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Review Article

A STUDY OF INTERNET OF THINGS ENABLED HEALTHCARE ACCEPTANCE IN MALAYSIA

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Abstract
The power of Internet of Things (IoT) has disrupted the traditional business models of industries, especially in healthcare industry. The emerging of connected sensors and devices, and the advancement of wireless technology, cloud computing, and data analytics, have been transforming the healthcare from case-based paid service to value-based care service. These value-based care services is known as IoT enabled healthcare applications. The aim of the IoT enabled healthcare is to eventually provide a low-cost, advanced technology, and high accessibility care services for patients and consumers. Some developed countries have been implementing the IoT enabled applications in healthcare sector and obtained satisfactory result. In this paper, Diffusion of Innovations (DOI) model was applied to study the IoT diffusion in public and Technology Acceptance Model (TAM) was used to study the degree of IoT is accepted in public. In addition, survey questionnaire was developed to collect data from the public and consequently identify the barriers for Malaysia to embrace the IoT into healthcare sector. After going through the data collection, IoT enabled healthcare application is accepted by most of the respondents. IoT healthcare application is reaching the decision stage that Malaysian need more persuasion to encourage them to make the decision of using the IoT healthcare application. Lastly, six major barriers for service provider and public to adopt IoT healthcare application were then identified in this paper.

Keywords: Adoption Barrier, IoT, Healthcare, Healthcare Facilities, Remote Monitoring, Telehealth, Wearable Device.

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INTRODUCTION

The innovation of Information Technology (IT) plays an important role to help the companies to face the challenges that come from the rapidly-evolving world in order to stay competitive. Over the past decade, one of the IT innovation, Cloud Computing, has been embraced by many companies and organisations in spite of the fact that it is yet to be a mature technology [1]. Cloud computing is an IT paradigm that provide the services such as data storage and accessing, applications, and infrastructures, are running in virtualised platforms over the internet instead of running them in a physical computer or server. These virtualised platforms are generally categorised into four cloud deployment models, they are private cloud, public cloud, hybrid cloud and community cloud. The cloud computing services are basically divided into three categories: Software-as-a-Service (SaaS), Platform-as-a-Service (PaaS), and Infrastructure-as-a-Service (IaaS) [2]. VMware, Amazon EC3, Google Apps, Microsoft Azure, and SalesForce.com, the major cloud computing service providers, have provided various cloud computing services and have benefited the corporations in numerous ways such as cost saving of setting up the upfront infrastructures and operations, fast software development and delivery, improving and accelerating collaboration, and environment friendly [2, 3].

The emergence of cloud computing has subverted the traditional way of using IT for organisations. Credit to its scalability and elasticity, the nearly zero setup time and infrastructure upfront, the extremely low administration cost and pay-per-use pricing, it has derived the demanding of moving database into cloud environment and therefore the arising of cloud database, Database-as-a-Service (DBaaS) [4]. The cloud computing has resolved the barriers of huge data storage and large scale of processing resources. It has enabled the data-intensive applications that require huge data in a measured size of terabytes or petabytes and hence, the Big Data is emerged [5]. The Big Data applications have been implemented into different industries such as retailers and consumers, finances and frauds services, web and digital media, health and life sciences, telecommunications, and ecommerce and customer services. The Internet of Things is one of the technology which works in conjunction with Big Data.

Although the technologies above are still continuously developing, improving, and evolving but they are matured enough to enable the industries and human lifestyle enter into a new era, the Internet of Things (IoT). IoT is a concept of connecting electronic devices, sensors, actuators and cameras via internet connectivity to enable the data exchange among the devices, servers, applications, service providers, and users. IoT is a mega trend in next generation technologies, which has been called the next revolution industrial, that impacts many industries and delivers drastic changes in business models of the industries. IoT is not a new concept instead, it was initially introduced by Peter T. Lewis in his speech at U.S. Federal Communications Commission (FCC) in 1985 [6]. He had coined that IoT allows the integration of connected sensors and electronic devices, people, and computerised systems to enable the data aggregation, manipulation and analytics, and consequently evaluate the trends of the connected devices for remote monitoring purposes. He was inspired by the idea of smart devices network which was implemented into the first internet enabled electronic device, the Coke vending machine [7]. This Coke vending machine was connected into internet for supplier to monitor the inventory status. However, this concept was only progressively accepted in 1999 and aggressively implemented during the past decade until now. The applications of IoT provides appropriate solutions which have been using in smart home, smart cars, smart city, industry 4.0, security, emergency services, retails, traffic control, logistics, and healthcare. There are many successful cases of transforming the

industries' business model by leveraging on IoT such as IBM and Microsoft in IT industry, Daimler in trucking industry, U.S. Bank in banking industry, Ericson Maritime in shipping industry, and ABB Group in heavy industry [8]. The most recent one is the Dubai's project, the Smart Dubai Government Establishment, aims to build the world-class most advanced IoT ecosystem in the smartest city [9].

In the health and healthcare industries, Health Information Technology (HIT), the current major information technology used in health information management, supports health information exchange in secure manner among the consumers, patients, caregivers and service providers across the computerised system. MarketResearch.com report [10] has estimated that by 2020, the amount of USD 117 billion will be contributed by the IoT enabled development in healthcare sector. The high potential of returns has driven the development of IoT enabled medical devices and equipment, and treatments in healthcare sector that not only resulting in cost saving and high profits for service providers but also resulting in improved effectiveness, efficiency, and accuracy of health monitoring and treatment systems. The healthcare professionals and caregivers can effectively monitor their patients' health status anytime and anywhere when they or their patients are not in the hospitals, medical centres, or clinics. Therefore, the IoT enabled in healthcare does not only create opportunities to the industries in high potential returns but also benefits the patients to experience the affordable high quality of healthiness caring, monitoring and treatment services [11]. By leveraging of IoT, connecting all the portable or stationary medical equipment, and wearable devices, it is not merely the information sharing as in HIT among the human but also the information exchange among the machines, equipment and devices as well. This is because of the IoT enables the objects to collect and send the data across the existing network infrastructure, and they are able to be controlled remotely as they are connected. IoT has created opportunities for creating appropriate computerised systems with lesser human intervention into the physical world and real life, that can significantly to improve the efficiency, accuracy, quality and cost in any industry and eventually benefits to human.

Various applications of IoT enabled are being used in healthcare sector. For example, non-invasive remote heart failure monitoring and management system, Chronic Obstructive Pulmonary Disease (COPD)/Asthma medication adherence and symptoms control, smartphone enabled continuous glucose monitoring for diabetes, wearable sensor for arrhythmia diagnosis, smartphone attachment to detect heart arrhythmia, wearable armband sensor to monitor across all vitals, video visits with physicians and psychologists, and weight monitoring for diabetes prevention, are implemented in many developed countries and have obtained remarkable outcomes [12].

The aim of this paper is to study the adoption of IoT enabled healthcare applications in Malaysia and identify the current barriers in Malaysia that move digital/IS-IT healthcare to IoT enabled healthcare. The rest of the paper is organized as follows. Section 2 provides a picture of what IoT enabled healthcare is and some related works are briefly discussed in section 3 thereafter. Furthermore, the methodologies of the research work are discussed in section 4. In addition, author has provided the research results and in-depth discussion in section 5. Lastly, the concluding remarks are given in section 7.

IOT ENABLED HEALTHCARE

In the report of Global Healthcare Internet of Things (IoT) Market Analysis and Forecasts 2016 - 2021 - Research and Markets, PR Newswire [13] mentioned the healthcare industry is poised to be driven by the high innovative connected health technologies which consist of IoT, applications, services and solutions. The core objective of digital health is to greatly reduce the costs and significantly improve the healthcare services and consequently make the IoT enabled healthcare applications are more realistic and viable. The IoT enabled healthcare are being redefined with the supports of two major development: the wearable technology and digital healthcare. Wood [14] mentioned that by leveraging the wearable devices in IoT, it delivers a range of health products and services from telemedicine to self-diagnosis and monitoring which results in reduce cost and becomes a major influence of driving the insurance company for IoT adoption. Ma et al. [15] also highlighted that the IoT enabled healthcare should deliver the core values that not only to benefit patients but also drive the entire healthcare industry to form an organism of health services. They proposed few objectives that the IoT enabled healthcare should provide services accessibility anytime and anywhere, reduce hospitalisation rate, decentralise the health and healthcare services, provide high accuracy and efficiency monitoring system, and reduce group injury.

There are two different types of stakeholders are connected to form a complex and comprehensive IoT enabled healthcare ecosystem [16]. First type of the stakeholders are patient with wearable IoT enabled devices and sensors, caregiver, healthcare institutes, social media and patient's family. The other type of the stakeholders are medicine industry and pharmacies, emergency response services, IoT enabled medical devices industry, and smart home industry. IoT allows patient health data is being transferred among the stakeholders in the cloud-based infrastructures. By leveraging the big data analytic, it enables data storing and analysing, auto or manual monitoring, and data sharing in a secured manner among the stakeholders. Thus, the IoT enabled healthcare can meet the objectives to provide the services such as real-time patient monitoring, improving the quality of patient care, and avoiding hospital mistake. Figure 2.1 illustrates the conceptual IoT enabled healthcare. Connected objects (Things) sense and collect the health data (Data) of patients (People) and then send it to cloud (private or public cloud). Those data will be analysed (Process) and become a useful health information (Data). Useful health information will be presented (Process) to caregivers (People) in a form of report or monitoring graphic user interface.

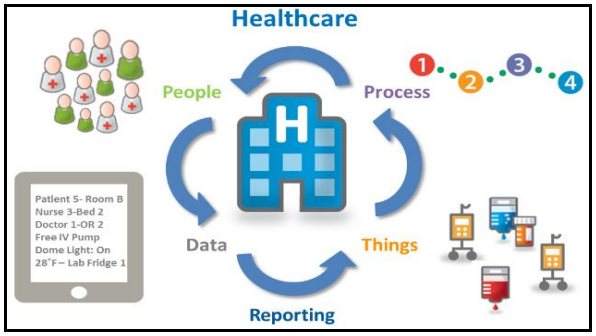

Figure 2.1: The concept of IoT enabled healthcare [16]

Numerous IoT researches and studies have been done for healthcare industry in various perspectives such as technical and technology perspective, survey of current IoT enabled healthcare applications, framework of adopting IoT in healthcare industry, solutions to overcome the barriers of adopting IoT in healthcare and et cetera. Few related works will be discussed in this section for reader to have an overview of what have been done in the current researches.

David and Kyle [12] define the Healthcare IoT as "Platforms that create actionable patient data to aid in the treatment or prevention of diseases outside of the traditional care setting, drastically reducing costs in the process (also referred to as Digital Health)". They have identified and concluded the viable digital health markets into three categories: Remote patient diagnostics and monitoring, Telehealth and Behaviour

modification. Remote Patient Monitoring provides a remote patient diagnostics and monitoring by using wearable devices which are embedded with sensors to collect the health status data such as heart rate, oxygen saturation and blood glucose and will be sent to caregiver or health service provider via patient's smartphone. Telehealth enables the doctor visit to be conducted remotely without visiting of hospital or clinic. Behaviour Modification provides a platform that can help patients to change their bad habits and adopt the healthier lifestyles in order to control their health status. They also provided few digital healthcare case studies across the three major verticals as shown in Table 2.1.

Islam et al. [11] have done a comprehensive survey on IoT enabled healthcare. IoT healthcare network (IoThNet) is one of the major elements of IoT enabled healthcare. IoThNet consists of the IoThNet topology, IoThNet architecture, and IoThNet platform and they categorised the IoT enabled healthcare into Services and Applications, and the potential verticals of each of them [11, 12]. He also provided a very comprehensive of IoT enabled healthcare applications and the sensors or devices are used in the applications such as using of non-invasive opto-physiological sensor for diabetes applications, using of adhesive capacitive electrodes for heart rate monitoring applications, using of wearable body temperature sensors for body temperature monitoring applications, using of wristband pulse oximeter for oxygen saturation monitoring applications, and et cetera. Further, plenty of smartphone applications are listed in the paper such as Google Fit, Cardiax Mobile ECG, OnTrack Diabetes, ECG Self-Monitoring, and so on. In addition, the security concerns, IoT enabled healthcare technologies, the policies of IoT enabled healthcare.

Table 2.1: Digital health case studies across the major vertical [13]

z	Company	Description
Remote Patient Monitoring	CardioMEMS	Remote heart failure monitoring and management through an implantable device.
	Vivify	Remote heart failure monitoring and management.
	DexComn	Continuous glucose monitoring connected to a smartphone application and social network.
	Propeller Health	Medication adherence and air-quality tracking for Asthma/COPD patients.
	iRhythm	14- Day continuous heart monitoring for arrhythmia diagnosis.
	AliveCor	ECG on a smartphone for arrhythmia diagnosis and monitoring.
	Biovotion	Arm-band based ICU grade vital signs measurement. Aims at monitoring glucose non-invasively.
Telehealth	Doctor on Demand	Virtual doctor visit (medical, psychiatric, lactation counselling) via a video conferencing platform.
Behaviour Modification	Omada	Weight-loss coaching for diabetes prevention.

Partha [18] proposed an architectural framework, Home Health Hub IoT (H^3IoT), for monitoring health of elderly people. H^3IoT is an IoT based model which includes connected biosensors, applications, internet, and the hardware platform, enabling the health monitoring for elderly people residing at their home and their health condition can be monitored by doctors, caregivers, hospital, and their relatives. Figure 3.3 has shown the details structure for the H^3IoT architectural framework.

It is constructed by five layers, they are Physiological Sensing Layer (PSL), Local Communication Layer (LCL), Information Processing Layer (IPL), Internet Application Layer (IAL), and User Application Layer (UAL). PSL is the bottom layer that enables the connected biosensor to collect the health condition data. The collected health data will be transferred via the 2nd bottom layer, LCL, and it will be sent to the 3rd layer, IPL, for data processing. Processed data will be conveyed to the higher layer, IAL, for storage and analysation in cloud platform, and visualisation in mobile Android or IOS platform. Service providers will use the data stored in cloud for further data analysis and provide the services and applications to the end users such as doctor, caregiver, hospital and relative. End users can easily and remotely monitor the health condition of elderly via mobile devices at anywhere and anytime.

Tyagi et al. proposed a more detailed IoT based healthcare framework by using cloud computing [19]. This framework provides various healthcare applications to suite different stakeholders need. These stakeholders comprise patients, family members, doctors, caregivers, pharmacists, labs, and hospitals. The proposed Cloud-IoT consists of various applications such as Electronic Health Records (EHR), personal health records, clinical decision report, laboratory system, real time location system, digital imaging, e-prescribing system, pharmacy system, and health information exchange. Physicians can obtain their improved clinical results and diagnosis via Cloud-IoT where patients can also monitor their health condition via Cloud-IoT.

The wearable monitoring devices are used to collect patient's health condition data. This health data will be conveyed to a cloud platform and will be processed and analysed by Cloud-IoT based healthcare applications which are hosted in the same cloud platform.

Verma et al. [20] also proposed a Cloud-centric IoT based student healthcare monitoring framework that consists of three phases. By using smart wearable body sensors, heart sensors, gastro sensors and ECG monitor to collect health condition data and diagnose the student whether if he or she has high heart rate, high blood pressure or high blood glucose level. The environment sensors such as temperature sensors and humidity sensors are used to collect environment condition data and bio-sensors are used to collect student's behavioural data such as skin conductance, temperature and motion. Students can also use their smart phone to answer some health related questionnaires via a mobile application for application to collect the student current health status and store into cloud repository. These all dataset are stored into the cloud subsystem for data processing and health status diagnosis. Student's parents, doctor an caregiver can monitor the student health status via mobile application. It can provides alert to student's parents or caregivers and it also can generate the alert to nearby hospital for emergency situation. Through a series of experiments, they has proposed a system to enable the diagnosis of diseases type by using the advanced data mining methods.

METHODOLOGY

In this paper, Diffusion of Innovations (DOI) model was applied to study the IoT diffusion in public. Secondly, Technology Acceptance Model (TAM) was applied to study the degree of IoT is accepted in public. In addition, some questions are set to identify the public barriers of IoT adoption in healthcare sector. Author also reviewed some relevant works to identify the provider adoption barriers of moving digital/IS-IT healthcare to

IoT enabled healthcare. Lastly, an interview was conducted for collecting data of enablers, stakeholders, feasibility services and applications, and variable factors in IoT enabled healthcare applications.

Diffusion of Innovations (DOI)

Diffusion is a process of how a new idea or thought is communicated through certain channels among the people of a social system over the time. DOI is a theory to rationality explain how, why, and what rate a new innovation idea and new technology is taken up in a population. The diffusion of an innovation cannot happens immediately but it occurs over the time throughout the following five–step decision-making process:

i. Knowledge: the adequate information of an innovation that is exposed to inspire the individual for adoption.
ii. Persuasion: how strong the evaluation that drives the individual's interest.
iii. Decision: whether the individual accepts or rejects the adoption of an innovation after weighting its advantages and disadvantages.
iv. Implementation: whether the individual stops or continues to adopt the innovation after evaluating the usefulness and no other superseder exists.
v. Confirmation: the final decision whether individual continues or discontinues the use of innovation.

DOI model are usually applied in the research works to describe how social systems deal with new innovative ideas and technologies, provide a framework for analyses to measure the effectiveness of a program, campaigns, or strategy, encourage or discourage the adoption of an innovation, and explain the success or failure of an innovation. Mary and Robert [21] applied DOI model in their healthcare research work. Mathur and Verma [22] proposed a modified DOI model in their research work for cloud computing adoption.

Technology Acceptance Model (TAM)

Davis [23] modified Fishbein and Ajzen's [24] Theory of Reasoned Action (TRA) and developed an information system theory, the TAM. TAM is a model to explain how a new technology is accepted and used by end-users. Davis described that "the key purposes of TAM is to provide a basis for tracing the impact of external factors on internal beliefs, attitudes, and intentions". An individual's intention of using a new system is determined by two particular beliefs:

i. Perceived usefulness (U): the degree to which individual believes the use of new system will enhance his/her job performance.
ii. Perceived ease of use (EOU): the degree to which individual believes the use of new system will need less effort.

TAM can be applied in the research work to understand the degree of a new technology or system is accepted by individual and explain the individual behaviour in a new technology or system. Yadegaridehkordi et al. [25] applied TAM in their cloud computing adoption research work. Yuvaraj [26] applied TAM to examine the librarians' behavioural intention to use the cloud computing applications.

RESULTS AND DISCUSSION

The survey questionnaire was started on 19th of May 2018 and ended on 30th of May 2018. The literature review of identifying the industries' barriers of adopting IoT in healthcare was started from 1st of May 2019 until 30th of May 2018 by going through some of the relevant researches which have been done in developed countries and in Malaysia. The following sections will present the collected survey data and the literature review data by the order of the objectives author has mentioned in Section 1. Total of one hundred of respondents volunteered to complete the survey questionnaire.

Diffusion of Innovations

Before an innovative idea is broadly diffused, it has to pass through the five stages: Knowledge, Persuasion, Decision, Implementation and Confirmation. To summarise the results from Question 5 to Question 9 as shown in Table 4.1, it has shown that only 35% of respondents know what IoT is, a 39% heard about IoT enabled healthcare applications, and a 44% know the camera is an IoT device for Telehealth application. However, it has also shown that a 78% know that the wearable device is an IoT device, and a 89% know that it can be used in healthcare applications. By averaging the results of these five questions, an average 57% of the respondents knowing what IoT is and author can assume that slightly more than half of the respondents are having knowledge of IoT.

Table 4.1: Survey results for DOI (Question 5-9)

Questions	Answers	Respondents Age Range				
		Below 31	31-40	41-50	51-60	Above 60
5. Internet of Things (IoT) in healthcare uses devices and sensors to collect the health data. Those collected data will be sent to the health service provider via internet connection. Have you heard about IoT before?	Yes, I know what is it	7	15	13	0	0
	Yes but not very clear what is it about	9	15	5	2	0
	No, I have not heard it before	6	24	4	0	0
6. Do you know that the wearable devices such as wristband and armband can measure and collect the heart rate or blood pressure, are one of the IoT devices?	Yes, I do	17	41	19	1	0
	No, I do not know	5	13	3	1	0
7. Do you know that those wearable devices can be used in healthcare monitoring purpose?	Yes, I do	21	47	19	2	0
	No, I do not know	1	7	3	0	0
8. Do you know that camera is also one of the IoT devices that it can be used in Telehealth?	Yes, I do	7	22	14	1	0
	No, I do not know	15	32	8	1	0
9. Have you heard the Remote Patient Monitoring, Telehealth, or Behavior Modification before?	Yes	10	21	6	2	0
	No	12	33	16	0	0

According to the Table 4.2, the results of Question 10, 11 and 12 have shown that a 79% of respondents agreed that IoT enabled healthcare is an innovative idea but only a 33% are using wearable device and 39% are using wearable device in IoT healthcare applications. Author is not going to average the

results as although IoT enabled healthcare is recognised as an innovative idea but it may not be converted to the real adoption. As what we can see from the results, it still has the low rate of using IoT device or application. Perhaps it still need more time and persuasion from other parties. These parties are identified from the result of Question 15 where an 89% of respondents agree that hospital is the major role to drive and persuade the public to adopt the IoT in healthcare sector. An 85% of respondents also agreed that government and health service provider have the responsibility to persuade public to adopt it. However, the result of the Question 13 has shown that a 73% of respondents claimed the current medias did not deliver the IoT related information enough to education them. Nevertheless, 93% of the respondents agreed and accepted that IoT enabled healthcare is the future digital healthcare and they are willing to adopt it. To summarise the discussion and analyses above, more than 50% of respondents knowing what IoT is where it has been starting to pass through the DOI Knowledge stage but it still need more efforts to deliver the IoT related information to public by leveraging the existing medias. Most of the respondents agreed that IoT enabled healthcare is an innovation idea that is attracting them to adopt it and 89% of them are ready to adopt it. Meaning that the IoT enabled healthcare is reaching the decision stage that Malaysian need more persuasion to encourage them to make the decision of using the IoT healthcare application as they are willing to adopt it. However, there is no actual implementation of IoT enabled healthcare in Malaysia despite the demands are there. The IoT enabled healthcare is wandering between the diffusion stages of Persuasion and Decision. Malaysian are waiting the actual implementation of IoT healthcare applications in order for them to decide whether or not to adopt it.

Table 4.2: Survey results for DOI (Question 10-15)

Questions	Answers	Respondents Age Range				
		Below 31	31-40	41-50	51-60	Above 60
10. Do you think IoT in healthcare such as Remote Patient Monitoring, Telehealth, or Behavior Modification is an innovative idea?	Yes, it is	19	38	20	2	0
	Not really	3	15	2	0	0
	No, it is not	0	1	0	0	0
11. Are you using any wearable IoT device such as wristband (e.g. iwatch, miband, fitbit and etc)?	Yes	10	15	8	0	0
	No	12	39	14	2	0
12. Are you willing to use the wearable IoT device such as wristband for the Remote Patient Monitoring, Telehealth, or Behavior Modification?	Yes, it is awesome	8	22	9	0	0
	I will consider it if it is useful	14	29	13	2	0
	No, I will not	0	3	0	0	0
13. Do you think that the current channels and medias are enough to deliver the information of IoT?	Yes	8	13	5	1	0
	No	14	41	17	1	0
14. Do you think that IoT healthcare is the future of digital health?	Yes	21	50	20	2	0
	No	1	4	2	0	0
15. Do you think which are the following parties should drive the adoption of IoT in healthcare? (You may choose more than one)	Government	19	45	20	1	0
	Private companies	12	25	13	0	0
	Hospitals	19	49	19	2	0
	Health service providers	19	46	19	1	0
	Government leaders	7	12	6	0	0

IoT Technology Acceptance

As shown in Table 4.3, although only 18% of respondents (result of Question 16) are using IoT healthcare application, but the overall results from Question 17 to Question 21 have positively shown that IoT healthcare applications are perceived usefulness. These five questions are developed from the perspectives of its usefulness (accounted total of 88% agreed), effectiveness (accounted total of 87% agreed), importance (accounted total of 80% agreed), necessariness (accounted total of 74% agreed), and improvement (accounted total of 60% agreed). An average of 77.8% believe it is perceived usefulness.

In spite of the result of Question 22 has shown that a total 68% of the respondents agreed that IoT healthcare application is ease of use but a 50% (result of Question 23) claimed that they need a user's manual to operate or use it. Based on Table 4.4, only a 24% (result of Question 24) thought that it is confusing to use but only 32% did not think that. Accounted 44% are site-neutral as it might be lack of hand on experience and hence no comment was given. The similar result of Question 25 also shows that 37% are site-neutral, 32% disagreed that they need to put efforts on how to use the IoT healthcare application whereas a 31% disagreed. The result of the Question 26 has shown that 42% are again site-neutral but accounted 41% disagreed that it is uncomfortable to be used whereas only a 17% agreed. Compiling the results from Question 23 to Question 26, by excluding the site-neutral respondents due to lack of hand on experience, an average of 31.5% agreed that IoT enabled healthcare application is perceived ease of use whereas an average of 30.75% disagreed. The result shows that half of the respondents thought that it is perceived ease of use but if we count the result of Question 22 in, it has higher count that it is perceived ease of use. As discussed in last section, respondents are willing to adopt the IoT healthcare application, meaning that the attitude of respondents towards using is positive and they have significantly shown the intention of using it. Applying the results into TAM, author has concluded that the IoT enabled healthcare application is accepted by most of the respondents.

Table 4.3: Survey results for TAM (Question 16-21)

Questions	Answers	Respondents Age Range				
		Below 31	31-40	41-50	51-60	Above 60
16. Are you using any IoT healthcare system such as Remote Patient Monitoring, Telehealth, Behavior Modification, Glucose Monitoring, Remote Cardiac Arrhythmia Diagnosis, or mobile health monitoring or tracking application?	Yes	6	10	2	0	0
	No	16	44	20	2	0
17. Do you agree that the monitoring system or application is useful?	Strongly agree	3	12	10	0	0
	Agree	16	32	11	2	0
	Undecided / Neutral	1	10	1	0	0
	Disagree	0	0	0	0	0
	Strongly disagree	0	0	0	0	0
18. Do you agree that the monitoring system or application is effectively to monitor your health status?	Strongly agree	3	11	5	0	0
	Agree	16	34	16	2	0
	Undecided / Neutral	3	7	1	0	0
	Disagree	0	2	0	0	0
	Strongly disagree	0	0	0	0	0
19. Do you agree that the monitoring system or application is important to monitor your health status?	Strongly agree	4	11	9	0	0
	Agree	14	29	11	2	0
	Undecided / Neutral	4	11	2	0	0
	Disagree	0	3	0	0	0
	Strongly disagree	0	1	0	0	0
20. Do you agree that the monitoring or application is necessary to monitor your health status?	Strongly agree	4	8	8	0	0
	Agree	11	30	11	2	0
	Undecided / Neutral	7	14	3	0	0
	Disagree	0	2	0	0	0
	Strongly disagree	0	0	0	0	0
21. Do you agree that the monitoring or application has improved your quality of healthiness?	Strongly agree	3	7	4	0	0
	Agree	9	28	8	1	0
	Undecided / Neutral	9	18	10	0	0
	Disagree	1	1	0	1	0
	Strongly disagree	0	0	0	0	0

Table 4.4: Survey results for TAM (Question 22-26)

Questions	Answers	Respondents Age Range				
		Below 31	31-40	41-50	51-60	Above 60
22. Do you agree that the monitoring or application is ease of use?	Strongly agree	2	6	8	0	0
	Agree	14	29	7	2	0
	Undecided / Neutral	6	18	7	0	0
	Disagree	0	1	0	0	0
	Strongly disagree	0	0	0	0	0
23. Do you agree that you always need a user's manual to use the monitoring system or application?	Strongly agree	0	8	2	0	0
	Agree	8	23	8	1	0
	Undecided / Neutral	12	13	4	0	0
	Disagree	2	9	6	1	0
	Strongly disagree	0	1	2	0	0
24. Do you agree that the monitoring system or application is confusing for you to use it?	Strongly agree	0	3	0	0	0
	Agree	5	15	1	0	0
	Undecided / Neutral	10	24	9	1	0
	Disagree	5	11	10	1	0
	Strongly disagree	2	1	2	0	0
25. Do you agree that you need to put a lot of efforts to use the monitoring system or application?	Strongly agree	0	3	0	0	0
	Agree	4	20	3	1	0
	Undecided / Neutral	8	17	11	1	0
	Disagree	9	13	6	0	0
	Strongly disagree	1	1	2	0	0
26. Do you agree that the monitoring system or application is uncomfortable to be used?	Strongly agree	1	3	0	0	0
	Agree	2	10	1	0	0
	Undecided / Neutral	7	23	11	1	0
	Disagree	11	18	8	1	0
	Strongly disagree	1	0	2	0	0

Barriers of Service Provider and Public Adoption

Author studied the service providers' adoption barriers in few reports which have been done by PwC Health Research Institute [27], Islam et al. [10], Deloitte [28], European Commission [29], David & Kyle [12], and MIMOS [30]. The barriers for service provider to adopt IoT in Malaysia healthcare are generally similar to the barriers that developed countries are facing. Table 4.5 is the survey results to show the barriers of public adoption. After analysing the reports and author's survey results in Table 4.5, below are the significant and pressing barriers that are required to be addressed in the first place and consequently enable the service providers and public to fully embrace the IoT in healthcare sector:

i. Readiness of infrastructure: Including the network capability for vast connected devices and coverage of connectivity, and the capable of cloud storage.
ii. Handling of vast collected health data: The technologies that are capable to process and analyse the health data into valuable health information.
iii. Talent shortage in IoT field: The capabilities of industry are driven by the capable people. Without the right people, IoT cannot be adopted in healthcare sector.
iv. Regulatory guidelines for IoT enabled healthcare: Including the regulatory to regulate the quality and security of IoT devices, and to ensure the service providers strictly adhere the guidelines.
v. Legal for patient and consumer data protection: Aims to eliminate the worry of health information leaking.
vi. Consistency reimbursement model for IoT development at scale: To provide a consistency reimbursement model and common direction for agencies to work coherency and coordinate in order to generate influential IoT research initiatives.

Table 4.5: Survey results for barriers of public adoption

Questions	Answers	Respondents Age Range				
		Below 31	31-40	41-50	51-60	Above 60
1. IoT enabled healthcare devices or wearable devices aim to collect your health data such as heart rate and blood pressure, and then send it to health service provider via internet connection. Which are the following issues that you are concerning? (You may choose more than one)	Privacy of biology information	18	36	18	2	0
	Security of sending biology data over the internet	15	30	17	1	0
	Doubting of usefulness of biology information	5	17	0	0	0
	Accuracy of biology information the device collects	13	31	12	1	0
	I do not have any concern	6	0	0	0	0
2. Many studies have disclosed that many types of IoT devices are broadly vulnerable to attack. Which are the following solutions do you think that it can reduce or eliminate the risk of security issues? (You may choose more than one)	Government legislates the regulations to urge the companies to produce vulnerability free of IoT devices	11	31	13	1	0
	Government to expand the legal protections for personal biology information which are collected by the health service providers	20	47	19	2	0
	Private companies are responsible and accountable to ensure the security and privacy of the patients	15	29	13	2	0
	No need to improve as current acts and regulations are enough to handle the security issues	1	0	0	0	0
3. Do you trust the new technology, IoT, that it can really help the patients to prevent the diseases and reduce the hospital admission?	Yes	19	43	20	2	0
	No	3	11	2	0	0
4. Are you ready to adopt new technology of IoT as part of your health monitoring which is provided by hospital or health service provider?	Yes	19	46	22	2	0
	No	3	8	0	0	0

CONCLUSION

In this paper, author have discussed the overview of IoT and its adoption in healthcare sector. Author also discussed the related works of IoT enabled healthcare. DOI and TAM were introduced as for the research methods. A comprehensive of data analysis was presented and they have been discussed. Furthermore, author has concluded that the IoT healthcare application is reaching the decision stage that Malaysian need more persuasion to encourage them to make the decision of using the IoT healthcare application as they are willing to adopt it. The current adoption of IoT technology in Malaysia healthcare industry is then identified throughout the data analysis. In addition, author has also concluded that the IoT enabled healthcare application is accepted by most of the respondents. The DOI and TAM have shown the positive outcomes that respondents are ready to adopt IoT enabled healthcare application but the lack of IoT enabled healthcare applications have become a barrier for them to adopt it.

After going through the data collection, the six major barriers for service provider and public to adopt IoT healthcare application were then identified, they are: readiness of infrastructure, handling of vast quantity of health data, talent shortage in IoT field, regulatory guideline for IoT enabled healthcare, legal for

patient and consumer data protection, and consistency reimbursement model for IoT development at scale. The above barriers must be addressed at the first place, thereafter to enable the IoT enabled healthcare research and development at full scale. Firstly, enhancement of existing infrastructure is necessary such as improving the broadband speed and coverage, increasing the spectrum and the readiness of IPv6 network. Moreover, the regional cloud storage is necessary for vast health data storage and data analytics. Secondly, adopting data analytic technologies to critical analyse the collected health data and transform them into useful health information. Furthermore, academies have to immediately breed the talent of the IoT needs, in the meantime, finalising a consistency reimbursement model for IoT development at scale, it can help to increase the research and development on IoT enabled healthcare. Lastly and the more importantly, government, corporations and organisations have to speed up the process to legislates the regulations and expand the legal of data protection to eliminate the worries of device quality and data leak of personal information.

Due to small sample size, population, and context of the study, it may have some limitations that may affect the generalization and validity of the result. Further validity test is required using large sample size. Data mining is one of the challenge on how to collect adequate data without containing personal data as the health data is currently bundled by the personal data protection act which does not allow the health data to be shared among the countries and even among the different companies, organisations and healthcare facilities. Therefore, in the future research, author hopes that this research work can inspire the other researchers to continue the research works such as to collect more data equally from different age ranges, and conduct an application implementation work to develop the conceptual framework.

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