EVALUATING HOME BLOOD PRESSURE MONITORING IN COMMUNITY PHARMACY USING HOT-FIT FRAMEWORK

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DECLARATION

I hereby declare that the work in this thesis is my own except for quotations and summaries which have been duly acknowledged.

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ABSTRAK

Peningkatan kes hipertensi yang semakin membimbangkan di Malaysia telah menyebabkan peningkatan kepada penggunaan alat pemantauan tekanan darah di rumah dalam kalangan masyarakat. Namun begitu, tahap kemahiran golongan pengguna ini dari segi proses pengambilan tekanan darah mengikuti tatacara yang ditetapkan masih perlu ditingkatkan. Akibatnya, bacaan-bacaan tekanan darah ini tidak dapat membantu pakar perubatan dalam saringan pesakit yang berisiko tinggi untuk mendapat hypertensi. Sistem rekod kesihatan elektronik merupakan salah satu teknologi digital yang dapat membantu menyelesaikan masalah ini. Tujuan kajian penyelidikan ini adalah untuk mengetahui faktor-faktor yang akan mempengaruhi bacaan tekanan darah semasa pengambilan dan kesan pelaksanaan sistem rekod kesihatan elektronik terhadap amalan pemantauan tekanan darah di rumah menggunakan konsep HOT-fit. Keputusan kajian menunjukkan bahawa tahap kemahiran pengguna semasa pengambilan tekanan darah adalah berkekurangan disebabkan oleh pengetahuan mengenai tatacara yang tidak mencukupi. Seterusnya, pelaksanaan sistem rekod kesihatan elektronik dapat membantu menyelesaikan masalah ini.

ABSTRACT

The high prevalence of hypertension has increased the use of Home Blood Pressure Monitoring (HBPM) for routine screening. However, it is unclear how well individuals measure their blood pressure according to recommended procedures. Physicians may hesitate to use this data clinically due to potential reporting errors. Electronic Health Records (EHRs) offer a possible solution to improve these barriers. They are now widely used in community pharmacies as a digital health solution. This study aims to identify factors influencing the accuracy of blood pressure readings and explore the potential of EHRs to enhance HBPM using the HOT-fit Framework. Questionnaires and a case study were conducted in a community pharmacy. Findings show the suboptimal quality of HBPM due to low awareness and knowledge among patients and healthcare professionals. Community pharmacists recognize EHRs as a valuable tool for improving HBPM. This research provides a foundation for integrating digital health interventions into healthcare management.

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LIST OF ABBREVIATIONS

ABPM	Ambulatory Blood Pressure Monitoring
ACC	American College of Cardiology
AHA	American Heart Association
BPT	Blood Pressure Telemonitoring
CPS	Clinic Pharmacy System
CVD	Cardiovascular Disease
DBP	Diastolic Blood Pressure
eHealth	Electronic Health
ESC	European Society of Cardiology
ESH	European Society of Hypertension
HBPM	Home Blood Pressure Monitoring
HIS	Health Information System
HOT-fit	Human, Organization and Technology-fit
ICT	Information and Communication Technology
mHealth	Mobile Health
MOH	Ministry of Health
NCDs	Non-Communicable Diseases
OBP	Office Blood Pressure
OBPM	Office Blood Pressure Monitoring
PhIS	Pharmacy Hospital Information System
PMR	Patient Medication Record
SBP	Systolic Blood Pressure
SD	Standard Deviation
UKM	Universiti Kebangsaan Malaysia

CHAPTER I

INTRODUCTION

1.1 RESEARCH BACKGROUND

Hypertension or high blood pressure is a chronic condition where the systolic blood pressure (SBP) $\geq$ 140 mmHg and diastolic blood pressure (DBP) $\geq$ 90 mmHg persistently. It has been estimated that 1.28 billion adults worldwide aged from 30 to 79 years old have hypertension, of which two-thirds are coming from low- and middle-income countries (Hypertension, 2023). In Malaysia, Non-Communicable Diseases (NCDs) like hypertension along with diabetes mellitus and high cholesterol has contributed to 71% of premature death (NHMS, 2019). The increasing burden of death among the younger population from hypertension has become an alarming health issue. There is an urgent need of promoting routine blood pressure monitoring in those who are at risk of developing hypertension for early detection and intervention.

Traditionally, office blood pressure monitoring (OBPM) is the most common method used by physicians to diagnose and manage patients with hypertension. However, it is well-known that OBPM is subject to observer bias and measurement errors, which can result in inaccurate blood pressure readings (Parati et al. 2021). One of the most well-known measurement errors is the "white-coat effect," which refers to the phenomenon of blood pressure readings being higher in a medical setting than they would be in a non-medical setting. This effect is thought to be caused by the stress and anxiety associated with being in a medical environment. Besides that, appropriate observer blood pressure measurement techniques are often difficult to validate in the office due to rushed visits (Hare et al. 2021.).

Relying solely on OBPM could lead to misdiagnosis of hypertension, as it is unable to detect different types of hypertension such as masked hypertension and white coat hypertension. Masked hypertension is a condition where a patient's blood pressure is normal during OBPM but elevated outside of the office setting. This is commonly seen when there is a difference between office blood pressure (OBP) readings with readings measured outside of the office such as the patient's home. Consequently, exposing patients to unnecessary therapy or increased risk of cardiovascular disease (CVD) due to delayed therapy. It can be said that OBP readings often do not reflect the patient's actual blood pressure. Any elevated blood pressure readings during visits should be interpreted cautiously to avoid overestimation or underestimation of blood pressure, causing misdiagnosis.

To reduce the risk of misdiagnosis, many international hypertension guidelines have begun to recommend out-of-office blood pressure monitoring methods such as home blood pressure monitoring (HBPM) and ambulatory blood pressure monitoring (ABPM) to complement OBPM in confirming the diagnosis of hypertension (Nerenberg et al. 2018; Umemura et al. 2019; Unger et al. 2020; Whelton et al. 2018; Williams et al. 2018). Both ABPM and HBPM offer a significant advantage by enabling more frequent blood pressure measurements in patients' living environments, which is not achievable in a clinical setting where the white-coat effect is more prominent. They also possess a greater prognostic ability than OBP in predicting CVD outcomes due to the distinct nature of the blood pressure information they provide. The key characteristics of blood pressure information produced by these blood pressure monitoring methods are illustrated in Table 2.1.

Table 2.1 Characteristics of blood pressure information

Item	**Office Blood Pressure**	**Home Blood Pressure**	**Ambulatory Blood Pressure**
Frequency of measurement	Low	High	High
Measurement standardization	Possible	Possible	Unnecessary
Reproducibility	Unfavorable	Most favorable	Favorable
White-coat phenomenon	Present	Absent	Absent
Drug efficacy assessment	Possible	Optimal	Appropriate
Evaluation of the duration of drug efficacy	Impossible	Most favorable	Possible
Evaluation of short-term variability (variations at 15- to 30-min intervals)	Impossible	Impossible	Possible
Evaluation of diurnal changes (evaluation of nocturnal blood pressure)	Impossible	Possible	Possible
Evaluation of day-by-day variability	Impossible	Possible	Impossible
Evaluation of long-term changes (seasonal variation)	Possible	Most favorable	Possible

Source: Journal of Human Hypertension 2021

Based on the information presented in Table 2.1, both HBPM and ABPM offer distinct advantages over OBPM in terms of the quantity and duration of blood pressure measurements. They provide a higher frequency of measurements and greater reproducibility, allowing for a more comprehensive assessment of blood pressure patterns and the effectiveness of prescribed treatments. Additionally, ABPM and HBPM readings may be lower compared to OBPM due to the absence of the "white coat effect" often experienced in clinical settings, where blood pressure tends to be elevated due to nervousness or anxiety. Moreover, both ABPM and HBPM offer the ability to gather additional information about blood pressure variations throughout the day and night, unlike OBPM which only captures a single moment during a clinic visit. These findings highlight the value of out-of-office blood pressure monitoring methods in providing more accurate information for evaluating an individual's risk of developing heart-related conditions.

Practically, whenever ABPM is not available, not well tolerated, or difficult to access, HBPM would be the preferred monitoring method. As HBPM is more affordable and widely available compared to ABPM which can be commonly purchased over the counter in any community pharmacy. Community pharmacists play a crucial role in the management of hypertension, particularly in promoting and facilitating HBPM. This is because HBPM allows patients to monitor their blood pressure in the comfort of their own homes, reducing the potential for "white coat hypertension" providing a more accurate picture of a patient's blood pressure status.

One potential enabler in supporting the prevention, management, and control of hypertension is digital health. Digital health or e-health is a broad term that refers to the use of digital technologies to support healthcare delivery and improve patient outcomes. Electronic health records (EHRs) are a core component of e-health, providing a comprehensive digital record of a patient's health information that can be shared with healthcare providers. Telehealth is another key aspect of e-health, allowing patients to receive healthcare services remotely through video conferencing, remote monitoring, and other digital technologies. Mobile health (mhealth) technologies, such as mobile applications and wearable devices, are another important part of e-health, providing patients with tools to track their health data, manage chronic conditions, and communicate with healthcare providers.

Community pharmacies can also play a significant role in e-health, offering a range of services such as medication management, health screenings, and lifestyle education. The integration of these digital technologies and community pharmacy services can offer a comprehensive approach to healthcare delivery, empowering patients to take an active role in managing their health and improving access to healthcare services. By leveraging digital technologies and community resources, e-health has the potential to improve patient outcomes and promote more efficient and effective healthcare delivery.

1.2 PROBLEM STATEMENT

In a cross-sectional study conducted in Malaysia by Kumar Devaraj et al. (2018), it was observed that a significant number of patients owned automated electronic upper arm devices for HBPM. However, a notable finding was that most of them reported not receiving proper instructions from healthcare professionals on how to accurately measure their blood pressure. This lack of guidance may contribute to a certain degree of measurement errors that patients may be unaware of while performing HBPM. Sometimes individual random errors may appear trivial, but their cumulative impact can significantly influence the estimation of blood pressure, as highlighted by Kallioinen et al. (2017). Insufficient knowledge and measuring skills of HBPM have the potential to compromise the accuracy and reliability of blood pressure readings.

Both Asayama et al. (2021) and Gulati et al. (2021) have emphasized the importance of accurate blood pressure measurement in the diagnosis and management of hypertension. This is crucial because inaccurate readings can lead to the overestimation or underestimation of a patient's blood pressure profile, which in turn can affect the physician's inertia. Physician inertia can be defined as the failure to initiate or intensify pharmacological therapy in patients with uncontrolled blood pressure due to inaccuracies. To tackle this problem, healthcare professionals should provide proper education and counseling on HBPM to ensure the accuracy and reliability of blood pressure readings.

However, it is rarely possible in the office as physicians are faced with challenges like limited time, manpower, and resources, making it difficult to provide comprehensive HBPM education and counseling. To alleviate this burden, task-sharing between allied healthcare professionals, such as community pharmacists, could be a beneficial approach. Community pharmacists are well-positioned to play an important role in instructing patients about general knowledge and measurement skills related to HBPM while providing follow-up support for their hypertension management. Since patients frequently visit community pharmacies to refill their hypertensive medications and purchase home blood pressure monitors over the counter. Allowing community pharmacists to ensure continuity of care from physicians and primary care facilities.

Hence, it is crucial to acknowledge that patients often face a lack of adequate knowledge and skills required for accurate HBPM performance. In the initial phase of our research, we aim to evaluate the extent of HBPM knowledge and measure proficiency among individuals with hypertension. Additionally, we intend to identify common errors that patients tend to overlook during the monitoring process.

In addition to poor HBPM knowledge and measuring skills, the conventional method of recording HBPM readings in manual logbooks for self-monitoring or healthcare professional review often leads to inaccuracies, incomplete data, and illegible entries due to misreporting and poor handwriting (Parati et al. 2021). Consequently, physicians may be hesitant to rely on these manual logbooks for making any clinical decisions due to a lack of confidence in the data accuracy. To address this issue and enhance physicians' confidence levels, the integration of EHRs with HBPM has emerged as a potential solution (Liyanage-Don et al. 2019).

Thanks to the advancement in information and communication technology (ICT), remote transmission and online recording of blood pressure readings have been made possible. Community pharmacies can play a key role in this ecosystem by building a health information system (HIS) utilizing EHRs and mobile applications to provide more comprehensive patient care. EHRs refer to digital systems that store an individual's health information electronically. These records enable convenient access and analysis of a person's health patterns over time, supporting healthcare professionals in making well-informed choices regarding treatment and care. While mobile applications can serve as a window into EHR-based patient portals allowing patients to upload their health data at any moment. These EHRs can be applied in HBPM where patients can measure their blood pressure at any time and upload their readings digitally through mobile applications. Community pharmacists can then remotely monitor patients' blood pressure data and provide care more efficiently.

Moreover, mhealth applications can serve as a valuable resource for educating patients on hypertension and proper HBPM techniques. By providing easy access to educational materials and instructions, these applications can help patients understand the importance of monitoring their blood pressure at home and how to perform accurate measurements. Patients who possess a strong understanding are more likely to consider adopting EHRs for recording and tracking their blood pressure measurements. Their awareness of the value of digital tools like EHRs in health data management would impact their readiness to embrace this technological advancement. This can not only improve patient compliance with their treatment plan but also empower them to take an active role in managing their condition.

However, to date, there has been no evaluation conducted to assess the performance of a HIS implemented in a community pharmacy setting. As most of the evaluations of the health sector HIS have been focused on clinic or hospital settings (Hapsari et al. 2021). To address this gap, we propose the utilization of the Human, Organization, and Technology-fit (HOT-fit) framework developed by Yusof et al. (2008a). This framework is an extension of both the Information Success (IS) Success Model by DeLone and McLean and the IT-Organization Fit Model from MIT90s. It can be used to evaluate the effectiveness of HIS implementation in healthcare settings by examining the alignment between three key factors: human, organizational, and technological dimensions. Unlike other frameworks that focus solely on one aspect only, this comprehensive approach ensures that the technological solution not only fits the organizational structure but is also attuned to the capabilities and requirements of human users. Therefore, this framework can offer valuable insights by pointing out areas that might need improvements across various dimensions, ultimately leading to a more successful HIS implementation.

Furthermore, the adaptability of the HOT-fit Framework also allows for its application in evaluating HIS across various healthcare contexts. Whether it's in a hospital, clinic, or, in this specific instance, a community pharmacy setting. The framework can be effectively used to gauge the harmony between human, organizational, and technological dimensions of any IS as well. Such versatility means that the IS evaluation process is not only limited to a singular healthcare environment but can also be deployed in other different sectors. Making the framework a valuable tool for understanding various IS effectiveness and optimizing its implementation across diverse settings. An illustration of the HOT-fit framework is shown in Figure 2.1. In the second phase of our research, we will conduct a case study that applies the HOT-fit framework to assess the performance of a HIS among users in community pharmacies.

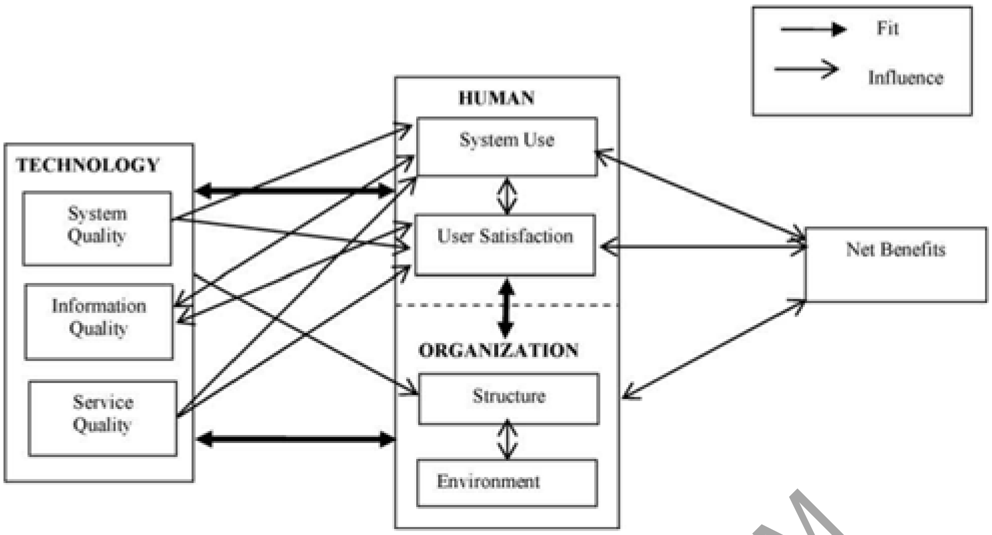

Figure 2.1 Proposed HOT-fit Framework

Source: International Journal of Medical Informatics 77 (2008) 386-398

1.2.1 Research Questions

Research Question 1: What are the common errors made by patients during HBPM?

Research Question 2: How can EHRs contribute to the enhancement of HBPM?

1.2.2 Research Hypothesis

Research Hypothesis 1: Poor compliance with recommended HBPM procedures may have an impact on the accuracy and reliability of blood pressure readings.

Research Hypothesis 2: The utilization of EHRs can enhance HBPM by facilitating improved communication between patients and healthcare providers.

1.3 RESEARCH OBJECTIVES

There are three research objectives for our study:

1. Objective 1: To identify the factors that influence patients' awareness to adopt EHRs for HBPM.

2. Objective 2: To assess the impact of EHRs in enhancing HBPM using the HOT-fit Framework within community pharmacies.

3. Objective 3: To assess the utilization rate of EHRs within community pharmacies for HBPM.

1.4 RESEARCH SCOPE

The research will take place in Caring Pharmacy outlets situated across the Cheras and Kuala Lumpur regions. The participants for the first part of the research design will be customers visiting the various outlets. For the second part of the research design, employees of Caring Pharmacy will be the respondents. The research duration will span from May 2023 to July 2023. This study will focus on assessing customers' knowledge and skills related to HBPM, as well as gathering feedback from employees regarding the application of the current HIS in hypertension screening and management. Notably, the Organization factor will be excluded from the analysis of the HOT-fit framework as we were not involved in any planning and decision-making before the implementation of the HIS.

1.5 THESIS ORGANIZATION

The thesis will be structured into five chapters. Chapter 1, the Introduction, will provide an overview of the background and the issues related to hypertension, HBPM, community pharmacy, and digital health. In Chapter 2, the Literature Review, previous studies exploring the effectiveness of digital health as a potential solution to enhance HBPM will be presented. Chapter 3, the Methodology, will detail the research approach and the specific locations where the study will be conducted. Following that, Chapter 4, Results and Discussion, will present the findings and provide an in-depth analysis. Finally, in Chapter 5, Conclusion and Recommendations, the verification of the hypotheses will be discussed, and suggestions for future studies will be provided.

CHAPTER II

LITERATURE REVIEW

2.1 HOME BLOOD PRESSURE MONITORING (HBPM)

Significant efforts have been dedicated to improving the effectiveness of HBPM over the years. These efforts encompass various aspects, including the design and functionality of the monitoring devices, as well as the education and training provided to patients and healthcare professionals. One critical aspect of using HBPM is ensuring that patients with hypertension use a validated automated electronic upper arm blood pressure monitor (Andraos et al. 2021; Shimbo et al. 2020a). Validated monitors have undergone rigorous testing and have been proven to deliver accurate and reliable blood pressure measurements in accordance with established standards. This ensures consistency and comparability of measurements over time, enabling healthcare professionals to make informed decisions regarding medication adjustments or other interventions.

Equally important is prioritizing education on the appropriate use and monitoring schedule of HBPM to effectively control blood pressure (Andraos et al. 2021). Insufficient knowledge of HBPM, identified by Liyanage-Don et al. (2019b), poses a barrier to its effective implementation among both patients and clinicians. Therefore, it is crucial to provide consistent education and training on HBPM practices to all healthcare professionals. Healthcare professionals play a vital role in guiding patients on HBPM, providing instructions on proper device usage, interpreting results, and advising necessary lifestyle adjustments based on the readings. Insufficient or inaccurate knowledge among healthcare professionals may hinder their ability to educate and train patients effectively. To address concerns and uncertainties surrounding proper HBPM techniques, conducting formal training sessions in the office setting can provide comprehensive guidance.

Additionally, a study conducted by Dymek et al. (2019) to assess the impact of pharmacist-led education on patients' knowledge and skills in HBPM demonstrated promising results. The study showed an increase in knowledge among all participants who received education from the pharmacist, as well as an improvement in self-measurement skills, resulting in a reduced frequency of measurement errors. However, it is important to note that knowledge and skills acquired through educational meetings tend to decrease over time, highlighting the need for periodic re-education. Based on the results, it may be valuable to re-educate patients at least every six months. The same principle applies to physicians, emphasizing the importance of ongoing education to maintain their knowledge and skills in HBPM.

Tucker et al. (2017) conducted a comprehensive meta-analysis of 25 studies to evaluate the effectiveness of HBPM when combined with co-interventions for blood pressure control. Co-interventions are additional support that may include patient education, training, counseling, medication management, and telemonitoring (Omboni et al. 2020; Shimbo et al. 2020). The meta-analysis showed a significant decrease in blood pressure, which was found to be linked to the level of additional support provided alongside the main treatment. In a separate study, Spirk et al. (2018) observed improved blood pressure control among a large population of hypertensive patients in Switzerland who practiced HBPM after receiving detailed information and training. The direct involvement of patients in utilizing HBPM has led to heightened disease awareness and adherence to therapy. Based on these findings, it is strongly recommended to incorporate additional support alongside HBPM as part of hypertension management. This may include personalized interventions, educational initiatives, and monitoring technologies to enhance disease management and improve blood pressure control.

Recently, telemedicine has emerged as a popular co-intervention, utilizing ICT to facilitate remote medical information exchange between patients and healthcare providers (Omboni et al. 2020). One specific telemedicine application gaining rapid traction is blood pressure telemonitoring (BPT). BPT enables the remote transmission of vital parameters like blood pressure data and other health information from patients' homes or any location to healthcare providers (Omboni, 2019). According to Parati et al. (2018), results from several randomized controlled trials have supported that regular and prolonged use of blood pressure telemonitoring has led to significant reductions in blood pressure compared to standard care. This decrease in blood pressure means that their high blood pressure levels become lower and healthier. This is particularly relevant for patients with high cardiovascular risk who require more intensive monitoring. In summary, blood pressure telemonitoring is generally well-received by patients and holds significant potential in the management of hypertension.

2.2 COMMON ERRORS IN HOME BLOOD PRESSURE MONITORING (HBPM)

In a systematic review conducted by Kallioinen et al. (2017b), an extensive analysis of blood pressure measurement identified up to 29 potential sources of inaccuracies that can occur throughout the process. While the focus of the studies was primarily on blood pressure measurement in office settings, many of the identified sources of inaccuracies are also relevant to HBPM. This is because both OBPM and HBPM utilize similar automated electronic upper arm devices for blood pressure measurements.

These sources of inaccuracies can be broadly categorized into four main groups: patient-related, device-related, procedure-related, and observer-related sources of inaccuracies. In the case of HBPM, many errors that may impact the accuracy of blood pressure readings primarily stem from patient-related and procedure-related factors. This finding is supported by the results of Nessler et al. (2021) cross-sectional study on the quality of self-performed blood pressure measurements in Polish hypertensive patients. The study revealed that only 3% of patients measured their blood pressure without errors, while as many as 60% of patients made three or more errors. The most common errors identified included using an incorrect pressure-gauge cuff, inadequate back support, and incorrect cuff placement on the upper limb, which are primarily procedure-related errors.

These findings suggest that many patients with hypertension may not accurately measure their blood pressure during HBPM. It is important to address patient and procedure-related factors to ensure the accuracy and reliability of HBPM by acquiring sufficient knowledge and skills for proper blood pressure measurement. In our research, we will investigate how well the patients measure their blood pressure in accordance with recommended guidelines to ensure the accuracy of HBPM readings.

2.3 HOME BLOOD PRESSURE MONITORING (HBPM) GUIDELINE

In a comprehensive review paper by Wang et al. (2021), a panel of 12 leading experts from 10 prominent Asian countries was assembled to share their insights on the current utilization of HBPM and identify areas for improvement to enhance its use in hypertension management. One particularly intriguing finding presented in the review was the discrepancy in the availability of local hypertension guidelines and HBPM guidelines across the Asian countries examined. While all 10 countries had published local hypertension guidelines that recommended the use of HBPM in clinical practice, only China, Indonesia, and Japan had formal local HBPM guidelines to guide physicians in this regard.

This suggests that the level of awareness and adoption of HBPM among physicians may be relatively low in other Asian regions, including Malaysia. The absence of relevant HBPM guidelines specific to these regions may contribute to insufficient knowledge of HBPM best practices. According to the experts, most physicians who follow guidelines tend to refer to international guidelines such as those provided by the European Society of Cardiology (ESC) and the European Society of Hypertension (ESH), or the clinical practice guidelines of the American College of Cardiology (ACC) and the American Heart Association (AHA). Consequently, for our research, we will utilize the HBPM guidelines from ACC/AHA as our reference for understanding HBPM best practices in terms of knowledge and measurement skills.

2.4 E-HEALTH

E-health, short for "electronic health," embraces the utilization of digital technologies like computers, mobile devices, and the internet to enhance and facilitate healthcare services. It encompasses a wide array of applications and services that leverage technology to improve different aspects of healthcare. One notable subset of e-health is telemedicine, which specifically revolves around delivering medical services remotely using telecommunications technology. Through telemedicine, healthcare professionals can provide consultations, diagnosis, and treatment to patients from a distance, ensuring convenient access to care regardless of physical location.

One main benefit of digital health interventions in hypertension is allowing patients to seamlessly measure and share data in a potentially better way than traditional hypertension screening and management (Hare et al. 2021). In a prospective observational cohort study, Ciemins et al. (2018) tested the use of smartphone technology with HBPM in patients with newly diagnosed or uncontrolled hypertension. EHRs are also integrated with smartphone technology allowing providers to monitor patients' home measurements more easily. They found that patients who participated in a wireless smartphone-assisted HBPM program led by a nurse navigator demonstrated a significantly great improvement in blood pressure control. This shows that affordable and feasible smartphone technology connected with EHRs can be combined with HBPM to improve hypertension control among patients.

Soreide et al. (2022) have conducted a retrospective cohort study to evaluate the effectiveness of a pharmacist-led intervention using digital tools in managing patients with uncontrolled hypertension. They found that the utilization of EHR-based electronic tools in managing these patients has achieved a higher rate of blood pressure control.

Lu et al. (2020) have conducted a case study evaluating the potential of EHRs in digital population health surveillance. By leveraging the power of EHRs, they can identify patients with markedly elevated blood pressure more efficiently for early intervention. As these groups of patients are associated with a higher risk of morbidity and mortality that often lack timely follow-up or subsequent control. Thus, patients who have a gap in care can be better identified and prioritized to receive more focused intervention using EHRs. A collaborative approach between physicians and other healthcare professionals combining digital tools could help to improve the overall blood pressure control rate.

2.5 HOT-FIT FRAMEWORK

In a literature review by Hapsari et al. (2021b), the HOT-fit framework was used to evaluate programs or information systems in different sectors across 30 articles. The review found that around 40% of the articles focused on the health sector, specifically assessing hospital information systems and other health-related systems using the HOT-fit framework. However, the HOT-fit framework is not limited to healthcare settings and has been widely used to evaluate information systems in various sectors. The framework's flexibility allows for its use at any stage of the system development life cycle, and it can be adapted to different research design approaches (Yusof et al. 2008b). This adaptability makes it a valuable tool for conducting comprehensive evaluations in identifying areas of improvement to enhance information system performance.

A noteworthy example of this framework's application in Malaysia is demonstrated in a study conducted by Iyzati et al. (2022) within the Ministry of Health (MOH) facilities. The HOT-fit framework was used in their research to assess staff satisfaction with the implemented Pharmacy Hospital Information System and Clinic Pharmacy System (PhIS & CPS). One significant outcome of this framework is its capacity to generate mean scores for each dimension, serving as an overall measure of user satisfaction. This evaluation involves a scoring methodology that gauges the level of contentment among users concerning the system. The findings revealed that the system users' satisfaction is the key driver to effective and continuous use of the PhIS & CPS. While the system users were generally satisfied with the overall system implementation, there was still room for improvements, especially in the human domain.

The significance of this observation lies in how the framework contributes to the realization of the system's overall benefit. The successful outcomes of a system are contingent upon its effective use and alignment with end-user requirements. This harmonization of dimensions, encompassing human, organizational, and technological aspects, is crucial for maximizing the system's utility and achieving its intended positive impacts. Thus, this research design will be the first to assess the implementation of HIS in community pharmacies using the HOT-fit framework. By employing this approach, any areas of dissatisfaction within specific sub-domains of each dimension can be identified, paving the way for targeted improvements. We hope to gain insights from the principal users of an Electronic Health Records (EHRs) System deployed in a community pharmacy, particularly community pharmacists, and how it can be harnessed to enhance Home Blood Pressure Monitoring (HBPM).

CHAPTER III

METHODOLOGY

3.1 INTRODUCTION

The research design employed in this study encompasses a combination of quantitative and observational methods, which collectively aim to address the following research questions. The first research question explores the common errors made by patients practicing HBPM. In the initial phase, our objective is to evaluate the level of HBPM knowledge and measuring skills among patients who measure their blood pressure at home. We aim to determine their familiarity with recommended procedures and identify any errors they may unknowingly commit. To accomplish this, a questionnaire will be distributed to customers visiting various community pharmacies located across Cheras and Kuala Lumpur. Specifically, customers who practice HBPM will be approached and invited to participate in the study. They will be provided with a questionnaire designed to assess their current knowledge of HBPM. In addition, a practical demonstration will be conducted to observe and evaluate the proficiency of patients in accurately measuring their blood pressure at home.

The second research question examines the potential impact of EHRs systems on enhancing HBPM. In the second phase of the study, a case study will be conducted to assess the effectiveness of a specific HIS implemented in a community pharmacy. The study will utilize the HOT-fit framework developed by Yusof et al. (2008b) to identify and describe the key factors influencing the adoption of the HIS by community pharmacists in the context of improving HBPM. This framework will provide valuable insights into the critical elements that contribute to the successful implementation and utilization of the HIS in community pharmacy settings.

3.2 PARTICIPANTS

We will conduct participant recruitment for both phases of the research study at Caring Pharmacy, a retail community pharmacy chain with multiple outlets across Malaysia.

In the first phase, we will employ a random selection method to identify customers visiting the pharmacy for various reasons, such as medication refills, blood pressure checks, or general shopping. We will approach these customers and inquire whether they practice regular HBPM at home. The participants may include individuals both with and without hypertension. Patients diagnosed with hypertension are often required to monitor their blood pressure regularly to ensure its control and assess the effectiveness of their medications. Similarly, individuals without hypertension may engage in regular blood pressure measurements as part of their health-conscious lifestyle to gain better insight into their cardiovascular health and risk for heart disease and stroke. Our goal is to recruit a minimum of 40 participants for the first phase, as this sample size is considered suitable for generating meaningful results in usability studies (Raluca Budiu & Kate Moran, 2021).

For the second phase, we will focus on recruiting employees of Caring Pharmacy, specifically community pharmacists who are at the forefront of patient care. They will be the primary subjects of investigation as they were early adopters of a HIS that has been implemented in Caring Pharmacy and received training during its initial implementation phase. The HIS has now become an integral part of the community pharmacists' daily routine, assisting them with various tasks through its comprehensive features. By involving these pharmacists, we aim to gain insights into their experiences, perspectives, and perceptions of the HIS in the context of enhancing HBPM practices. The existing HIS implemented at Caring Pharmacy will be discussed in detail in the Case Study section.

3.3 DATA COLLECTION

Two separate sets of questionnaires will be utilized in both phases of the research study to gather the necessary data for analysis and interpretation.

The initial set of questions for the first questionnaire is adapted from a multicentric survey conducted by Flacco et al. (2015). This survey aimed to assess the level of adherence to HBPM recommendations based on the 2008 Italian hypertension guidelines for HBPM. These questions are then further modified by referencing an updated HBPM procedures guide, which serves as a resource for patient training by healthcare professionals. The AHA Scientific Statement titled "Measurement of Blood Pressure in Humans" provides a comprehensive overview of HBPM procedures used for patient training (Muntner et al. 2019). These procedures are presented in Table 3.1, outlining the specific steps and guidelines involved in conducting HBPM accurately and effectively. Consequently, the adopted questionnaire is refined to consist of three main parts.

Part 1 comprises 7 questions that capture participant demographics. Part 2 consists of 13 questions, including a mixture of binary, multiple-choice, and Likert scale responses, to assess general knowledge of HBPM. Lastly, Part 3 involves an observational study where participants will be requested to perform their routine HBPM procedures. Any noteworthy observations during the demonstrations will be recorded in the comments section for discussion. A sample of Questionnaire 1, titled "Questionnaire on Assessing the Quality of Patient's Home Blood Pressure Monitoring (HBPM)," will be included in the Appendix for reference.

Table 3.1 Guidance for Conducting HBPM

Patient training provided by healthcare staff or providers
Provide information about hypertension diagnosis and treatment
Provide information on the proper selection of a device
Provide instruction on how patients can measure their own BP (if possible, demonstrate the procedure)
Provide instruction that the HBPM device and BP readings should be brought to healthcare visits
Provide education that individual BP readings may vary greatly (high and low) across the monitoring period
Preferred devices and cuffs
Use an upper-arm cuff oscillometric device that has been validated
Use a device that can automatically store all readings
Use a device that can print results or can send BP values electronically to the healthcare provider
Use a cuff that is appropriately sized for the patient's arm circumference
Best practices for the patient
Preparation
Have an empty bladder
Rest quietly in a seated position for at least 5 minutes
Do not talk or text
Position
Sit with back supported
Keep both feet flat on the floor
Legs should not be crossed
BP cuff should be placed on a bare arm (not over clothes)
BP cuff should be placed directly above the antecubital fossa (bend of the arm)

to be continued…

…continuation

	The center of the bladder of the cuff (commonly marked on the cuff by the manufacturer) should be placed over the arterial pulsation of the patient's bare upper arm
	The cuff should be pulled taut, with comparable tightness at the top and bottom edges of the cuff, around the bare upper arm
	The arm with the cuff should be supported on a flat surface such as a table
Number of readings	
	Take 2 readings at least 1 minute apart in the morning before taking antihypertensive medications and 2 readings at least 1 minute apart in the evening before going to bed
Duration of monitoring	
	The preferred monitoring period is ≥7 days (i.e., 28 readings or more scheduled readings); a minimum period of 3 days (i.e., 12 readings) may be sufficient, ideally in the period immediately before the next appointment with a provider
	Monitoring conducted over consecutive days is ideal; however, readings taken on non-consecutive days may also provide valid data
Analyzing readings	
	For each monitoring period, the average of all readings should be obtained. Some guidelines and scientific statements recommend excluding the first day of readings. If the first day of readings is excluded, the minimum and preferred periods of HBPM should be 4 and 8 days, respectively.

Source: Hypertension. 2019 | Volume 73, Issue 5: e35–e66

The second questionnaire is designed from scratch, drawing inspiration from measures outlined in studies conducted by Iyzati et al. (2022) and Syahidul Haq et al. (2022), which have previously utilized the HOT-fit framework to evaluate information systems in different sectors. Although it was not possible to obtain a sample questionnaire specifically deployed for HOT-fit framework evaluation, the content of the questions is aligned with how the HIS can be applied to enhance community pharmacy practices in the context of HBPM. The questionnaire will encompass three domains: Human, Technology, and Net Benefits. Each domain will be further divided into sub-domains, and questions will be structured according to the respective evaluation measures.

Under the Technology domain, the sub-domains include system quality, information quality, and service quality. The Human domain explores system use and user satisfaction. Lastly, the Net Benefits domain evaluates whether the HIS manages to achieve the anticipated benefits when integrated with HBPM practices. A sample of Questionnaire 2, titled " Questionnaire on Assessing the Performance of Patient Medication Record (PMR) Systems with Home Blood Pressure Monitoring (HBPM) in the Management of Hypertension by Adopting the HOT-Fit Framework " will also be included in the Appendix.

3.4 DATA ANALYSIS

Once the questionnaires are completed and collected from the respondents and participants, the data will be entered and organized in Microsoft Excel. Descriptive analysis will be performed using Excel formulas to calculate key parameters such as frequency, percentage, mean, and standard deviation (SD) of the data. The results will be presented in tables and charts to visually depict trends and facilitate a better understanding of the data. Noteworthy findings will be carefully noted and discussed in the Results and Discussion section.

For further statistical analysis, IBM SPSS Statistics Version 29.0.1.0 (171) will be utilized to conduct relevant analyses based on the collected questionnaire responses. This may include conducting reliability tests to assess the internal consistency of the questions and using the Pearson correlation coefficient to explore any significant relationships between variables. Any interesting observations or feedback received from the questionnaires will also be discussed to provide additional insights into the results obtained from the data analysis.

3.5 CASE STUDY OF PATIENT MEDICATION RECORD (PMR) SYSTEM

Our research design involves a case study strategy to evaluate the effectiveness of a specific HIS implemented in Caring Pharmacy. The primary HIS utilized in Caring Pharmacy is the MyHealth Record System, also known as the Patient Medication Record (PMR) System, which was launched in July 2019. This EHRs system is predominantly used by community pharmacists to record patients' current medications, monitor their adherence to prescribed treatments, and track allergens. Additional features such as pill alarms and reminders are also available for configuration to ensure patients' adherence to their medications or supply. However, this aspect of the system is not the focus of our study.

The PMR System also includes a Health Summary function that, compared to the previous aspect, is not being utilized as regularly. This function allows both community pharmacists and patients to enter and update health parameters at any time after conducting measurements. All the recorded data is securely stored online in the cloud, enabling community pharmacists to access and retrieve these health parameters for monitoring purposes. Traditionally, blood pressure readings obtained through in-pharmacy measurements or HBPM are commonly recorded manually on paper or in logbooks. However, with the availability of EHRs systems like the PMR System, we aim to assess how community pharmacists perceive and utilize the system for recording and monitoring patients' blood pressure.

The focus of this study is to evaluate the PMR System's performance in recording, monitoring, and sharing health records, particularly blood pressure data, to improve HBPM for hypertension management. We will employ the HOT-fit framework to assess the effectiveness of the PMR System. The evaluation will specifically consider the alignment between human and technological factors. Our study concentrates on the community pharmacists of Caring Pharmacy who are the primary users of the PMR System that have received training for the PMR System. Hence, the organizational factor will not be assessed in this case, as these users were not involved in any higher-level organization decision-making processes during the planning and development of the information system.

CHAPTER IV

RESULTS AND DISCUSSION

4.1 RESULTS

The results from both Questionnaire 1: Assessing the Quality of Patient's Home Blood Pressure Monitoring (HBPM) and Questionnaire 2: Assessing the Performance of Patient Medication Record (PMR) Systems with Home Blood Pressure Monitoring (HBPM) in The Management of Hypertension by Adopting the HOT-fit Framework will be presented and analyzed in the subsection below.

4.1.1 Knowledge and Measuring Skills of Home Blood Pressure Monitoring (HBPM)

In Questionnaire 1, a total of 31 questions were designed and divided into three parts: respondents' information, their general knowledge of HBPM best practices, and an observational test on their demonstration of measuring blood pressure at home. One of the statistical analyses we conducted was a reliability test to assess the internal consistency of the 24 questions related to HBPM knowledge and measuring skills, excluding demographic information. We used IBM SPSS Statistics Version 29.0.1.0 (171) to calculate Cronbach's alpha (α) value. Typically, an α value above 0.7 is considered acceptable.

However, the calculated α value was found to be 0.423 as shown in Table 4.1, which falls below the acceptable range. A low α value suggests that the questions may not align well with the research objective or fail to measure the intended construct. To address this issue, there are several options to consider, such as increasing the number of items to capture more opportunities, removing problematic questions, or rephrasing existing questions to eliminate confusion that could lead to inconsistent responses.

Table 4.1 Questionnaire 1 Reliability Statistic

Cronbach's Alpha (α)	**N of Items**
0.423	24

To identify potential questions that contributed to the low α value, we further explored the individual question statistics by checking their α values if they were deleted. Higher α values when specific questions were removed indicated the inappropriateness of the current formatting of those questions. As a result, we identified three questions that could be improved for future research, as highlighted in Figure 4.1.

Item-Total Statistics

	Scale Mean if Item Deleted	Scale Variance if Item Deleted	Corrected Item-Total Correlation	Cronbach's Alpha if Item Deleted
Receive instructions before	39.62	36.958	.242	.418
Instructions Provider	37.30	37.344	-.119	.519
Measurement Schedule	38.55	29.177	.435	.322
Measure At The Same Hour	38.25	35.628	.095	.427
Measurement Time	37.62	43.369	-.363	.576
Measure Using The Same Arm	36.00	36.462	.104	.424
Resting Period Before Measurement	38.95	37.690	-.011	.442
Number Of Readings Per Day	38.80	36.369	.156	.418
Small Break Between Consecutive Measurements	37.27	33.846	.149	.415
Smoke, Exercise, Or Consume Caffeinated/Alcoholic Drinks 30 minutes Before Measurement	38.80	36.933	-.002	.449
Empty Bladder Before Measurement	38.17	30.969	.377	.350
Record Of Measurements	38.07	29.610	.455	.322
Share BP Diary With Healthcare Professionals	37.95	28.921	.440	.319
Interested In Recording BP Readings Electronically	39.70	37.190	.152	.423
Right Cuff Size	39.47	38.153	.000	.434
Pull The Cuff Taut	39.80	37.036	.155	.422
Place The Cuff Over Bare Arm	39.67	36.020	.405	.402
Bottom Of The Cuff Above Bend Of Elbow?	39.60	37.169	.213	.421
Center Of The Cuff Placed Over Arterial Pulsation Of Bare Upper Arm	39.70	36.574	.274	.412
Silent During Measurement	39.70	37.703	.052	.431
Legs Uncrossed	39.65	37.464	.115	.427
Both Feet Flat On The Ground	39.60	37.785	.062	.431
Back Supported	39.87	36.574	.222	.414
Arm Supported	39.55	37.844	.073	.431
Arm Positioned At The Same Height As Heart	39.70	37.036	.182	.420

Figure 4.1 Questionnaire 1 Item Total Statistics

The variables identified as problematic in the reliability analysis come from the questions of instruction provider, measurement time, and smoking, exercise, or consumption of caffeinated/alcoholic drinks 30 minutes before measurement specifically. Removing these items would result in a higher Cronbach's alpha value, indicating improved internal consistency. The predicted new alpha value after removing these three items is 0.704, which is considered acceptable, as shown in Table 4.2. Therefore, we recommend revisiting and improving the responses provided for these three questions to better capture the relevant information in future research. Specifically, we suggest simplifying the response choices for instruction providers and measurement time and breaking down the last variable into multiple questions to gather more detailed information about participants' measuring habits. These modifications aim to enhance the reliability of the questionnaire and ensure more accurate data collection.

Table 4.2 Questionnaire 1 Reliability Statistics Post Items Removal

Cronbach's Alpha	**N of Items**
0.702	21

Furthermore, we propose that the overall level of knowledge and measuring skills is strongly influenced by whether respondents have received any instruction and who provided the instruction. To support this proposal, we conducted a Pearson correlation coefficient calculation using IBM SPSS Statistics Version 29.0.1.0 (171) to measure the strength of the relationship between these two variables. As shown in Figure 4.2, the calculated Pearson correlation coefficient is 0.719 with a p-value of < 0.001, indicating a statistically significant and very strong positive relationship. This suggests that for our study respondents who have received instruction, their HBPM knowledge level is highly correlated with the source of instruction they received.

Correlations

		Receive instructions before	Instructions Provider
Receive instructions before	Pearson Correlation	1	.719**
	Sig. (2-tailed)		<.001
	N	40	40
Instructions Provider	Pearson Correlation	.719**	1
	Sig. (2-tailed)	<.001	
	N	40	40

**. Correlation is significant at the 0.01 level (2-tailed).

Figure 4.2 Pearson Correlation

Table 4.3 provides an overview of the respondent's characteristics who willingly participated in the questionnaire. The distribution of respondents shows an equal representation of both males and females, indicating balanced gender participation in this research. These respondents represented various age groups, ranging from 18 – 24 years old to individuals aged 65 and above, demonstrating a broad awareness of the importance of routine blood pressure monitoring across different age demographics.

From the table, we can see that even respondents who live alone do take the initiative to perform HBPM for self-monitoring purposes, showcasing a proactive approach towards personal health management. Approximately 47.50% of respondents reported having a family history of hypertension, highlighting the prevalence of this chronic condition. These individuals are often considered high-risk candidates for developing hypertension, emphasizing the importance of vigilant blood pressure monitoring for early detection and intervention.

Interestingly, while around 42.50% of respondents have been officially diagnosed with hypertension by a physician, only approximately 32.50% reported taking anti-hypertensive medications to control their blood pressure. This indicates a gap in awareness among respondents regarding the severe complications of uncontrolled hypertension, including the heightened risk of stroke, heart attacks, and long-term kidney damage.

Encouragingly, a significant 77.50% of respondents expressed interest in recording their blood pressure readings electronically, showing their openness to adopting digital health technology like EHRs if available. Overall, the characteristics of the respondents in Table 4.3 provide valuable insights into their current engagement with HBPM and their receptiveness toward technological solutions.

Table 4.3 Characteristics of Respondents Practicing Home Blood Pressure Monitoring (HBPM)

Respondents	Total (n = 40)	Percentage (100%)
Gender		
Male	19	47.50
Female	21	52.50
Age Group		
18 – 24	5	12.50
25 – 34	9	22.50
35 – 44	3	7.50
45 – 54	13	32.50
55 – 64	4	10.00
≥ 65	6	15.00
Living Status		
Alone	8	20.00
Living with Family	32	80.00
Family History of Hypertension		
Yes	19	47.50
No	21	52.50
Diagnosed with Hypertension		
Yes	17	42.50
No	23	57.50
Taking Anti-hypertensive Medication		
Yes	13	32.50
No	27	67.50
Interest in Electronic Recording		
Yes	31	77.50
No	9	22.50

Table 4.4 provides insights into the sources of instructions that respondents have relied upon to acquire knowledge about best practices and correct procedures for performing HBPM. 75% of respondents have reported receiving instructions in the form of written materials, verbal explanations, or physical demonstrations. On the other hand, the remaining 25% of respondents mentioned that they had not received any instructions before, but they referred to the instruction manual accompanying their purchased blood pressure monitor to learn instead. This suggests that this subgroup of respondents may have obtained their devices through alternative channels other that the most common route from community pharmacies.

As for the providers of instructions, approximately 52.50% of respondents indicated that they received instructions from community pharmacists, while 12.50% reported receiving instructions from doctors. The remaining respondents sought guidance from either their friends or family members. This highlights the pivotal role of community pharmacists as the primary point of contact for any interested individuals who would like to purchase HBPM devices and learn how to properly utilize them. Consequently, community pharmacists have the potential to play a crucial role in promoting the use and awareness of HBPM.

Table 4.4 Source of Instructions

Respondents	**Total (n = 40)**	**Percentage (%)**
Receive Instructions Before		
Yes	30	75
No	10	25
Instructions Provider		
Instruction Manual	10	25
Families	3	7.50
Friends	1	2.50
Community Pharmacist	21	52.50
Doctor	5	12.50

Table 4.5 presents important requirements for high-quality HBPM, including measurement frequency, timing, resting period, and number of readings. Among the respondents, 62.50% measure their blood pressure at any time without a fixed schedule, while only 12.50% adhere to daily measurements, which is ideal for obtaining a comprehensive view of their overall blood pressure control.

The preferred timing for measurements throughout the day varies among respondents, with no clear majority. Further inquiry reveals that some respondents measure their blood pressure sporadically, especially when they're experiencing symptoms of discomfort like dizziness or rapid heartbeat. It is recommended to measure their blood pressure before taking anti-hypertensive medication in the morning and before bedtime but this practice is followed by only 40% of respondents.

Regarding the resting period, 57.50% of respondents rest for at least 1 minute before measurement. However, it is important to emphasize that a minimum of 5 minutes of quiet rest is necessary for accurate readings. As this allows the body to reach a stable state after being physically active and reduces the impact of external factors on blood pressure.

Lastly, we can see that the adherence to the recommended number of readings is low. Approximately 42.50% of respondents take only one reading per day, and 50% take two readings. This lack of adherence compromises the reliability of the obtained readings. It is recommended to take at least two readings in the morning and two in the evening, totaling four readings per day. As this approach provides a more accurate assessment of blood pressure fluctuations throughout the day, considering various influencing factors.

Table 4.5 Measurement Requirements

Respondents	Total (n = 40)	Percentage (%)
Measurement Schedule		
Anytime	25	62.50
Once a Week	6	15.00
Twice a Week	1	2.50
≥ Twice a week	3	7.50
Everyday	5	12.50
Measurement Time		
Before breakfast/taking antihypertensive medication	11	27.50
After breakfast/taking antihypertensive medication	9	22.50
Before dinner	8	20.00
After dinner	3	7.50
Before bed	5	12.50
Others	4	10.00
Resting Period Before Measurement		
1 minute	23	57.50
5 minutes	15	37.50
15 minutes	2	5.00
Number of Readings Per Day		
1 reading	17	42.50
2 readings	20	50.00
3 readings	2	5.00
4 readings	1	2.50

Figure 4.3 provides insights into respondents' habits and preparations related to HBPM best practices. One of the positive trends is the majority of the respondents consistently measure their blood pressure using the same arm, recognizing the importance of consistency for accurate readings. Second, up to 73% of respondents also recognize the need to avoid influencing factors like smoking, exercising, and consuming caffeinated or alcoholic drinks before measurements, which can affect blood pressure readings.

However, some areas require improvement. A significant proportion of 65% of respondents do not adhere to a consistent measurement time, which can impact the accuracy and reliability of readings. Around 33% of respondents do not take a break between consecutive measurements, which may be linked to the low number of readings per day only. Surprisingly, about 51% of respondents do not empty their bladder before measurement. This shows that half of the respondents overlooked the importance of a relaxed state during measurements, as a full bladder can potentially impact blood pressure readings.

Lastly, a notable finding is that approximately 55% of respondents do not maintain a diary of their blood pressure recordings or share them with healthcare professionals for periodic review. Keeping a record and sharing it with healthcare professionals is crucial for monitoring treatment efficacy and progress. These findings emphasize the need for increased education and awareness regarding HBPM best practices.

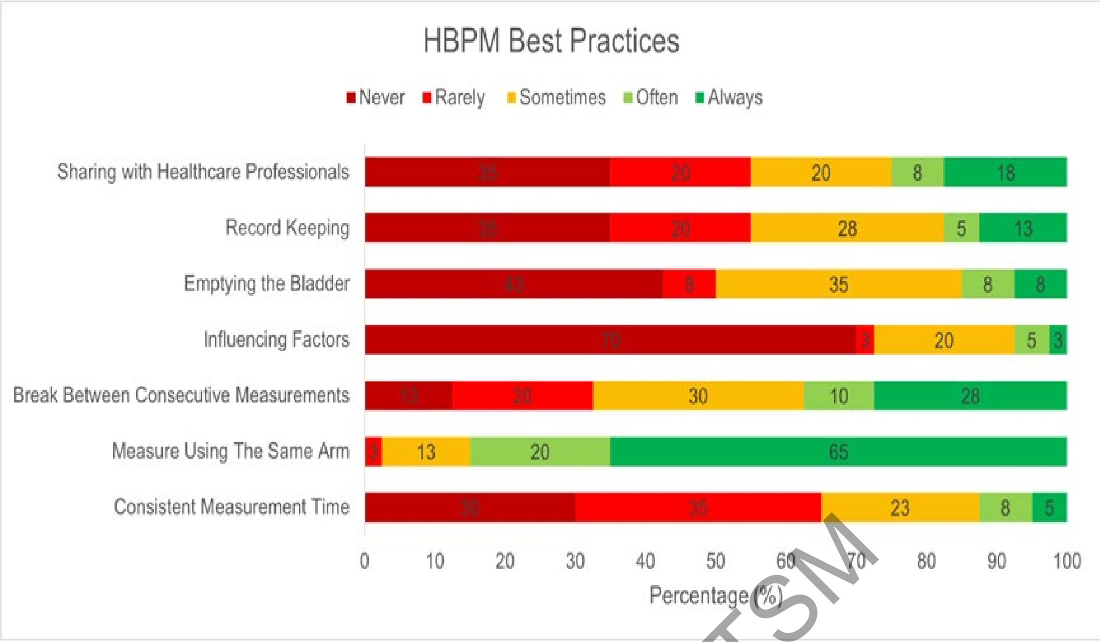

Figure 4.3 HBPM Best Practices

Figure 4.4 displays the results of the observational study conducted to assess respondents' technical skills in cuff placement and body positioning during HBPM. Several observations can be made from the data. Firstly, it is encouraging to see that all respondents were able to select cuffs that fit their arms comfortably, avoiding issues of overly tight or loose cuffs that could impact readings. However, approximately 20% of respondents placed the cuff over their clothes instead of directly on their bare arms. It is worth noting that this is a common occurrence among respondents, as they often face challenges due to wearing clothing that is not suitable for rolling up their sleeves to allow placing the cuff directly on their bare arms.

In terms of cuff placement, one common error observed was that approximately 33% of respondents failed to pull the cuff taut appropriately. These individuals often wrapped the cuff quickly without ensuring a proper fit, resulting in loose or improperly attached cuffs. Some respondents also placed the cuff without checking for the correct alignment, initiating the measurement without any proper adjustments. These actions may lead to less reliable readings. Additionally, around 13% of respondents made slight errors in cuff placement, positioning it slightly below the elbow instead of over the upper arm arterial pulsation.

Regarding body positioning, the most frequent error was the lack of back support, with approximately 40% of respondents not resting their backs against the chair during measurements. Around 13% of respondents did not keep both feet flat on the ground and crossed their legs. Another noteworthy observation is that 23% of respondents did not remain silent during the measurement, engaging in conversations over the phone or with accompanying friends. On the positive side, the least common error was the lack of arm support, with only 8% of respondents unaware of the importance of supporting the arm during measurements. However, approximately 23% of respondents did not position their arms at the same height as their hearts, indicating a potential lack of awareness regarding proper arm positioning. These cuff placement and body positioning errors can potentially affect the accuracy of readings. Overall, respondents demonstrated better measuring skills than their general knowledge of HBPM best practices.

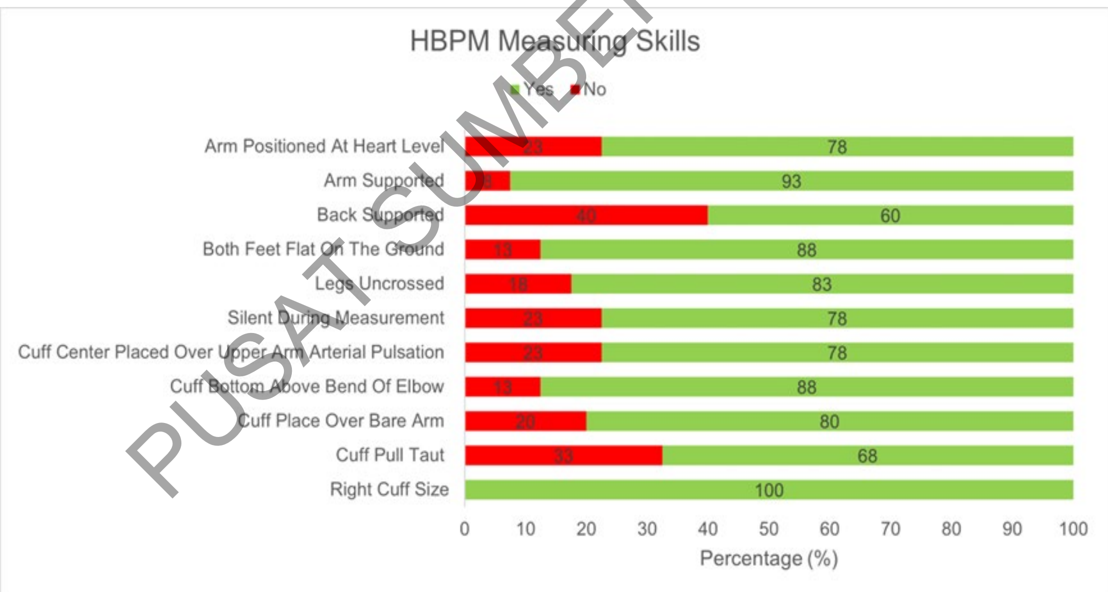

Figure 4.4 HBPM Measuring Skills

4.1.2 Case Study of Patient Medication Record (PMR) System

In Questionnaire 2, a total of 46 carefully designed questions were included, divided into two parts. The first part consisted of 5 questions aimed at gathering participants' information, while the second part comprised 41 questions tailored based on the HOT-fit Framework to evaluate the performance of the PMR System in the context of HBPM. To ensure comprehensive responses, we employed a Likert scale, which offered a range of response options, including "Strongly Disagree," "Disagree," "Neutral," "Agree," and "Strongly Agree." First, we conducted a reliability test to assess the internal consistency of the 41 questions related to the PMR System, excluding participants' information using IBM SPSS Statistics Version 29.0.1.0 (171).

The calculated α value was found to be 0.957 as shown in Table 4.6. This high α value indicates excellent internal consistency and a strong correlation between the designed questions. The outstanding result instills confidence in the overall quality and accuracy of our research instrument. This high level of reliability also ensures that the questionnaire effectively captures the desired information from the participants.

Table 4.6 Questionnaire 2 Reliability Statistics

Cronbach's Alpha	**N of Items**
0.957	41

Table 4.7 provides an overview of the participants' demographics in the Case Study. Most of the participants are female and there is a balanced distribution across various age groups. All participants have reported attending training sessions for the PMR System regardless of their tenure. This indicates that mandatory training will be provided to all participants who have joined the company. Interestingly, approximately 69% of the participants have been employed at Caring Pharmacy for more than 5 years. However, only 23% of the participants have reported working with the PMR System for over 5 years. This discrepancy suggests that the PMR system was not implemented simultaneously across all outlets. Instead, a pilot approach was adopted, selecting specific outlets for initial testing and implementation.

Table 4.7 Participants' Information

Participants	**Total (n =13)**	**Percentage (100%)**
Gender		
Male	4	30.77
Female	9	69.23
Age Group		
20 - 29	4	30.77
30 - 39	5	38.46
40 - 49	2	15.38
50 - 59	2	15.38
Employed at Caring Pharmacy		
< 1 year	1	7.69
1 – 5 years	3	23.08
> 5 years	9	69.23
Attended PMR System Training		
Yes	13	100
No	0	0
Worked with the PMR System		
< 1 year	2	15.38
1 – 5 years	8	61.54
> 5 years	3	23.08

Figure 4.5 illustrates the distribution of responses for the System Quality sub-domain. Most participants (≥ 85%) agree that the PMR System is user-friendly, facilitating easy learning and usage. They also recognize its effectiveness as a blood pressure monitoring system for HBPM.

All participants unanimously agree that the PMR System grants access to all patient profiles, streamlining the process of entering new blood pressure records for any encountered patients. However, 8% of participants express disagreement regarding the simplicity of the patient registration process and the responsiveness of the user interface. This discrepancy may be attributed to certain operational aspects of the PMR System, as up to 31% of participants report dissatisfaction with system performance, particularly due to noticeable lag. Such issues could potentially impact the efficiency of the registration process. Once blood pressure data is successfully entered into the PMR System, ≥ 84% of participants respond positively when it comes to searching, editing, and printing them. This indicates a high level of participants' satisfaction with these specific functions of the system.

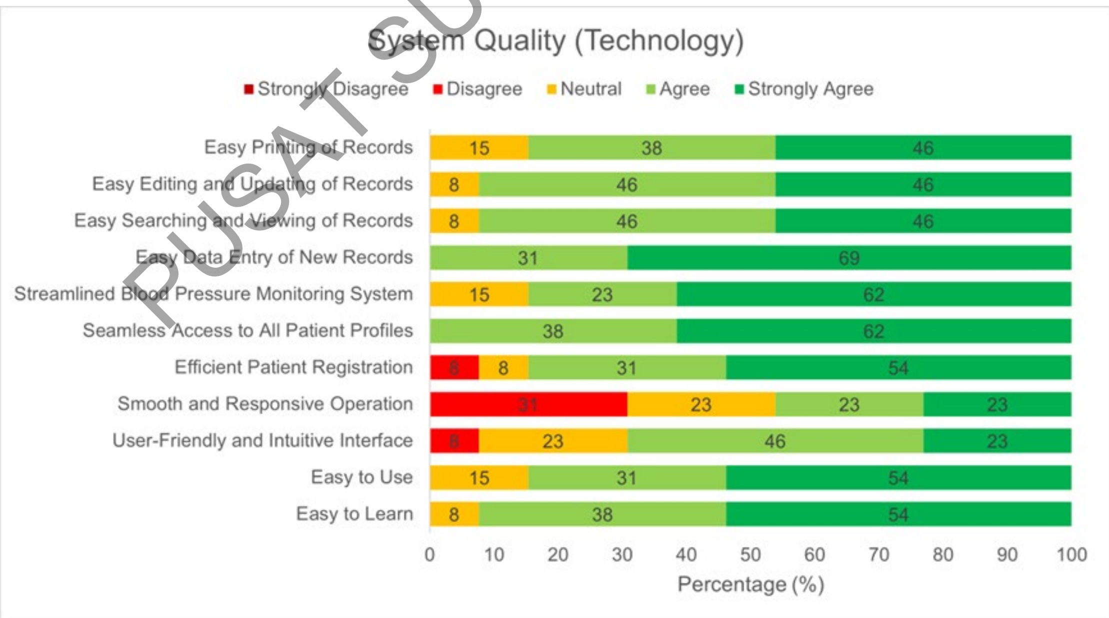

Figure 4.5 System Quality Responses

Figure 4.6 illustrates the distribution of responses for the Information Quality sub-domain. An impressive ≥ 92% of participants agreed with the level of accuracy, validity, and completeness of the blood pressure data recorded in the PMR System. This indicates a high level of confidence in the reliability of the information stored within the system. While all participants recognized the PMR System as a potential tool for hypertension monitoring, only approximately 60% believed it can aid in the hypertension diagnosis and detection of white-coat or masked hypertension. There are 8% of participants disagreed with using the PMR System for diagnostic purposes. This discrepancy could be attributed to the differing responsibilities of physicians and pharmacists within Malaysia's healthcare practices. Physicians primarily hold the responsibility for diagnosing diseases while pharmacists have a complementary role in disease management and monitoring. Furthermore, 8% of participants also disagree with the PMR System's capability to display averages and trends of blood pressure control. Thus, this is a potential area for improvement in the PMR System's ability to provide better visualization of blood pressure control over time.

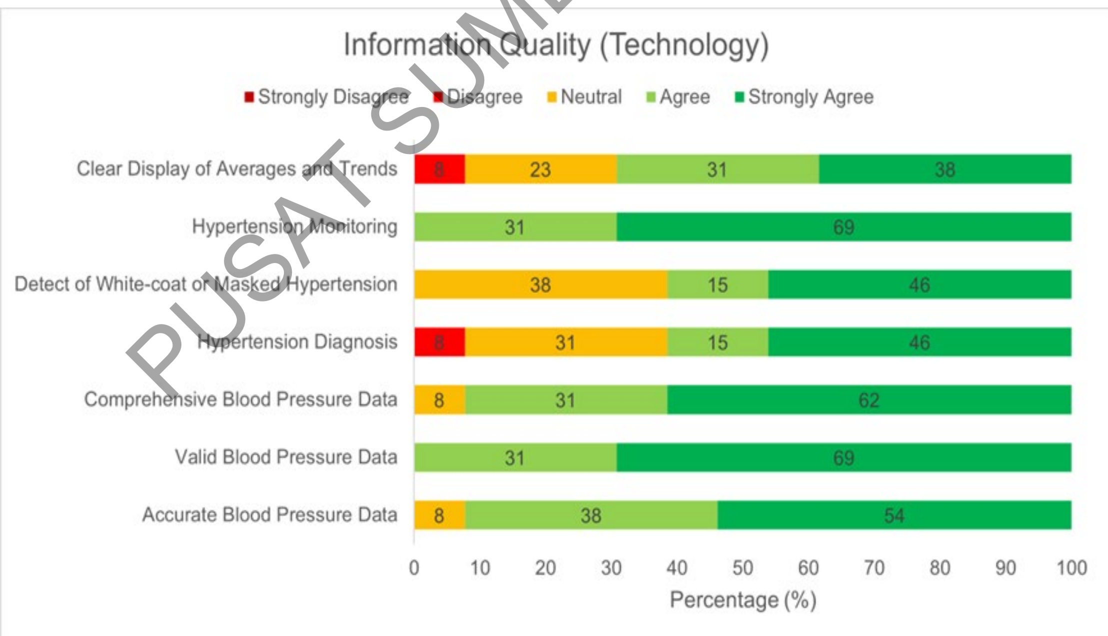

Figure 4.6 Information Quality Responses

Figure 4.7 illustrates the distribution of responses for the Service Quality sub-domain. A significant majority of ≥ 62% of participants expressed agreement with the continuous availability of the technical support team behind the PMR System. They acknowledged the team's responsiveness in promptly addressing any issues that arise during work, troubleshooting problems, and performing regular updates on the PMR System.

However, it is worth noting that approximately 8% of participants disagreed with the technical team's ability to effectively resolve raised issues and their regular system updates. This could stem from the participants' perception that some of the system updates provided are not relevant or do not address their specific concerns to enhance the overall system's performance.

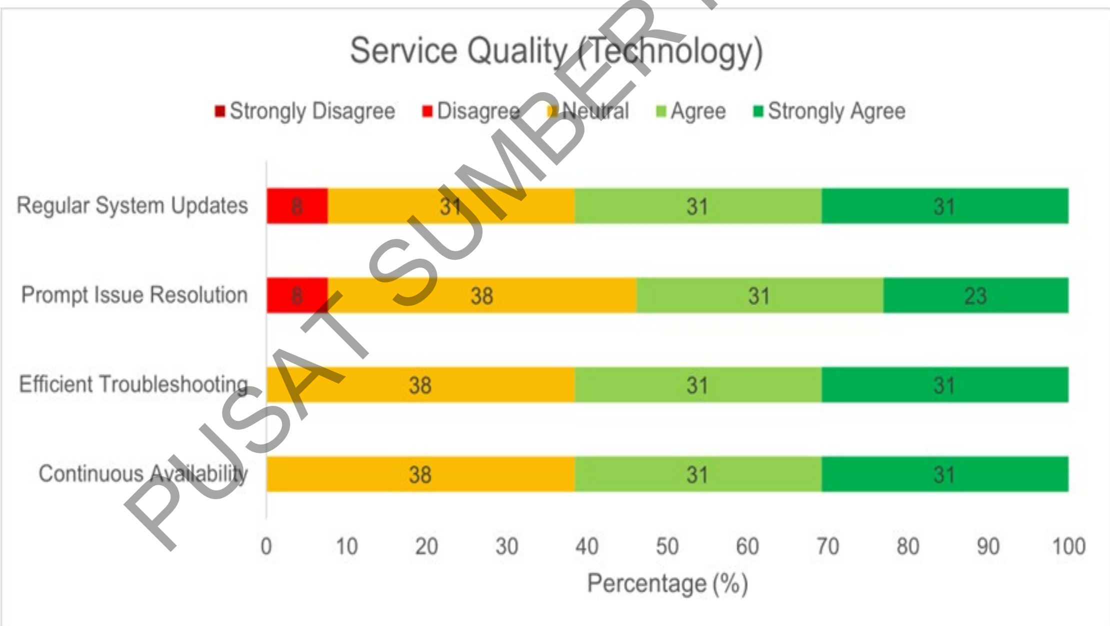

Figure 4.7 Service Quality Responses

Figure 4.8 illustrates the distribution of responses for the System Use sub-domain. A minimum of ≥ 54% of participants actively promote the utilization of the PMR System for blood pressure recording among patients and colleagues. Although the PMR System is considered user-friendly and provides access to all patient profiles, the actual utilization rate for recording, monitoring, and sharing health records is surprisingly low, with only ≤ 23% of participants reporting active usage. Moreover, 8% of participants expressed reluctance to employ the PMR System for these purposes, while the remaining ≥ 62% showed varying levels of engagement or non-engagement with the system. However, it is worth noting that approximately 62% of participants still expressed interest in future training and updates for the PMR System. These findings highlight the existence of potential issues within the Technology domain that require further investigation. It is essential to explore the specific flaws or challenges hindering the widespread utilization of the PMR System to enhance its adoption.

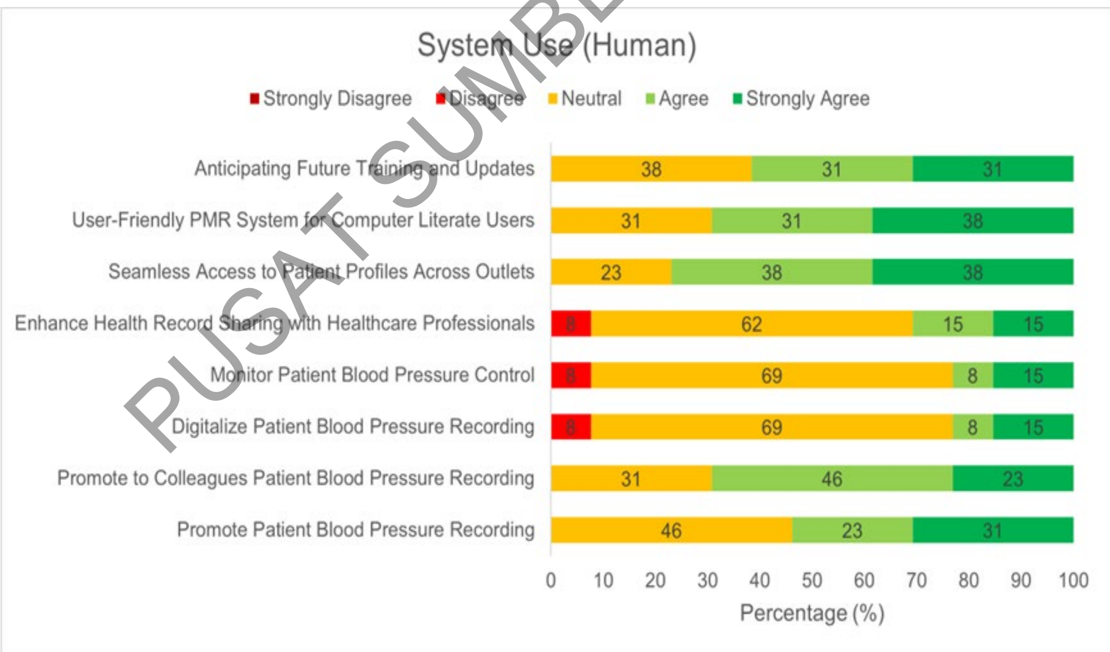

Figure 4.8 System Use Responses

Figure 4.9 illustrates the distribution of responses for the User Satisfaction sub-domain. There is ≥ 61% of participants agree that the PMR System effectively records accurate and real-time blood pressure data, facilitating a better understanding of patient blood pressure control. However, around 15% of participants disagree that the system can effectively reduce HBPM reporting errors. This is because the participants still need to manually input their blood pressure data into the PMR System, which introduces the possibility of human errors during the data entry process. As a result, some participants remain unconvinced about the system's ability to eliminate reporting errors completely. In terms of overall satisfaction, ≤ 38% of participants find it efficient in reducing their daily workloads and improving productivity simultaneously. Up to 16% of participants express dissatisfaction with using the PMR System to record and monitor blood pressure data. This dissatisfaction may stem from poor system quality, including occasional lag and a non-user-friendly interface, which negatively impact the user experience.

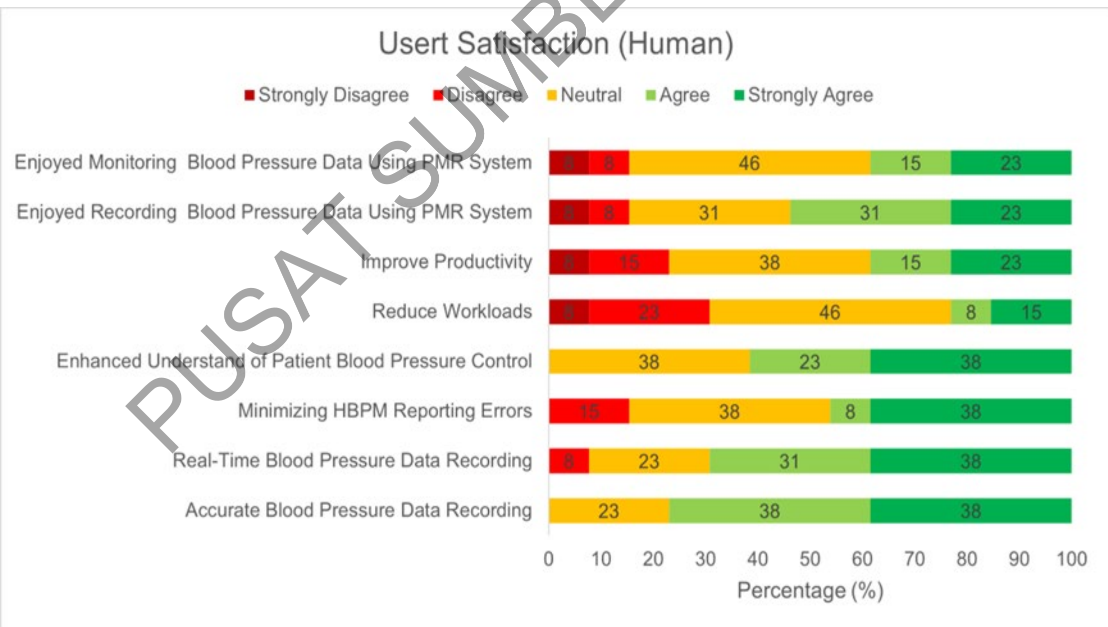

Figure 4.9 User Satisfaction Responses

Figure 4.10 illustrates the distribution of responses for the Net Benefit domain. A significant majority of ≥ 69% of participants strongly believe that the utilization of the PMR System can greatly enhance the accuracy and reliability of HBPM. This improvement in the accuracy of HBPM readings has the potential to positively impact hypertension diagnosis and monitoring by healthcare professionals, enabling them to make more informed decisions and provide better care to patients. Consequently, the utilization of the PMR System offers a collaborative opportunity by enhancing communication between patients and community pharmacists.

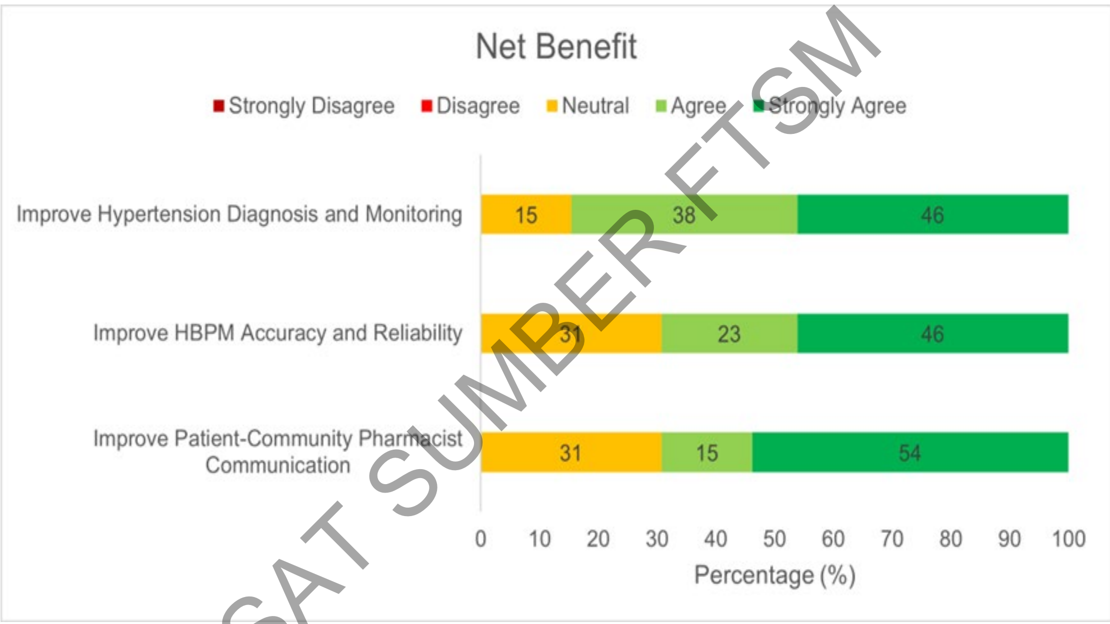

Figure 4.10 Net Benefit Responses

Table 4.8 presents the mean performance scores of the Technology, Human, and Net Benefit domains for the PMR System. The performance scores are categorized into three levels: low, neutral, and high. To establish these intervals, we divided the difference between the highest and lowest possible mean scores by 3, resulting in an interval of 1.33 (Low = 1.00-2.33, Neutral = 2.34-3.67, High = 3.68-5.00).

From the table, we can see that most of the sub-domains have achieved a high-performance level of > 3.68, indicating their effectiveness in contributing to the overall benefits of the PMR System. However, the User Satisfaction sub-domain scores a neutral performance level of 3.63 ± 1.09. This suggests that some participants expressed less satisfaction with the PMR System, despite its overall high performance in facilitating net benefits. These findings indicate the need for further exploration and improvement in the User Satisfaction aspect of the PMR System.

Table 4.8 Overall Performance Scores of the PMR System

Domain	Mean ± SD
Technology	
System Quality	4.29 ± 0.75
Information Quality	4.35 ± 0.76
Service Quality	3.85 ± 0.91
Human	
System Use	3.74 ± 0.85
User Satisfaction	3.63 ± 1.09
Net Benefit	4.23 ± 0.86

Due to the previously reported neutral performance score in User Satisfaction, we conducted further exploration to identify specific questions that contributed to this result. Table 4.9 displays all the questions under the User Satisfaction domain with neutral scores category (2.34-3.67). Participants indicated disagreement with the following aspects of the PMR System: its ability to reduce their daily workloads (3.00 ± 1.15) and improve their productivity at work (3.31 ± 1.25). Additionally, participants expressed a lack of enjoyment when using the PMR System for recording (3.54 ± 1.20) and monitoring patients' blood pressure data (3.38 ± 1.19).

After analyzing other questions in the Technology and Human domains, we identified potential factors contributing to these dissatisfactions, which can be improved. These factors are primarily related to the System Quality and System Use of the PMR System. In terms of System Quality, the PMR System does not consistently operate smoothly, as reflected by a mean score of 3.38 ± 1.19. Occasional noticeable lag may occur, which can negatively impact User Satisfaction. This lag could be attributed to poor or outdated hardware that hinders the system's performance and speed. Possibly unable to keep up with regular system updates. Furthermore, the lag may inconvenience participants when using the PMR System for tasks such as recording and monitoring patient blood pressure data (3.31 ± 0.85), as well as sharing health records with other healthcare professionals (3.38 ± 0.87).

Table 4.9 Potential Factors Affecting User Satisfaction

Sub-Domain	Mean ± SD
System Quality	
Operates smoothly without any noticeable lag	3.38 ± 1.19
System Use	
Record patient blood pressure instead of manually	3.31 ± 0.85
Monitor patient blood pressure control	3.31 ± 0.85
Share the health records with other healthcare professionals	3.38 ± 0.87
User Satisfaction	
Reduce daily workloads	3.00 ± 1.15
Improve productivity at work	3.31 ± 1.25
Enjoyed using the PMR System to record patient's blood pressure data	3.54 ± 1.20
Enjoyed using the PMR System to monitor patient's blood pressure control	3.38 ± 1.19

4.2 DISCUSSION

4.2.1 Home Blood Pressure Monitoring (HBPM) Best Practices

Based on our findings, we have observed a similar trend to the study conducted by Kumar Devaraj et al. (2018b), where a significant number of patients owned automated electronic upper arm devices for HBPM. In our study, we found that people of various age groups, regardless of whether they have hypertension or not, are practicing HBPM to some extent. This indicates that awareness of routine blood pressure screening is gradually increasing among the population, with more and more younger individuals taking proactive steps to manage their health, including hypertension.

Our results highlight a significant lack of knowledge regarding HBPM best practices among customers. Many customers who practice HBPM do not adhere to a fixed monitoring schedule. Instead, they perform HBPM randomly once or twice a week at different times of the day based on personal preference. This inconsistent monitoring approach is concerning due to various sources of inaccuracies that can influence the accuracy of blood pressure measurements as highlighted by Kallioinen et al. (2017c). As a result, the HBPM readings obtained and reported by these individuals may not be accurate and reliable. Therefore, any single blood pressure reading outside the expected range should be interpreted cautiously for clinical decisions.

According to Bello et al. (2018), the recommended number of measurements for a reliable estimate of HBPM is a minimum of 2 morning and 2 evening readings, or at least 1 morning and 1 evening reading over a minimum period of 3 days. Preferably taken before taking antihypertensive medications in the morning and before going to bed in the evening (Muntner et al. 2019b). Given that most of the customers in our study reported performing less than 2 readings, the obtained readings may not accurately reflect their overall hypertension control. It is important to emphasize the significance of consistent monitoring and the need to calculate the average of multiple readings. As this information can help to provide clinicians with a more reliable representation of an individual's blood pressure status for better clinical assessment and interventions.

Upon evaluating the extent of HBPM quality among individuals in our research, there is also a lack of adequate measuring skills required for accurate HBPM performance. Regarding the technique of positioning during HBPM, we observed that only 60% of patients demonstrated successful positioning for each criterion. One common error we observed was the lack of back support from the chair, with patients often unknowingly leaning forward. Followed by some respondents did not pull the cuff taut. These positioning errors could significantly impact the accuracy of blood pressure readings as shown in Figure 4.11. Thus, it is important to ensure these customers possess a strong fundamental with the necessary preparations for HBPM. Therefore, acquiring sufficient knowledge and skills for proper blood pressure measurement is vital in ensuring the accuracy and reliability of HBPM readings.

Figure 4.11 Effects of Improper Positioning on Blood Pressure Readings

Source: American Heart Association (AHA) Target:BP

We also observed that approximately 75% of the customers reported receiving instructions from healthcare providers, with the majority coming from community pharmacists. This highlights the important role that community pharmacists can play in educating patients on HBPM best practices. Since patients often visit pharmacies for medication refills, community pharmacists are well-positioned to provide guidance on proper HBPM techniques whenever needed. In contrast, physicians in clinics may have limited time and resources to effectively conduct such education due to their other responsibilities. Community pharmacists can fill this gap by empowering patients with the necessary HBPM knowledge to reduce the frequency of measurement errors.

One of the main factors contributing to the poor knowledge and measuring skills in HBPM is the source of information from which customers receive guidance. Without up-to-date knowledge and awareness of the latest recommendations, there will always be a lack of proficiency in HBPM. This is particularly evident when it comes to adhering to best practices in HBPM, as many customers demonstrated incorrect measurement techniques. Hence, it is crucial to emphasize the importance of reliable information sources, as they ultimately affect the competency of those practicing HBPM. Insufficient knowledge of HBPM poses a barrier to its effective clinical implementation for both patients and healthcare professionals, as discussed by Liyanage-Don et al. (2019b). Therefore, consistent education and training on HBPM practices should be provided not only to patients but also to all healthcare professionals. Formal training should be implemented for healthcare professionals, along with periodic re-education to avoid the deterioration of knowledge and skills over time as suggested by Dymek et al. (2019). By enhancing the knowledge and skills of both patients and healthcare professionals, we can improve the overall quality and effectiveness of HBPM in the management of hypertension.

Another potential contributing factor is the lack of a localized HBPM guideline widely accepted and followed by healthcare professionals in Malaysia, as highlighted by Wang et al. (2021b). The absence of such guidelines may lead to lower awareness of HBPM and inadequate knowledge of best practices. Currently, various international guidelines are available online, and different healthcare professionals may refer to different guidelines based on their personal preferences and practices. This can result in confusion or non-standardized instructions in the instructions provided. To address these issues, it is recommended to develop a standardized HBPM guideline specific to the local context. This would ensure consistent and reliable information dissemination by healthcare professionals to improve the overall quality of patient HBPM.

4.2.2 Technology

In terms of the Technology factor, three sub-domains were assessed: System Quality, Information Quality, and Service Quality of the PMR System. For System Quality, the current level of the Health Summary features is ready to be used as a blood pressure monitoring system. The overall system can be considered user-friendly and easy to learn. Basic tasks such as entering new blood pressure records, searching, editing, and printing health records can be performed accordingly without any issues, indicating that the PMR System has the necessary functionality to serve as an HBPM application.

However, despite the satisfactory functionality of these basic features, we did identify some concerns regarding the system's operation and user interface. One notable issue is the occasional lag experienced when using the PMR System for data input. These lag problems may contribute to other complaints, such as a non-efficient registration process and a less user-friendly interface. These issues can directly impact the user experience, particularly during busy periods at the community pharmacy when community pharmacists need to navigate and retrieve patient records swiftly for review while serving customers simultaneously.

A similar issue arises with the user interface, as the current registration process can only be completed through the PMR System confirmation at the community pharmacy interface, limiting the convenience for individuals who wish to register for the service through the Caring Pharmacy mobile application. Ideally, customers should have the option to complete the registration themselves at their convenience, alleviating the additional workload for community pharmacists.