A THEORETICAL FRAMEWORK TO EVALUATE THE BEHAVIOURAL INTENTION TOWARDS A HABIT CHANGE SUPPORT SYSTEM IN HOSPITALS

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by

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ABSTRAK

Seiring dengan kemajuan teknologi dalam pelbagai bidang, pengumpulan dan pemprosesan data kesihatan masih belum mencapai potensi sepenuhnya. Kajian ini bertujuan untuk mereka bentuk rangka kerja teori bagi menilai niat tingkah laku terhadap sistem sokongan perubahan tabiat di hospital. Kajian ini menggabungkan teori-teori penerimaan yang biasa digunakan seperti Technology Acceptance Model (Tam et al.), Unified Theory of Acceptance and Use of Technology (UTAUT), dan Theory of Planned Behaviour (TPB). Sebuah model teori yang mengandungi 10 pembolehubah telah dibangunkan untuk mengkaji kebolehgunaan, kebolehlaksanaan dan niat tingkah laku untuk menggunakan Doctive dan diuji menggunakan pendekatan kuantitatif. Kajian ini dijalankan menggunakan tinjauan dalam talian dengan pengedaran kod QR di kalangan profesional perubatan, di mana 162 respons diterima dari dua hospital kerajaan di Pulau Pinang, Malaysia. Analisis menggunakan Partial Least Squares Structural Equation Modelling (PLS-SEM) untuk menilai rangka kerja dan hipotesis. Sebanyak 15 hipotesis dicadangkan bersama dengan rangka kerja kajian ini, yang terdiri daripada 9 kesan langsung pembolehubah bebas dan 6 kesan pengantaraan. Hasil kajian menunjukkan bahawa walaupun "Perceived Feasibility" tidak mempunyai kesan yang ketara terhadap Niat Tingkah Laku, kedua-dua pemboleh ubat iaitu "Perceived Feasibility" dan Kebolehgunaan memainkan peranan pengantaraan penuh dalam penerimaan sistem sokongan perubahan tabiat di hospital. Hasil kajian ini memberikan wawasan tentang bagaimana pengamal perubatan boleh menggunakan sistem IoHT seperti Doctive untuk meningkatkan diagnosis awal, memantau tabiat dan mengurangkan penyakit tidak berjangkit dalam komuniti.

A THEORETICAL FRAMEWORK TO EVALUATE THE BEHAVIOURAL INTENTION TOWARDS A HABIT CHANGE SUPPORT SYSTEM IN HOSPITALS

ABSTRACT

As technology advances across various fields, healthcare data gathering and processing have yet to reach their full potential. This study aims to design a theoretical framework to evaluate the behavioural intention towards a habit change support system, in hospitals. The study integrates commonly used adoption theories such as the Technology Acceptance Model, the Unified Theory of Acceptance and Use of Technology (UTAUT), and the Theory of Planned Behaviour (TPB). A theoretical model comprising 10 variables was developed, to find the usability, feasibility and behavioural intention to use Doctive and tested using a quantitative approach. This study was carried out using an online survey with the distribution of QR codes among medical professionals, out of which 162 responses were returned from two government hospitals in Penang, Malaysia. The analysis employed Partial Least Squares Structural Equation Modelling (PLS-SEM) to evaluate the framework and hypotheses. A total number of 15 hypotheses was proposed along with the framework of this study, a combination of 9 direct effects of independent variables and 6 mediating effects. The findings revealed that while Perceived Feasibility did not significantly impact Behavioural Intention, both Perceived Feasibility and Usability played a full mediating role in the adoption of a habit change support system. These results offer insights into how healthcare providers can implement IoHT systems like Doctive to improve early diagnosis, monitor habits and reduce non-communicable diseases in the community.

CHAPTER 1
INTRODUCTION

1.1 Background

This first chapter introduces the research background, problem statement, research questions along with the objectives, significance of study, research scope and a walkthrough on the organization of this thesis based on each chapter.

Referring to the United Nations Sustainable Development Goal No. 3 (SDG – Goal 3), it is critical to promote health and well-being for people of all ages in order to achieve sustainable development. In every 2 seconds, it is apparent that someone between the ages of 30 and 70 dies prematurely due to a noncommunicable disease such as cardiovascular disease, chronic respiratory disease, diabetes, or cancer ((WHO), 2020). Two of their primary goals are to reduce one-third of the noncommunicable disease premature mortality through prevention and treatment, mental health awareness and well-being, and by strengthening the capacity of all countries, especially developing countries, for early warning, risk reduction, and management of national and global health risks ((WHO), 2020). Therefore, these goals can be achieved through effective and continuous healthcare monitoring.

Growing rates of lifestyle diseases, sedentary lifestyles, hectic work schedules, technological advances in healthcare monitoring equipment, and increased use of remote devices appear to be some of the major causes driving the need for a systematic and analytical healthcare system. Despite the fact that healthcare monitoring devices are expected to be technologically innovative and provide advanced as well as basic healthcare monitoring features, apart being available at various price ranges based on features, the aspect of data gathering and processing has not bloomed to its fullness (Pantea Keikhosrokiani, 2020; Pantea Keikhosrokiani, Mustaffa, & Zakaria, 2018; P. Keikhosrokiani, Mustaffa, Zakaria, & Sarwar, 2012; Pantea Keikhosrokiani et al., 2015). This could be partly due to the large amount of information given to hospitals, where data is not segregated and evaluated in a systematic manner. In addition, hospitals may also be lacking in effective systems, valuable input, and real-time data from patients, which further complicates data management.

Data processing in healthcare is often slow due to a variety of factors. One key issue is the fragmentation of systems; many healthcare organizations use multiple, disconnected systems for managing patient information, such as electronic health records, laboratory information systems, and billing systems. This lack of integration makes it challenging to access and process data quickly, leading to delays. Additionally, despite technological advancements, many healthcare providers still rely on manual data entry for patient records and test results. Manual processes are not only time-consuming but also prone to human error, further slowing down data processing and introducing potential inaccuracies.

The sheer volume of data generated in healthcare also contributes to delays. Hospitals produce vast amounts of information daily, including patient records, imaging studies, and lab results. Processing this large volume of data requires significant time and resources, often resulting in backlogs. Moreover, the lack of standardization across healthcare systems complicates data aggregation and analysis. Different systems may use varying formats for data collection and reporting, making it difficult to quickly derive insights or generate reports. Compounding these challenges is inadequate training; healthcare staff may not be fully trained to use data management systems effectively, leading to inefficient use of technology and slower processing times.

According to a World Health Organization ((WHO), 2020) report, this raises a red flag as the mortality rate is rising as a result of heart and chronic diseases. Despite a huge and sudden increase in death rates due to the Covid19 pandemic (Troeger, 2021), heart disease remains the primary cause of death worldwide. Current hospitals lack real-time monitoring systems in many hospitals. Without these systems, healthcare providers may not receive timely alerts or updates on changes in a patient's condition, delaying critical responses. The Internet of Things (IoT) has the potential to revolutionize healthcare by expanding the use of sensors and increasing the number of patients being continuously monitored for medical issues. This can lead to fewer unnecessary tests and consultations, ultimately reducing healthcare costs. Additionally, IoT technologies can enhance early diagnosis and intervention by analysing symptoms more accurately, allowing healthcare providers to identify the root cause of illnesses or other health challenges more effectively. Because the Internet and digital technologies have expanded the boundaries of healthcare and health

communication beyond their traditional scope (Palfrey and Gasser, 2011; Schiavo, 2013), a simple habit change in the right direction is all that is required to avoid future health problems. The confluence of IoT and big data represents a new paradigm in healthcare. Because of this convergence, healthcare processes and procedures may now be handled more effectively. Using big data analytics, health-care trends and patterns can now be forecasted, autonomously studied, and recommended. As a result, a new intelligent paradigm has emerged in which IoT and big data analytics are complementary technologies used to disrupt the healthcare industry (Saheb & Izadi, 2019). With its five primary qualities, proper implementation and acceptance of Big Data in healthcare can bring significant potential in many areas, including the quality of care and aid to patients. These attributes are referred to as the 5Vs: volume, velocity, variety, veracity, and value (Mehta & Pandit, 2018).

In a feasibility study, a proposed plan or project is evaluated for its practicality (Simplilearn, 2023). A project or business idea is assessed for its viability as part of a feasibility study to ascertain if it will be successful. It studies the objective and rational analysis of a prospective business or initiative that is carried out to identify its strengths and weaknesses, potential opportunities and threats, resources needed to execute, and chances of success in the long run (Simplilearn, 2023).

Medical professionals such as doctors, medical officers and medical assistants are the essence of a healthcare. The key to providing excellent treatment in healthcare is thought to be these professionals, who work with the systems and software used and needed to monitor patients. They are also knowledgeable about the relevant diseases and healthcare systems (Mieronkoski et al., 2017). As a result, they are better suited to be studied, in order to identify the feasibility and behavioural intentions in adopting an Internet of Health Things (IoHT) based Habit Change Support System (Doctive) for hospitals. Therefore, medical professionals' adherence and engagement with Doctive are essential to their success (Martínez-Caro, Cegarra-Navarro, García-Pérez, & Fait, 2018). The long-term success of Doctive healthcare system will, in many situations, depend on its feasibility and ongoing use by the medical staffs.

1.1.1 Doctive

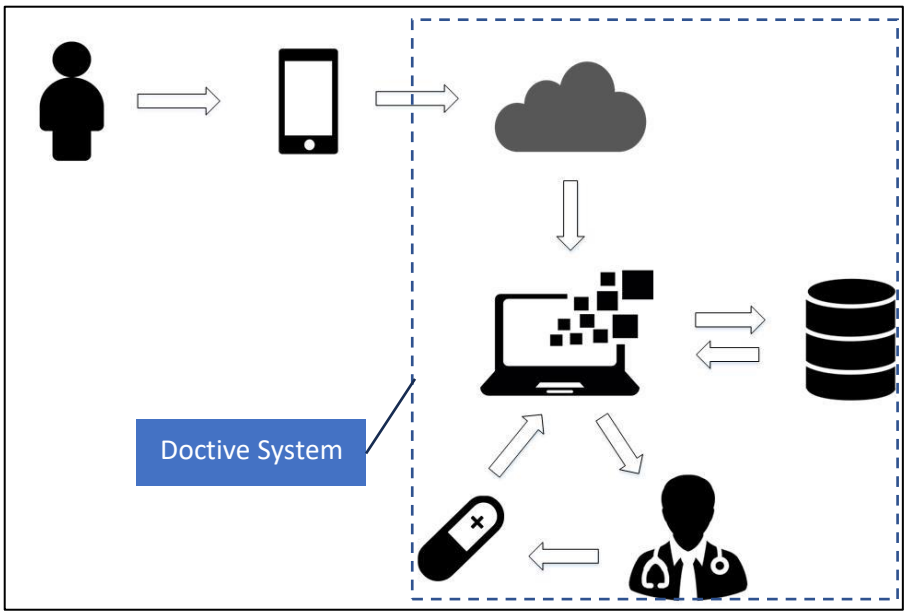

Figure 1.1 Simplified Doctive Architecture

The IoHT-based HCSS called Doctive was developed in the year 2020 in Penang, Malaysia for hospitals. This system emphasizes that patients should be supported, monitored and analysed depending on their habit-change patterns. Figure 1.1 illustrated a simplified architecture of the Doctive system. The Doctive system gathers and retain information about patients and their poor habits through the Behabit smartphone application that is linked to an IoT powered smartwatch (Ravichandran & Keikhosrokiani, 2021). Doctive provides patients with the necessary prescriptions and supervision from competent and authorised medical personnels based on their habits and progression to avoid potential diseases. Despite all the obvious advantages that IoT technologies have to offer for the healthcare industry, its potential for adoption at all levels of healthcare society cannot be assumed. There are numerous difficulties in ensuring its implementation. The only way to overcome these obstacles is through extensive implementation of the system, which necessitates its study and introduction to the professional medical staffs, particularly doctors, medical assistants and nurses.

1.2 Problem Statement

Heart diseases or lesser-known part of non-communicable diseases remains the leading cause of death in Malaysia and globally, largely due to the lack of early detection, inadequate habit monitoring, and insufficient preventive measures. The continuous increase in mortality rate due to heart and chronic diseases rings a warning

sign, based on the survey done by World Health Organization ((WHO), 2020) and the analysis based on The Peterson-KFF Health System Tracker is an information centre dedicated to monitoring and evaluating the performance of the United States health-care system (Jared Ortaliza, 2022).

Heart disease remains as the constant leading cause of death as displayed in Figure 1.2, even during the pandemic in the U.S. between March 2020 to February 2022, apart from the sudden spike in Covid19 deaths in January 2022 (Jared Ortaliza, 2022). Despite advancements in medical technology, many cases go undiagnosed until it is too late, resulting in preventable fatalities. Lifestyle factors such as poor diet, physical inactivity, and stress are key contributors, but the absence of effective systems to monitor these habits and promote timely interventions exacerbates the problem. Addressing these gaps in early diagnosis and preventive care is crucial to reducing the mortality rate associated with heart disease.

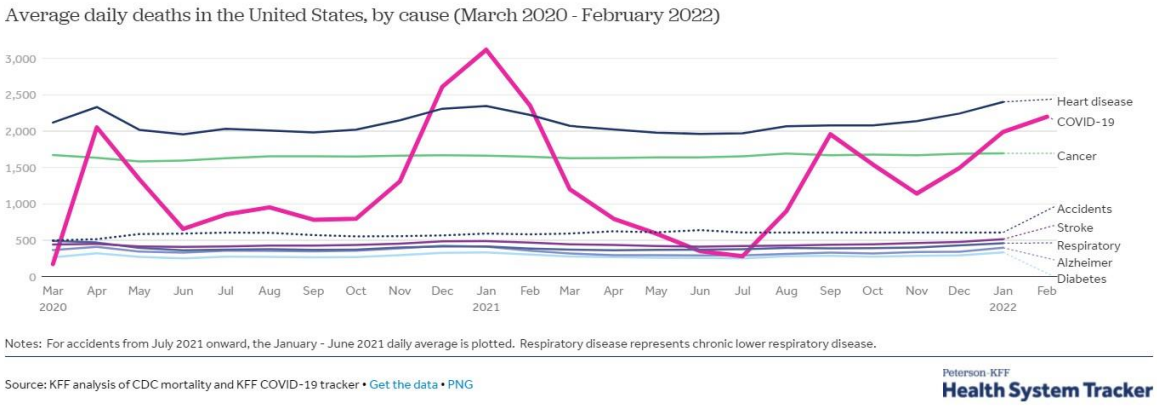

Figure 1.2 Average Daily Deaths in the United States by Cause

The Internet of Things (IoT) concept has emerged as a result of recent improvements in information technology. IoT now has a big impact on many areas of life, including healthcare in particular, not only communication. IoHT, often known as healthcare IoT, is the term used to describe IoT in the healthcare industry. The healthcare industry is aware of this developing technology's potential to help healthcare systems go beyond their current usage of IT and offer more sophisticated services (Martínez-Caro et al., 2018).

The current healthcare systems that are available in hospitals lack IoT technology, and therefore lack the ability to monitor and track patients' bad habits. Most diseases affecting communities are largely influenced by individuals' habits. Since habits vary

from person to person, monitoring and promoting changes in unhealthy behaviours can help foster a healthier generation. Patients suffering from cardiovascular and other chronic diseases are often impacted by unhealthy habits such as lack of exercise, poor eating patterns, insufficient sleep, smoking, and more.

Emotions are a significant driving force behind an individual's attitudes and behaviours. They play a crucial role in influencing how people respond to various situations, making them a key factor in persuading individuals to change their attitudes, behaviours, and ultimately their habits. Recent research has also demonstrated the relevance of early disease identification and diagnosis using healthcare systems that use Big Data (Jagadeeswari, Subramaniyaswamy, Logesh, & Vijayakumar, 2018 & Vijayakumar, 2018).

Apart from the absence of IoHT technology in hospitals, this paper also highlights the lack of feasibility and acceptance study of habit change support system in hospitals such as Doctive, among medical practitioners.

1.3 Research Questions

Most importantly, this study is sought to find the keys to the following research questions (RQ):

1) How to determine the usability of Doctive among medical professionals in Penang, Malaysia?

2) How to find the effective factors to predict the Behavioural Intention to use Doctive?

3) What is the relationship between Perceived Feasibility, Usability and Behavioural Intention to use Doctive?

1.4 Objectives

The main aim for this study is to determine the effective theories and factors behind the usability and behavioural intention of medical professionals in implementing an IoHT-based hospital system. This process will be carried out by studying the usability of the system, the awareness on the importance of tracking and

analysing habits and the concept of an IoHT habit change support system in healthcare. The effective factors are those factors that have an impact on the use of the system as well as user satisfaction towards system success (Pantea Keikhosrokiani, Mustaffa, Zakaria, & Abdullah, 2020). The three distinct goals of this study are as follows:

1) To investigate the usability of Doctive among medical professionals in Penang, Malaysia.

2) To propose a theoretical framework to predict effective factors of Behavioural Intention (BI) to implement Doctive.

3) To investigate the mediating effects of Perceived Feasibility between Usability and Behavioural Intention to use Doctive.

1.5 Significance of Study

This study discusses the many theories involved with the prediction of behavioural intention towards using Doctive in hospitals or healthcare facilities and the factors that play important roles in them, as well as a proposal of a new and modified theoretical framework based on previous studies, models and approaches. A HCSS like Doctive, has a number of advantages and is significant in healthcare as it aids in managing, organising, monitoring and analysing patient data. Emotional-persuasive features are implemented in the Behabit mobile application (Ravichandran & Keikhosrokiani, 2021), is connected to the Doctive system (Augustine & Keikhosrokiani, 2021) in order to track, motivate and change a patient's habit. Additionally, using Big Data analytical tools and features along with data visualisation tools like Tableau based on the data obtained from users' smartwatches that are retrieved from the cloud, their health statuses can also be monitored and analysed in a straightforward manner by qualified medical experts. Therefore, a more personalized prescription and advices (Cirillo & Valencia, 2019) can be given to help them improve their medical conditions and to lead a healthy lifestyle, focussed on eliminating non-communicable diseases.

1.6 Research Scope

The prediction of usability, feasibility, and behavioural intention of medical professionals towards the implementation of an IoHT-based Habit Change Support System, known as Doctive, is the main focus of this research paper. In order to implement the Doctive hospital system, it is vital to study the effective factors that affects the usability, feasibility, and behavioural intention towards using the system. This study will be conducted in two government hospitals in Penang. The target population will include all medical graduates working and registered in the medical board, which include, doctors, medical officers, medical assistants and nurses. The research will also have to meet the required sample size of respondents before proceeding with analysis of the proposed theoretical framework in this study.

1.7 Organization of Thesis

This research thesis is structured into five main chapters.

- Chapter 1: Presents the general overview of the research's background, research problem, objectives, research scope, propose method, the significance and the research scope.
- Chapter 2: Presents the literature review that has background or theories that resembles the designed model. In this chapter, overview of the Internet of Health Things, comparison of existing healthcare systems, description of theories with their related models and summary of findings.
- Chapter 3: Presents the framework of the research model.
- Chapter 4: Presents the methodology and results of the pilot study
- Chapter 5: Presents the prediction results of the related models used for comparison and the implemented solution. The results obtained are discussed as well.
- Chapter 6: Concludes the findings, contributions, and recommendations for the future work of this research.

CHAPTER 2
LITERATURE REVIEW

2.1 Introduction

This chapter begins by emphasizing the importance of the Internet of Things (IoT) in healthcare, setting the stage for a comprehensive review of existing healthcare systems as depicted in Figure 2.1. Following this, a systematic literature review is conducted to critically analyse existing research and identify the most prevalent theories and factors discussed in the studies. This chapter also delves into theories related to Behavioural Intention, examining them individually to better understand their relevance to the study. Derivative and prior works are explored to narrow down and identify the most pertinent papers that align with the current research focus. The chapter concludes with a concise summary, tying together the insights gained from this section.

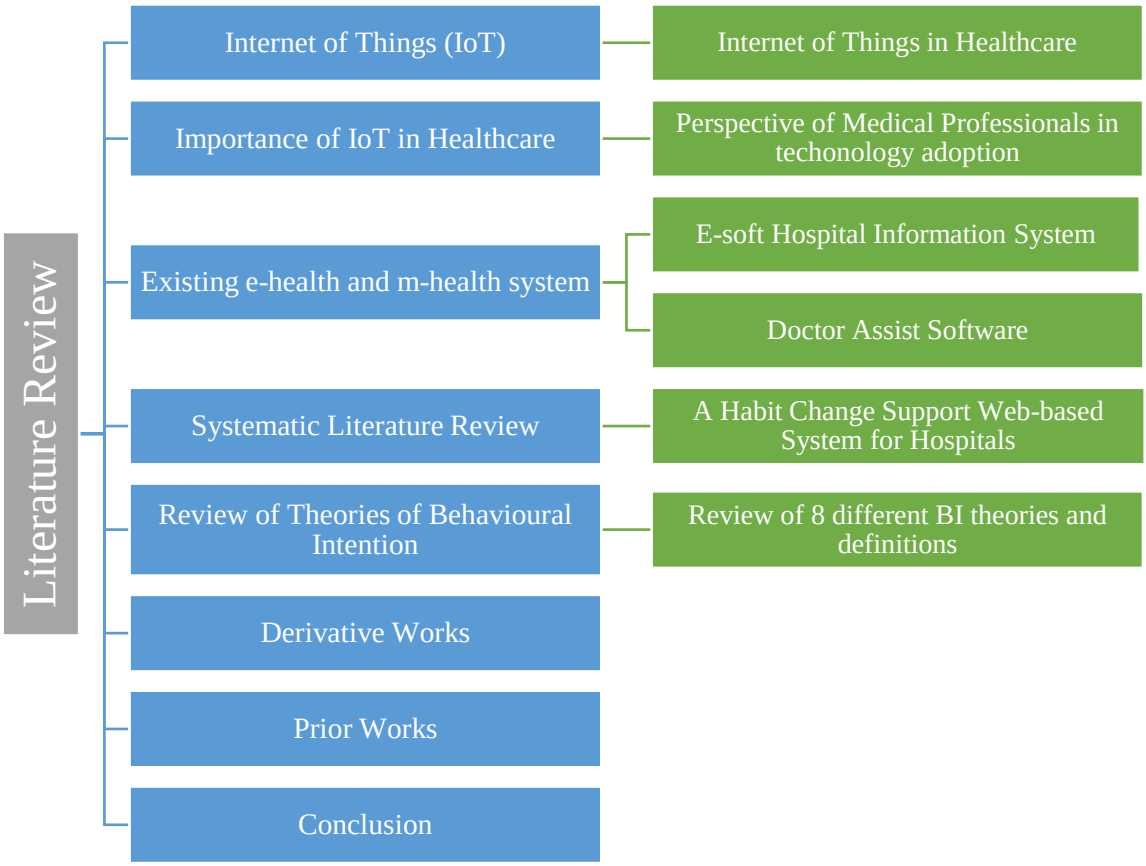

Figure 2.1 Overview of Literature Review

In Malaysia, various support systems like eHealth technologies are making significant contributions to the healthcare landscape. For instance, the MyHealth Portal is a government initiative that provides Malaysians with access to reliable health information, health services, and the ability to engage in e-consultations with healthcare professionals. Another example is Mobile Health (mHealth) initiatives like MySejahtera, initially developed for COVID-19 management, which tracks health status, vaccination records, and provides health updates to users. Additionally, ePrescription systems are being implemented in some hospitals and clinics, allowing doctors to prescribe medications electronically, thereby improving accuracy and efficiency.

The distinction between eHealth and Digital Health technologies lies in their scope, focus, and integration. eHealth refers specifically to the use of electronic technologies to manage health information and services, such as telemedicine, electronic health records (EHRs), and health information systems. In contrast, Digital Health encompasses a broader range of technologies, including eHealth, but also integrates areas like mobile health (mHealth), wearable devices, health apps, artificial intelligence, and big data analytics in healthcare. While eHealth primarily focuses on improving healthcare delivery and efficiency through the electronic management and transmission of health information, Digital Health aims to empower patients, enhance health outcomes, and innovate healthcare practices through various digital tools, often emphasizing patient engagement and personalized care. Additionally, eHealth technologies are typically integrated within existing healthcare systems to enhance operational efficiency and service delivery, whereas Digital Health technologies may include emerging innovations that can fundamentally transform healthcare delivery, reflecting a more comprehensive approach to health innovation.

The Internet of Health Things (IoHT) idea is seen as the use of IoT in e-health due to the constant acceptance of IoT in modern healthcare (Rahman, Hossain, Islam, Alrajeh, & Muhammad, 2020). It offers a technically and financially viable option for medical providers to connect with and interact with patients. IoHT supports a wide range of healthcare situations, including paediatric care, elderly supervision, patient monitoring (M. S. Hossain, 2017), chronic disease diagnosis, and managing overall fitness and well-being of society health. IoHT solutions not only deliver better patient care in less time, but they also ensure that patients are safe. Healthcare challenges are

growing on a daily basis as the population of sustainable cities continues to grow. In real-time, massive amounts of healthcare-related raw data are gathered from several heterogeneous sources. Many aspects of patient data are obtained on a regular basis. However, the disease diagnosis task is adversely affected to a greater extent because to a shortage of competent labour, delays in functions, and traditional manual techniques. In such circumstances, accurate detection of medical illnesses is critical. It is easier to diagnose chronic disease patients if medical personnel are aware of the physiological and genetic elements that contribute to their condition.

2.2 Internet of Things (IoT)

The Internet of Things, or IoT, refers to the billions of physical devices connected to the internet, all collecting and exchanging data throughout the world. Its success is dependent on sophisticated technological advancements, including nanotechnology and wireless sensors in numerous significant industries. The IoT vision's key strength is its significant impact on a variety of facets of daily life and the behaviour of potential consumers. The idea of Internet of Health Things (IoHT), is commonly referred to as IoT in healthcare, relating to e-health and digital technologies for healthcare systems. Connecting all of these disparate items and attaching sensors to them provides digital intelligence to machines that would otherwise be irrational allowing them to communicate real-time data without requiring a person.

The Internet of Things connects the digital and physical worlds, making our surroundings smarter and more responsive (Ranger, 2020). The IoT has the ability to support the development of numerous different applications that are built on it. The healthcare industry can use IoT in a variety of ways. These programmes support simple illness monitoring, ad hoc diagnosis, and quick access to medical assistance in the event of accidents or emergencies. The ability to implant and wirelessly maintain a patient's medical history can help save lives in situations, especially those involving diabetes, cancer, coronary heart disease, stroke, pulmonary obstructions, cognitive impairment, seizure disorders, and Alzheimer's (Laplante, Laplante, & Voas, 2016).

2.2.1 Internet of Things in Healthcare

In sustainable cities, modern healthcare is gradually adopting IoT technology. The healthcare business, where doctors, nurses, and orderlies frequently need to know the exact position of patient and patient-assistance assets, benefits greatly from IoT

asset monitoring (Oracle, 2022). With the emergence of Internet of Health Things (IoHT) a network of physical devices can communicate, interact, detect, and transmit data without the need for human intervention. This innovation aligns with the United Nations Sustainable Development Goal No. 3 (SDG – Goal 3), which emphasizes the critical importance of promoting health and well-being for people of all ages to achieve sustainable development. By enabling more efficient, responsive, and accessible healthcare, IoHT contributes directly to advancing global health equity and sustainability (Mishra, Thakkar, Mallick, Tiwari, & Alamri, 2021).

IoHT is the next phase of the Internet in which machines communicate with one another autonomously. The programmes are intended to evaluate data and deliver swift solutions. With the emergence of IoT, there has been a noticeable improvement in the healthcare domains (Jemima Jebaseeli, Anand Deva Durai, & Dinesh Peter, 2020). Remote health monitoring systems and smart wearable IoHT devices, in combination with a cloud-based healthcare system, can help to avoid diseases by providing for early diagnosis and management, as well as managing treatment and rehabilitation for patients. With the introduction of a variety of wearable gadgets and smartphones, various IoHT-based devices are altering and evolving the traditional healthcare system into a smarter and more personalised one.

The Internet of Health Things (IoHT) can significantly contribute to sustainable healthcare through various mechanisms that enhance efficiency, improve patient outcomes, and reduce costs. Several ways IoHT ensures sustainable healthcare, are through IoHT devices, such as wearables and remote monitoring tools, enable continuous tracking of patient health metrics. This capability leads to early detection of potential health issues, reducing the need for hospital visits and minimizing healthcare costs. For instance, a study by (Hwang, 2019) highlights that remote monitoring can decrease hospital readmissions and enhance chronic disease management.

Besides, IoHT facilitates the collection of vast amounts of health data, which can be analyzed to improve healthcare delivery. By leveraging big data analytics, healthcare providers can identify trends, optimize treatment protocols, and improve resource allocation. As noted by (Yang, 2018), data-driven insights lead to more informed decision-making, ultimately improving patient outcomes and reducing

waste. With IoHT, healthcare can shift from a one-size-fits-all approach to personalized treatment plans tailored to individual patient needs. By analyzing data from IoHT devices, providers can customize interventions based on real-time health information. Research by (Hensel, 2021) suggests that personalized healthcare improves patient engagement and adherence to treatment plans, contributing to better health outcomes.

Apart from that, IoHT technologies help reduce operational costs for healthcare facilities by streamlining processes and improving efficiency. For example, a study by (Saheb & Izadi, 2019) indicates that IoHT can lower the costs associated with managing chronic diseases by minimizing hospital visits and optimizing resource utilization. At the same time, IoHT promotes environmentally sustainable practices by reducing the carbon footprint associated with healthcare delivery. Telemedicine and remote monitoring limit the need for travel to healthcare facilities, reducing emissions from transportation.

By providing patients with access to their health data and progress, through user-friendly applications and devices, IoHT promotes health literacy and encourages adherence to treatment plans. As highlighted by (Gonesh, Saha, Saha, & Devi, 2023), increased patient engagement is linked to improved health outcomes and reduced healthcare costs. With the implementation of IoHT, communication between patients and healthcare providers can be enhanced, allowing for timely interventions and improved care coordination. By integrating IoHT devices with electronic health records (EHRs), healthcare teams can access real-time patient data, leading to more effective collaboration and care management. Research by (Jamal, McKenzie, & Clark, 2009) emphasizes that better communication reduces medical errors and enhances patient safety.

In summary, IoHT plays a pivotal role in ensuring sustainable healthcare by improving patient monitoring, enhancing data collection, promoting personalized care, reducing costs, supporting environmental sustainability, engaging patients, streamlining communication, and integrating health services.

2.3 Importance of Internet of Things in Healthcare

The Internet of Things (IoT) and associated technologies play a pivotal role in reducing health-related issues such as medical errors, fraud, system failures, the use of

illegal items, and inefficient processes. Despite these advantages and the growing adoption of IoT technologies, healthcare organizations often underutilize their potential. One of the significant barriers to IoT integration in healthcare is the low acceptance level among users (Bodur, Gumus, & Gursoy, 2019).

A modern healthcare system, also known as the Personalised Healthcare System (PHS) (Papa, Mital, Pisano, & Del Giudice, 2020) is gradually replacing the traditional hub-based system due to advancements in IoT technologies. This shift enables the provision of various services, such as remote patient monitoring, patient location tracking, access to electronic health records (EHRs) and medical data, transfer of medical data and biomedical signals, and timely emergency services. These capabilities empower better decision-making and enhance medical treatment.

The primary objectives of IoT technology applications in the e-healthcare sector are cost-effectiveness, reliability, and safety (Bodur et al., 2019). To achieve these goals, various IoT-based systems have been implemented, including wearable technology, protective systems, smart medical sensors, mobile-centred healthcare solutions, smart healthcare services, and systems for remote patient follow-up, diagnostics, and monitoring (Bodur et al., 2019). These innovations have the potential to revolutionize healthcare by enhancing efficiency, reducing costs, and improving patient outcomes.

According to a 2010 report from the Institute of Medicine (Adeniyi, Arowoogun, Chidi, Okolo, & Babawarun), doctors and nurses will need to develop cutting-edge approaches to deliver healthcare services in the future using telemedicine, the internet

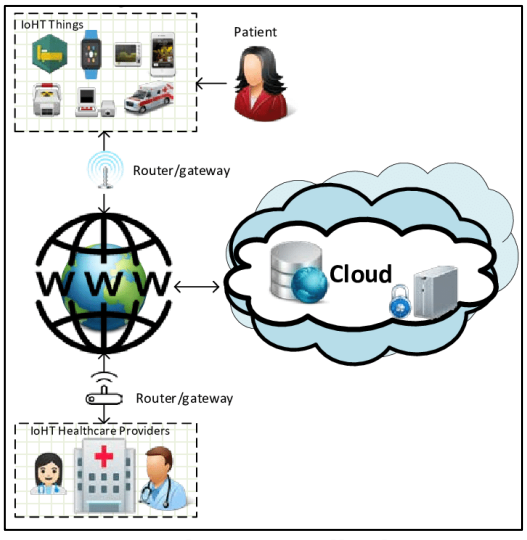

Figure 2.2 The IoHT (Albesher, 2019)

of things (IoT), connected homes, mobile applications, and artificial intelligence. Modern healthcare systems must now include integrated medical information systems as a critical component. According to studies by (Aktas, Çeken, & Erdemli, 2016) and (Mieronkoski et al., 2017), IoT-assisted devices have the potential to help with patient monitoring, tracking movements and aiding in emergencies. It is anticipated that vital signs will be gathered utilising an IoT system, allowing for interactive patient follow-up with medical staff.

Therefore, an Internet of Health Things (IoHT) framework supports proactive healthcare by emphasizing preventive measures rather than reactive treatments. Continuous monitoring of health metrics allows IoHT to identify potential health risks before they escalate into serious conditions (Mishra et al., 2021). This focus on prevention distinguishes IoHT from other digital health initiatives that may not prioritize continuous health surveillance and proactive interventions (Gonesh et al., 2023). Interoperability and data sharing are also central to the IoHT approach. IoHT facilitates seamless data sharing among healthcare providers, patients, and devices, thereby enhancing care coordination. The ability to aggregate and analyse data from various sources promotes comprehensive insights into patient health, fostering collaborative decision-making among healthcare teams (Yang, 2018). While other digital health technologies may focus on individual applications or platforms, IoHT emphasizes a cohesive data-sharing ecosystem.

The Internet of Health Things (IoHT) distinguishes itself from other digital health concepts through its interconnected ecosystem of devices, including wearables and smart medical tools, enabling real-time data sharing and comprehensive health monitoring. Unlike isolated applications, IoHT fosters seamless collaboration among devices, supports personalized care plans through continuous data collection, and emphasizes preventive care by identifying risks before they escalate. Its robust real-time monitoring capabilities enhance chronic disease management and acute care responsiveness, while its focus on interoperability improves care coordination. By leveraging advanced technologies like AI and machine learning, IoHT provides precise insights and scalable solutions adaptable to various healthcare settings, making it a transformative force in modern healthcare.

2.3.2 Perspective of Medical Professionals in adoption of a new technology

Studies on the Technology Acceptance Model (Tam et al.) suggest that perceived ease of use and usefulness significantly affect healthcare providers' willingness to adopt new technology. Medical professionals are more likely to embrace technology if they believe it will improve their efficiency or enhance patient outcomes (Davis, 1989). Factors such as training, support, and organizational culture also play essential roles in acceptance, for example, (Venkatesh, Thong, & Xu, 2012) found that adequate training and support increase the likelihood of technology adoption.

Medical professionals often have concerns about how new technologies will affect their workflow. While innovations such as electronic health records (EHRs) can improve data accessibility, they may also add steps that slow down processes (Adeniyi et al., 2024). Additionally, some studies indicate that technology can impact the doctor-patient relationship. For instance, (Kibuuka & Extension, 2024) found that while telemedicine expands care access, it may reduce the personal connection typically achieved in face-to-face consultations.

Many healthcare providers recognize that technologies like telehealth and remote monitoring can improve patient outcomes by enabling timely interventions and continuous monitoring (Galetsi, Katsaliaki, & Kumar, 2019). However, concerns remain about data accuracy and reliability. Medical professionals worry about the potential for errors in automated systems, which may not always produce accurate information (Jagadeeswari et al., 2018).

The ethical implications of new technologies, especially regarding patient privacy and data security, are significant. Studies show that healthcare providers are increasingly concerned about data breaches and the ethical responsibility to protect patient information (Hwang et al., 2020). Additionally, new technology raises questions about informed consent, as providers must ensure that patients understand how their data will be used and the broader implications of technology in their care (Beauchamp & Childress, 2019).

Continuous education is crucial for medical professionals to keep up with rapidly advancing technologies. Studies reveal that access to resources and support strongly influences the likelihood of technology adoption (E. T. Straub, 2009).

Furthermore, collaboration with colleagues and shared experiences can foster a positive attitude toward adoption by creating a supportive environment (W. Wang, Chen, Xiong, & Wang, 2021).

Medical professionals commonly express concerns about the compatibility of new technologies with existing systems. Research highlights that interoperability issues can lead to frustration and reluctance to adopt new systems if they disrupt established workflows (Zhang, Luo, Nie, & Zhang, 2017). There is also a call for more standardized technologies to ensure smoother integration, as inconsistent systems can complicate data sharing and communication within clinical practices (Häyrinen, Saranto, & Nykänen, 2008).

Overall, the literature reveals that while medical professionals are generally supportive of new technologies that enhance patient care and efficiency, several factors influence their acceptance and use. These include perceived benefits, training and support, workflow integration, ethical considerations, and concerns about data quality and security. Addressing these factors is essential to foster a positive outlook toward adopting new healthcare technologies.

2.4 The existing examples of e-health and m-health systems

The Hospital Information System (HIS) for Public Health Ministry hospitals is built on the backbone of Sistem Pengurusan Pesakit (SPP). Sistem Pengurusan Pesakit (SPP) is one of the existing hospital management information systems, locally produced with Intellectual Property Rights (IPR) owned solely by the Ministry of Health Malaysia. There have been continuous upgrades of the SPP versions, where

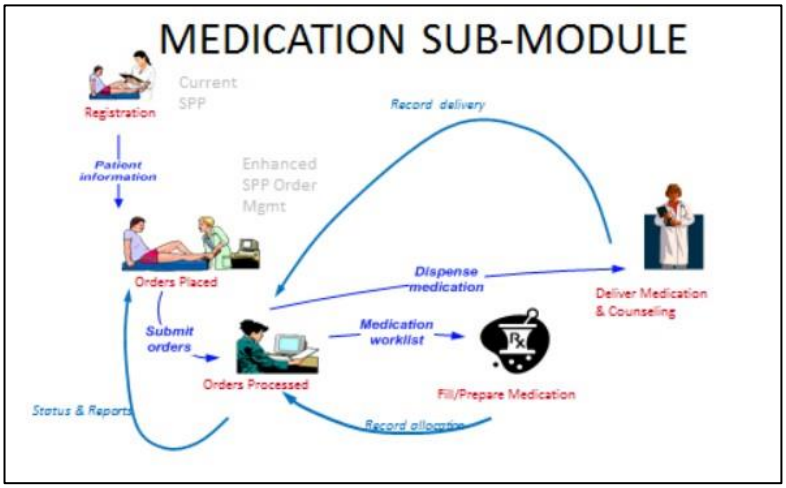

Figure 2.3 Sub-Module of SPP

improvements were made based on user requirements. In SPPV3.0, there were 8 modules prepared. The cycle of Sistem Pengurusan Pesakit (SPP) begins with patient registration at the counter, followed by the procedure for admitting the patient, "Order" management to the Departments of Pathology, Radiology, Pharmacy, Diet and Catering, and finally access to the Bill and Payment Management Module. The Patient Management System can also be used to schedule an appointment. Staff Management in the system can be used to manage information about the staffs such as rosters, shifts, and annual leave.

Figure 2.4 The cycle of Sistem Pengurusan Pesakit (SPP)

2.4.1 E-soft Hospital Information System

SMI Malaysia's Ultimate Business Software, in 1990, Everise launched their MRP software system for manufacturing. The E-Soft Hospital Information System a client-server network-based software designed specifically for the healthcare industry was completed in 2010. It enables scalability, central control of business rules, and lower maintenance and overhead costs. E-Soft HIS is a cost-effective healthcare ERP software solution that is simple to manage, ready to use, scalable, and economical. It is designed specifically for small, medium, and big hospitals and clinics in Malaysia. E-Soft HIS on the other hand, consists of 9 modules that include, Patient Registration with Mykad, Outpatient Management, Inpatient & Ward Management, Doctor's Consultation Desktop, Pharmacy for Dispensary and Label, Stock Control System,

Laboratory, Procedure and Surgery, Patient Billing and Insurance and the User Management module (E-Soft, 2022).

2.4.2 Doctor Assist Software

Doctor Assist™ by Mywam Sdn. Bhd. (MyWam, 2022) was developed completely for the first time in 2009 with a vision to transform doctors to run digital smart operation and to promote awareness on treatment options based on patients' problem and needs. It is a comprehensive information system designed and supported locally for all levels of operation, from private clinics to large-scale hospitals. This information system is also said to reduce paperwork, increase productivity while as the same time reduce the unnecessary costs. Doctor Assist™ can be set to access data wirelessly over a secure network in addition to serving as an efficient information system for storing and managing data locally (MyWam, 2022). Doctor Assist™ is bounded on three key principles:

1) Intuitive customer/patient registration platform with SMS and care line services

2) Digital hand writing recognition system for ease of communication among healthcare staff

3) Dispensary & settlement via itemized or non-itemized bills.

In short, we can conclude that three of these Hospital Information System (HIS) is a centralised system designed to manage administrative, financial, and clinical operations within a hospital, focusing on tasks like patient records, billing and resource tracking within the institutional boundary but fail to recognize the benefits of Big Data, its importance and how it can be used to analyse and improve patients' health.

In contrast, the Internet of Health Things (IoHT) extends healthcare beyond hospitals, using IoT-enabled devices like wearables and sensors for real-time patient monitoring, remote diagnostics, and telemedicine. While HIS primarily supports intra-hospital workflows and structured data management, it lacks IoHT capabilities that emphasizes connected, patient-centric care, integrating real-time, unstructured data from multiple environments to enhance preventive and personalized healthcare.

2.4.3 A Habit-Change Support Web-Based System for Hospitals (Doctive)

Figure 2.6 illustrates the detailed system architecture of the "Doctive" healthcare system, which is composed of two primary components: the Behabit smartphone application (Ravichandran & Keikhosrokiani, 2021), linked to an IoT-powered smartwatch and the Doctive system in hospitals. The Behabit mobile application plays a crucial role by collecting and tracking various user demographic data and health-related habits, such as heart rate, step count, calories burned, mood, exercise levels, and other behavioural patterns. This data is then aggregated, processed, and transferred via the internet to the Hadoop cloud platform, allowing Doctive to access and utilize the information for further analysis and application.

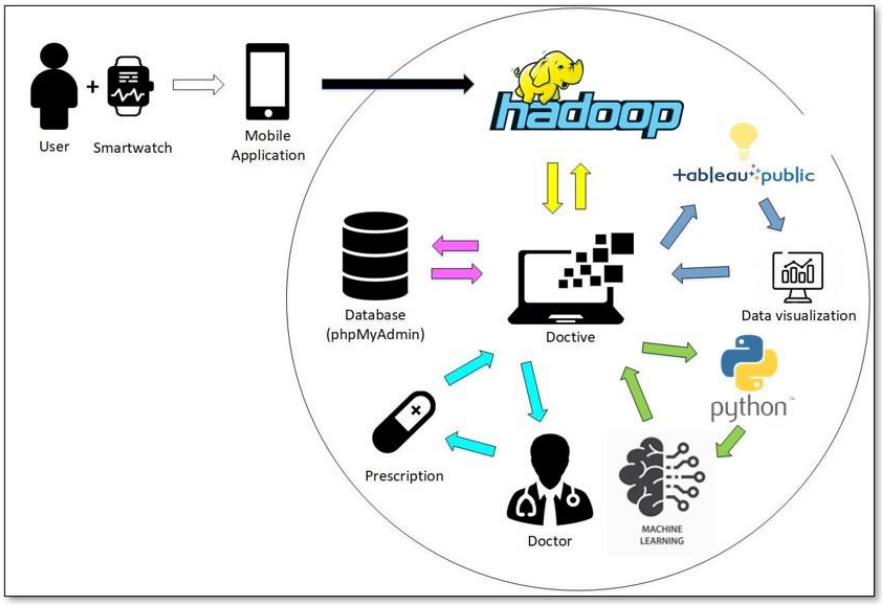

Figure 2.6 Doctive System Architecture

The key benefit of this system lies in its ability to significantly improve how hospitals organize, manage, and analyse patient data. Integrated with emotional-persuasive features, the Behabit mobile application helps motivate and encourage patients to adopt healthier behaviours, ultimately promoting positive habit changes. Moreover, patients' health statuses can be monitored and analysed by healthcare professionals using advanced machine learning tools like Weka and data visualization platforms such as Tableau. This enables the generation of accurate prescriptions and personalized advice based on the data, which helps prevent and manage chronic diseases. By leveraging this data-driven approach, Doctive supports healthcare providers in offering tailored solutions to improve patient health and well-being.

This study specifically examines the behavioural intention of medical professionals towards adopting Doctive, which is a novel system with unique features that have not been explored in previous research. Through this case study, the research aims to evaluate Doctive's usability, feasibility and the behavioural intention of medical practitioners in Penang, Malaysia, in adopting the system. The findings will contribute to understanding how the integration of technology, such as IoT devices, mobile applications and hospital systems, can enhance patient care, streamline medical workflows, and ultimately lead to more efficient healthcare delivery.

2.5 Systematic Literature Review (SLR)

The ongoing expansion of research, along with the need to properly summarise the available knowledge to influence consumer and stakeholder decisions has resulted in the formal establishment of systematic reviews. A SLR was conducted in this study to identify, summarize and evaluate research results of all relevant past individual studies over behavioural intention towards IoHT-based systems. Besides, it can assist on a topic, typically to a larger extent than the results obtained from a single study. The goal of SLR is to analyse the important components of current knowledge on a topic about research problems in order to identify potential areas for further studies.

The SLR conducted in this study includes four steps as shown in Figure 2.5. The first step involved literature screening using the keyword “behavioural intention towards healthcare system” in three different databases which initially included PubMeb, but unfortunately, it could not accommodate the paper that were needed for this study. Therefore, ScienceDirect and Springer that is well known for big data and healthcare systems were chosen as the electronic databases for this study. A huge number of 6381 papers appeared from the screening results in Science Direct, while half the number of papers in the previous database, 2882 papers appeared in Springer; however, duplicate publications were manually removed from the screening results. After applying filtrations on journal articles published from 2019 to 2021, 2509 papers remained from Science Direct and 1240 papers from Springer.

The papers were then read through to remove irrelevant papers based on reviewed articles, title screening, abstract screening, full paper screening, no mention of theories, no mention of behaviour change, no mention of behavioural intention, no theoretically

proposed model and no involvement of system or devices. Therefore, only eight papers

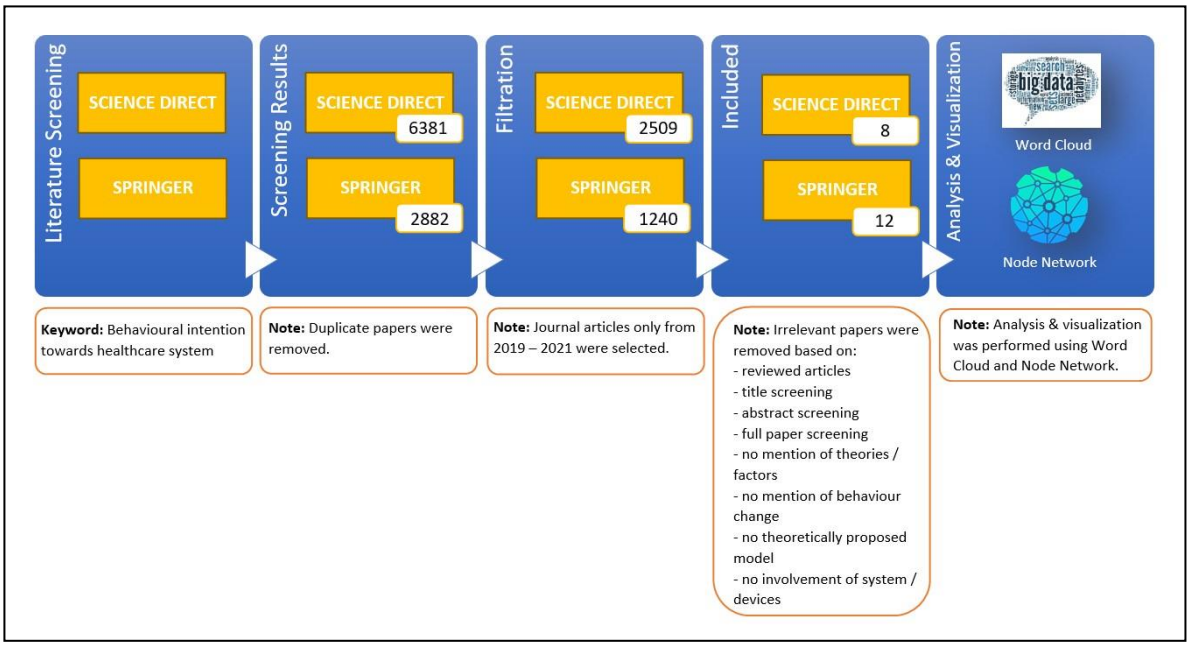

Figure 2.5 Five Steps of the Systematic Review

were included from Science Direct and 12 from Springer database, with a total count of 20 articles. Finally, a qualitative analysis was then carried out with Word cloud, followed by Node-network visualization of connected papers to determine the common theories and factors used in the studied papers. Methodology for this SLR is adopted from (Pantea Keikhosrokiani, 2021b) (Pantea, Norlia, Nasriah, & Ahmad Suhaimi, 2019).

2.5.1 Behavioural Intention to use IoHT-based habit change support system (Doctive)

Individual behaviour and behavioural intention of information technology have become a research hotspot in the field of information systems since the 1980s, and a number of information technology acceptance models have emerged (Davis, 1989, 1993; Venkatesh, Morris, Davis, & Davis, 2003). Based on the Theory of Planned Behaviour, which formerly started off as the Theory of Reasoned Action back in 1980, Behaviour Intention (BI) refers to the motivating factors that drive a specific activity, with the stronger the intention to conduct the behaviour, the more likely it will be performed. Therefore, Behavioural Intention postulates the motivating factors that drive the intention towards implementing an IoHT-based habit change support system known as Doctive in hospitals.

2.6 Discussion

As outlined in the methodology, a Systematic Literature Review (SLR) was conducted, incorporating a total of 20 journal articles. Among these, 8 were sourced from Science Direct, while 12 related studies were selected from the Springer electronic database. These databases were intentionally selected due to their extensive coverage of topics such as big data, healthcare systems and behavioural intentions, which align closely with the study's objectives. The studies summarized in Table 2.1 include various theories and factors related to behavioural change intentions, which were often missing in many journal articles during the filtration phase. These theories and factors provide valuable insights into understanding the variables affecting adoption and usability in healthcare systems. Notably, many journal articles reviewed during the filtration phase lacked a robust focus on behavioural change intentions, highlighting the importance of the selected studies in filling this gap.

Table 2.1 Extraction of 20 scientific papers

Study	**Aim**	**Theories**	**Factors**	**System/Area**	**Method**	**Tool**	**Respondents**
(Al-Dhaen, Hou, Rana, & Weerakkody, 2021)	The continuous intention by healthcare professionals to use the Internet of Medical Things (IoMT) in combination with responsible artificial intelligence (AI)	Diffusion of Innovation (DOI)	-Relative advantage -Compatibility -Complexity -Observability -Trialability -Novelty seeking -Age -AI awareness -Motivation -Training	Internet of Medical Things (IoMT)	Quantitative approach	A self-administered Questionnaire, online survey; Only closed and multiple-choice questions were included	276 healthcare professionals; who have experiences of using IoMT
(Al-Jumaili et al., 2021)	To assess the extent to which healthcare students use five informational technologies for daily academic purposes; to examine the changes in student perceptions toward these technologies over five years.	Technology Acceptance Model (Tam et al.); TAM has five main domains	Perceived usefulness (PU), perceived ease of use (PEU), attitude toward using (ATU), facilitating conditions (FC) and behavioural intention to use (BIU)	-	cross-sectional descriptive study	Electronic surveys and administered using Qualtrics Survey Software;	administered to convenience samples of students at the colleges of pharmacy, medicine, and dentistry in participating universities; Total of 3,113 valid surveys collected in 2015, 2018, and 2020