

# Adoption of the Internet of Things in the Healthcare Services of Sri Lanka

Rajphriyadharshini Rajmohan, Md Gapar Md Johar

**Abstract:** *The study explored the research issue of factors in the adoption of the Internet of Things in the health care services of Sri Lanka. To address this issue, the study examined Four research objectives respectively Evaluation of the impact of the proposed technological acceptance determinants on adoption towards IoT in the healthcare system evaluation of the moderating effect of Provincial area, Gender, Age in adoption towards IoT in the healthcare system. By extending UTAUT2 with other significant variables, such as perceived credibility and attitude, this study brought the novel insights into consideration for further research. UTAUT2 argued that the most influential antecedent to adoption intention was performance expectancy. This study gave a new perspective to identify trust as an influential factor driving intention to adopt IoT technology. This study provided insights for companies, to understand better what the determinants of adopting IoT products are. The research suggests that increasing physician's adoption towards IoT and healthcare organizations should create awareness of IoT products. This could be done in two comprehensive stages; first increase awareness among healthcare staff, which should be the focus on the way to bring business benefits to the organization. Secondly, awareness should be created among the patients, the final customers of IoT technology, which should be focused on enhancing both novelty and quality of IoT enabled healthcare products. However, the IoT technology is still in its early premature stage of development and requires an intense evangelization. To a certain extent, this research had identified the critical factors that impact adoption towards IoT in the healthcare industry in the Sri Lankan context. Then results were supported by the empirical study of the research and can be implemented both theoretical as well as managerial context to impose a radical change in the field of technology adoption of the healthcare industry.*

**Keywords:** *Internet of things, Healthcare, mHealth, UTAUT About four key words or phrases in alphabetical order, separated by commas.*

## I. INTRODUCTION

### A. Background

In the era of digitalization, where electronic gadgets and smart devices proliferate rapidly. The inception of the internet made these phenomena a forward-moving trend in the industry. The Internet enables devices to connect which helps to communicate and exchange information involuntarily for numerous purposes.

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Internet of Things (IoT) has the potentiality of connecting various smart devices and facilitate the decision-making process to be accurate.

The healthcare sector is one of the most essential and necessary needs for humankind. The sector was advancing its knowledge of disease and medication. Nerveless the last couple of decades, concern shifted in the sector's advancement towards digitalization. Retrospective studies of the last decade indicated that the prospects of healthcare would move towards globalization as well as the care delivery pattern will shift in the direction of digitization. According to the World Health Organization (WHO), numerous developing countries like Sri Lanka have serious healthcare workforce shortages. On the one hand, the rapid penetration and growth in access to mobile phones and on the other hand an acute shortage of health workforce in Sri Lanka, seeds to IoT initiatives in the country (Ministry of Health, 2019).

Adoption is a vital condition for the successful implementation of such IoT programs. Yet, systematic assessment of the Adoption of the stakeholders for IoT services in the country is deficient (Kahn, Yang & Kahn, 2010). To conduct a significant evaluation of IoT initiatives it is vital to understand the acceptability of IoT technologies in the milieu of health service as well as health promotion involvement. Thus this research will study the factors in the adoption of the Internet of Things in the Healthcare Services of Sri Lanka. In this chapter the background of the study, problem statement, theoretical foundations, nature, scope, limitations, and significance of the study are discussed.

The Internet of Things can connect gadgets intelligently. The IoT can comply with Industry 4.0 standards; it allows the physical process virtualization as well as their transformation into medical services. Even though the technological growth in the health domain such as; smart devices, smart pharmaceuticals, artificial organs, and biosensors. The incorporation of IoT in healthcare helps healthcare professionals and patients to move towards personalized medicine by linking up devices and technologies. Smart Industry 4.0 is defined as content-aware which assists people with equipment towards executing tasks. Context-aware means that the system considers context data to conclude real-life and virtual tasks. Clinics, pharmacies, and distributed healthcare agencies provide arrangements such as public nurses, General Practice Networks. Facilitate context-aware people's assistance using the hospital information system via practicing the IT system. The successful application of IoT in disease management and health education is an essential aspect of the triumph of personalized medicine.



Health specialist, health service providers as well as decision-makers can apply IoT to assess condition dynamically and interact with behavioral or environmental aspects. For example; IoT by providing connectivity between devices enables doctors to observe patient status virtually from any location in the world and control patient's tests and questionnaires.

Thus this research concentrated on the adoption of a healthcare professional on IoT in the hospital to understand their efficiency in applying IoT to achieve successful personalized medicine, in Sri Lanka.

**B. Internet of Things**

**1) The concept of the Internet of things**

Internet, the most significant inventions of the modern world becomes a reality now. It was available for the public to use about 15 years ago. A most important aspect of the internet is its utilization (Gushima and Nakajima, 2017).

Even though machine to machine communication is not a new concept the idea of the internet of things (IoT) is more holistic to understand. Various definitions were given to describe IoT. According to Van Kraneburg (2008), IoT is defined as a self-configuring global network, based on a standard communication protocol. Things in IoT describes both physical and virtual products that have identities, virtual personalities and physical attributes and use intelligent interfaces that are continuously integrated into the information network. Coetzee & Eksteen (2011) defined the term IoT more simply as a vision where every object becomes a part of the internet and uniquely identified within the network, where services, as well as intelligence, are added to identify the position and status of each object by fusing the digital and physical world. Numerous definitions in the literature carry different meanings to the same extent. Anyhow IoT even after its initiation about 15 years from now only gained depth and width as a concept. Also, the proliferation of the IoT technology becomes successful as yet; it is not the best idea to narrow the concept too much at this point.

According to Atzori *et al* (2010), IoT is defined as an internet-oriented perspective or as a Things oriented perspective, however, neither definition did not the full picture of the concept. Thus Atzori *et al* (2010) argue that a complete definition of IoT incorporates both perspectives indicated as semantic orientation. This comprises every unique addressed technology as well as the communication between the paradigm of IoT by meeting three main components including internet, Things, as well as semantics. The definition of 'Things' in IoT is wider as it comprises a variety of physical elements. The list extends as including all the personal gadgets we daily use, comprising smartphone, smartwatch, tablets, and digital cameras. Coetzee & Eksteen (2011) stated it also adds other elements of our life consisting of anything that can be connected to the internet in a way to bridge connections and communication. Varies wireless sensors and RFID (Radio Frequency Identification Tags) are the foundation of 'Things' in IoT. These objects have the smart capability to collect data and produce information enable efficient data mining and analysis. Anyhow the true nature of such objects will only be revealed if it is coupled together for a single purpose.

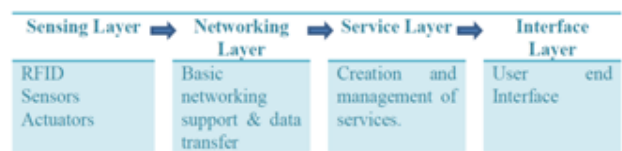
Internets of Things (IoT) services become widely popular after the introduction of newer concepts such as smarter

planet and smarter city (Rohokale, 2011). The smarter planet was introduced by IBM in 2008. It facilitates effective information interchange, real-time sensing and reducing energy consumption. A similar concept was adopted in the smart city which was followed in many commercial cities of China in their long term strategic plans (Tarouco, 2012). Pervasive connectivity also called ubiquitous computing defined as the constant availability of network-connected into everyday objects which minimize the end user's interaction with the computer and ease the interaction among things, humans and both. IoT provides such pervasive connectivity to support decision-making activities as well as to acquire real-time data.

IoT concept was proposed by MIT, originated from Auto ID (Schreier, 2010). The term Auto-ID refers to any type of identification technology like efficiency improvement, error reduction, and automation. Electronic product code network is also known as EPC, the initial step of IoT technology was launched in 2013. EPC objects can be tracked while they are moving from one place to another (Jara, 2010). The next generation of EPC incorporated in microchip made IoT as a global mainstream commercial means. Harald (2010) mentioned that the successful development and implementation of RIFD (Radio Frequency Identification Tags) enabled IoT to go out of the laboratory and to lead a new era in the IT industry. In 2002 National Science Foundation (NSF) convergent technology implies intraparty nanotechnology with ICT to improve the quality of life and productivity of nations (Bui and Zorzi, 2011). In 2005 International Telecommunication Union (ITU) suggested combining IoT concepts in object identification, sensor, wireless network, and the embedded system as these things could be tagged, sensed and controlled over the internet. IoT consists of varieties of technologies that can support the interaction between a broad range of networked devices and appliances (Pare *et al*, 2010).

**2) Architecture behind IoT**

A simplified service-oriented architecture (SOA) was described by Xu, He & Li (2014). SOA defines as the infrastructural architecture that concentrates on proving service than networking. Since IoT requires integrating heterogeneous systems and devices, SOA was proposed for IoT by the author. The framework has four contracted layer which is shown in figure 1. The conceptualization of IoT can be understood through this layered architecture.



**Figure 1: Four layered SoA for IoT (Adapted from Xu et. al 2014)**

The first layer, the sensing layer consists of physical hardware used in data collection. The connected devices in this layer sense and collect data. During the first generation of IoT, RFID tags were considered as a sensing source. However, nowadays more comprehensive technologies were developed by where more actuators and sensors are being included in this layer.



Today smart sensors with tags of sensing layer phones and communicate with different devices.

The second layer comprises the network layer that connects all the 'things' (devices). The layer also can segregate information from accessible IT infrastructure. Since the network is enormous and sustainable this is the vital layer in the IoT architecture. There are abundant issues related to network structure such as data and signaling processing, service discovery, energy efficacy, security and the ability to manage a heterogeneous network. Thus the network layer of the architecture needs to be designed cautiously.

The service layer that relies on the middleware provides solutions that the applicants intend to deliver. This layer provides a cost-effective platform to the IoT infrastructure by allowing reusing both hardware and software together, A well-defined service layer is expected to give protocol and API to common application requirements that support to achieve users' needs. This layer is further broken down into four distinct components such as service delivery, trustworthy management, service composition, and service APIs.

The final layer is an interface that shows the face of application to the end-user. Since many applications are developed by different organizations to retrieve information from the same database, each of these entities must make sure they maintain the same standards while retrieving the data. Thus such issues are dealt with by the interface layer which provides high accessibility as well as ease of use to the consumer. All these four layers together act to provide a meaningful architecture. The SOA model of IoT offers functionally standard services that can improve the efficiency of the system significantly.

### 3) Current Situation of IoT in Sri Lankan Hospitals

The first IoT initiative in Sri Lanka was introduced by the Information and Communication Technology Agency of Sri Lanka (Private) Limited (ICTA) in 2015 in 25 government hospitals of Sri Lanka. Thereafter various projects were incorporated in the country were table 1 shows some of the most widely used IoT applications in Sri Lankan hospitals.

**Table 1: IoT applications in Sri Lankan hospitals**

Types of IoT applications widely in Sri Lankan hospitals	Usage rate (percentage)
Hospital Health Information Management System	95%
Mhealth apps	98%
Personal Health Number & Master Patient Index	70%
Electronic Indoor Morbidity and Mortality Register	85%
Electronic reproductive Information Management System	82%
District Nutrition Management System	74%
electronic Non-Communicable Diseases System	67%
"Suwasariva" Telehealth Programme	77%
Essential Drug Stock Alert Tracker	87%
RFID tagged patient monitoring system	45%

Currently, 430 government hospitals (47.5% of total) and 67 private hospitals (74.4% of the total) are using at least one form of IoT application. Figure 1 illustrates the percentage

of hospitals that use IoT in different provinces of the country.

Sri Lanka suffers from an extreme shortage of doctors. The global average of the doctor-patient ratio is 17 per 1000 population. Whereas in Sri Lanka, there is only one doctor for 1000 population which is far below the standard ratio (Ministry of Health, 2018). According to Statista, (2018) the mobile penetration which was 97% in 2012 was drastically increased to 136% in 2018. Thus today with such increasing mobile penetration in Sri Lanka Information Communication Technology can overcome the low doctor/patient ratio.

A newer technology known as the Internet of Things provides patients and healthcare workers a novel solution by connecting them virtually 24/7. Currently, numerous IoT projects are being implemented in the country. Still, many of these projects could not able to spread over the country effectively, due to the reluctance of users (Senanayake & Senanayake, 2017). The reason for this is there were only very few formative researches or pre-implementation evaluations carried out to investigate the adoption rate of IoT in healthcare institutions of Sri Lanka. Thus this study focuses on this issue and attempts to identify the factors that influence the adoption of IoT by physicians of Sri Lanka, in a way to enlighten the issues concerning the main users, of this technology in the healthcare sector of Sri Lanka.

The study aims to analyze the adoption of the internet of things by the physicians to effectively communicate with the patients, to overcome the communication gap arising due to the low doctor/patient ratio in Sri Lanka. While examining the factors that can determine the adoption rate of this new technology, with the support of increasing mobile technology in Sri Lanka.

### C. Theoretical Foundation

Today investigating the reason behind accepting as well as rejecting any new technology become the most critical area in the field of Information technology. Studying IoT user's acceptance. Adoption use of technology has been recognized. Since the 1970s as it is a requirement for technology's realization and utilization. For an organization, it helps to decide of either increase or decrease their investment towards the particular technology. Technology adoption was defined by Venketesh and Davis (2000) as the implementation of software and hardware technology in an organization to improve processing speed, increase productivity, overcome competitive advantage and expand the availability of Information readily. Technology acceptance models and theories aim to express the concept of user's knowledge forward acceptance of how technology and how they would use such technology. Accordingly, for any novel technology, there would be many variables that influence an individual's decrease moving process of when could how they will use the particular technology.

When Looking back at the history of technology accepting theories, researches could able to understand the evolution and the development of such theories throughout the years, as well as the similarities and the difference between them, can be revealed. Below the most widely used, significant, and famous theories for technology acceptance that were used to study IoT adoption by numerous peer-reviewed researches are explained, briefly.

All technology acceptance theories are developed in a way to measure the degree of satisfaction as well as acceptance toward any technology of IT system, but from a different point of view, through different determinants and constructs, they represent each structure. Some of the most common theories or models on adaptation and technology acceptance cited in the literature included below, as shown in Figure 2. By comparing similarities as well as the difference among previously used sociology and psychology models, Venkatesh and Morris (2003) identified four antecedents at the acceptance of information systems. They have developed the UTAUT model by tailoring 14 constructs from 8 acceptance theories. The four determinants of UTAUT are; Performance Expectancy, Effort Expectancy, facilitating condition and social influence. Moreover, four significant moderating factors such as gender, age, the voluntariness of use and experience are used in this model. The relationship between these constructs was also confirmed by Weerakkody et al. (2017). In other fields including electronic learning, cloud computing, electronic commerce and electronic learning. Figure 2 illustrated the UTAUT model. More details concerning this model are elaborated below.

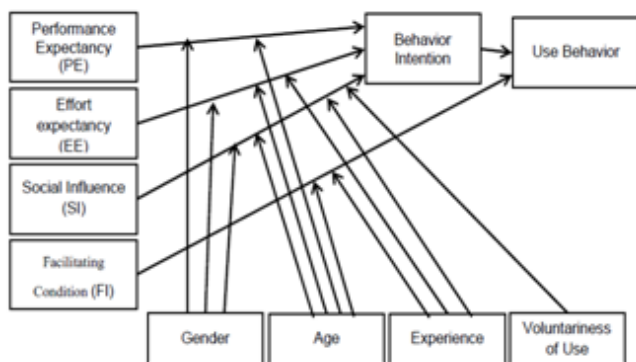


Figure 2: UTAUT model

**D. Conceptual Framework**

Among all the theoretical models reviewed the UTAUT model was found to be most suitable for this study. When Venkatesh et al. (2003) developed UTAUT, they compared the determinants of UTAUT and considered similarity between them as similar to such an approach. This research incorporated the understanding of definitions and functions of the variables that conceptualize the framework of the study. The framework consists of four independent variables that are extended from reviewed literature as well as supporting theories. As shown in figure 5, all these four independent variables are expected to affect the dependent variable the behavioral intention which in turn might affect the user behavior of IoT services.

As mentioned earlier the UTAUT was developed from eight theories, including TAM, TRA, TPB, MM, C-TAM-TPB, IDT, MPCU, SCT., which intention introduced as a new theory of IT acceptance. Figure 2.4 illustrates the four primary determinants proposed in UTAUT, such as PE, EE, social influence, and facilitating condition. Besides, the model includes four moderators that affect the determinant. They are age, experience, gender, the voluntariness of use from the perspective of social psychology.

Next when we compare this determinant of UTAUT with other acceptance theories on how it affects the behavioral intentions. First Performance Expectancy uses the

determinant similar to the perceived usefulness of TAM, TAM2, and C-TAM-TPB. Next Effort expectancy has the same determinates such as Complexity from MPCU, Perceived ease of use (found in TAM, TAM2) as well as Ease of use, which is used in IDT. After that Social influence similar to social factors of MPCU, a subjective norm that is used in TAM2, TPB/DTPB, TRA, C-TAM-TPB.

Among the variables used in this study, performance expectancy is defined user's performance of information technology, whereas Effort expectancy is defined as the extent of ease regarding the use of the system. Thirdly Social influence is defined as how others impact an individual's decision on where he or she should use such a novel system. The next Subjective norm is not system-specific factors. Finally facilitating condition is defined as the degree of an individual's believes that technical infrastructure or an organization support their use of the new system (Venkatesh et al., 2003). Figure 3 presents the research model of the study, which was expanded based on the Unified Theory of Acceptance and Use of Technology. The main UTAUT factors include performance expectancy, social influence, effort expectancy, behavioral intention and facilitating conditions. After reviewing numerous literature, external factors including Perceived creditability, Attitude, and provincial areas are also added to the framework. Furthermore, the researcher incorporated it.

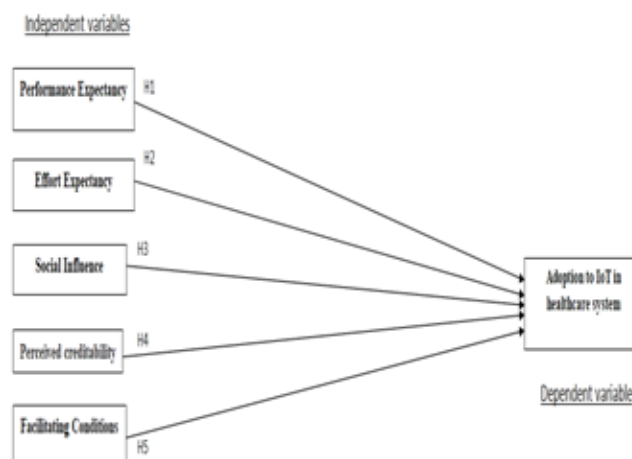


Figure 3: Conceptual Frame Work of the study (developed by the author)

**II. METHODOLOGY**

**A. Population**

The target population is physicians who work in different provinces of Sri Lanka. The focus of the study was on the physicians, who are registered at Sri Lanka Medical Council (SLMC), the authorized government body of the country. According to the Ministry of Health (2019), there are 33,116 physicians of 995 hospitals working in the country. In 2017 Information and Communication Technology Agency (ICTA) of Sri Lanka; the Specialty Board in Biomedical Informatics, Postgraduate Institute of Medicine, University of Colombo (PGIM); and the Health Informatics Society of Sri Lanka (HISSL) collaboratively published the number of hospitals that use IoT technology in each province of Sri Lanka in their booklet named "Digital health in Sri Lanka".



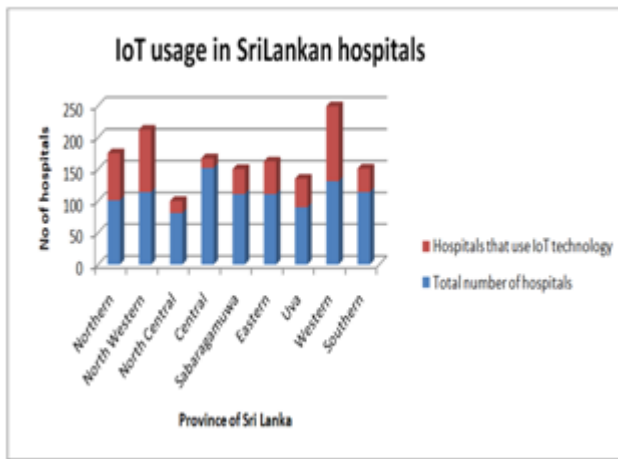


Figure 4 : IoT usage in Srilankan hospitals (developed by the author, source: ICTA (2019))

The population for this study is considered to be 16,558. Krejcie and Morgan, (2010) table cited by Connaway and Powell (2010) was used in determining the sample size of the population. Therefore, the sample size of this study was taken as 375.

### B. Survey Instrumentation

The survey instrument of the present study is a questionnaire administrated personally by an allocated data collection team. This enabled us to collect the completed responses within the allocated period. It also enabled the respondents to clarify any doubts at the same time if there was any. The questionnaire that was prepared by the researcher was to be answered within not more than ten minutes of the respondent's time. Furthermore, it ensured is to be completely anonymous and confidential, in case if there were any particular questions the respondents did not want to answer. The entire questionnaire was constructed in English and in layman terms to ensure that it would not cause any inconvenience and time consuming to the respondents. The subjects for this study include physicians who work for hospitals in each provincial area of Sri Lanka. Initially, 45 questionnaires were distributed to the participants for the pilot study in two hospitals and 40 responses were received (92% response rate for the pilot study). Finally 480 questionnaires were distributed to physicians, 394 questionnaires were returned. Eight questionnaires were discarded due to invalid responses (many incomplete answers). Thus, 386 usable questionnaires were yielded which resulted in an 77.4 % response rate across the 28 hospitals (Table 3.3).

## III. RESULTS

### A. Characteristics of the respondents

Concerning the job status of the 375 respondents of the study; 48.5% are Medical officers, 34.5% are Resident officers 34.5%, 11.5% Full-time General physician and 5.5% are Full-time Surgeon/Specialist. The composition of the sample indicated that 46.9% of respondents are represented by females while the remaining 53.1% are represented by male respondents. The furthermore largest group of respondents fell into the 30-35 years age group (38.5%). Of the rest, 23.5% are of 35-40 year age group, followed closely by the 41-45 age groups at 21% and only 8 respondents are above the 50 year age group. Regarding the work experience of the 375 respondents, 44.5% have below

2 years of experience and 25.5% have 3-5 years of experience. Out of the total respondents, 17% have more than 7 years of experience in the existing health care organization. Out of the total respondent, 52.3% are working in the community hospital, 11.7% are working in a private hospital and 9.3% are working in government hospitals. Regarding the duration spend in mobile by the 375 respondents, shows 44.5% use mobile for more than 3 hours whereas only 26% rarely use mobile, followed by 17.6% of the respondents use less than one hour.

### B. Assessment of Normality

Descriptive statistical analysis used the mean score of components of concepts to check the normality of the main data. Mainly considered were the skewness and kurtosis values (Chinna, 2012) for the assessment of normality. Kline (2005) suggested skewness and kurtosis values should not exceed three and ten respectively. The skewness and kurtosis values of this study are within the recommended levels indicating univariate normality of the data. The summary of Normality is given below in the table 2.

Table 2: Summary of Normality of the study

Variables	Mean	Std	Skewness	Kurtosis
Performance expectancy	3.31	1.067	-0.33	-0.742
Effort expectancy	4.21	1.053	-0.418	-0.316
Social influence	4.09	0.609	-0.587	-0.242
Facilitating condition	3.66	0.667	-0.707	-0.023
Perceived creditability	3.61	0.596	-0.36	-0.88
Adoption of IoT	3.58	0.549	-0.88	-0.547
Provincial area	3.48	1.08	-0.639	-0.282

### C. Testing of Multicollinearity

The assumption of multicollinearity examines by the correlation matrix. The correlation matrix presented in Table 6. In this study, the correlation matrix indicated that all the correlations were below .8 and thus, multicollinearity was not a problem. (Sekaran & Bougle, 2010). Further, multicollinearity examined through tolerance value and the variance inflation factor. The tolerance values and the VIF values present in (Table 7). They do not exceed the common cutoff points .1 and VIF values 10. Hence, multicollinearity was not a problem in this study (Tabachnick & Fidell, 2007).

Table 3: Tolerance and VIF values

Model	Collinearity Statistics	
	Tolerance	VIF
PE	.982	1.019
EE	.979	1.021
SE	.936	1.069
FC	.974	1.027
PC	.947	1.056

a. Dependent Variable: AI

**D. Structural model**

Byne (1989) described the objective of a structural model is to explain the direct or indirect relationships with other constructs. Thus, the purpose of the structural model in this study is to test the research objectives and the hypotheses of the study. The final structural model was developed after reviewing the final measurement model. This resulted in all fit indices being within the desired range (Table 4).

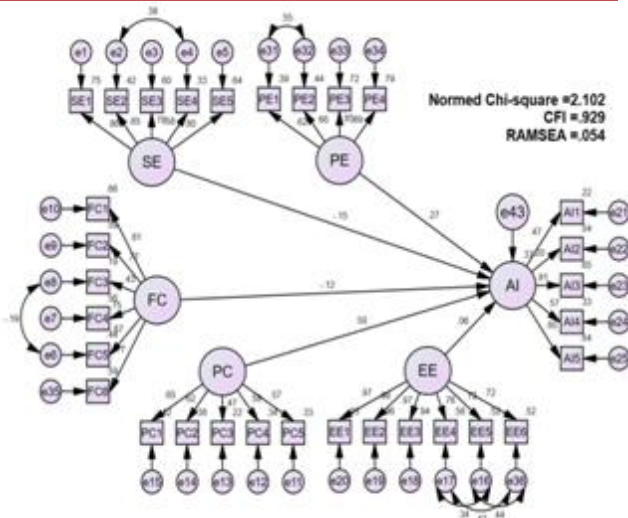
**Table 4: Final measurement model results**

Fit indices	Accepted values	Result
Chi square (df)	>0.05	1407.31(717)
Chi square/df	<3	1.963
AGFI	>0.9	0.936
GFI	>0.9	0.930
CFI	>0.9	0.934
TLI	>0.9	0.952
RMSEA	<0.08	0.051
P value	>0.000	0.064

The chi-square was significant ( $X^2 = 1407$  df =717.  $p = 0.064$ ,  $N = 375$ ). The GFI=.930, AGFI=.936, CFI=.934, TLI=.952 and RMSEA=.051,  $\chi^2/df = 1.963$ . These results also demonstrate that the structural model is the best fit for the data (Hair, et al 1998; Kline, 2005). The results of the relationship between variables in the final structural model are shown in Table 5. All the relationships were statistically significant ( $p < .05$ ). The regression weights for the final structural model are as follows:

**Table 5: The regression weights of the final structural model**

			Unstd. Estimate	S.E.	C.R.	P	Std. Estimate
AI	<---	FC	.074	.082	.899	.039	.046
AI	<---	SE	.077	.087	.885	.036	.046
AI	<---	PE	.258	.098	2.650	.008	.178
AI	<---	PC	.242	.153	1.581	.014	.090
AI	<---	EE	.016	.064	.252	.001	.012



**Figure 5: Structural model obtained from the study**

**E. Results of Testing the Hypotheses**

Hypotheses were tested through the proposed final model of the study, which was developed by the final structural model (Figure 5). Summary conclusions for the six hypothesized relationships are provided in Table 6.

**Table 6: Testing hypotheses using standardized estimates**

Hypothesized path	Standardized estimate ( $\beta$ )	P-value	Conclusion
H1: PE $\rightarrow$ AI	0.17	0.008	Supported
H2: EE $\rightarrow$ AI	0.12	0.003	Supported
H3: SE $\rightarrow$ AI	-0.61	0.376	Not Supported
H4: PC $\rightarrow$ AI	0.23	0.014	Supported
H5: FC $\rightarrow$ AI	0.15	0.009	Supported

**H1: Performance Expectancy positively related to adoption towards IoT in the healthcare system**

H1 tests the relationship between the Independent variable of Performance Expectancy and the dependent variable of Behavioral Intention. The results (Table 4.68) show that there is a positive influence between Performance Expectancy and Behavioral Intention ( $\beta=0.17$ ,  $p < 0.05$ ). Thus, H1 is supported by the data.

H2: Effort Expectancy is positively related to adoption towards IoT in the healthcare system H2 tests the relationship between the Independent variable of Effort Expectancy and the dependent variable of Behavioral Intention. The results (Table 4.68) show that there is a positive influence between Effort Expectancy and Behavioral Intention ( $\beta=0.12$ ,  $p < 0.05$ ). Thus, H2 is supported by the data.

**H3: Social Influence positively to adoption towards IoT in the healthcare system**

H3 tests the relationship between the independent variable of Social Influence and the dependent variable of Behavioral Intention. The results (Table 4.68) show that there is an insignificant relationship between Social Influence and Behavioral Intention ( $\beta=-0.61$ ,  $p > 0.05$ ). Thus, H3 is not supported by the data.

**H4: Perceived credibility positively related to adoption towards IoT in the healthcare system**

H4 tests the relationship between the Independent variable of Perceived credibility and the dependent variable of Behavioral Intention. The results (Table 4.68) show that there is a positive influence between Perceived credibility and Behavioral Intention ( $\beta=0.23$ ,  $p < 0.05$ ). Thus, H4 is supported by the data.

**H5: Facilitating Conditions positively related to adoption towards IoT in the healthcare system**

H5 tests the relationship between the Independent variable of Facilitating Conditions and the dependent variable of Adoption of IoT in the healthcare system. The results (Table 4.68) show that there is a positive influence between Facilitating Conditions and Adoption of IoT in the healthcare system ( $\beta=0.15$ ,  $p < 0.05$ ). Thus, H5 is supported by the data.

#### IV. DISCUSSIONS

The researchers analyzed the relationship between demographic factors and adoption towards IoT. It is reviewing demographic factors (sec 4.1). It was found that 70% of the physician is included in the female group with regards to age majority are below 35 years (40%). The results of the study are in line with similar studies carried out by Jayawarathana et al. (2019). There are over 43% of the physicians have less than five years of work experience. It was found that work experience has no impact on adoption towards IoT. Thus this research dropped the in-depth analysis of the moderating effect of work experience on adoption towards IoT. By examining given demographic factors such as job status, age, gender, experience, and internet experience indicated that there is no significant difference. However, there were no differences in responses due to the educational of respondents and factors that influence adoption toward IoT, such as performance expectancy, effort expectancy, social influence, perceived creditability, and facilitating conditions ( $P > .5$ ). According to Kavin (2019), since the minimum qualification of the respondents (physicians) is MBBS, which is considered as a high, literate level. Therefore it does not affect the usage of IoT as well as adoption towards IoT. Although, physicians who have less internet experience demonstrated emphasized significantly lower adoption toward IoT as compared to physicians who have higher internet experience educational backgrounds. The Similar result was found in the study by Allaid et al. (2018), the researcher found a similar perception among members in the higher internet experience group when compared to that of the lower internet experience groups (internet experience level made the difference between these two groups their thinking pattern, attitudes; calculation of risk of their work and finding sufficient challenge in work is superior in the higher internet experience group rather than in, the lower internet experience group). This study was conducted to answer a research question: what factors influence the adoption of IoT in the healthcare industry? To find answers to this question, this study relied on UTAUT2 to build the initial research model, with the addition of several significant. The results indicate that the main factors are performance expectancy, effort expectancy, social influence, perceived creditability and facilitating conditions, which act as significant determinants to users' behavioral intention towards the adoption of IoT. Moreover, the study also investigated the impact of moderators such as gender, age, as well as the provincial area on their indirect effect on the relationship between independent variables and the adoption of IoT.

The first hypothesis examines the relationship between Performance Expectance and adoption toward IoT. Performance expectancy (H1) was found to have the most positive direct effect on behavioral intention towards the adoption of IoT, whereas social influence was found to have no direct effect on behavioral intention, as well as no significant direct effect on the adoption of IoT. However, gender, age, and provincial areas are moderators that have an indirect effect on social influence on the adoption of IoT. The results showed that performance expectancy had the most potent effect on the adoption of all the main determinants. The results are consistent with previous studies (Chang et al., 2017; Yi et al., 2016). IoT technology

helps to support medical service care in the healthcare industry. This can be justified by the use of the robotic surgery method in oncology and gynecology. This method saves both time and space. Also, it helps to finish complicated surgeries more conveniently and comfortably. This enables physicians to treat patients quickly and more effectively, leading to an increase in their performance. On the other hand, patients will also have less bleeding small and secure wounds. Therefore patients will get well soon and can return to their routine lives happily. In turn, it ensures a more satisfied physician-patient. As of healthcare services in line with the study by Davis (2018) which that such an increase in satisfaction between patients and physicians enables them to believe that usage of IoT technology will enhance the performance.

A similar finding was also shown by Chang et al. (2017) when they stated that when physicians believe that the technology they perceive will be useful based on the actual usage, that they will adopt such IoT technology and will use it to provide a high degree of excellent services to patients.

Among the three significant variables of UTAUT in the study, performance expectancy had the highest contribution to predicting intention to adopt IoT. This was supported by the original study of UTAUT, noting that performance expectancy appeared to be a determinant in most situations of technology adoption (Venkatesh, Morris, Davis, & Davis, 2013). Some studies (Carlsson et al., 2016; Zhou, 2018; San Martín & Herrero, 2012; Oliveira et al., 2014) mentioned that performance expectancy was the most potent factor into technology adoption, while other studies (Alalwan, Dwivedi, & Rana, 2017; Im, Hong, & Kang, 2011) only indicated that performance expectancy had a positive contribution to predicting technology adoption. From the findings of this study and combined with other literature, it could be articulated that Indonesian users considered the performance of IoT products before they have an intention to adopt it. The product performance was reflected from the perceived usefulness, users' job-accomplishments, the increased productivity and users' achievements on essential tasks.

The second hypothesis examines the relationship between Effort expectancy (EE) and adoption towards IoT. The term EE refers to the effort required to use the particular IoT system. As mentioned by Bates, (2019), the critical character of IoT is its ease of the usage of the IoT system, Lee and Chao (2017) stated that the use of CPOE, the IoT application that enables physicians to write order online, increase physician's legibility to identify patient descriptions in medicines. Also, it enables pharmacists to read physicians' orders quickly as well as immediately; this overcomes the daunting problem related to the inability to read the physician's handwriting. Moreover, this reduces medical errors as well as the frequency of adverse drug effects. CPOE provides support to physicians by enabling more accurate, comfortable, faster and careful decision making. Therefore it can be said that EE increases physician's adoption towards IoT according to Delone (2018), ease of use of IoT technology increases physician's satisfaction, as per their feeling of whether it will be easier to use conventional method and finally have an enormous impact on the performance of their jobs.

The third hypothesis examines the relationship between facilitating conditions and adoption towards IoT. For facilitating conditions, this study supported UTAUT2 findings that resources and knowledge were perceived essentials before adopting new technology (Venkatesh, Morris, Davis, & Davis, 2003). However, system compatibility and assistance, which were parts of UTAUT items, were not significant in this study. Hence, for facilitating conditions, this study only took into account resources and knowledge, or also known as the perceived behavioral control. Resources are associated with money, time, and locality. The people who possess sufficient time and money, as well as located in the reachable area of delivery, show higher intention to adopt IoT compared to those who do not. Therefore, hypothesis H3 proposed in this study was supported; and in line with other research findings (Zhou et al., 2012; Kijisanayotin et al., 2019; Chang et al., 2017; Gupta et al., 2018). This entails that infrastructure support, such as laptop systems and information area units are necessary. Also, internal as well as external organizations support physicians to permit IoT technology to affect their behavior. IoT technology policy includes a necessary characteristic that maintain adoption by physicians. The interior organizations of healthcare industry support technical help to victimization IoT to IT workers, who work as technology support assistants for the physician. physicians could be part of the information that is necessary to control attention technology, however, this is not enough. Hence IT workers ought to even be used in healthcare to supply support for attention technology., the Ministry of Health, will facilitate to enhance related to healthcare, which will encourage computer code centralization for IoT technology which has been chosen to be suitable for training purposes.

The fourth hypothesis examines the relationship between Social influence and adoption towards IoT. The study showed that Social influence has no significant effects on adoption towards the adoption of IoT. The result is consistent with an earlier study conducted by Chismar and Wiley-Patton (2012) about internet technological adoption. In their study, social norms and images are similar to the social influence determinants in the UTAUT.

Physicians do not need to perceive pressure from social influences. Because their decision to adopt IoT technology is not influenced by pressure exerted by others in the healthcare industry. Chang et al. (2017) also presented findings that social influence has less of an effect on the behavioral intention for technology acceptance in target physicians. The majority of physicians showed proficient technical skills and high egos. Also, the limited time available to physicians for patient interactions. Additionally, Doctors do not need to gain benefits from using these IoT technologies because they also perceived their usefulness and ease of use.

Social influence, in which the measurement items in this study were modified compared to the original scales in UTAUT, still demonstrated the positive effect on the intention to adopt. It was proposed in the theoretical framework that social influence was related to the subjective norm and included interpersonal influence, such as the influence by family, friends, and colleagues (Bhattacharjee, 2000).

Compared to the original construct of social influence in UTAUT, this study only took subjective norms into account

but excluded social factors and image. This study considered that by adding the source of influence, which is interpersonal influence, the social influence construct would be more coherent. The improvisation of social influence construct also appeared in existing literature, such as by adding interpersonal influence and external influence (Bhattacharjee, 2000) as well as proving that in UTAUT model, subjective norms construct itself drove intention to adopt the technology (Al-Gahtani et al., 2007; Laumer et al., 2010). This study highlighted that Social Influence could be explained as the influence of people who are essential and influencing users, which might act as friends, family, and colleagues. On the other hand, external influence, which was proposed earlier in the measurement items of this study, was not significant in the social influence construct; therefore, we can ignore the external influence entirely (Taylor & Todd, 1995). External influence covered the influence of mass media including advertisements in online and offline media (Bhattacharjee, 2000).

Finally, subjective norm and interpersonal influence brought positive contributions to enhance the intention to adopt the technology. This could be explained that Srilankan physicians are more likely to be influenced by their peers (e.g., friends, family, colleagues), not by the external influence (e.g., mass media, advertisements, etc.). The closeness and trust to the people who are essential or influencing their behavior devoted and significant effect on Social Influence.

The fifth hypothesis examines the relationship between Perceived credibility and adoption towards IoT. Perceived credibility is another significant factor that influences the adoption of IoT in the healthcare industry. Perceived credibility is found to be insignificant, which is contrary to the finding from Ifinedo (2012) and other studies (Kuan and Chau 2001; Zhu and Kraemer 2005; Zhu, et al. 2006b; Alam 2009; Ramdani et al. 2019, 2013; Oliveira et al. 2017, Thiesse et al.2014). This result of insignificance is infrequent, and the researcher recognizes that the different result in this study is because of the uniqueness of the characteristics of the Srilankan public hospitals, which are public organizations that receive government subsidies but also operate as profit-seeking companies.

The result conforms to the finding from Kim, et al. (2018) and Zhu, et al. (2006a), who both argued that security and privacy are critical factors of Perceived credibility that influence in IoT adoption. Zhu et al. (2006a) mentioned that security concern is a more critical inhibitor than the financial costs of technology. The result confirms that the protection of privacy has a positive impact on the adoption of technology, and this was argued by Alaiad and Zhou (2014). Cao *et al.* (2014) suggested that the privacy and security of patients' information have to be guaranteed when adopting IoT. The result of the Perceived credibility is a surprise to the researcher and initially seemed implausible. However, apart from the explanation given by the informants, precisely the same result has been found by Goodhue and Thompson (2015). The interpretation was that the adopters who depend heavily on IoT system usage know the potential issues of the IoT system, and also would be more frustrated by the 'instability' or the downtime of the system because of the high dependability, and therefore would tend to rate IoT system as unreliable. As reported by Valaitis and O' mara (2015),



'some technical glitches will occur with the use of any technology' (pp159) and is to be expected.

## V. FUTURE RESEARCH

The result of the research can be enhanced by several ways to overcome the limitation faced on the research and to utilize in the future for managerial implementation as well as to be a stepping stone to future researchers; some are; first this study was carried out cross-sectional as one-time sample collection. Therefore repeating the questionnaire with (possible modification) after some time (like one year) would give more inside on the research. Increasing the sample size and spreading different target healthcare industries, geographically is also another suggestion. Thirdly a qualitative analysis (interview) on the same sample group could provide valuable answers on different influences of factors in adoption toward IoT. This could discover details by inquiring each physician individually for example how the adoption of IoT is done in hospitalized and a more inside view on the impact of hospital-specific on IoT adoption. Fourthly it will be worthful to perform similar research on other groups of healthcare staff (i.e., nurses, IT staff) to get the complete picture of adoption toward IoT by the health care sector.

## VI. CONCLUSION

IoT technology is transforming the healthcare industry; by adopting IoT, hospitals could increase the efficiency of professionals as well as provide better quality medical service. Srilankan public hospitals are unique organizations; they are technically public organizations because they receive funding from the government, but they operate like profit-seeking organizations; because the government subsidies only account for a tiny amount (9% in 2019) of their total income, they have to have their profitability in order to survive.

The principal purposes of this study are to develop a model that can be used to predict the adoption of IoT by physicians in Sri Lanka public hospitals, to test the hypotheses, to explore why certain factors are significant in adoption decision-making while others are not, and also to reveal the reasons why hospitals adopt IoT at all. Those research questions emerged while doing the literature review. Although innovation adoption is a heavily studied and relatively mature area, the findings of the organizational innovation adoption are inconclusive and fragmented; in the healthcare context, most of the studies were concentrating on one of the health IoT technologies adoption, such as the adoption of mhealth, RFID. The theories and models are diverse, so are the predictors developed within the models. Different theories and models combined with different factors under different backgrounds are used in adoption studies; there are hardly any conclusive models or factors that fit all organizational adoption studies due to various aspects. For example, in the healthcare context, Hu *et al.* (1999) applied TAM to study the adoption of telemedicine in Hong Kong; the factors included in the TAM model are perceived usefulness and perceived ease of use; Wu *et al.* (2011) studied mobile healthcare adoption in Taiwan, an integrated model of TAM and TPB was used and the factors included were attitude, perceived behavioral control, subjective norm, perceived usefulness, perceived ease of use, personal innovativeness and perceived service

availability; Pichitchaisopa and Naenna (2013) applied UTAUT, which included performance expectancy, effort expectancy, social influence, facilitating conditions and provincial areas as constructs to study hospital information technology adoption and the place of research was Thailand; Sezgin and Özkan-Yıldırım (2016) integrated TAM, TPB, and UTAUT to study IoT adoption in Turkey; the predictors used were behavioral intention, perceived ease of use, perceived usefulness, perceived behavioral control and system factors. Even if some of the studies were at the organizational level, the models used were initially created to study individual adoptions such as UTAUT2.

Moreover, most of the adoption studies, that used the traditional prominent models (Sezgin and Özkan-Yıldırım, 2016; Alaiad and Zhou, 2014; Tsai, 2014; Deng et al., 2014; Sun et al., 2013). The result of the study showed that by incorporating performance expectancy, social influence, facilitating conditions, perceived creditability, and attitude this study has brought the empirical results to an extension of UTAUT2. This extended model is proposed to understand the physician's intention to adopt IoT. UTAUT suggests effort expectancy as the most critical factor in technology adoption, but this study offers that performance expectancy is the most influential determinant in technology adoption, specifically IoT in the healthcare industry. From a theoretical perspective, this study shows that technology adoption is strongly related to uncertainty, and hence physicians put their attitude before having the intention to adopt IoT. Therefore, this study recommends, from a practical perspective, that healthcare marketers need to build consumers' trust in the company and the IoT product. This can be achieved by establishing proper relationships with users, offering friendly customer service, creating a pleasant customer journey and convincing users that the product was created to help them. The role of social influence, facilitating conditions, perceived creditability, provincial area, and age should also be considered since they bring a positive impact on the intention to adopt IoT in the healthcare industry.

## REFERENCES

1. Alaiad, A., & Zhou, L. (2017). Patients' Adoption of WSN-Based Smart Home Healthcare Systems: An Integrated Model of Facilitators and Barriers. *IEEE Transactions On Professional Communication*, 60(1), 4-23. doi: 10.1109/tpc.2016.2632822
2. Alilom, A. R., & Mohammed, A. H. (2006). Customers satisfaction with health services provided by emergency departments of federal teaching hospitals, Khartoum 2(X)5. *Sudanese Journal of Public Health*, 1(3).
3. Atkins & Cullen (2013). *Medical Care* 51:3 Suppl 1, March 2013, S1-S3.
4. Atzori, L., Iera, A., & Morabito, G. (2017). The internet of things: A survey. *Computer networks*, 54(15), 2787-2805.
5. Avis, M., Bond, M., & Arthur, A. (1995). Satisfying solutions? A review of some unresolved issues in the measurement of patient satisfaction. *Journal of Advanced Nursing*, 22(2), 316-322.
6. B. Nath, F. Reynolds, R. Want, RFID technology and applications, *IEEE Pervas. Comput* 5 (1) (2006) 22-24.
7. Babakus, F., & Mangold, W. G. (1992). Adapting the SERVQUAL scale to hospital services: an empirical investigation. *Health Services Research*, 26:767-776.
8. Bailey, C. A. (2006). *A guide to qualitative field research*. SAGE Publications, Incorporated.
9. Bertakis, K.D. (1977). The communication of information from physician to patient: A method for increasing patient retention and satisfaction. *Journal of Family Practice*, 5(2): 217-222.

10. Belanche, D., Casaló, L., & Flavián, C. (2012). Integrating trust and personal values into the Technology Acceptance Model: The case of e-government services adoption. *Cuadernos De Economía Y Dirección De La Empresa, 15*(4), 192-204. doi: 10.1016/j.cede.2012.04.004
11. Belanche, D., Casaló, L., & Flavián, C. (2012). Integrating trust and personal values into the Technology Acceptance Model: The case of e-government services adoption. *Cuadernos De Economía Y Dirección De La Empresa, 15*(4), 192-204. doi: 10.1016/j.cede.2012.04.004
12. Bellin, S.S. & Geiger, Hi. (1972). The impact of a neighborhood health center *mi* patient behavior and attitudes relating to healthcare: A study of a low income housing project. *Medical Care, 10*(3): 224.239.
13. Bengtsson, U., Kjellgren, K., Hallberg, I., Manhem, K., & Taft, C. (2018). LINKS BETWEEN BLOOD PRESSURE AND LIFE-STYLE FACTORS REPORTED VIA A MOBILE PHONE-BASED SELF-MANAGEMENT SUPPORT SYSTEM. *Journal Of Hypertension, 36*, e63. doi: 10.1097/01.hjh.0000539137.18258.1e
14. Clay, K., & Strauss, R. (2013). Institutional Barriers to Electronic Commerce: An Historical Perspective. *Advances In Strategic Management, 19*, 247-273.
15. Dinesen, B., Huniche, L., & Toft, E. (2016). Attitudes of COPD Patients towards Tele-Rehabilitation: A Cross-Sector Case Study. *International Journal Of Environmental Research And Public Health, 10*(11), 6184-6198. doi: 10.3390/ijerph10116184
16. Donabedian A, (1976). The quality of care: How can it be a.sses.sed? *JAMA.260*, 1743-8.
17. Eiriz, V., & Figuciredo, i. A. (2005). Quality evaluation in healthcare services based on customer-provider relationships. *International Journal of Healthcare Quality Assurance, 18*(6), 404-412.
18. Fayaz-Bakhsh, A., & Rostami Golmohamadi, F. (2016). Regarding: "Access to Mobile Communication Technology and Willingness to Participate in Automated Telemedicine Calls Among Chronically Ill Patients in Honduras". *Telemedicine And E-Health, 18*(4), 316-316.

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