In this study, we provided a review of related information to identify the individual factors that impact the utilization of IoT in the healthcare system. The purpose of this study was to understand the related factors that induce healthcare staff to utilize IoT in providing their healthcare services. Most of these factors were identified from the statistical and descriptive analyses of the related articles, where the statistical and descriptive analyses produced more consistent results.

There are several factors that influence users to utilize IoT technology in the healthcare sector to enable the exchange of information requirements for patient records. From our review of the literature it appears that the main critical factors to achieve the potential benefits when using IoT technology for health information exchange are based on electronic patient records. Figure 6 shows the percentage of the main factors.

The researchers identified the other related factors that also have an effect on the utilization of IoT in the healthcare sectors. These factors were identified form the descriptive analysis of the related information. Figure 5 shows the related factors most frequently mentioned.

The researchers found that communication and collaboration between physicians and nurses across hospitals are still a problem in healthcare [14]. The lack of knowledge and motivation to use this information as well as the absence of control over transmission and receipt of the information during high loading work periods leads to many difficulties in locating and using patient information [3], [36]. In the health information exchange, different types of user behavior were perceived to exist from the interaction system to more detailed and complex patterns targeted at various kinds of information used. The recent studies show the interaction of nurses, pharmacists, and public health workers with the use of the patient information more than the physicians [6], [9], [19].

Most of the physicians depend on the literature rather than trust electronic patient information records [3]. This is because some physicians do not have high medical literacy, and lack training or knowledge [6]. Some issues affect user trust such as application and middleware when using new technology like IoT [42]. The trust in communication devices and channel would be enhanced among users when the devices used show the information clearly and adequately. Eventually user trust in the communication devices and channel employed in the IoT system could be established [37]. Poor quality training is another reason that affects the proper use of IoT and the exchange of electronic patient records. This however depends on the institution and organization that provides the training [34]. Different studies refer to trust in the existing information at any time as the most important factor in utilizing the EPR system especially at the emergency department [35], [37].

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

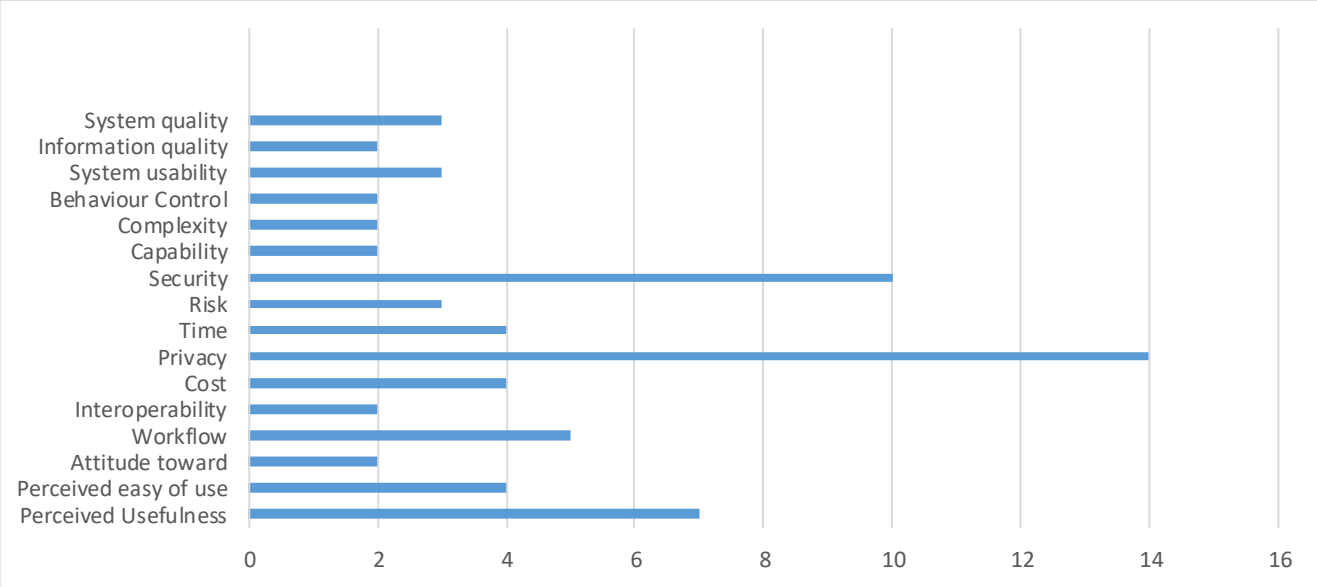

Figure 6: Related factors most frequently found in descriptive analysis

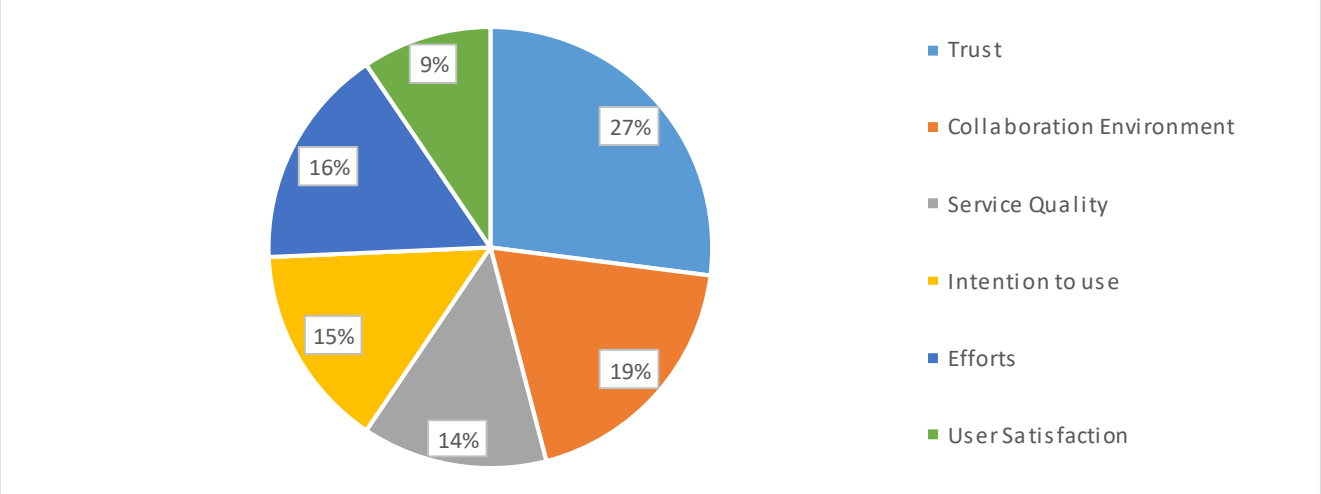

Figure 5: the percentage of main factors

Recent studies have focused on incentives for the users to increase their use of electronic health information exchange [39]. Otherwise, the electronic health records system will reduce the efforts of the medical staff, particularly the physicians, who will then resort to memory to retrieve the information about the patients from paper-based documents [5].

Some of factors were found have a negative effect on the medical efforts such as fatigue, miscommunication of patient information and workload [14], [23]. Reducing the medical errors and increasing the accessibility will enhance the quality of care. Recent studies on the use of health records have focused on understanding end user perspectives for the patient state, and accuracy clarity in recording patient information. Integration of health information system with clinical staff involves multiple logins that can be disruptive [6], [40].

A number of research has been done on the user acceptance for IoT [21], [25] in which possible to apply this technology for the user, where other focus on design a strategy to implement IoT in inter-organization [2], [24], [26]. Yusof & Aziz, (2015) focuses on the organization, in which the readiness of change in order to adoption new technology. Most of these studies find the human are the main goal to facilitate the implementation IoT in healthcare organization. The literature found these factors are the main contirbution from the users such as the medical staff or patients. For

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

instance, the trust in the management play important role for readable data and integrated the user with system will help them to overcome perceptions of risk. McFarland & Hamilton, (2006), declared the unusable information system may effect on viability of the organization, in case the information system is considered a necessity where also mention by [7], [30]. However, study the human factors is considered as a requirement to apply IoT technology in hospitals and to promit the exchange health information among them [2], [16], [23], [29].

From this study we can conclude that intention to use, user satisfaction, collaboration environment, trust, efforts, and service quality influence physicians and IT practitioners to utilize IoT in the healthcare context in order to promote data exchange among healthcare staff and healthcare providers.

For future work, we recommend that the factors revealed in this paper need to be tested empirically and to investigate how these factors are related that effect on the acceptance and the use of IoT technology in health care sector. The development of a new model for IoT services utilization for health information exchange will be carried out based on this initial work. The identified factors will be inclusive in the proposed model. We would like to argue that the usability amount for exchange health information should be developed based the IoT services. This could be a future research direction and more interesting topic research in health records management area.

4. ACKNOWLEDGEMENTS

The authors would like to acknowledge with thanks the assistance provided by the Faculty of Information Science and Technology (FTSM), Universiti Kebangsaan Malaysia (UKM) in providing facilities throughout the course of this research.

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