EVALUATION OF GHANA's NATIONAL HEALTH INSURANCE SCHEME (NHIS)'s MOBILE RENEWAL SERVICE INTERVENTION

BY

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Abstract

Background: Taking advantage of technological advancement, the National Health Insurance Authority (NHIA) of Ghana launched the Mobile Renewal Service (MRS) in December 2018 to allow the National Health Insurance Scheme (NHIS) subscribers to renew their membership on mobile money platforms in Ghana. The MRS intervention offers a simple, quick, and cost-effective method for NHIS Subscribers to renew their membership annually without physically visiting an NHIS district office. However, there has yet to be any rigorous evaluation of the effectiveness of this intervention. Also, there is limited understanding of the barriers and facilitators influencing the adoption of the intervention from the perspective of NHIS subscribers and the intervention implementers in West Africa. Therefore, this thesis seeks to contribute knowledge on the effectiveness of MRS in Ghana and provide empirical evidence on the barriers and facilitators influencing the adoption of MRS. This contribution could offer evidence-informed policies that could have significant public health implications by ensuring timely insurance renewals and continuous insurance coverage, which could potentially prevent mortalities and morbidities due to health accessibility interruptions.

Methods: The thesis adopted multiple approaches, including a literature review, interrupted time series analysis and a Delphi study. Twenty-five studies in West Africa were reviewed to understand how they approached this research topic, identify knowledge gaps on mHealth around the evaluation of mobile renewal service, establish what is known about the topic, and provide the research questions and methodological directions for this thesis. After that, an Interrupted Time Series Analysis (ITSA), using an Ordinary Least Squares (OLS) regression model, was fitted to examine and evaluate the effectiveness of MRS using secondary data from the NHIS's membership database. Afterwards, stakeholders (NHIS subscribers and policy implementers) were engaged through online survey platforms to explore their perspectives on barriers to MRS adoption and interventions to tackle the identified barriers. Structural equation modelling, Delphi and thematic analyses were then conducted to ascertain the barriers and facilitators affecting the implementation of MRS and the need for more evidence on the critical drivers of adherence to MRS.

Results: The literature review identified research scarcity on the evaluation of mHealth utilisation and a lack of evidence on the critical drivers of adherence to MRS adoption from the perspective

of users and policy implementers. The ITSA showed that the MRS intervention significantly increased NHIS subscription renewal compared to the conventional/manual renewals (Coefficient = 6.06; $p<0.05$), resulting in a statistically significant decline in manual renewals over a 60-month period ($p<0.05$). On facilitators of MRS usage, the subscribers highlighted factors, such as time and travel cost saving, convenience and comfort of renewal, as the key drivers of MRS adoption while the implementers. These findings were corroborated by the policy implementers as they also indicated that ease of use and operational convenience, perceived usefulness, and affordability are the critical enablers of MRS adoption. However, there was divergence in their perspectives on the barriers to MRS adoption. For example, while the policy implementers indicated that illiteracy, poverty and resistance to change as the key barriers to MRS adoption, the subscribers mentioned peer pressure and community endorsement, and the platform's engagement appeal as the key challenges to adopting MRS. Notwithstanding, they both agreed that network connectivity is a significant barrier to using the MRS intervention.

Conclusion: The MRS intervention has significantly increased NHIS renewals, translating into an uninterrupted access to healthcare through health insurance. To upscale the potential of the MRS intervention, the NHIA could consider addressing key barriers, such as network connectivity, to ensure the continuous uptake of the intervention to enhance healthcare accessibility in Ghana.

Declarations

I, Richard Aidoo, declare that this thesis is my original work, except where otherwise acknowledged. I also declare that the materials contained in this thesis have not been submitted wholly or in part for any academic award or qualification other than that for which it is now submitted.

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Dedication

This thesis is dedicated to my three lovely children, Nana Akua Adom Aidoo, Ewuramah Alua Aidoo and Papa Kwabena Ennin-Aidoo.

Table of Contents

List of tables

List of Figures

List Equations

List of Boxes

List of Abbreviations

NHIA – National Health Insurance Authority

NHIS – National Health Insurance Scheme

MRS – Mobile Renewal Service

OLS – Ordinary Least Square

USSD – Unstructured Supplementary Service Data

IVR – Interactive Voice Response

CASP – Critical Appraisal Skills Program

ORS – Oral Rehydration Solution

MNCH – Maternal, Newborn, and Child Health

ANC – Antenatal Care

RCT – Randomised Controlled Trial

MM – Mobile Midwife

CDA – Client Data Application

QALYs – Quality Adjusted Life Years

CSC – Collaborative Stepped Care

UTAUT2 – Extended Unified Theory of Acceptance and Use of Technology

ITSA – Interrupted Time Series Analysis

TRA – Theory of Reasoned Action

TAM – Technology Acceptance Model

TPB – Theory Planned Behavior

SEM – Structural Equation Modelling

RMSEA – Root Median Square Error of Approximation

CFI – Comparative Fit Index

TLI – Tucker-Lewis Index

KMO – Kaiser-Meyer-Olkin

ARIMA – Autoregressive Integrated Moving-Average

LMICs – Low-Middle-Income Countries

IQR – Interquartile Range

ACF – Autocorrelation Function

PACF – Partial Autocorrelation Function

PE – Performance Expectancy

EE – Effort Expectancy

FC – Facilitating Conditions

SI – Social Influence

HM – Hedonic Motivation

PV – Price Value

UB – Use Behaviour

BI – Behavioural Intention

HT - Habit

AVE – Average Variance Extracted

KMO – Kaiser-Meyer-Olkin

ICR – Internal Consistency Reliability

CA – Cronbach's Alpha

CR – Composite Reliability

AVE – Average Variance Explained

CFI – Comparative Fit Index

TLI – Tucker-Lewis Index

CHAPTER ONE: INTRODUCTION

1.1 Background

The integration of technological advancements into healthcare delivery systems has significantly reshaped global health services over the years (McCraken et al., 2017; Gopal et al., 2022). Among these advancements, mobile health (mHealth) technology has emerged as a transformative solution, addressing challenges inherent in traditional healthcare systems, including geographical and economic accessibility barriers (Ventola, 2014; Chang et al., 2012). mHealth refers to the utilisation of mobile devices—such as smartphones, tablets, and personal digital assistants (PDAs)—to support medical and public health practices, with the goal of enhancing health outcomes (WHO, 2011). mHealth leverages mobile devices to enhance health outcomes by improving disease understanding, patient-provider communication, and care quality. It is recognised as a subset of eHealth, integrating digital tools to advance healthcare accessibility across economic and geographical boundaries.

Low- and middle-income countries (LMICs), in particular, are adopting mHealth to support their pursuit of universal health coverage, aligning with Sustainable Development Goal (SDG) 3.8 (Obadha et al., 2020; Chemin, 2018). Its applications range from increasing patient understanding of diseases to fostering communication between patients and healthcare providers (Labrique et al., 2013). Despite its potential, the implementation of mHealth and digital health interventions remains uneven, with barriers such as technological limitations, inconsistent outcomes, and inadequate digital literacy among target populations (Rokicki and Fink, 2017; Gurupur and Wan, 2017).

While mHealth holds promise, alternative strategies, such as leveraging Community Health Workers (CHWs), have been emphasised by the World Health Organisation (WHO) as complementary or substitute approaches, particularly for marginalised populations who may not benefit from mobile health technologies due to a lack of access to mobile phone where these technologies operate. (Tulenko et al., 2013; Cometto et al., 2018). CHWs act as crucial intermediaries between these populations and healthcare system accessibility; therefore, they could be provided with mobile phones, which they could use to offer mHealth services to these

populations en masse, promoting the upscale of these contemporary technologies and addressing accessibility-related health inequality (Ahmed et al., 2022; Pallas et al., 2013).

1.2 Ghana's mHealth landscape and research problem

Ghana introduced the National e-Health Strategy in 2010, which aimed to leverage mHealth solutions for improved healthcare delivery (Afagbedzi et al., 2013). One of the key interventions in the e-Health Strategy is the implementation of the National Health Insurance Scheme's (NHIS) Mobile Renewal Service (MRS) to facilitate an easy and convenient process for renewing health insurance subscriptions. The service, delivered in conjunction with mobile telecommunications providers in Ghana, aimed to enhance the uptake, retention and continuous subscription to the NHIS, prevent disruptions to healthcare delivery due to challenges in manually renewing health insurances (such as NHIS renewal office closures), and ultimately address financially inaccessibility to healthcare in Ghana (Boaheng et al., 2019; Nsiah-Boateng et al., 2023). Ultimately, MRS facilitated a transition from the traditional 'cash and carry system' to an insurance-based health delivery system, as it offered a cost-effective solution for insurance renewal, marking a significant milestone in enhancing healthcare accessibility (Aryeetey, 2012). This healthcare evolution provides valuable insights into opportunities of mHealth implementation and their scalability implications for enhancing healthcare accessibility in Ghana. However, systemic inefficiencies, including enrollment bottlenecks and inequitable access, persist (Kotoh and De Geest, 2016).

While the service has been commended for its crucial benefits, its uptake and adoption are considerably low (Awoonor-Williams et al., 2016). In addition, while studies have examined the uptake of MRS intervention, its aim of retaining subscribers of NHIS is scarce in the literature (Awoonor-Williams et al., 2016; Boaheng et al., 2019). There is a need to examine whether subscribers continue to use the service after their initial subscription/registration, as this is central to promoting the NHIS's objective of preventing healthcare accessibility disruptions. Therefore, there is a need to first understand why the uptake is low and, second, examine whether the intervention has been effective in ensuring a continuous uptake of the service. The findings from these analyses could inform the scalability and sustainability of the MRS intervention. This study,

therefore, examined the barriers and facilitators to MRS adoption from the perspectives of subscribers and NHIS policy implementers and evaluated the effectiveness of MRS by comparing the renewal trends of MRS to those of the conventional manual renewal system.

1.3 Setting the scene for positioning mHealth within the context of MRS for health insurance

mHealth interventions are traditionally designed to improve healthcare delivery, patient engagement, and clinical outcomes. Accordingly, MRS for health insurance renewal and purchase differ fundamentally from mHealth because it does not directly provide healthcare. Nonetheless, it enables financial risk protection for future healthcare needs. Therefore, understanding how mHealth frameworks apply to MRS requires an exploration of the behavioural motivations and decision-making processes behind adopting mobile technologies for health insurance services. These motivations include digital accessibility and ease of use because the same factors that drive mHealth adoption—convenience, accessibility, and reduced costs—also facilitate health insurance enrollment via MRS (Agarwal et al., 2016). Others are behavioural nudges, e.g., just as SMS reminders in mHealth improve medication adherence, similar mobile notifications and automated renewal prompts, which are system-generated reminders for policy renewal, enhance insurance renewal rates (Free et al., 2013). Thus, while health insurance uptake is not the same as healthcare utilisation, both share common adoption facilitators and challenges that make mHealth frameworks relevant to MRS interventions.

The rationale for not considering other insurance markets, like life or car, was because traditionally, they focus on risk pooling, moral hazard, and premium pricing dynamics. These markets help understand long-term risk assessment and financial sustainability. However, they are not fully applicable to MRS adoption for NHIS renewal because unlike car or life insurance, where risks are probabilistic and claims may never materialise, health insurance is linked to the inevitability of health risks (Arrow, 1963). Further, people buy life or car insurance due to legal obligations or long-term financial planning. In contrast, health insurance purchase and renewal often depend on perceived health risks and immediate affordability (Pauly et al., 1990). In addition, health insurance schemes, e.g., Ghana's NHIS, often involve government subsidies, public sector

engagement, and equity-focused policies, which differ from private insurance markets that operate on profit-maximising principles (Lagomarsino et al., 2012). Therefore, while some elements of insurance market frameworks could be relevant (e.g., behavioural economics in insurance uptake), they were not prioritised in this thesis because MRS operates within a public health and financial protection framework rather than a purely commercial insurance model.

1.4 Aim and Objectives

This study seeks to evaluate the effectiveness of Ghana's NHIS's MRS and explore barriers and facilitators influencing its adoption. The specific objectives are:

1. **Effectiveness Evaluation:** Assess the effectiveness of the NHIS's MRS – is the NHS's MRS more effective than the manual renewal service?
2. **Subscribers Perspectives:** Investigate the factors influencing the adoption of MRS – What factors influence the adoption of the NHIS's MRS by subscribers?
3. **Policy Implementers Perspectives:** Explore the barriers and facilitators to the adoption of MRS from the perspective of NHIS implementers and policymakers - What are the barriers and facilitators to the NHIS's MRS adoption according to policy implementors?

1.5 Theoretical and methodological approaches

The study adopted multiple approaches to explore the impact of NHIS's MRS. First, it employed a quasi-experimental design, complemented by an Interrupted Time Series Analysis (ITSA), to assess MRS's effectiveness compared to the conventional manual renewal approach. It used 5-year renewal trends (2016 – 2020) data as an outcome for the MRS effectiveness assessment. The choice of the quasi-experimental design was because it was the most relevant experimental design for the effectiveness analysis because it was impossible to randomly assign participants into intervention and control groups (Brenner, S et al., 2020). This impossibility was due to the nature of MRS and the lack of access to participants to ensure randomisation. After the ITSA analysis, a Structural Equation Modelling (SEM) was conducted to ascertain whether the increase in NHIS renewals post the implementation of MRS could be attributed to MRS. This second-layer

examination was first to validate the ITSA's effectiveness analysis findings and, second, to offer a robust analysis that could offer more precise evidence to support policy discourses and decisions around the scalability of MRS.

After the effectiveness analyses, the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) theoretical framework was leveraged to explore the barriers and facilitators to adopting MRS from the NHIS's subscribers' perspectives. The rationale for using the UTAUT2 was informed by the literature, its sensitivity to examining the drivers of mHealth interventions/services, and its comprehensiveness in eliciting all the potential drivers of e-health technology innovations (Venkatesh et al., 2012). For example, the UTAUT2 framework offers a wide-ranging array of all the potential factors that could influence e-health technology adoption, such as operational convenience (Effort Expectancy), perceived usefulness (Performance Expectancy), affordability (Price Value), peer pressure and community endorsement (Social Influence) (Venkatesh et al., 2012). Therefore, integrating this framework in examining the barriers and facilitators of MRS adoption provided a robust lens that ensured a holistic understanding of the drivers of MRS adoption.

The UTAUT2 framework was not used to examine the drivers of MRS adoption from the perspectives of the policy implementers. The rationale for this exemption was first to offer a complementary approach to how the implementer's perspectives have been examined in the literature, allowing evidence validity. More importantly, many of its constructs, including performance expectancy, effort expectancy, and social influence, were more hinged around elucidating behavioural dynamics of technology adoption, and these were less relevant in the implementer's analyses, where the focus was on understanding operational challenges and facilitators to technology adoption. Therefore, the Delphi approach was used to examine the policy implementers' perspectives on barriers and facilitators to MRS adoption. This methodological approach offered the implementers an iterative opportunity to achieve consensus on the critical drivers of MRS adoption to guide relevant policy decisions on MRS scalability from the perspective of policy implementers.

Despite the selective application of the UTAUT2 framework, the findings from theoretical and empirical analyses were integrated cohesively into the discussion chapters, creating a unified

narrative. This integration maximized analytical depth and practical relevance, reflecting a deliberate methodological choice to align theoretical tools with the specific demands of the research questions. It underscores the study's commitment to methodological flexibility and its aim to produce robust and actionable findings. By using alternative methods to examine the user and implementer perspectives, the study offers complimentary findings that expanded its understanding of MRS beyond user-centric factors to include systemic and operational dimensions.

1.6 Contributions of the thesis

This thesis makes significant contributions to the existing body of knowledge, policy formulation, and practical application of mHealth interventions. From a literature standpoint, the research addresses critical gaps by providing empirical evidence on the effectiveness of mobile renewal services within Ghana's NHIS. It also explores the barriers and facilitators to adoption, offering a nuanced understanding of the factors influencing the acceptance and use of mHealth technologies in low- and middle-income settings.

Methodologically, the study applies robust analytical tools such as Interrupted Time Series Analysis (ITSA) and Structural Equation Modelling (SEM) to evaluate the intervention's longitudinal impact and the causal relationships that shape user behavior and policy outcomes. These methods offer innovative frameworks for assessing mHealth interventions, particularly in resource-constrained environments. Additionally, the findings yield critical insights for policymakers, providing a data-driven foundation for designing scalable and user-centric mHealth solutions. The study's evidence-based recommendations highlight strategies to enhance the effectiveness and sustainability of mHealth systems, making them more inclusive and impactful in achieving universal health coverage.

1.7 Public health significance

The findings of this study have substantial public health implications, particularly for addressing systemic inefficiencies associated with financial accessibility to health. By evaluating MRS for health insurance renewals, the research highlights how digital health solutions can reduce health

insurance enrollment bottlenecks and improve access to essential health services, especially for underserved populations. This aligns with global efforts to achieve universal health coverage by leveraging technology to address healthcare disparities. Furthermore, the study underscores the importance of addressing barriers to adoption, including technological, cultural, and infrastructural challenges, to ensure equitable implementation of mHealth interventions. Through its focus on Ghana, the research also contributes to a broader understanding of how mHealth initiatives can be tailored to local contexts while addressing global challenges. The results emphasise the need for sustainable funding mechanisms, stakeholder engagement, and integration into existing healthcare frameworks. These elements are critical for ensuring the longevity and scalability of mHealth interventions, which are increasingly recognised as vital tools for improving public health outcomes.

1.8 Structure of the thesis

The structure of this thesis ensures a logical progression from the identification of the research problem to the presentation of findings and their implications. Chapter one introduces the study, outlining the research problem, objectives, and significance while establishing the theoretical and methodological frameworks that guide the research. Chapter two provides a systematic review of mHealth interventions, synthesizing existing evidence to contextualize the study and identify gaps in the literature. Chapter three details the research design, data collection methods, and analytical techniques employed, providing a comprehensive explanation of how the study's objectives are addressed. Chapters four and five examines the effectiveness of the NHIS's MRS using ITSA and comparative analysis to evaluate trends and disparities in membership renewal before and after the intervention. Chapter six explores the perspectives of NHIS members, analysing the barriers and facilitators influencing the adoption of MRS, while Chapter seven shifts the focus to policy implementers, investigating their viewpoints on the challenges and opportunities in adoption. Finally, Chapter eight concludes the thesis by summarizing the key findings, discussing their implications, and offering recommendations for policy and practice. The organisation of the thesis ensures a cohesive narrative that integrates empirical analysis with theoretical and practical insights. Figure 1.1 sumarises the structure of the thesis.

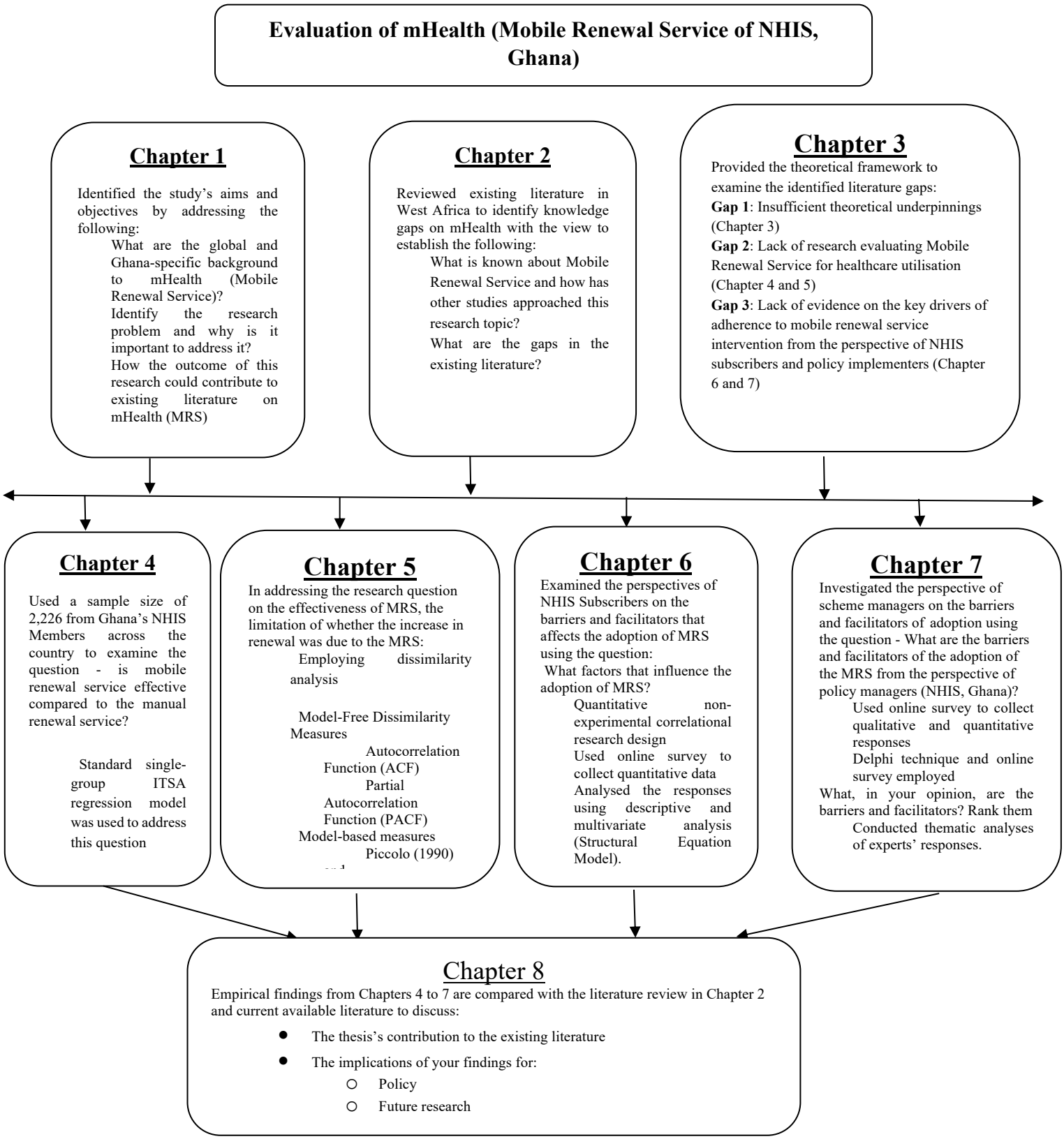

Figure 1. 1:Thesis's structure

1.9 Chapter summary

This chapter discussed the study's background, problem statement, objectives and contributions to the literature. In the next chapter, the study will establish the justification of the methods selected for the literature review. Here, more emphasis is placed on the search strategy, data extraction, and quality appraisal, among others. Finally, the study discusses the findings emanating from the empirical review conducted.

CHAPTER TWO: LITERATURE REVIEW ON EVALUATION OF MHEALTH INTERVENTIONS IN HEALTHCARE DELIVERY

2.1 Introduction

This chapter explores empirical studies on mHealth interventions in West Africa, focusing on their effectiveness, cost-effectiveness, and barriers to adoption. Concentrating on West Africa allows for a geographically and contextually cohesive analysis, given the shared healthcare challenges and opportunities across the region (Azevedo, 2017; Shumen et al., 2017). The chapter aims to identify gaps in existing literature, establish the theoretical underpinnings of the study, and inform the methodology for empirical analysis.

Systematic reviews are instrumental in synthesizing existing research to inform decision-making (Mulrow, 1994). However, they are subject to inherent limitations, such as selection bias and statistical heterogeneity, which may impact the reliability of findings (Muka et al., 2020). Despite these challenges, this systematic review forms the basis for identifying unexplored areas and justifying the need for this study.

. The primary objectives of this review are:

1. To explore and synthesise evidence on the effectiveness of mHealth interventions
2. To assess gaps in the literature, gap on mHealth evaluation
3. To establish the appropriate methods and theoretical framework for the empirical analysis conducted in this research.

Systematic reviews play a pivotal role in research, effectively integrating existing information and providing data crucial for informed decision-making (Mulrow, 1994; Moosapour et al., 2021). However, it is essential to acknowledge potential limitations associated with systematic reviews (Owens, 2021). For example, primarily, systematic reviews rely on a retrospective, observational research design, making them susceptible to systematic and random errors (Lockwood and Oh, 2017). Furthermore, potential limitations include risks of bias, encompassing selection bias, inadequate blinding, attrition bias, and selective outcome reporting. Inconsistencies in the form of clinical or statistical heterogeneity, as well as the risk of publication bias, add to the array of

challenges that may impact the reliability and generalisability of the review's findings (Muka et al., 2020). Regardless of these limitations, the systematic review was relevant in this study as it was crucial in identifying the gaps in knowledge and determining the appropriate methodology and theoretical framework for the empirical analysis conducted in this research.

2.2 Method

Protocols for systematic reviews play a crucial role in ensuring transparency, consistency, and methodological rigor throughout the review process. By establishing a clear plan and predefined methods, protocols serve as a guide for researchers, preventing unilateral decision-making and potential biases (Gough and Oliver, 2019; Gurevitch et al., 2018). They also enable readers to assess the reliability and comprehensiveness of the review by allowing comparisons between the planned procedures and the completed review. Notably, international organisations like the Cochrane and Campbell Collaborations and the Agency for Healthcare Research and Quality (AHRQ) often require and publish protocols. In the context of this research, the systematic review's protocols were published in PROSPERO (CRD42021242403) before the review commenced, aligning with established best practices. The method of this review was informed by a pilot review (shown in Appendix 1) conducted initially to seek information on the methodology used in previous review studies on mHealth.

To enhance the reporting consistency and clarity of the review, the Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) checklist was followed (Page et al., 2021). PRISMA is a widely recognised guideline that helps ensure comprehensive reporting of systematic reviews. By adhering to PRISMA, the review maintains a standardised approach to selecting relevant papers and reporting the findings. This promotes transparency, allows for better evaluation of the review's methodology, and facilitates reproducibility (Moher, 2009; Jumah, 2021).

2.2.1 Search strategy

Four electronic databases: SCOPUS, Web of Science, PubMed, and PsycInfo were systematically searched with the view to identifying relevant articles published in peer-reviewed journals between 2010 and 2020. The ten-year period was chosen for the systematic review to capture recent

developments in mHealth interventions (Xiao and Watson, 2017). This time frame ensures relevance to the latest technological advancements and the dynamic healthcare landscape. It aligns with standard practices in systematic reviews, balancing comprehensiveness and manageability, and facilitates comparisons with existing literature (Okoli and Schabram, 2010). The focus on the past decade optimizes the retrieval of readily accessible and relevant literature through electronic databases.

Also, the ten-year period selected for the systematic review also aligns with the emergence and growth of mHealth interventions in West Africa (Sey, 2011; ITU, 2013). During this timeframe, there have been notable examples of mHealth takeoff in the region. For instance, in Ghana, the Mobile Technology for Community Health (MOTECH) initiative has been implemented to enhance maternal and child healthcare through mobile phone-based interventions (Willcox et al., 2019). Similarly, in Nigeria, the use of mHealth applications like the Mobile Midwife and Mobile Birth Registration has facilitated access to healthcare information and improved maternal and child health outcomes (Otu et al., 2021).

The date restriction was further tested by conducting a pilot review to capture a breadth of the literature. The findings demonstrated an evident surge of publications on digital technologies in the field of health and medical research starting in the 2000s, explaining the date restriction. The search strategy, inclusion, and exclusion criteria were specified in advance based on a pilot review (Appendix 1) that was conducted to inform the methods of this literature review.

A combination of the keywords and terms as shown in Table 2.1 below were used in the search domains.

Table 2. 1:Search terms

Constructs	**Search terms**
mHealth	*mobile health" OR mHealth"; OR "electronic health" OR "eHealth" OR "digital health" OR "mobile app" OR "mobile application"*
Intervention	*"intervention" OR "controlled trial" OR "RCT"* OR "*disease management*" *OR* "*disease prevention*"

Effectiveness of mHealth	*"cost" OR "economic evaluation" OR effectiveness OR cost-effectiveness OR cost-analysis OR evaluation*
Setting*	*West Africa* OR "*Benin"* OR *"Burkina Faso" OR* "*Cameroon"* OR "*Cape Verde" OR* "*Côte d'Ivoire" OR* "*Gambia" OR* "*Ghana"* OR "*Guinea" OR* "*Guinea-Bissau" OR "Liberia* "*OR* "*Mali" OR* "*Mauritania*: *OR* "*Niger*" *OR* "*Nigeria*" *OR* "*Senegal*" *OR* "*Sierra Leone" OR* "*Togo"*

'Effect size/effect' was not captured as a keyword in the search term under the 'effectiveness of mHealth' construct. Nonetheless, the broad nature of the keywords captured under this construct allowed the identification and inclusion of studies that mention 'effect/size/effect'. All the same, given the critical relevance of 'effect size/effect' for quantifying interventions' impacts and drawing precise conclusions in systematic reviews, it is recommended that future iterations should incorporate this term to ensure a more robust synthesis of findings.

2.2.2 Eligibility criteria

The study applied the PICOS framework (participants, interventions, comparisons, outcomes, and study design) (Eriksen et al., 2018). This framework provided a structured approach for defining key elements in formulating and selecting the relevant studies. Studies were included if they met the PICOS criteria. While the reviewed interventions primarily target health outcomes, their relevance to this thesis lies in their potential to inform strategies for improving insurance renewal processes. The parallels between mHealth's broader health applications and its use in insurance renewal provide a foundation for exploring user engagement and adoption barriers. For example, interventions aimed at improving adherence to medication regimes inform strategies for designing effective mobile renewal systems that enhance user retention. This connection justifies the inclusion of health outcome-focused interventions in the systematic review, as they offer insights into the mechanisms that may influence adoption and effectiveness. Table 2.2 below is a detailed description of the inclusion and exclusion criteria.

Table 2. 2:Description of the inclusion and exclusion criteria

Population	● Studies conducted in West Africa
Intervention	● Any ICT program using a smartphone or tablet to assist, educate, measure, and manage health outcomes.
Comparator	● All comparators, including normal care/practice, no intervention, or other non-technological healthcare approaches
Outcomes	● Measures of effectiveness (e.g., change adherence, uptake, adoption, health outcomes) ● Measures of cost effectiveness (e.g., cost per unit change in uptake or change in health outcome) ● Drivers of effectiveness or cost effectiveness
Study designs	● Studies were included if they were randomized controlled trials (RCTs), quasi experimental studies and pilot studies. ● Mixed method, involving qualitative and quantitative data analysis.

2.2.3 Data extraction

Predetermined data extraction questions, self-designed on an excel sheet, were used to extract pertinent information from selected studies. The data extraction sheet included the following key components: year of publication, research objective, study design, type of intervention, features of the mHealth application, and outcome measures. Including these specific questions in the data extraction template served important purposes. For example, the year of publication provided a temporal context and allowed for the identification of trends or changes in mHealth interventions over time. The research objective helped determine the specific focus and intent of each study, providing insights into the research question being addressed. The study design information was crucial for assessing the quality and validity of the evidence by understanding the methodological approach used in the research. Extracting details about the type of intervention and the features of the mHealth application enabled categorization and comparison of different intervention strategies, technologies, or approaches. Lastly, extracting outcome measures allowed for a comprehensive understanding of the effects and effectiveness of the mHealth intervention, encompassing changes in health behaviors, clinical outcomes, patient satisfaction, and health system impacts. The data extraction questions covered two main themes, i.e., general data and methodology.

The methodology section included a question (Q18, table 2.3) that extracted the findings of eligible studies. These findings were initially extracted as part of the broader data extraction process to allow a detailed and robust data extraction process that prevents the omission of critical

information from the studies. This approach ensured that the methods and findings were distinctly represented, allowing analytical clarity. Nonetheless, future reviews could consider this dynamic in line with their reviews' aim. The data extraction questions are illustrated in Table 2.3 below.

Table 2. 3: Data Extraction Questions

Themes	***Review questions***
General Information	1. Authors 2. Year 3. Aim 4. Country/Setting of study
Methodology	5. What was the source of data used? 6. What study design was used? 7. What was the sample size? 8. What was the statistical basis of the sample size? 9. What sampling method was used? 10. Characteristics of the population 11. What statistical methods were used? 12. What method was used for data analysis? 13. What was the theoretical underpinning of the study? 14. Was an evaluation conducted? 15. Was an intervention undertaken? 16. What type of evaluation? 17. What type of intervention? 18. What are the outcomes of the effectiveness analysis? 19. What were the limitations of the study?

2.2.4 Quality appraisal

Two frameworks were employed for quality appraisal in this study: the Critical Appraisal Skills Program (CASP) and the Drummond checklist (see appendices 2 and 3). The CASP framework was employed to assess the quality of studies that focused on mHealth interventions. Its choice was informed by its widely recognised suitability in appraising a diverse range of study designs, offering a systematic approach to evaluate the methodological rigor and validity of research (Harris et al., 2014). Its versatility was particularly relevant for assessing the quality of studies that explore the effectiveness, impact, and outcomes of mHealth interventions (Long et al., 2018). The specific CASP tools used for the appraisal was informed by the study designs of the identified studies. For example, the CASP tool for Randomised Controlled Trials (RCTs) was used to assess the quality

of RCTs included in this review. This approach helped avoid oversimplifying the quality assessment, offered robust assessment of the studies' quality and potentially addressed limitations associated with using a uniform CASP tool. In the appraisal, a maximum of 2 points was allocated to a study if it fully met the requirements of defined CASP items, 1 point if it met some of the requirements, and 0 if the requirement was unmet/not applicable/not specified. Accordingly, studies with scores 17 – 20 were rated good quality, 16 – 13, moderate quality and those with scores below 13 were rated poor quality.

In instances where the studies centered on the economic evaluation of mHealth interventions, the Drummond checklist was utilised for quality appraisal (Drummond et al., 2005; Edmunds et al., 2018). The Drummond checklist is specifically designed for economic evaluations and offers a comprehensive set of criteria to assess the robustness and validity of economic studies. This framework is well-established in the field of health economics, ensuring that studies focusing on the economic aspects of mHealth interventions undergo a thorough and targeted quality appraisal. The Drummond checklist (Drummond et al., 2005) assessed the quality of the economic evaluations. The Drummond checklist for economic evaluation critiques considers: 1) the research question; 2) the description of the study/intervention; 3) the study design; 4) the identification, 5) measurement, and 6) valuation of costs and consequences; 7) whether discounting was done; 8) incremental analysis; 9) presentation of results with uncertainty and sensitivity analyses; and 10) discussion of results in the context of policy relevance. The checklist elements were scored using Doran (2008)'s rating system. The aggregate findings indicate poor (2–7 points), moderate (8–15 points), and high (16–22 points) economic quality.

2.2.5 Data synthesis

The data synthesis in this study utilised a narrative approach. The narrative synthesis involved summarising and interpreting the findings from the selected studies in a descriptive and qualitative manner, rather than employing statistical or quantitative methods (Rai et al., 2020). Given the heterogeneous nature of mHealth interventions and the potential differences in study designs, populations, and outcomes, a narrative synthesis provides a flexible and comprehensive means of summarising and presenting the results (Rai et al., 2020). In the data synthesis, themes were used to structure and enhance the organisation of the identified data. The themes were generated based on the objective of this review and data commonality in the identified studies. This approach

improved the data synthesis rigour and made it easier to compare the studies under key thematic areas: intervention types, barriers, and outcomes. To enhance clarity and accessibility, the synthesised results were also summarised in tables (O'Sullivan and Jefferson, 2020). This tabular presentation facilitates a condensed and structured overview of key study characteristics, interventions, and outcomes, allowing for easier comparisons and identification of patterns within the diverse body of literature. The combination of a narrative synthesis and tabular summaries ensures a nuanced and comprehensive presentation of the synthesised data, catering to the varied dimensions of the included studies.

2.3 Result

The search strategy produced 6,920 records in total from four databases (Scopus = 6,580; PubMed: 257; Web of Science: 62 and PsycInfo: 21). 313 duplicates were removed, and 6,607 studies screened for eligibility. 6,532 studies were removed after title and abstract screening. The remaining records (n = 75) was then screened against the inclusion and exclusion criteria. A further (n = 50) were excluded after a full-text screening because while their titles and abstracts were consistent with the purpose of this review, their full-text were either unavailable (n = 7) or did not show the specific m-Health interventions they examined (n = 32), or their articles were not peer-reviewed (n = 11). Accordingly, the added layer of full-text screening allowed methodological rigour, as it helped unearth critical methodological concerns that could have had implications for the review's findings. To confirm the rigorousness of the screening and avoid omission of relevant papers, the excluded papers were independently reviewed to verify their exclusion from the review. While these processes ensured robustness, search strategies must be constantly revisited to reflect on their potential impact on the sensitivity of literature searches and the comprehensiveness of a review. The thorough screening resulted in the inclusion of 25 studies that met the review's eligibility criteria. The Prisma flow diagram in Figure 2.1 below shows the studies' selection process.

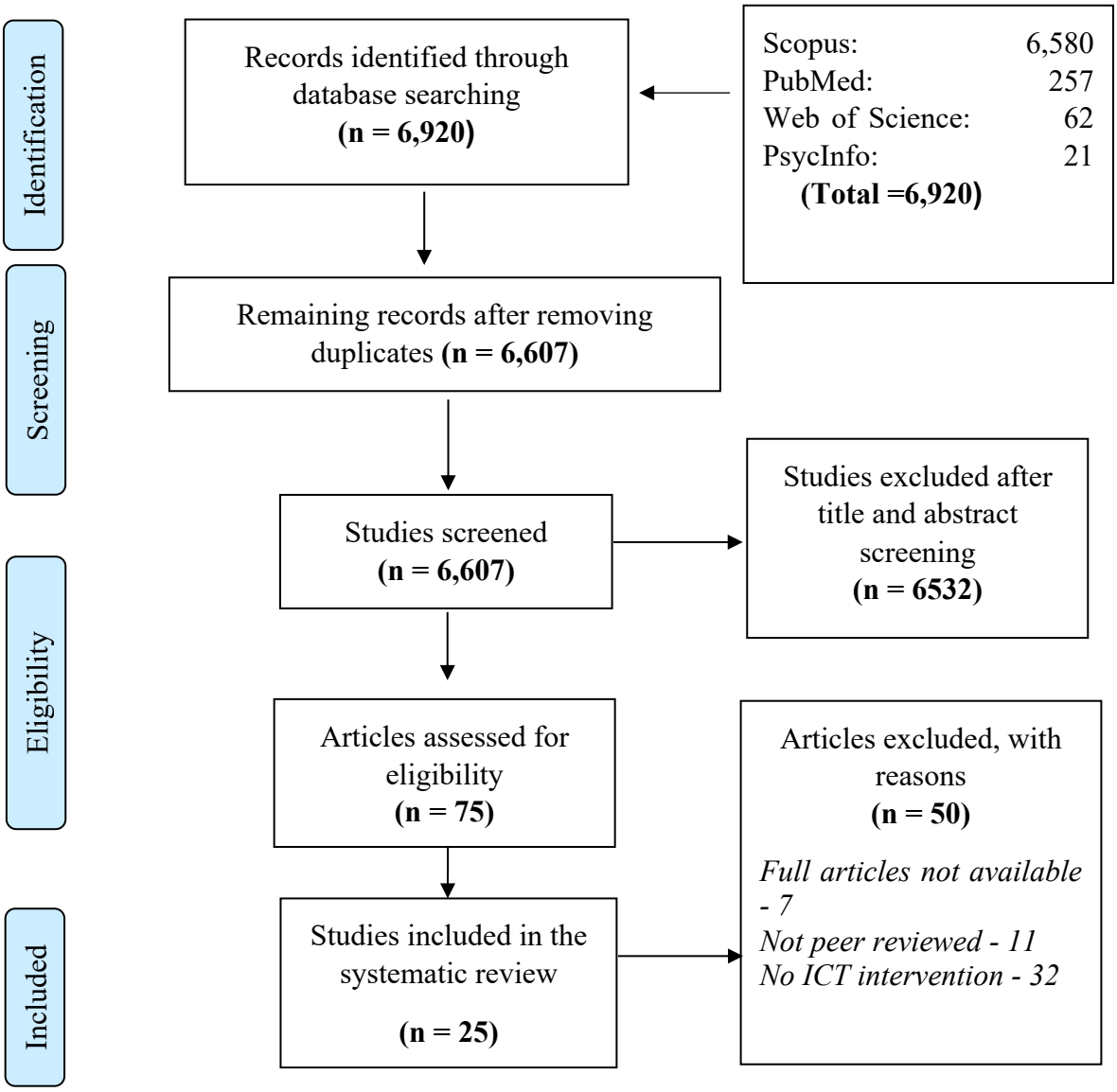

Figure 2. 1: PRISMA diagram showing study selection process

2.3.1 Characteristics of the included studies

As illustrated in Figure 2.1, a total of 25 studies were included in the review. The predominant focus was on Ghana, with 10 studies, closely followed by Nigeria, also with 10 studies. The remaining studies were distributed across Senegal, Niger, Burkina Faso, and Togo. Out of the 25 reviewed studies, 20 focused on the assessment of mHealth app intervention, while the remaining five assessed the economic evaluation of mHealth intervention. Table 5 illustrates the study and sample characteristics. Of the 25 studies, one (Brinkel et al., 2017) was qualitative, one (Nelissen et al., 2018) used the mixed-method approach, and the remaining (n = 23) are quantitative. Twelve

(12) of the included studies are listed as Randomized Control Trials (RCT), while one study (Downs et al., 2019) was a pilot study.

Data collected by the included studies were both primary and secondary. The primary data was collected with varied instruments, such as focus group discussions, in-depth interviews, and questionnaires. The sample size of the studies included in this review ranged from 7 participants (Velez et al., 2014) to 9,368 participants (Kawakatsu et al., 2020). Most studies, especially the randomized controlled trials (RCTs), employed a simple random sampling approach for participant selection. The settings of the studies in this review ranged from rural outpatient clinics and health centers to regional hospitals and drug shops. Appendix 4 illustrates a summary of the 25 studies reviewed in this study. Categorically, these studies have been divided into three parts: assessment of mHealth projects, economic assessment of mHealth projects, and users' perception about mHealth projects.

2.3.2 Results of the Quality Appraisal of Studies

2.3.2.1 Studies Using CASP checklists

Twenty studies were evaluated using the appropriate CASP checklists, each designed for the unique research type. The tests included eight RCTs, five descriptive/cross-sectional studies, 4 cohort studies, and three qualitative studies. All the eight RCTS assessed were deemed of high quality, with ratings ranging from 22 to 26. Additionally, the five cross-sectional studies had scores ranging from 20 to 22, classifying them as high in quality. The four cohort studies evaluated received scores ranging from 25 to 27, indicating a high quality. Finally, the three qualitative studies were of high quality, with scores ranging from 18 to 19. The comprehensive findings are shown in Tables 2.4 to 2.8.

Table 2. 4: CASP checklist results for RCTS

Study	Q1	Q2	Q3	Q4a	Q4b	Q4c	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Total Score
Babalola et al. (2019)	Y	Y	Y	Y	Y	C	Y	Y	Y	Y	Y	Y	Y	24
Fatoye et al. (2020)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	26
Friedman et al. (2015)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	24
Modrek et al. (2014)	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	25
Mohammed et al. (2019)	Y	N	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	22
Olajubu et al. (2020)	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	23
Raifman et al. (2014)	Y	Y	Y	N	N	N	Y	Y	Y	Y	Y	Y	Y	23
Zakus et al. (2019)	Y	Y	N	Y	N	N	Y	Y	Y	Y	Y	Y	Y	23

CASP questions scoring: Yes =2 Can't Tell (?) = 1 No = 0 - ***High Score:*** *20 to 26;* ***Average Score****: 10 to 19;* ***Poor Score****: 0 to 9*

Table 2. 5: CASP checklist results for the qualitative studies

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Total Score
Brinkel et al. (2017)	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	19
Downs et al. (2019)	Y	Y	Y	Y	N	N	Y	Y	Y	Y	18
Akinfaderin et al. (2012)	Y	Y	Y	Y	Y	N	Y	Y	Y	Y	19

CASP questions scoring: Yes =2 Can't Tell (?) = 1 No = 0 - ***High Score:*** *16 to 20;* ***Average Score****: 8 to 15;* ***Poor Score****: 0 to 7*

Table 2. 6: CASP checklist results for the cross-sectional studies

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Total Score
LeFevre et al. (2017)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	22
Rokicki and Fink (2017)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	22
Lepère et al. (2019)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	22
Ngozi, Ogochukwu and Allen (2015)	Y	Y	Y	N	Y	Y	Y	N	Y	Y	Y	20
Peprah et al. (2019)	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	22

*CASP questions scoring: Yes =2 Can't Tell (?) = 1 No = 0 -**High Score**: 17 to 22; **Average Score**: 10 to 16; **Poor Score**: 0 to 9*

Table 2. 7: CASP checklist results for the cohort studies

Study	Q1	Q2	Q3	Q4	Q5a	Q5b	Q6a	Q6b	Q7	Q8	Q9	Q10	Q11	Q12	Total Score
Nelissen et al. (2018)	Y	Y	N	Y	Y	Y	Y	N	Y	Y	Y	Y	Y	Y	26
Velez et al. (2014)	Y	Y	N	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	26
Ebenso et al. (2018)	Y	Y	N	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	Y	27
Mbuagbaw et al. (2014)	Y	Y	Y	N	Y	Y	N	N	Y	Y	Y	Y	Y	Y	25

*CASP questions scoring: Yes =2 Can't Tell (?) = 1 No = 0 -**High Score**: 22 to 28; **Average Score**: 11 to 21; **Poor Score**: 0 to 10*

2.3.2.2 Studies using the Drummond checklist

using the Drummond checklists. Their quality per the checklist ranged from 15 to 20, indicating moderate to high-quality studies. Table 2.8 shows the quality of the economic evaluation studies included in this review.

Table 2. 8: Drummond checklist - quality appraisal scores

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Q11	Score
Bowser et al. (2018)	Yes	Yes	Yes	No	Yes	No	Yes	No	No	?	Yes	16/22
Adewuya et al. (2019)	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	?	Yes	20/22
Kawakatsu et al. (2020)	Yes	Yes	Yes	No	Yes	No	Yes	No	No	?	Yes	15/22
Nsiah-Boateng et al. (2017)	Yes	Yes	No	Yes	No	No	No	No	No	No	Yes	15/22
Willcox (2018)	Yes	Yes	Yes	No	Yes	No	Yes	No	No	?	Yes	16/22

Drummond checklist questions scoring: Yes =2; No = 1 Not Clear (?) =0; Not appropriate=0

2.3.3 Data analysis

All the included studies reported both descriptive and inferential analyses. However, most of the studies used descriptive analysis. The inferential analysis techniques used in the selected studies included regression analysis (linear and logistic), difference-in-differences (DID) analytic method, and propensity score. A number of studies used nonparametric tests such as the Mann-Whitney U test, Friedman test, Kruskal-Wallis, and Wilcoxon tests. None of the studies reported the use of any statistical model diagnostics. Table 2.9 blow depicts the category of data analysis, and the type of data analysis used by the reviewed studies.

Table 2. 9: Data analysis

Types statistical methods	Statistical tests	Number of studied using it	%
Descriptive Analysis (only)	Frequencies, percentages	12	48

Types statistical methods	Statistical tests	Number of studied using it	%
Economic Analysis	Cost effectiveness Sensitivity analysis Differences in total cost Incremental cost	5	20
Regression models	Linear Logistic Multiple	9	36
Nonparametric Tests	Mann-Whitney U test Friedman test Kruskall-Wallis Wilcoxon tests	5	20
Parametric Tests	Difference-In-Differences (DID) Propensity Score Chi-Square T-test	5	20

2.3.4 Theoretical framework

Theoretical frameworks are fundamental to research, offering conceptual clarity, guiding study design, and aiding hypothesis development (Luft et al., 2022). They provide a basis for interpreting findings, structuring literature reviews, and facilitating discussions. The use of theoretical frameworks enhances the rigor of research, contributes to generalisability, and can increase the likelihood of obtaining research funding. Overall, theoretical frameworks play a pivotal role in establishing a solid foundation for research studies and contributing to the cumulative growth of knowledge within a specific field (Hiebert et al., 2023). Of the 25 included studies, only 3 of them (Downs et al., 2019; Mohammed et al., 2019; Ngozi, Ogochukwu, and Allen, 2015) presented theoretical models. The models used in these three studies includes Health Belief Model and the Theory of Planned Behaviour as indicated in table 2.10 below.

Table 2. 10: Theoretical framework used in the reviewed studies

Author (s)	Title	Theoretical framework applied	Brief description of framework	Applicability to research context
Ngozi, Ogochukwu and Allen, 2015	Study on E-Health Utilisation among Nigeria University Undergraduate Students	Health Belief Model (HBM)	The concept assumes that health perceptions drive health behavior change (Gryphon, 2012; Scarinci et al., 2012). Individual perspectives, modifying variables, and health behaviors motivate people.	Not Applicable to the research context. The focus of this study is the adoption and use of the mobile platform to renew premium payment.
Mohammed et al., 2019	SMS for malaria control: quasi-experimental research.	Theory of Planned Behavior	The notion of planned conduct predicts and explains behavior in many settings. The TRA assumes volitional conduct. Attitudes, subjective standards, and perceived behavioural control determine behavioural intents.	Not applicable to the research context.
Downs et al., 2019	mHealth voice communications to enhance baby and early child feeding practices in Senegal	Theory of Planned Behavior	*Described above*	Not applicable to the research context.

2.4 Empirical review findings

The empirical review examines the findings obtained from the comprehensive analysis of mHealth interventions. This synthesis aims to provide insights into key aspects, including the characteristics of the interventions, the types of mHealth strategies employed, and the impact on clinical outcomes. The subsequent subsections discuss these dimensions, offering a detailed understanding

of the diverse landscape of mHealth initiatives and their implications for healthcare delivery and patient outcomes. This section synthesises findings from the reviewed studies, highlighting their relevance to the thesis. While most interventions targeted clinical outcomes, parallels are drawn to their applicability in improving user engagement and adoption within insurance systems. For instance, SMS-based interventions that enhance adherence to treatment protocols offer insights into designing effective mobile renewal reminders.

2.4.1 Characteristics of the mHealth interventions

The mHealth interventions identified in the reviewed studies are mobile phone app, SMS only, both phone-based SMS and voice messages, mHealth app and mHealth platform. Clearly, majority (62.5%) of the interventions described in the reviewed studies are mobile phone based. The mobile phone interventions are driven by adopting one-way text messaging platforms in most of the interventions. The first category of the mHealth intervention is the mobile phone app. Multiple studies (Brinkel et al., 2017; Babalola et al., 2019; Downs et al.2019; Fatoye et al., 2020; Friedman et al., 2015; Modrek et al., 2014; Raifman et al., 2014; Visser et al., 2021; Zakus et al., 2019) have concentrated on interventions disseminated through dedicated mobile applications. These applications are intricately designed to offer distinct functionalities, including medication reminders, symptom tracking, support for behaviour change, and the provision of health education materials. Capitalizing on the advanced features of smartphones, these mobile apps serve as conduits for personalized interventions and contribute to the facilitation of remote monitoring. Examples of mHealth interventions in this category include a study by Friedman et al. (2015) that investigated the management of childhood diarrhea. Brinkel et al. (2017) developed a two-way conversation mobile app designed to systematically assess disease symptoms in sick children and provide relevant health information based on the history of illness received through a mobile-based Interactive Voice Response (IVR) system. Additionally, Fatoye et al. (2020) created a mobile phone app for the management of chronic low back pain.

The second distinctive characteristic among these interventions involves those utilising SMS only. In studies such as Olajubu et al. (2020), short message service (SMS) served as the predominant mode of intervention delivery. SMS interventions entailed sending text messages to patients' mobile phones, delivering reminders, educational content, motivational messages, and

appointment notifications. This approach leveraged the extensive availability and accessibility of mobile phones equipped with SMS capabilities.

Another characteristic of mHealth interventions is the integration of phone-based SMS and voice messages. Numerous studies (Fatoye et al., 2020; Friedman et al., 2015; Modrek et al., 2014; Mohammed et al., 2019; Rokicki and Fink, 2017) adopted a hybrid approach, combining SMS messages with voice messages delivered via phone calls. This amalgamation aimed at enhancing interactivity and engagement, particularly within populations with lower literacy levels or limited access to smartphones. The inclusion of voice messages allowed for more detailed instructions, motivational cues, and personalized support. For instance, Friedman et al. (2015) implemented a strategy where SMS messages were sent every Monday, Wednesday, and Thursday for 8 weeks. These messages focused on encouraging the recommendation of Oral Rehydration Solution (ORS) and zinc while discouraging the use of antimicrobials and antidiarrheal.

The characteristics of these interventions also encompass mHealth apps and mHealth platforms. Several studies (LeFevre et al., 2017; Nelissen et al., 2018; Visser et al., 2021) delved into comprehensive mHealth applications that incorporated a diverse array of features and functionalities. These applications often integrated multiple components, including remote monitoring devices, data collection tools, communication platforms, and decision support systems. In some instances, studies evaluated interventions deployed through mHealth platforms, centralized systems facilitating the delivery of various mHealth interventions such as mobile apps, SMS messages, remote monitoring devices, and data analytics. An illustrative example is the MOTECH platform, where the Mobile Midwife app delivers prerecorded audio messages on Maternal, Newborn, and Child Health (MNCH) education and care in the local language or SMS messages on mobile phones, timed to a woman's gestational age or that of her infant. Nelissen et al. (2018) delved into the effectiveness and utilisation of OMRON, an mHealth app designed for remote patient monitoring. Likewise, Velez et al. (2014) examined the potential of mClinic software. Visser et al. (2021) investigated mobile medical applications for malaria diagnosis.

2.4.2 Types of mHealth interventions

In addition to examining the characteristics of mHealth interventions, another way to understand them is by classifying them based on their function. This classification provides insights into the

specific purposes and goals of different mHealth interventions. Consistent with the categorization proposed by Labrique et al. (2013), the interventions reviewed can be divided into three broad categories: patient follow-up and medication adherence, communication and information for HCWS and health promotion and disease prevention. A general explanation of the various mHealth intervention types identified in the review is provided in the sections below.

2.4.2.1 Patient follow-pp and medication adherence

Four out of the reviewed studies can be listed under the patient follow-up and medication adherence (Brinkel et al., 2017; Fatoye et al., 2020; Modrek et al., 2014; Raifman et al., 2014). Out of the four studies, two used quantitative methods. One of these (Brinkel et al., 2017) experimented with the use of a mobile application that assesses disease symptoms and provides health education in the care of sick children. The study reports that participants rated the IVR system (mobile app) with a medium acceptability score of 79.3 (SD 7.4), indicating the level of acceptance. Another quantitative study by Fatoye et al. (2020) tested a mobile phone application with the capability to tele-monitor participants' performance and provide enhanced care support for the management of chronic low back pain. The study reported that the mean treatment effect of the participants assessed at week 4 and week 8 showed significant difference for clinical effectiveness within the Tele-rehabilitation-based McKenzie therapy (TBMT) and Clinic-based McKenzie therapy (CBMT) groups of 0.143 to 0.1571 and 0.085 to 0.145 respectively from baseline to week 4 and week 8. The study concludes that the changes in health outcomes from baseline to week 4 and week 8 showed a significant difference ($P<.001$) for patients who used the mobile app. The two RCT studies (Modrek et al., 2014; Raifman et al., 2014) both focused on the treatment of malaria using one-way mobile-based SMS messages to remind and support caregivers in their treatment of malaria. Both studies indicated a high feasibility of the proposed implementation for the treatment of malaria. Overall, the studies examined in this category can be seen as appropriate since the main objective relates to 'patient follow-up and medication adherence.'

All the research concurs on the viability and promise of mHealth implementations for patient adherence to treatment and follow-up. In these studies, the only mobile treatments consisted of simply reminding patients to take their medications or visit clinics. These applications are practical and efficient. The use of sophisticated apps in the management of complex health concerns in this

category does not appear to be supported by a lot of solid evidence. More research is likely to provide additional studies examining the use of complicated apps in the treatment of complex diseases.

2.4.2.2 Communication and information for community healthcare workers

Four studies (Nelissen et al., 2018; Velez et al., 2014; Ebenso et al., 2018; Zakus et al., 2019) dealt with communication and information for HCW. The mHealth projects for this category are primarily smartphone/mobile applications designed to record data and provide support for health workers. The first study (Nelissen et al., 2018) investigates the acceptability of 'OMRON,' an mHealth app for remote patient monitoring. When adopted and used properly, the mHealth app would enhance retention in care, medication adherence, and quality of care. This study reports general enthusiasm for mHealth. The second study (Velez et al., 2014) investigated 'mClinic software,' a mobile application that collects form-based data and transmits it to the e-health database. This provides point-of-care decision support and in-context health information to midwives. The study finds that it is possible for midwives to use mClinic, but it also highlights the need for further capabilities. The following study (Ebenso et al., 2018) experimented with the use of the clinical patient administration Kit (CliniPAK), a point-of-care data capture and decision assistance tool that is tablet computer-enabled and allows field healthcare workers to collect patient health information and send pertinent data to remote servers through mobile networks. The outcomes demonstrate the viability of the app and its potential to improve basic healthcare.

The usefulness of a smartphone application to enhance excellent case management and provide good timely clinical data to diagnose and treat diarrhea, malaria, and pneumonia was also studied by Zakus et al. in 2019. According to the study, using a smartphone and mHealth app increased the quality of care, attributed to better evaluation. Results from studies on communication and information for healthcare workers show that mHealth treatments are often feasible. However, further research with a larger sample population and more diversified health contexts is required before advocating widespread deployment because the objective of this category is to provide clinical assistance to healthcare professionals.

2.4.2.3 Health promotion and disease prevention

The potential of texts or interactive text questions to enhance health knowledge and behaviours was the focus of seven studies on health promotion and illness prevention (n = 7). These studies were conducted, with one being a pilot study and the other six being RCTs that evaluated the efficiency of SMS messages or campaigns in delivering health information on the following crucial topics:

- Contraceptive usage (Maternal health)
- Infant and young child feeding behaviors.
- Management of childhood diarrhea
- Utilisation of maternal and newborn child health (MNCH) services
- Malaria prevention
- Antenatal care (ANC)
- Reproductive health

The results of all these interventions were very satisfactory. For example, in the RCT study by Babalola et al. (2019) for contraceptive usage, the results showed that the intervention was efficacious in improving relevant ideational and behavioural outcomes. Also, the pilot study by Downs et al. (2019) revealed a significant increase in the number of children consuming various kinds of food after the intervention. Further, Rokicki and Fink (2017) investigated the use of a two-way Instruction/Education SMS mobile phone-based app to educate girls on reproductive health, finding that higher engagement levels were associated with higher knowledge scores. However, one study (LeFevre et al., 2017) raised concerns about the complexity of the MOTECH platform intervention, consisting of two components: Mobile Midwife (MM) and Client Data Application (CDA). The authors concluded that improvements to the program's software were mostly required. Evaluations in the field of health promotion and disease prevention often reported successful outcomes.

2.4.3 The cost-effectiveness of mHealth interventions

Five (5) of the twenty-five (25) studies included in this review explicitly delved into the cost-effectiveness of their respective projects, refer to table 4. These five studies adopted a cost-effectiveness analysis approach, examining the economic implications of their interventions specifically from the perspective of scheme members. Diverse economic analyses were integrated

into the studies to evaluate the interventions exhaustively. Cost-utility analysis has been instrumental in providing valuable information on the cost-effectiveness of health interventions by examining the ratio of costs to benefits. This method evaluated the costs compared to the advantages in terms of the number of years lived in good health by the users. Furthermore, Comparative Cost Analysis and Incremental Cost-Effectiveness analyses were used to provide nuanced viewpoints on the economic consequences of the actions. These methodologies facilitated a thorough analysis of the comparative expenses and gradual advantages linked to each action.

Quality Adjusted Life Years (QALYs) was found in this review as a prevalent measure of outcomes in four of these investigations. It offers a standardised measure that makes it easier to evaluate the total effect of treatments on both the quality and duration of life. This approach guarantees a thorough comprehension of the effectiveness of the interventions by considering not only their economic aspects but also their impact on the long-term health-related quality of life. For instance, Bowser et al. (2018) employed a retrospective micro-costing technique to extract costing data from health facilities and administrative offices. They aimed to estimate the costs associated with implementing mHealth antenatal care program and to further assess the cost of facility delivery for individuals utilising the antenatal care services in the year 2014. The cost-effectiveness ratio for this program, considering antenatal care without demand-side generation for facility delivery, was determined to be US$13,739 per life saved. Introducing an additional demand-side generation for facility births reduced the cost-effectiveness ratio to US$9,806 per life saved. The authors concluded that mHealth programs are not only cost-effective but also contribute significantly to saving lives for the investment made.

In a separate study, Adewuya et al. (2019) investigated to assess the efficacy and acceptability of incorporating mobile telephone adherence support into a Collaborative Stepped Care (CSC) intervention for the primary care management of depression in Lagos, Nigeria. The findings revealed that, at the 6th-month mark, the Mobile Collaborative Stepped Care (mCSC) group (n = 439 participants) exhibited a significantly higher adherence rate compared to the Ordinary Collaborative Stepped Care (oCSC) group (n = 456 participants) (90.0% vs 67.8%, ARR 1.31, 95% CI 1.22-1.40). This difference persisted at the 12th-month follow-up, with the mCSC group maintaining a superior adherence rate (78.1% vs 59.2%, ARR 1.30, 95% CI 1.20-1.43). In contrast to the oCSC group, the mCSC group demonstrated a notably higher recovery rate, enhanced

quality of life, increased retention in treatment, cost-effectiveness, and a heightened level of acceptance among clients.

2.4.4 Acceptability of mHealth interventions

According to Black et al. (2011), the use of technology to enhance healthcare has rarely been completely successful, indicating the need for methodical adoption aided by formative assessments. Up to 60% to 80% of digital health intervention users are reported to have stopped using them (Lie et al., 2017), and the quality of evidence demonstrating their efficacy often lacks (Kiluk et al., 2011). Digital health interventions are frequently reported to have high rates of attrition and disengagement (Christensen, Griffiths, and Farre, 2009). Five studies examined the acceptability and usefulness of mHealth treatments in this review. For instance, Fadekem et al. (2012) found that while mobile phone availability is substantial, SRH information and services are rarely accessed via phones. Barriers to using these services include costs for young women clients, requests for sociodemographic information that could compromise anonymity, poor marketing and publicity, sociocultural beliefs and expectations, unique personality and beliefs, and infrastructure/network quality. The mHealth initiative showed acceptance signs, but the hurdles encountered made it difficult to demonstrate usefulness.

Lepevre et al. (2017) evaluated a mobile health intervention's acceptance among people living with HIV (PLHIV) in Togo, Côte d'Ivoire, and Burkina Faso. They found no country-specific variance in the overall acceptance rate of mHealth, which was 98.8%. They concluded that mHealth should be regarded as an effective tool and highly accepted among PLHIV. Similarly, Mbuagbaw et al. (2014) examined the acceptability and preparedness for ownership of an intervention among people living with HIV in Yaoundé, Cameroon, developing an implementation framework. Both qualitative and quantitative strands of this mixed-method study demonstrated high levels of acceptance and preparedness. Finally, two studies (Ngozi, Ogochukwu, and Allen, 2015; Peprah et al., 2019) explored undergraduate students' exposure, attitudes, and utilisation of mHealth resources in Nigeria and Ghana, respectively. The results showed that while 60% of Nigerian undergraduate students rely on e-health for proactive health actions, 74% of Ghanaian undergraduate students used mHealth irregularly. The Ghanaian study (Peprah et al., 2019) also revealed a statistically significant difference between genders in awareness of mobile phones' use for accessing healthcare information (53.8% vs. 46.2%; $p < 0.011$). The Ghanaian study (Peprah

et al, 2019) also revealed statistically significant difference between genders in awareness of the use of mobile phones for accessing healthcare information (53.8% vs. 46.2%; $p < 0.011$).

2.4.5 Clinical outcomes

Several clinical outcomes were measured in the included studies, which are summarised in appendix 5 and expounded here under the following areas:

- Revisit Rates – In most cases revisit rates were reduced after the initial treatment due to the interventions as follow-up care provided via mHealth solutions
- Patient Engagement - Patient engagement increased as a result of the introduction of mHealth interventions, thereby improving self-management of health conditions, adherence to treatments, and overall health outcomes.
- Patient Experience – Patient experience with the interventions were positive. However, the experience could be enhanced by making mHealth interventions and tools user-friendly, providing clear and supportive communication, and ensuring patients feel connected and their needs catered for.
- Patient Satisfaction - The expected goal of mHealth interventions is to maximize patient satisfaction by ensuring that mHealth projects are tailored to meet the needs of patients and ensure that their preferences are catered for. In most of these interventions, patient loyalty could not be assessed.

2.5 Discussion

The primary aim of this systematic review was to comprehensively investigate and synthesise evidence regarding mHealth interventions, their cost-effectiveness, and to identify knowledge gaps in the existing literature, providing valuable insights for the current study. Adhering to the specified inclusion and exclusion criteria, a total of 25 studies selected for this review. The review successfully achieved its objectives and yielded significant findings. The discussion explicitly situates the review's findings within the context of insurance renewal, addressing how lessons from health outcome-focused mHealth interventions can inform strategies for improving insurance processes. This includes understanding user engagement, technological barriers, and system-level facilitators. The discussion contextualizes the review findings in terms of their implications for insurance renewal. For example, the role of user-friendly designs and real-time feedback in

mHealth apps is explored as a potential strategy for increasing NHIS membership renewals. Additionally, the cost-effectiveness of mHealth interventions is discussed, emphasising the economic viability of scaling mobile renewal systems.

One noteworthy observation is that the majority of mHealth interventions implemented in West Africa are characterized by four predominant features: mobile phone apps, SMS-only interventions, phone-based SMS and voice messages, and broader mHealth applications and platforms. This categorization reflects the diverse technological approaches employed to deliver healthcare interventions in the region. This perspective is reinforced by Wei et al. (2020), who, in their study, identified universal design features across various modes of mHealth interventions, including mobile apps, website platforms, and text messages, spanning diverse health themes. Similarly, Triantafyllidis et al. (2019) highlighted in their review that divergent features were employed in 14 interventions, yielding notably positive outcomes.

Contrastingly, Sockolow et al. (2021), in a recent systematic review focusing on chronic illness and mHealth self-care interventions, observed a variability in the description of mHealth characteristics. They noted instances where studies lacked specificity regarding data input or message content. To optimize the functionality of mHealth interventions, it becomes imperative to tailor these interventions to specific age groups and health conditions (Onukwugha et al., 2022). This approach ensures a more targeted and effective application of mHealth technologies, addressing the diverse needs and preferences of distinct demographic groups and health contexts.

Functionally, the reviewed studies revealed that mHealth interventions can be broadly categorized into three main groups: patient follow-up and medication adherence, communication and information for healthcare workers, and health promotion and disease prevention. This categorization provides insights into the specific areas of focus and objectives of the interventions. This observation aligns with the taxonomy proposed by Lee et al. (2016), who categorized 15 interventions into distinct functions, encompassing health information delivery, reminders, data collection, test result turnaround, peer group support, and psychological intervention. Supporting this perspective, Gayesa et al. (2023) uncovered significant positive effects of mHealth interventions on various maternal and child health outcomes. Their findings indicated improvements in facility delivery rates, postnatal care utilisation, exclusive breastfeeding practices, and enhanced knowledge of danger signs. In the context of evolving mobile technology,

Yan et al. (2023) emphasised the versatility of mobile devices in delivering timely behavioral support to individuals in their daily lives. This adaptability underscores the potential of mHealth interventions to be tailored to address a wide spectrum of healthcare issues. The dynamic nature of mobile technology allows for the design of interventions that are responsive to diverse health needs, providing personalized and context-specific support to users.

The economic assessment of mHealth interventions indicated that they are cost-effective compared to traditional hospital administrations (Bowser et al. 2018, Nsiah-Boateng et al., 2017, Willcox 2018). This finding suggests that mHealth interventions have the potential to provide efficient and resource-effective healthcare solutions, particularly in resource-constrained settings. This consistent observation is echoed in various studies. For instance, Meyer et al. (2020), in their exploration of a complex mHealth intervention in Uganda, highlighted the transformative potential of mHealth technologies in making the delivery of public health interventions more direct and efficient. To overcome potential barriers, implementers are advised to invest in and adapt to local human and material resources, prioritize feedback from end users, and optimize data management and quality assurance procedures.

Similarly, a systematic review by Rinaldi et al. (2020) aimed at summarising and evaluating the quality of published evidence on the cost and cost-effectiveness of mHealth interventions for type 2 diabetes mellitus revealed substantial variation in the cost of mHealth interventions based on the type and combination of technology used. However, when cost-effectiveness results were reported, the interventions were found to be cost-effective. In another study focusing on the costs or cost-effectiveness of mHealth interventions used by women during pregnancy, Carrandi et al. (2023) concluded that preliminary evidence suggests mHealth interventions may be cost-effective and 'low-cost'. Nonetheless, they underscored the need for more evidence to ascertain the cost-effectiveness of mHealth interventions concerning positive maternal and child health outcomes and longer-term health service utilisation. This call for further evidence emphasises the evolving nature of the field and the importance of ongoing research to solidify the understanding of the cost-effectiveness of mHealth interventions in diverse contexts.

Lastly, the systematic review revealed a high acceptance rate of mHealth interventions in the sub-region. As previously stated, the majority of mHealth projects examined in this study demonstrated performance in terms of acceptability, viability, cost-effectiveness, or positive real health results.

Some results included an increase in patient uptake of counseling and disease testing (Babalola et al., 2019; Rokicki and Fink, 2017; LeFevre et al., 2017), and improvement in patient adherence to treatment (Brinkel et al., 2017; Fatoye et al., 2020; Modrek et al., 2014; Raifman et al., 2014). Health workers can obtain support through professional networks or focus efforts where needed most (LeFevre et al., 2017), and increase their role in active case identification, to name a few benefits of mHealth projects. Patients also benefit from routine appointments as they save money and receive more care and support from health professionals (Kawakatsu et al., 2020). SMS has been shown to help bridge the communication gap between health staff and patients in the health sector (Kawakatsu et al., 2020; Mbuagbaw et al., 2014). This positive reception signifies the willingness of both healthcare providers and recipients to embrace and engage with mobile health technologies, highlighting their potential to address healthcare challenges and improve health outcomes in West Africa.

Despite the positive results about the efficacy of these mHealth interventions, it is essential to recognise that the projects are all relatively modest, and the success of similar large-scale projects is not assured. One major flaw observed by most of the included studies in this review is that claimed benefits are often undefined, and long-term outcomes are unknown (Babalola et al., 2019; Friedman et al., 2015). Most studies disclose some level of limitation due to data collection weaknesses or technical problems (Bowser et al., 2018; Brinkel et al., 2017).

External obstacles and weaknesses may lead to project failure (Fadekem et al., 2014). Limiting factors must be considered from the project's beginning. Moreover, to integrate mHealth into existing structures, current care delivery processes must be revamped (e.g., change to electronic records and data). Healthcare organisations and providers must build the cultural and organisational resources needed to handle digital health data (Brinkel et al., 2017). Due to a lack of capability, late reporting, a lack of feedback, and incomplete data collection may occur.

Also, it remains unknown how mHealth technologies impact patient-reported experience and outcome measures. Despite this development, there is a scarcity of data on whether mHealth technologies are scientifically sound and efficient enough to warrant widespread adoption (Michie et al., 2017). It is particularly uncertain whether mobile health innovations positively affect clinical outcomes, although most studies report positive results.

Several opportunities exist to extend mHealth implementation and applications in West Africa, but future steps must be taken cautiously. While there are obstacles and risks to mHealth programs, opportunities are also abundant. The expanding mobile phone coverage represents the most significant opportunity for mHealth. As cell phone network coverage grows and new networking technologies emerge, the possibilities for mHealth applications are still plentiful. Scalability could be improved by advances in automatic text messaging and collaborations with mobile app developers, for example.

2.5.1 Comparison of the review findings to other reviews

Comparing the findings of this review to other relevant studies provides a broader perspective on the state of mHealth interventions. The findings of this study align with previous research, supporting the use of mobile phone technology in health initiatives aimed at improving health outcomes in underdeveloped countries (Hoffman et al., 2010; Pop-Eleches et al., 2011; Zurovac et al., 2011; Carrandi et al., 2023; Meyer et al., 2020). These studies have demonstrated the potential and effectiveness of mHealth interventions in diverse settings. However, despite the positive outcomes observed, this study also highlights the need for further empirical research on mHealth adoption and utilisation, particularly in rural areas. While existing studies have provided valuable insights, there may be specific challenges and contextual factors unique to rural settings that warrant closer examination. Understanding the barriers, facilitators, and specific needs of rural populations in adopting and utilising mHealth interventions can inform the development of targeted strategies to maximize their impact. Future research should aim to explore the factors influencing the uptake and sustained use of mHealth interventions in rural areas, including issues related to infrastructure, digital literacy, cultural considerations, and healthcare access. Additionally, investigating the perspectives of key stakeholders, such as patients, healthcare providers, and community leaders, can provide valuable insights into the design and implementation of effective mHealth interventions tailored to the specific needs of rural populations.

In addition, the identification of specific features of mHealth interventions in this study is consistent with findings from previous research. For example, studies conducted by Wei et al. (2020) and Triantafyllidis et al. (2019) have also highlighted the presence of universal design features across various mHealth modalities, such as mobile apps, website platforms, and text

messages. This alignment underscores the importance of incorporating user-friendly and accessible design elements in mHealth interventions to ensure usability and effectiveness. Moreover, the recognition of the need for tailored interventions targeting specific age groups and illnesses, as suggested by Onukwugha et al. (2022), reinforces the importance of enhancing the functionality and customisation of mHealth interventions. Different age groups and diseases may have unique requirements and preferences, and tailoring interventions to address these specific needs can enhance engagement and improve health outcomes. By building upon the findings of previous studies, the current research expands our understanding of the features and functionalities of mHealth interventions. It emphasises the significance of incorporating universal design principles while also recognising the importance of customisation and personalization to effectively address the diverse needs of individuals across various age groups and health conditions.

Furthermore, the findings of this study are in line with previous research regarding the cost-effectiveness of mHealth interventions compared to traditional hospital administrations. Meyer et al. (2020) highlighted the potential of mHealth technologies to improve the delivery of public health interventions, which aligns with the positive economic assessments discussed in this review. Similarly, Rinaldi et al. (2020) and Carrandi et al. (2023) emphasised the variable costs and cost-effectiveness of mHealth interventions, further supporting the economic evaluations conducted in this study.

By leveraging mobile technologies, mHealth interventions have the potential to provide cost-effective solutions, particularly in resource-constrained settings. The reduction in costs can be attributed to factors such as decreased reliance on physical infrastructure, streamlined communication, and improved efficiency in service delivery. It is important to continue exploring and assessing the economic impact of mHealth interventions in different healthcare settings and contexts. Further research can focus on conducting robust cost-effectiveness analyses, taking into account factors such as implementation costs, long-term sustainability, and scalability of mHealth interventions. Additionally, investigating the potential cost savings and benefits for healthcare systems, patients, and society as a whole can provide valuable insights for decision-makers and policymakers.

Finally, the findings of this study are consistent with earlier research conducted by Zhang, Xu, and Ni (2013) and Kjaergard et al. (2001), which highlighted the potential overestimation of intervention effects in small trials with inadequate or unidentified outcomes. These previous evaluations underscore the importance of using robust research designs and larger sample sizes to determine the true efficacy of interventions. In contrast to earlier evaluations, the majority of data utilised in this study were derived from randomized controlled trials (RCTs) that specifically examined the effectiveness of mHealth intervention programs. RCTs are considered more reliable in assessing intervention efficacy as they employ rigorous methodologies, involve larger sample sizes, and often have extended intervention or monitoring durations. By relying on such high-quality evidence from RCTs, this study contributes to strengthening the evidence base regarding the effectiveness of mHealth interventions.

However, the findings also highlight the need for further research with extended intervention durations and larger sample sizes to establish a definitive benefit of mHealth interventions for health-related behavior modifications. Conducting studies with longer follow-up periods can provide insights into the sustainability and long-term impact of mHealth interventions on behavior change. Additionally, larger sample sizes can enhance statistical power and improve the generalisability of findings to broader populations.

2.5.2 Implications of review findings

The findings of this review carry significant implications for both research and practical applications in the realm of mHealth interventions in West Africa. Firstly, the review findings highlight the importance of tailoring mHealth interventions to specific age groups, illnesses, and contextual factors. This emphasis on customisation and personalization is supported by previous studies conducted by Triantafyllidis et al. (2019) and Onukwugha et al. (2022). Designing mHealth interventions that consider the unique needs and preferences of target populations is crucial for maximizing their effectiveness in promoting behavior change and improving health outcomes. By understanding the diverse characteristics of different age groups, such as varying technological literacy, cognitive abilities, and communication preferences, practitioners can develop interventions that are accessible, engaging, and user-friendly. Similarly, tailoring interventions to specific illnesses allows for the incorporation of disease-specific information, self-management tools, and support systems that address the challenges and requirements associated with particular

health conditions. This can enhance adherence to treatment plans, encourage healthy behaviors, and facilitate better management of chronic diseases. To achieve successful tailoring of mHealth interventions, practitioners should engage in user-centered design processes, involving end-users in the development and testing phases (Saparamadu et al., 2021; Korpershoek et al., 2020). This participatory approach ensures that the interventions align with the preferences, needs, and capabilities of the target populations, leading to higher engagement and better health outcomes.

Additionally, the functional categorization of mHealth interventions into patient follow-up, communication for healthcare workers, and health promotion and disease prevention provide a practical framework for comprehending the various roles that these technologies can play in healthcare. This categorization allows policymakers and healthcare providers to strategically implement mHealth solutions based on their intended function, thereby maximizing their impact and benefit. Also, by understanding the distinct functions of mHealth interventions, policymakers and healthcare providers can align their implementation strategies with specific healthcare goals and priorities (Barkman and Weinehall, 2017). For example, in settings where improving patient follow-up is a priority, resources can be allocated towards implementing remote monitoring technologies and patient engagement platforms. On the other hand, if enhancing communication among healthcare workers is a priority, investments can be directed towards secure messaging systems and telemedicine infrastructure.

The review findings provide compelling evidence regarding the cost-effectiveness of mHealth interventions in comparison to traditional healthcare administrations. This has significant implications for healthcare financing and resource allocation decisions at various levels, including government agencies, healthcare organisations, and insurance providers. By demonstrating the cost-effectiveness of mHealth interventions, decision-makers are encouraged to consider the economic benefits of investing in technology-driven healthcare solutions. Allocating resources towards mHealth interventions can lead to improved efficiency in healthcare delivery, reduced healthcare costs, and optimized healthcare outcomes. One key aspect of cost-effectiveness is the potential for mHealth interventions to reduce the burden on healthcare systems by shifting certain aspects of care delivery from traditional hospital settings to mobile platforms. By leveraging mobile technologies, mHealth interventions can provide remote monitoring, self-management tools, and access to health information, thereby reducing the need for in-person visits and hospital

admissions. This can result in cost savings for healthcare systems, particularly in terms of reduced utilisation of expensive healthcare resources.

Furthermore, mHealth interventions have the potential to enhance preventive care and early intervention, leading to better health outcomes and cost savings in the long run. By facilitating timely access to healthcare information, promoting healthy behaviors, and enabling remote monitoring of chronic conditions, mHealth interventions can help prevent the progression of diseases, reduce hospitalizations, and minimize the need for more intensive and costly interventions. However, it is important to note that the cost-effectiveness of mHealth interventions can vary depending on specific contexts, populations, and healthcare systems. Therefore, further research and economic evaluations are needed to assess the cost-effectiveness of mHealth interventions across diverse settings and to identify the most efficient and sustainable models of implementation. This view is in line with research done by Ghani et al., 2020 that performed a systematic review on the cost-effectiveness of mHealth interventions for older adult.

2.5.3 Strengths and limitations of this review

One of the key strengths of this review is its comprehensive and holistic approach. The review employed a comprehensive set of inclusion criteria, ensuring that a diverse range of mHealth interventions in West Africa were considered and the search of four major databases, including SCOPUS, Web of Science, PubMed, and PsycInfo, enhances the robustness and inclusivity of the literature coverage. Also, the use of two frameworks, the Critical Appraisal Skills Program (CASP) and the Drummond checklist, for quality appraisal adds depth to the evaluation of the included studies, considering both general and economic aspects.

However, certain limitations have been observed in this review. First, the focus on studies published between 2010 and 2020 may limit the inclusion of recent developments in mHealth interventions, potentially overlooking emerging trends or innovations. Second, relying predominantly on studies published in peer-reviewed journals introduces the possibility of publication bias, as unpublished or grey literature might be omitted, affecting the comprehensiveness of the review. Further, the diverse nature of mHealth interventions, encompassing various technologies and functionalities, poses a challenge in synthesising findings cohesively and drawing overarching conclusions. Finally, despite rigorous criteria, the potential

for bias in the selection of studies exists, impacting the generalisability and representativeness of the overall findings.

Notwithstanding the identified limitations, this review stands as a valuable source of insights into the dynamic landscape of mHealth interventions in West Africa. The review contributes to the understanding of the impact and challenges associated with mHealth initiatives in the sub region and will serve as a valuable resource for researchers, policymakers, and practitioners interested in understanding the mHealth interventions deployed in West Africa.

2.5.4 Gaps identified in literature

A research gap is a research question that has not been adequately addressed. Robison et al. (2011, p.135) defines a research gap as a situation where the systematic reviewer's ability to draw conclusions is limited. Identifying the gap for this study is essential, as it will help address specific unanswered questions or problems that need solutions relative to mHealth interventions. The systematic review identified gaps in the existing research related to mHealth interventions in West Africa. These gaps include:

1. Lack of evaluations on the effectiveness of mobile renewal services/technologies for health insurance renewals.
2. Insufficient exploration of adherence drivers in mHealth interventions.
3. Limited incorporation of theoretical frameworks, hindering the development of a conceptual understanding of adoption dynamics.

The review showed a scarce literature on evaluations of mobile renewal services for health insurance renewals, and their role in healthcare accessibility. In addition, no studies had specifically addressed the barriers and facilitators influencing the adoption of mobile renewal services in West Africa from the perspective of the service’s subscribers and implementers. The study, therefore, aimed to address these gaps, with a focus on Ghana, one of the West Africa countries with limited literature on mobile renewal service impacts (Nsiah-Boateng, 2019). The rationale for addressing these gaps is to enhance the understanding of how these services impact healthcare accessibility.

The identified gaps are further discussed below:

2.5.4.1 Lack of research on the evaluation of mHealth technologies for health insurance renewals

A significant research gap exists concerning evaluating mobile renewal services/technologies. Among the studies included in the systematic review, none specifically delved into the evaluation of mobile renewal services for health insurance utilisation and retention. A contributing factor to this gap is the limited attention paid to the insurance aspects of mHealth utilisation. This phenomenon is because the literature suggests that mHealth services and technologies are focused on health outcomes assessments and service delivery and not on health service subscription renewals (Mensah, 2022; Palas et al., 2022; Namirad et al., 2023). While the systematic review identified a few studies that evaluated the service renewals aspect of mHealth innovations, it is essential to acknowledge that these studies are in the pilot phase (Babalola et al., 2019; Friedman et al., 2015). This acknowledgement underscores the need for in-depth evaluations of the mobile renewal services of mHealth technologies, particularly for health insurance renewals, to first address the literature dearth and second to scale the potential benefits of mobile renewal services of mHealth technologies. The potential benefits of these services, such as increased subscriber retention and improved healthcare access, underscore the importance of addressing this research gap. The significance of addressing this research gap is particularly pronounced for Ghana, where there is a growing emphasis on upscaling the NHIS's mobile renewal services to enhance the retention and growth in the numbers of NHIS subscribers, and subsequently address financial barriers to healthcare.

2.5.4.2 Lack of evidence on the key drivers of adherence to mHealth

There is a significant research gap in understanding the key drivers that influence adherence to and the overall effectiveness of mHealth interventions. While certain review papers, such as those authored by Brinkel et al. (2017), Fatoye et al. (2020), and Modrek et al. (2014), have explored the broader theme of patient follow-up and medication adherence, they have not delved into the specific examination of the pivotal factors driving adherence.

Addressing this gap assumes significance for several reasons. Firstly, understanding the key drivers of adherence is fundamental for optimizing the design and implementation of mHealth interventions. Without a nuanced comprehension of the factors influencing users' adherence to

prescribed behaviors or health regimens, the full potential of mHealth initiatives may remain unrealized. Secondly, the identification of key drivers can inform tailored strategies to enhance adherence rates. Different populations may respond differently to mHealth interventions, and recognising the determinants of adherence allows for the customisation of interventions to specific user groups. This targeted approach increases the likelihood of sustained engagement and positive health outcomes. Thirdly, dealing with this gap is crucial for promoting the overall effectiveness of mHealth interventions. The success of these interventions is inherently tied to users' adherence to recommended actions or interventions. By uncovering and addressing the key drivers of adherence, mHealth strategies can be refined, leading to more impactful and sustainable outcomes.

2. 5.4.3 Lack of theoretical underpinnings

The literature reveals a gap in the incorporation of clear theoretical frameworks within mHealth research, indicating a need for greater theoretical grounding in empirical studies. It is common research practice to utilise theoretical frameworks to guide empirical studies (Collins and Stockton, 2018). These frameworks serve multiple crucial functions within empirical studies. Firstly, they provide a structured foundation for research by outlining analytical methods for tasks like data collection and interpretation (Abraham, 2008). Secondly, theoretical frameworks contribute to a deeper understanding of the study's concept and context, allowing readers to grasp the significance of the research results within a broader theoretical framework (Grant and Osanloo, 2014). However, despite the benefits and importance of theoretical frameworks, only a small fraction of the papers included in the review (three out of 25) were underpinned by a conceptual or theoretical framework. This highlights a significant gap in mHealth research, where many studies lack a strong theoretical foundation and robustness of the current body of mHealth literature.

Addressing this gap assumes significance for several reasons. Firstly, incorporating theoretical frameworks enhances the methodological rigor of mHealth studies, providing a systematic approach to research design, data collection, and analysis. This, in turn, contributes to the credibility and reliability of research findings. Secondly, theoretical frameworks help establish a conceptual foundation for mHealth interventions, guiding the development and implementation of these initiatives. A solid theoretical grounding ensures that interventions are theoretically sound and more likely to achieve their intended outcomes. Thirdly, dealing with this gap is crucial for advancing the theoretical understanding of mHealth as a field. It allows researchers and

practitioners to build upon existing theories or develop new frameworks that are specific to the unique challenges and opportunities presented by mHealth technologies.

2.6 Conclusion

The systematic review underscores the transformative potential of mHealth interventions while identifying critical gaps in the existing literature. This thesis aims to address these gaps by providing a comprehensive evaluation of mobile renewal services in Ghana. Therefore, the next chapter discusses the methodological framework to address the gaps identified in this chapter.

CHAPTER THREE: FRAMEWORK FOR EMPIRICAL ANALYSIS

3.1 Introduction

This study aims to evaluate the effectiveness of Ghana's NHIS Mobile Renewal Service (MRS) and assess the barriers and facilitators influencing the service's adoption from the perspective of NHIS subscribers and policy implementers. Chapter 2 reviewed existing literature on mHealth in West Africa and identified gaps that directed the empirical chapters of this study. This chapter provides the methodological frameworks used to investigate and address the identified gaps. The chapter first outlines the specific research questions to address each research gap from Chapter 2. After, it discussed the methodological approaches to explore the research questions and, by extension, the research gaps. Table 3.1 summarises the identified literature gaps, their related research questions, and the thesis chapter that addressed them. The ensuing texts show how each thesis chapter investigated the research gaps and questions in table 3.1.

Table 3. 1:Identified Literature Gaps, Related Research Questions, Thesis Chapters, Tools for Data Analysis, and Expected Findings

Literature Gap	Research Questions	Thesis Chapter	Tools for Data Analysis	Justification for Method	Model diagnostic test
Limited evaluation of MRS effectiveness for health insurance renewals?	Is MRS effective in improving NHIS membership renewals compared to the conventional manual renewal method?	4	Interrupted Time Series Analysis (ITSA) regression analysis	**ITSA** provides robust pre- and post-intervention trend analysis, using a quasi-experimental design to assess MRS impact on manual and total renewals.	Cumby-Huizinga test was performed to determine the order of autoregressive order
	To what extent can we attribute changes in NHIS renewal outcomes to the MRS intervention?	5	Dissimilarity analysis	**Dissimilarity Analysis** allows further and additional analyses, using advanced statistical metrics like autocorrelation and ARIMA-based models, to ensure an attribution of the	

				findings of the ITSA to the MRS intervention.	
Lack of evidence on user adoption drivers	What factors drive the adoption of MRS for by users /subscribers?	Chapter 6	Structural Equation Modeling (SEM), multivariate analysis	**SEM** identifies causal relationships between UTAUT2 constructs (e.g., ease of use, affordability) and user adoption, offering quantitative insights into behavior determinants.	Root Median Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI) to determine the goodness of fit.
Minimal understanding of implementation barriers	What are the key barriers and facilitators faced by implementers of MRS?	Chapter 7	Delphi technique (Thematic and descriptive analysis)	**Thematic Analysis** uncovers in-depth perspectives from policymakers and stakeholders, using qualitative data to map barriers and enablers comprehensively.	

3.2 Theoretical framework

As previously noted in Chapter 2, the outcome of only three studies was informed by a theoretical framework: the Theory of Planned Behavior (TPB) and the Health Belief Model (HBM). However, neither framework aligns with the focus of this study on technology adoption, specifically for insurance renewal. Consequently, this thesis adopts and adapts the Extended Unified Theory of Acceptance and Use of Technology (UTAUT2) model. The UTAUT2 model is particularly suited for this study due to its adoption-oriented constructs, such as price value, and habit, which address contextual factors influencing technology adoption. While UTAUT2 has not been widely applied in the context of insurance renewal, its flexibility allows for adaptation to understand adoption

behaviors in mHealth systems. To bridge the identified gaps, the UTAUT2 framework integrates the constructs of Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), Facilitating Conditions (FC), and the consumer-specific factors of Hedonic Motivation, Price Value, and Habit. These constructs were mapped to the behavioral intention to adopt MRS, with age serving as a moderating variable.

Although insurance renewal is not a traditional application area in UTAUT2 literature, the model's constructs are applicable to understanding user interactions with mobile renewal platforms. For instance:

- **Performance Expectancy** evaluates whether users believe MRS will simplify and enhance policy renewals.
- **Effort Expectancy** measures the ease of using the service.
- **Price Value** is crucial, given that financial considerations often drive insurance renewal behaviors.

This theoretical grounding strengthens the study's ability to address the gaps in insurance renewal research, offering a novel application of UTAUT2 to healthcare financing contexts.

3.2.1 UTAUT2

The UTAUT2 model is a robust model for predicting technology adoption behaviors, demonstrating a 70% accuracy rate than other technology adoption theories (Venkatesh et al. (2012). Its reliability is underscored by its extensive utilisation in over 5,000 peer-reviewed publications, where it served as a framework to understand the acceptance of new technologies (Crawford, 2020). The original UTAUT model focused on four key constructs: Performance Expectancy (PE), Effort Expectancy (EE), Social Influence (SI), and Facilitating Conditions (FC). These constructs were instrumental in predicting the behavioral intention to use technology and its actual use, with variables like gender, age, and experience serving as moderators (Venkatesh et al., 2003). The UTAUT2 model enhances this framework by incorporating additional consumer-focused constructs: Hedonic Motivation, Price Value, and Habit. These constructs were included in this study to provide a more nuanced understanding of the factors influencing the adoption of the mobile renewal service. Hedonic Motivation refers to the pleasure or enjoyment derived from

using the technology, Price Value denotes the cost-benefit analysis undertaken by the user, and Habit captures the extent to which users tend to perform behaviors automatically due to learning.

In addressing the study's specific objectives and research questions, the UTAUT2 constructs, including PE, EE, SI, FC, HM, PV, and Habit, were used as predictors. Behavioral Intention was considered the dependent variable, with age acting as a moderating variable. This approach allowed for a comprehensive analysis of the behavioral intentions of subscribers towards MRS (see adapted model in figure 31.). The adoption of these constructs was based on the premise that they provide a robust framework for understanding the complex interplay of factors influencing technology adoption, particularly in the context of mHealth (Venkatesh et al., 2012; Crawford, 2020). The application of UTAUT2 in this study thus offered a theoretically grounded and empirically validated approach to investigating technology adoption behaviors. Table 3.2 illustrates adapted constructs and its operationalized definition.

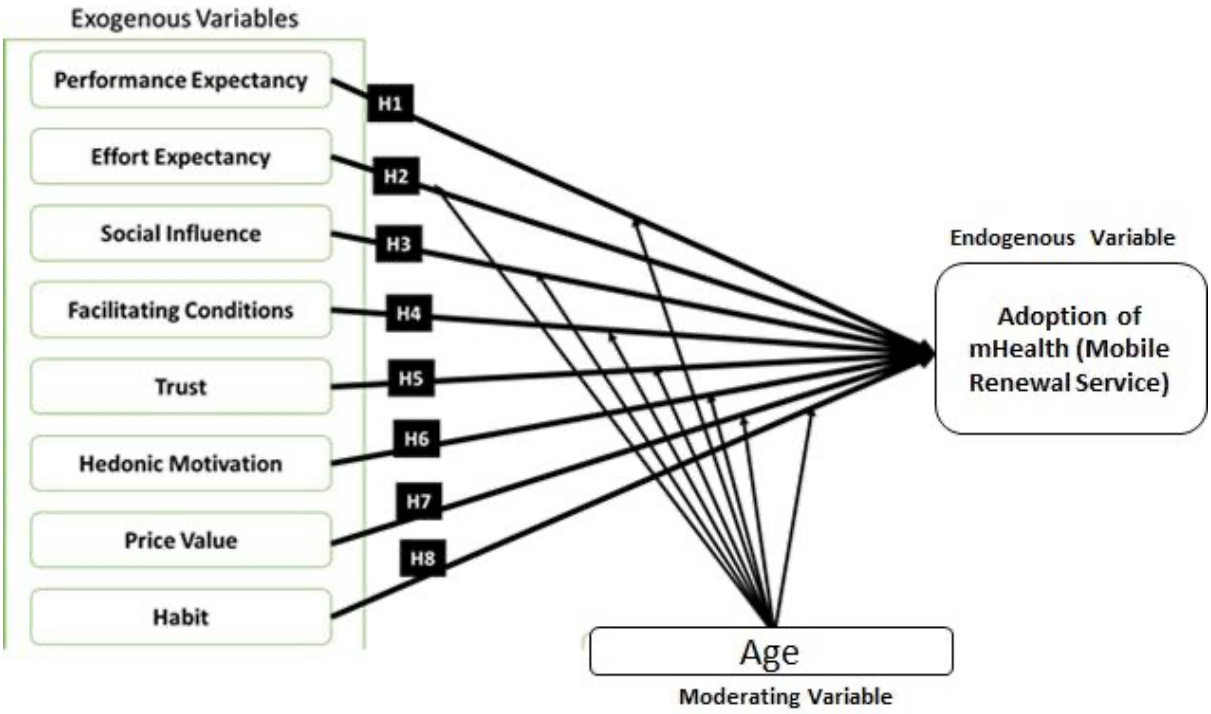

Figure 3. 1:Adapted UTUAT2 model

Table 3. 2: Adapted constructs and its operationalised definitions

Construct	Operationalised definition in MRS context	Role
Performance Expectancy (PE)	The belief among users that using the mobile renewal service will enhance their efficiency in renewing healthcare policies.	Independent
Effort Expectancy (EE)	The degree to which users perceive the mobile renewal service as easy and effortless to use.	Independent
Social Influence (SI)	The extent to which users perceive that important people in their social circle (like family, friends, or colleagues) believe they should use the mobile renewal service.	Independent
Facilitating Conditions (FC)	Users' perceptions of the availability of resources and support necessary for using the mobile renewal service effectively.	Independent
Hedonic Motivation	The pleasure or enjoyment users derive from using the mobile renewal service, beyond its functional aspects.	Independent
Price Value	Users' cognitive trade-off between the perceived benefits of the mobile renewal service and the monetary cost associated with its use.	Independent
Habit	The extent to which users tend to use the mobile renewal service automatically due to learning or past experiences.	Independent
Behavioral Intention	Users' intention to use the mobile renewal service for healthcare policy renewals.	Dependent
Age	The age of the user, which may affect how the above constructs influence the behavioral intention to use MRS	Moderator

The UTAUT2 model, however, has some limitations, particularly as its dimensions are too technologically oriented and ignore other dimensions that might influence mHealth adoption such as health condition and health literacy (Duarte and Pinho, 2019). Nevertheless, the merits of UTAUT2 outweighs the limitations. UTAUT2 has been widely used by researchers to examine various user's types of mHealth adoption (Dwivedi et al., 2016). UTAUT2 was developed with consideration to other theoretical models such as the Theory of Reasoned Action (TRA), Technology Acceptance Model (TAM), and the Theory of Planned Behavior (TPB). Also, the UTAUT model has a superior explanation power when compared to other theoretical models (Lee and Rho, 2013). This was very important in ascertaining and understanding the barriers and facilitators that influence the adoption of mobile renewal service.

3.3 Methodological Approaches

The methodological approaches used to address the research questions for the identified literature gaps in this thesis are discussed below:

3.3.1 Gap 1: Limited research evaluating MRS for health insurance renewals

Secondary data was used in addressing the research question for this identified literature gap. A quasi-experimental design was employed, comparing the pre-intervention period, where renewals and payments were done manually, to the post-intervention period that introduced the MRS option. This design allowed for a direct comparison between the traditional/conventional methods and the new, technologically enhanced approach (Brenner, S et al., 2020). Data for addressing this limitation was accessed from the NHIA database. The database provided an extensive data on the number of renewals and premium payments made both before and after the introduction of the MRS intervention. This data was crucial in conducting an ITSA regression, a statistical method that helped to identify and quantify any changes in trends following the introduction of MRS. (Melamed, 2018). ITSA is adept at estimating changes over time, making it suitable for evaluating interventions like the introduction of MRS in December 2018 (Wagner et al., 2002; Bernal et al., 2017). This quasi-experimental design allowed for the examination of renewal levels and trends pre- and post-introduction of the mobile service, while accounting for ongoing manual renewal processes and other confounding factors. The choice of ITSA was instrumental in quantifying the impact of the mobile renewal service on the total number of renewals for the NHIS, offering a rigorous methodological approach to evaluate the effectiveness of this technological intervention.

Within the literature, ITSA designs are broadly categorised into autoregressive integrated moving-average (ARIMA) models and Ordinary Least Squares (OLS) regression models. For this research, the OLS regression model was selected, a decision informed by its demonstrated flexibility and applicability in ITSA studies as highlighted by Velicer and Harrop (1983), Box et al. (2016), and Linden and Ray (2017). The OLS model's suitability for this context is further supported by its ability to accommodate various data types and its relative ease of interpretation. Following the methods outlined by Huitema and McKean (2000), Linden and Adams (2011), Simonton (1977a, b), and Linden (2017), a standard single-group ITSA regression model was employed. This approach is well-regarded for its capacity to discern the impact of an intervention, accounting for

pre-existing trends or patterns that might exist in the data. The ITSA model used in this research is shown in equation 1:

$$Renewals_t = \beta 0 + \beta 1 \cdot Time_t + \beta 2 \cdot X_t + \beta 3 \cdot (Time_t \times X_t) + \epsilon_t$$

Equation 3. 1: ITSA equation

In this model, 'Renewals_t' represents the cumulated NHIS subscription renewals for month t, 'Time_t' denotes the time since the study began, and 'X_t' is a dummy variable indicating the pre- or post-intervention period. The coefficients (β0, β1, β2, β3) represent the intercept, slope, immediate impact, and the renewal effect over time, respectively. The term 'ε_t' is a random variable accounting for error. To refine the model and ensure its robustness, adjustments were made for potential seasonality, heteroscedasticity, and autocorrelation. The Newey-West (1987) variance estimator was applied to address heteroscedasticity and autocorrelation, which are common concerns in time series data. Additionally, the Cumby-Huizinga test was conducted to determine the appropriate order of autoregressive order, further enhancing the model's reliability and the validity of the results. These methodological choices strengthened the study's ability to accurately assess the impact of the mobile renewal service on NHIS subscription renewals, providing a comprehensive understanding of its effectiveness over time.

Despite the aforementioned strengths of OLS as an ITSA design (Velicer and Harrop, 1983; Box et al., 2016 and Linden and Ray, 2017), other researchers have asserted that data analyses by OLS regression techniques tends to use unrealistic assumptions. Failure to recognise the source and nature of heterogeneity, and vulnerability to extreme observations is also deemed to be some of the limitations of OLS (Haupt and Stemmler, 2014). To address these perceived limitations, the researcher made adjustments for potential seasonality, heteroscedasticity, and autocorrelation (Newey-West, 1987). The OLS regression analysis technique’s ability to explore whether one or multiple variables (the independent variable) can predict or explain the variation in another variable (the dependent variable), was instrumental in the researcher’s decision to select ITSA to evaluate the effectiveness of the mobile renewal service (Wooditch et al., 2021).

3.3.2 Lack of evidence on the key drivers of MRS health insurance renewal adoption – users' perspectives

To address the gap regarding the lack of evidence on the key drivers of MRS adoption, the study leveraged the Structural Equation Modeling (SEM) approach. This approach facilitated a comprehensive exploration of the barriers and facilitators influencing adoption, capturing insights from both users and policy implementers. SEM was employed to analyse survey data from the users/subscribers of NHIS, focusing on the relationships between the constructs outlined in the UTAUT2 framework and users' behavioral intention to adopt MRS. This quantitative method was instrumental in quantifying the relative impact of key the UTAUT2 constructs, such as Performance Expectancy and Effort Expectancy, on users' adoption decisions. In analysing these relationships in Chapter 6, SEM provided a nuanced understanding of the factors driving behavioral intention, allowing for the identification of statistically significant determinants of adoption.

3.3.3 Lack of evidence on drivers to adoption MRS for health insurance renewals – policy implementers perspectives

This thesis addressed the gap on policy implementers perspectives on barriers and facilitators to the adoption of MRS for health insurance renewals in Ghana. The policy implementers included the directors of Ghana's NHIS. This exploration was essential in understanding the key barriers to MRS utilisation for health insurance renewal by policy implementers in a real-world context (Alonge et al., 2019). The methodology employed a mixed-method approach, integrating both qualitative and quantitative data (Greenhalgh et al., 2018). This comprehensive strategy was pivotal in dissecting the multifaceted nature of the service implementation process. Primary data were collected through interviews with District, Regional and National Managers of the NHIS. These interviews were crucial in gathering first-hand insights into MRS utilisation challenges. The selection of the interviewees was guided by the objective to capture a broad spectrum of experiences and viewpoints (Hogan, T. et al., 2015). The research adhered to the ethical guidelines set forth by the Ethics Committee of Brunel University London and NHIA-Ghana, ensuring that the study was conducted with the highest standards of research ethics and integrity.

The barriers and facilitators, as identified by NHIS Regional Directors and District Managers, were analysed under several indicators. These included the ease of use (usability), performance, functionality, security/privacy (credibility), and content (accuracy). The ease of use was a significant factor, as it directly influences the adoption and effective utilisation of MRS (McLean, G et al., 2020). Performance and functionality were also critical, as they determine the efficiency and effectiveness of the service. Security and privacy were especially important, given the sensitive nature of health-related data (Wilkowska, W. et al., 2012). Finally, the accuracy of content was fundamental in ensuring trust and reliability in the service. The research employed thematic analysis and factor analysis to dissect the data collected. Thematic analysis allowed for the identification and examination of themes and patterns within the qualitative data collected from the policy implementers. This method was instrumental in understanding the nuanced perspectives of the respondents (Braun, V., et al., 2019).

Chapter 7 of the thesis presented a comprehensive analysis of the policy implementers data, contextualising them within the broader framework of policy implementation in the healthcare sector. The chapter synthesised the complex interplay of factors identified and offered insights into how these factors collectively influenced the implementation of the mobile renewal service within NHIS in Ghana. The findings of this research have implications for policy formulation and implementation, providing valuable insights for stakeholders in the healthcare sector, particularly in developing contexts like Ghana.

3.4 Data sources

In this study, both primary and secondary data sources were utilised to comprehensively address the research objectives. The primary data was collected using a quantitative approach, specifically designed to investigate the UTAUT2 model's applicability in understanding user adoption of MRS and the secondary data was used for the ITSA analysis. Both data sources were essential in offering a holistic understanding of the MRS intervention from different perspectives – user adoption (primary data) and service effectiveness over time (secondary data).

3.4.1 Primary data

Primary data was collected via an online survey targeting NHIS members/subscribers aged 18–60 years. The survey, designed using the UTAUT2 framework, included nine sections covering constructs like Performance Expectancy, Price Value, and Habit. A 7-point Likert scale measured responses, providing quantitative insights into user perceptions. The primary data was gathered through a closed-ended questionnaire, developed and validated based on the survey instrument designed by Venkatesh (2012). The questionnaire, structured using Microsoft Forms, was divided into three sections: an introduction and consent section, a screening question section, and the survey question section. The survey questions were segmented into nine parts, covering various aspects of the UTAUT2 model, including Performance Expectancy, Effort Expectancy, Social Influence, and others. Participants, drawn from the National Health Insurance Scheme members aged between 18 to 60 years, were asked to respond to statements on a 7-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree). The decision to employ a primary data collection method using a survey was to directly capture the perceptions and attitudes of the scheme members towards the mobile renewal service, providing fresh and context-specific insights (Wilcox, A. B et al., 2012). The sample size for this aspect of the study was calculated using the Research Advisors' sample size calculator, determining a minimum requirement of 1,536 participants from a population of 16 million scheme members, ensuring statistical significance at a 95% level with a 2.5% margin of error (Research Advisors, 2006).

3.4.2 Secondary data

Secondary data from the NHIA database (2016–2020) provided the basis for ITSA. This dataset included anonymized records of renewals and payment platforms, enabling a robust analysis of MRS effectiveness over time. This data was sourced from the NHIA membership database, spanning from 2016 to December 2020. The dataset included anonymised membership IDs, gender, regions, districts, start and end dates of subscriptions, registration dates, payment categories, and platforms used for NHIS membership renewal. The use of secondary data in this context was justified by the need for a comprehensive historical perspective on the service's impact over an extended period (Kitchin, R. 2014). The secondary data provided a pre-existing, extensive dataset, which was crucial for conducting an effective ITSA. The choice of secondary data ensured

the availability of a large volume of data, enhancing the reliability and validity of the time series analysis. All data analyses were conducted with Stata 16 (64-bit) software.

3.5 Conclusion

This chapter outlined the theoretical and methodological framework to address the literature gaps and ensuing research questions in this thesis. It argued the rationale of using the UTAUT2 framework and the ITSA model to address the research questions on the effectiveness and drivers of MRS adoption. The subsequent chapter (Chapter 4) of this thesis adopts the ITSA model to evaluate the effectiveness of Ghana's MRS intervention.

CHAPTER FOUR: EVALUATING THE EFFECTIVENESS OF THE MOBILE RENEWAL SERVICE OF NHIS, GHANA

4.1 Introduction

This chapter explored the effectiveness of the MRS intervention by comparing its outcomes to that of the pre-existing renewal intervention, i.e., the manual renewal approach. The MRS outcome herein is defined as the number of NHIS renewals since the inception of the MRS intervention in December 2018. As outlined in the previous chapter, ITSA was utilised to answer the research question for this chapter: Is mobile renewal service effective? The subsequent sections of this chapter assessed the effectiveness of the MRS, present the results, and conclude with practical implications.

4.2 Methods

4.2.1 Research design

The ITSA study design was used to gauge the effectiveness of the mobile NHIS's MRS intervention. ITSA is a quasi-experimental design that estimates an intervention's effect by comparing trends and changes of defined outcomes pre-and-post the intervention over a period (Wagner et al., 2002; Bernal et al., 2017). Its incorporation of pre-data (usually defined as the control group/comparator), serving as counterfactuals, ensures rigour in estimating changes that could be attributed to the intervention, enhancing the understanding of the intervention's impact (Linden, 2018). This advantage of the ITSA approach in incorporating comparable data enhances the reliability of the intervention's impact and provides robust evidence that could inform pragmatic interventions compared to the other observational designs (Linden, 2018). The study adopted the ITSA design for the effectiveness analysis because of its robustness in examining sequential or longitudinal observational data from pre- and post-intervention studies compared to other observational designs, like the cohort design (McDowall et al., 2019). For this study, the comparator was the NHIS renewal data from 2016 to 2018, the period of the manual renewal approach. Accordingly, the ITSA approach allowed the comparison of the NHIS manual renewal trends (comparator) to the mobile renewal trends (intervention: from December 2018) to estimate the intervention's effectiveness. However, the comparator also included data from post-2018,

when the mobile intervention was introduced. This is because the manual and mobile renewal approaches were used concurrently following the introduction of the intervention, and this could potentially affect isolating the intervention's impact on the outcome from the comparator. Nonetheless, the NHIS database (source of data for this chapter) delineates renewal outcomes specific to each of the renewal approach, i.e., the mobile and manual renewal approaches, increasing the probability of isolating renewals outcomes for each approach in the overlapping years.

4.2.2 Data

Secondary data was accessed for this chapter. It was accessed from the NHIS database. It included 51,368,189 NHIS subscription data from January 2016 to December 2020. The dataset included variables such as subscriber's age, sex, date of birth, district, region, start and end dates of subscription, type of registration and payment category. The subscriber's data is collected at the district registration centres across Ghana during in-person registrations. Given that the NHIS policy is universal in Ghana, all Ghanaians are eligible to be registered in the NHIS database. Therefore, all Ghanaians registered with the NHIS and have their data in the NHIS database were included in this chapter's analysis. The accessed data from the NHIS database is anonymised. Ethics approval for accessing the data was granted by the Ethics Committee of Brunel University London College of Health, Medicine and Life Sciences and the Ethics Committee of the NHIA, Ghana. For this study, the data on new users (those whose registration and membership is less than a year) in the NHIS database were not included in this chapter as the focus was on determining the preferred method of renewal and whether renewals had increased as a result of the intervention. Table 4.1 below shows an overview of the variables in the NHIS dataset.

Table 4. 1: Variables in the dataset included in this chapter

Variable	Specification
Membership ID	Unique identification number for every scheme member. Anonymised for the purpose of this research
Gender	Women/Men

Variable	Specification
Region and District	Region and District of members who renewed their membership, either manually or via mobile
Start and End Dates	Start date is the actual renewal date and spans for one year (end date)
Registration Date	Shows when the member joined the scheme
Type of Registration	New, Renewal
Payment Categories	Dependent, Informal, Children under 5, SSNIT Contributor, Person age 70 and over, Leap, AHME, Pregnant Woman, etc.
Payment Platform	Manual (BMS/ EBS), Mobile Renewal (MC_API) ***BMS*** – Biometric Membership System; ***EBS*** – The formal registration system used at the District/Scheme Office for new/renewal registration

Source: NHIS data, 2016-2020

For the purpose of this chapter, three independent variables, namely, gender, region and platform were included in the analysis. The decision to include these variables was informed by the outcome of the systematic literature review (LeFevre et al., 2017; Fadekem et al. 2012; Ngozi, Ogochukwu and Allen, 2015; Peprah et al. 2019). Other studies included variables such as age, sex, ethic group marital status and education (Brinkel et al., 2017).

4.2.3 Intervention

The NHIS's MRS was the intervention in this study. The study defines interventions, in the context of MRS, as strategic measures implemented to enhance the accessibility, efficiency, and uptake of health insurance renewals via mobile technology. These interventions could include:

- Technology integration: Implementing mobile platforms or USSD codes to facilitate seamless health insurance renewal.
- Public awareness campaigns: Educating users on how to use mobile renewal services effectively.
- Incentives and discounts: Encouraging adoption by offering discounts for mobile renewals.
- Customer support systems: Providing call centres or chat support to assist with mobile renewals.

- System optimisation: Enhancing network connectivity and platform usability to reduce transaction failures.

These interventions are typically aimed at improving health insurance coverage and retention to enhance healthcare accessibility, particularly for rural and underserved populations.

As mentioned above, the NHIS' MRS was the evaluated intervention in this chapter. It was implemented alongside the manual renewal. Therefore, this chapter aims to determine its effectiveness in increasing NHIS renewals compared to the sole use of manual renewal. This understanding informed the use of the quasi-experimental design, as it was impracticable to randomly assign NHIS subscribers to control and experimental groups to estimate the MRS effectiveness. Ghana's MRS intervention allowed NHIS subscribers renew their health insurance via a mobile device (Atakorah et al., 2024). Scheme members/subscribers using MRS renew their subscription by dialling a dedicated NHIS short-code *929# from any mobile network in Ghana. On dialling the dedicated short code, they are presented with four options: Option 1 (Check Policy Expiry), option 2 (Renew), option 3 (Benefit Package) and option 4 (Medicine List) as shown in figure 4.1. Members must choose option 2 and enter their membership number in order to access the service. The system prompts the scheme member to pay the required annual premium of about $3.50 and a convenience charge of about US$0.58 from their mobile money wallet. Once a completes the mobile renewal process, the NHIS database and the health service provider system are updated with the renewal to enable the scheme member access health care (Nsiah-Boateng et al., 2023). This mobile renewal service is akin to a similar intervention in Kenya (Jumia, 2017).

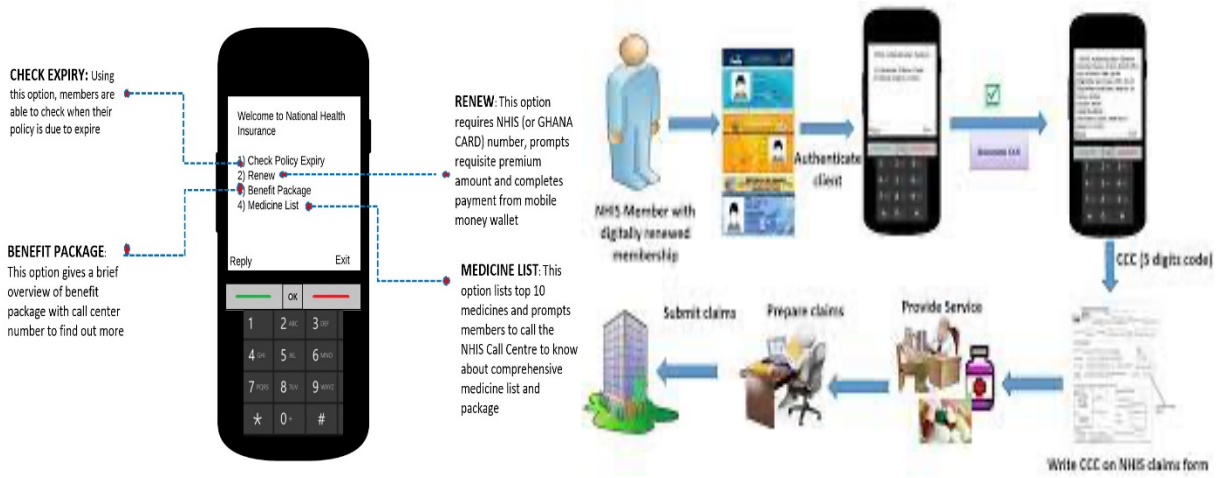

Figure 4. 1: USSD Menu of NHIS

Source: NHIS, Ghana

4.2.4 Comparator

The comparator for this chapter is the manual renewal service only. To assess the effectiveness of the mobile renewal service, it is important to compare it with an alternative mode of renewal, which in this case is the manual renewal which was in existence prior to the introduction of the mobile renewal (Boateng et al., 2013, Akweongo et. al., 2023). With the manual renewal, subscribers go to the district NHIS office with their membership card to renew by paying the appropriate fees (premium and processing fee). Renewal is done once every year. In assessing the effectiveness of the mobile renewal service and overall renewal (manual and MRS), choosing an inappropriate comparator, will make the results unsuitable for decision-making purposes, hence the decision to use the manual renewal (Ziouani et. al., 2016).

4.2.5 Outcome

The outcome for this chapter is the total number of NHIS renewals. These outcomes were informed by the literature and the objective of the NHIS mobile renewal intervention, which is to increase the number of NHIS subscribers and retention rates and, subsequently, the number of persons with increased financial access to healthcare in Ghana (Awoonor-Williams et al., 2016; Boaheng et al., 2019). Therefore, the primary outcome is specified in practice as the number of NHIS renewals, and this could trickle down to the secondary objective of the NHIS, which is to increase NHIS members' retention rates (Boaheng et al., 2019). Other objectives of the NHIS mobile intervention,

such as reduction in the bureaucracy processes associated with the manual renewal approach (Awoonor-Williams et al., 2016), were not included as an outcome because it is not relevant for this thesis. Nonetheless, future studies could consider other methodological approaches to examine when the mobile renewal service intervention has addressed this objective.

4.2.6 Statistical analysis

Two main categories are present in the literature on ITSA design and implementation: Autoregressive Integrated Moving-Average (ARIMA) models and ordinary least squares (OLS) regression models. This study used the OLS regression model, given its robust justification and recommendations by proponents like Velicer and Harrop (1983), Box et al. (2016), and Linden and Ray (2017) due to OLS's sensitivity, flexibility and applicability in the ITSA design. Further, following methodological recommendations from Huitema and McKean (2000), Linden and Adams (2011), Simonton (1977a, b), and Linden (2017), the standard single-group ITSA regression model was employed. This approach allowed for assessing the mobile NHIS renewal intervention's impact over time, considering the trends from the manual renewal approach. In practice, the model was specified as follows:

$$\text{Renewals}_t = \beta_0 + \beta_1 \cdot \text{Time}_t + \beta_2 \cdot X_t + \beta_3 \cdot (\text{Time}_t \times X_t) + \epsilon t$$

Equation 4. 1:Single model ITSA regression model

where:

- Renewals_t: Cumulated NHIS subscription renewals for month t
- Time_t: Time since the study began
- X_t: Dummy variable for the intervention (0 for pre-intervention and 1 for post-intervention)
- $\text{Time}_t \times X_t$:The product of the time since the study began and dummy variable for the intervention
- $\beta_0, \beta_1, \beta_2, \beta_3$: Coefficients representing intercept, slope, immediate impact, and renewal effect over time, respectively
- εt: a random variable

Adjustments were made for seasonality, heteroscedasticity, autoregression and autocorrelation using the Newey-West (1987) variance estimator and the Cumby-Huizinga test. Autocorrelation is a statistical phenomenon that occurs when a correlation exists between successive observations in a time series. This can lead to biased parameter estimates and incorrect inferences in statistical

models. To account for this issue, the study re-estimated the coefficients of Equation 2 using a Prais-Winsten-based technique that explicitly adjusts for autoregression at lag one. This technique is commonly used in time series analysis to correct for autocorrelation. Utilising Prais-Winsten estimation allows for more accurate estimation of the coefficients, as it considers the autocorrelation present in the data. The five-year NHIS data (2016-2020) used for the ITSA has fluctuations in terms of annual subscriber registration and renewal. Adjustment for seasonality was done to isolate the impact of the mobile renewal service from any recurring patterns in the subscribers' data. With a renewal data of 40,931,500 collected over a five-year period, the variability of the number of renewals (outcome variable) per year changed overtime. To avoid bias in the estimation of the intervention effect, adjustments were made for heteroscedasticity (to satisfy constant variance condition) with a view to ensuring that estimates made are accurate. Further to making adjustments for seasonality and heteroscedasticity, adjustment was also made for autocorrelation (correlation exists between the values of the time series variables at different points) to ensure that estimation of the effect of the mobile renewal service and overall significance is free from bias (Newey-West, 1987; Linden 2017).

4.3 Findings

4.3.1 Descriptive findings

Of the 51,368,189 subscribers from the NHIS database (2016 – 2020), 10,436,689 (20.32%) were new users, while 40,931,500 (79.68%) were renewals. Therefore, given the objective of this study, only the data of the renewals are analysed and present here. Many of the subscribers were women (60.41%), used a Biometric Membership System (BMS) for their NHIS renewal (69.5%) and lived in the Ashanti region (18.0%). Table 4.2 below details the descriptive analyses findings.

Table 4. 2:Descriptive findings

Data characteristics	Frequency	Percent
Gender		
Women	24,727,661	60.41
Men	16,203,839	39.59
Platform		

Data characteristics	Frequency	Percent
BMS (Manual Renewal)	28,457,159	69.5
MC API (Mobile Renewal)	12,474,341	30.5
Region		
Ahafo	927,484	2.3
Ashanti	7,365,033	18.0
Bono East	2,387,561	5.8
Bono	1,942,679	4.8
Central	3,046,486	7.4
Eastern	4,807,292	11.7
Greater Accra	837,193	2.1
North-East	2,188,781	5.4
Northern	5,219,413	12.8
Oti	669,209	1.6
Savannah	738,011	1.8
Upper East	2,693,116	6.6
Upper West	1,816,126	4.4
Volta	2,487,055	6.1
Western North	2,489,278	6.1
Western	1,316,783	3.1

Source: NHIS data, 2016-2020.

4.3.2 Single-group analysis

Table 4.3 shows the parameter estimates, with Panel A presenting the specific effects of the mobile renewal intervention on manual renewals, and Panel B offering the overall effect. The starting value of manual renewals was 541,241 subscribers, and the trend was about 60,556 before the intervention was introduced. The immediate effect of the intervention was a reduction of 391,477 manual renewals, while manual renewals decreased over time by 16,497. There is a statistically significant overall effect of the intervention on manual renewals. Table 4.3 further provides the Newey-West parameter estimates for manual renewals, with Panel A showing the specific effects of the intervention, and Panel B presenting the post-intervention linear trend. The parameter

estimates demonstrate a statistically significant reduction in manual renewals following the introduction of the mobile renewal service.

Table 4. 3:Newey –West based parameter estimates for manual renewals

Panel A: Parameter Estimates			
Variable	Coef.	Std. Err.	T-statistic
$Time_t$	6.056***	2.106	2.880
X_t	-391.477***	67.796	-5.770
$Time_t$ *x* X_t	-16.497***	4.873	-3.390
Cons	541.241***	47.803	11.320
Panel B: Post-intervention Linear Trend: 2018m12			
Linear Trend	Coef.	Std. Err.	T-statistic
Treated	-10.441***	4.211	-2.480
No. Obs	60		
F-value	77.420***		

*Notes: The parameter estimates are obtained using Newey –West (1987) variance estimator to correct the effects of autocorrelation and heteroskedasticity. ***/** denote significance at 1% and 5%, respectively. F-valve test shows that the regressors are jointly significant. 60 months are (number of observations) used in the ITSA (2016-2020).*

$Time_t$ *x* X_t in Table 4.3 refers to the interaction between the time since the study began and the dummy variable for the pre-intervention and post-intervention. The product of this interaction provides the possibility that the relationship between the number of renewals (dependent variable) and the independent variables, such as sex, changes over time. The product of the interaction term *Timet x Xt* is significant when the intervention's effect on the number of renewals is not constant but changes over time. The *Coefficient* in Table 4.3 provides the estimated coefficients of the variables in the regression model. Also, *the Standard Error* in Table 4.3 represents the standard errors associated with the estimated coefficients. The *T-Statistic* is essential in determining the statistical significance of the estimated coefficients in the chosen regression model, and it is computed by dividing the Coefficient by the standard error of the Coefficient. In addition, the *Constant* represents the constant term or the intercept. It is the estimated number of renewals when all other dependent variables are zero.

Under Panel B in Table 4.3, the coefficient for the post-intervention linear trend variable is -10.441 with a t-statistic of -2.480, suggesting that there is a negative relationship between the dependent variable and the post-intervention period. The relationship is statistically significant. Also, overall

regression model was found to be statistically significant with F-value is 77.420 at the 1% significance level. The observed variations in the number of renewals can be explained by the regression model due to the high obtained F-value. The variables in table 4.3 are critical to the ITSA, as they help to appropriately evaluate the impact of the introduction of MRS on number of policy renewals by subscribers.

The effect of the intervention, as shown in Figure 4.2, highlights the reduction in manual renewals following the introduction of MRS. The results suggest that the introduction of MRS had a significant impact on manual renewals of NHIS subscriptions. The use of the Newey-West variance estimator helped to account for the effects of autocorrelation and heteroskedasticity, providing robust parameter estimates.

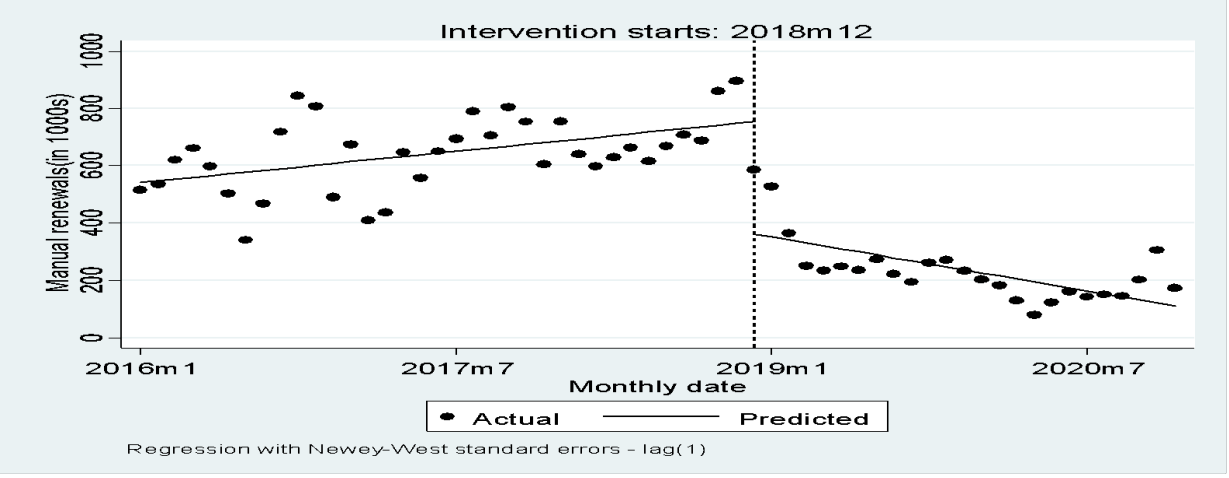

Figure 4. 2:The graph of the estimated parameters using the Newey-West Standards errors at lag one (1) to adjust for the effects of heteroskedasticity and autocorrelation

The test results on table 4.4 show that there is significant autocorrelation at the first and fourth lags, indicated by the CHI2 values of 14.725 and 6.770, respectively, both significant at 1% level. The p-values for lags 2, 3, 5, and 6 were greater than the 0.05 level of significance, indicating the absence of autocorrelation. The results show that the parameter estimates obtained from Equation (1) were robust, and the Newey-West variance estimator used in Table 4.3 was effective in correcting for the effects of autocorrelation and heteroscedasticity. The information provided indicates that there are significant autocorrelations at lags 1 and 4.

Table 4. 4:Cumby-Huizinga test for autocorrelation

LAG	CHI2	DF	P-value
1	14.725***	1	0.000
2	0.570	1	0.450
3	1.467	1	0.226
4	6.770***	1	0.009
5	2.785*	1	0.095
6	1.093	1	0.296

*Notes. ***/**/* denote significance at 1%%, 5% and 10%, respectively. DF represent the degrees of freedom, while CHI2 is the chi-square test statistic.*

Table 4.5 presents the Prais-Winsten-based parameter estimates for manual renewals. Panel A provides the parameter estimates for the specific effects of the introduction of the mobile renewal platform on manual renewals, while Panel B shows the overall effect of the intervention. The results demonstrate that the starting value of manual renewals is 542,143, and the trend of manual renewals is approximately 57,778 before the introduction of the intervention. The immediate impact of mobile renewal was a reduction of 368,393 in manual renewals, and the manual renewals declined over time by 16,837. There was a statistically significant overall effect of the mobile renewal platform on manual renewals. The Durbin-Watson statistic, which measures autocorrelation in the regression residuals, improved significantly from 1.011 to 1.838 after controlling for the effects of autocorrelation in the estimation. The results obtained using Prais-Winsten estimation are similar to those in Table 4.3, indicating the robustness of the findings. The graphical presentation of the effect of the intervention is shown in Figure 4.3, which displays a sharp decrease in manual renewals immediately after the introduction of mobile renewal in December 2018. The results suggest that the mobile renewal platform had a significant impact on manual renewals of NHIS subscriptions in Ghana.

Table 4. 5:Prais-Winsten based parameter estimates for manual renewals

Panel A: Parameter Estimates			
Variable	Coef.	Std. Err.	T-statistic
$Time_t$	5.778**	2.771	2.090
X_t	-368.393***	76.149	-4.840
$Time_t \times X_t$	-16.837***	5.519	-3.050
cons	542.143***	56.374	9.620

rho	0.498		
Panel B: Post-intervention Linear Trend: 2018m12			
Linear Trend	Coef.	Std. Err.	T-statistic
Treated	-11.059	4.411	-2.507
F-value	31.310***		
R-squared	0.627		
Adj. R-squared	0.610		
Durbin-Watson statistic (original)			1.011
Durbin-Watson statistic (transformed)			1.838

*Notes: The parameter estimates are obtained using Prais-Winsten approach to correct the effects of autocorrelation and heteroskedasticity. ***/** denote significance at 1% and 5%, respectively.*

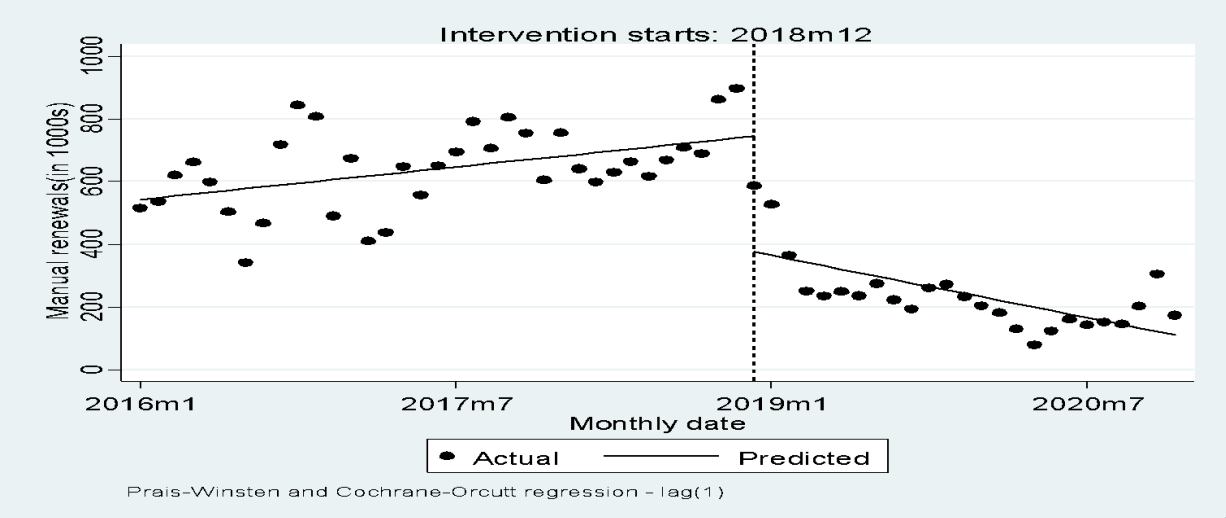

Figure 4. 3:The graph of the estimated parameters using the Prais-Winsten standard errors that follows a first order autoregression model (AR (1)) to adjust for the effects of heteroskedasticity and autocorrelation

Table 4.6 presents the parameter estimates for total renewals. Panel A displays the specific effects of mobile renewals on total renewals, while Panel B presents the overall effects of the intervention. The intercept value denotes the starting value of total renewals, which is 540,123. The trend of total renewals before the intervention was approximately 61,650, which reduced by 61.6 immediately after the introduction of mobile renewals. The effect of mobile renewals on total renewals was not statistically significant, as shown by the insignificant coefficient of -2.824 and

the p-value of 0.610 in Panel A. However, the overall effect of the intervention was statistically significant, as indicated by the F-value of 3.930 and a significance level of **, in Panel B.

Table 4. 6:Newey –West based parameter estimates for total renewals

Panel A: Parameter Estimates			
Variable	Coef.	Std. Err.	T-statistic
$Time_t$	6.165***	2.122	2.900
X_t	-61.633	56.968	-1.080
$Time_t \times X_t$	-2.824	4.628	-0.610
cons	540.123***	47.897	11.280
Panel B: Post-intervention Linear Trend: 2018m12			
Linear Trend	Coef.	Std. Err.	T-statistic
Treated	3.341	4.174	0.800
No. Obs	60		
F-value	3.930**		

*Notes: The parameter estimates are obtained using Newey –West (1987) variance estimator to correct the effects of autocorrelation and heteroskedasticity. ***/** denote significance at 1% and 5%, respectively.*

Table 4.7 presents the Prais-Winsten based parameter estimates for total renewals, where the effects of the introduction of the mobile platform for renewals on the total renewals of the NHIS in Ghana are examined. The parameter estimates are obtained using the Prais-Winsten approach to correct the effects of autocorrelation and heteroskedasticity. Panel A presents the parameter estimates for the individual effects of the intervention, while Panel B provides the post-intervention linear trend. The results show that the coefficient of T is statistically significant at the 5% level, indicating that time has a positive and significant effect on total renewals. However, the coefficients of $T_{2018m12}$ and $TX_{2018m12}$ are statistically insignificant at the 10% level, implying that the introduction of the mobile platform for renewals has a negative and insignificant effect on the total renewals of the NHIS in Ghana over the sample period.

Table 4. 7:Prais-Winsten based parameter estimates for total renewals

Panel A: Parameter Estimates			
Variable	Coef.	Std. Err.	T-statistic
$Time_t$	7.348**	3.113	2.360
X_t	-123.002	88.316	-1.390

$Time_t \times X_t$	-1.991	6.159	-0.320
cons	526.280***	62.889	8.370
rho	0.441		
Panel B: Post-intervention Linear Trend: 2018m12			
Linear Trend	**Coef.**	**Std. Err.**	**T-statistic**
Treated	5.357	4.997	1.072
F-value	2.500*		
R-squared	0.118		
Adj. R-squared	0.071		
Durbin-Watson statistic (original)			1.164
Durbin-Watson statistic (transformed)			1.874

*Notes: The parameter estimates are obtained using Prais-Winsten approach to correct the effects of autocorrelation and heteroskedasticity. ***/**/* denote significance at 1%, 5% and 10%, respectively.*

Moreover, Panel B shows that the coefficient of the treated variable is positive but insignificant, suggesting that the introduction of the mobile platform for renewals has no significant effect on the post-intervention linear trend of total renewals. The findings from Table 4.7 indicate that the launching of the mobile platform for renewals did not significantly impact the total renewals of the NHIS in Ghana over the sample period. The results support this assertion, as the graphical presentation of the Prais-Winsten based parameter estimates for total renewals in Figure 4.4 shows no significant change in the trend of total renewals after the introduction of the mobile platform.

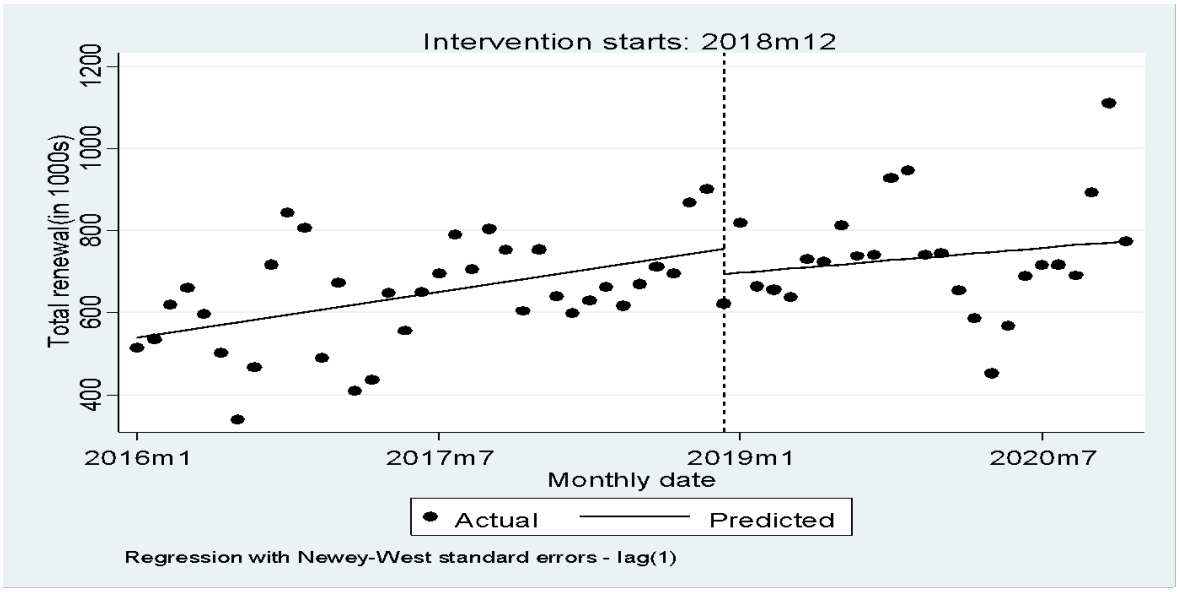

Figure 4. 4: Prais-Winsten based Parameter Estimates for Total Renewals

Source: NHIS Data (2022)

4.4 Discussion

The thesis evaluated the effectiveness of the NHIA's MRS intervention. The analysis showed that the MRS resulted in about 80 percent increase in new NHIS users between 2016 and 2020. This increase in user adoption is in harmony with the broader mHealth literature that typically underscores the positive reception and efficacy of digital health interventions. For example, studies by Brinkel et al. (2017) and Zakus et al. (2019) have illuminated the practicality and ease of use of mHealth solutions, underscoring their ability to streamline healthcare delivery and enhance data reliability. Conversely, early skepticism, such as the findings by Akinfaderin-Agarau et al. (2012), which suggested low utilisation rates of mobile health interventions, seems increasingly misplaced in the context of more recent data, highlighting an evolving user engagement landscape.

Despite the study's findings aligning with contemporary research that advocates for the beneficial impacts of mHealth on health outcomes and service delivery in LMICs (McCool et al., 2022; Tshikomana and Ramukumba, 2022; Vogelsang et al., 2022), it posits a critical reflection on the necessity of periodic reviews to ensure it is context-appropriate and meets user needs to improve

its sustainability. Such evaluations ensure the interventions remain relevant and user-centric, a prudent approach given the dynamic nature of technological advancements and societal needs.

The gender disparity in enrolment, with a higher women participation rate, might intuitively align with the broader trends observed in healthcare utilisation, where women often demonstrate a higher propensity towards engaging with health services (WHO, 2019). This inclination could be attributed to a myriad of factors, including gender roles and responsibilities that inherently make women more proactive in healthcare matters. Moreover, the study's insights into the regional disparities in NHIS renewals suggest an uneven distribution of awareness and resources, a revelation that underscores the need for targeted strategies to bolster enrollment in less engaged regions. Such an approach resonates with the broader discourse on healthcare equity, advocating for tailored interventions that address geographical and socio-demographic nuances (Boateng and Awunyor-Vitor, 2013; Peters et al., 2016).

The study's use of the ITSA to evaluate the transition from manual to mobile renewals post-2018 exemplifies a robust methodological framework (Penfold and Zhang, 2013). This approach not only confirmed the effectiveness of the MRS intervention but also revealed the resilience and adaptability of mHealth solutions in the face of unprecedented challenges such as the COVID-19 pandemic. While the pandemic-induced decline in 2020 renewals could be viewed as a setback, it also opens a dialogue on the importance of considering external factors that could impact digital health interventions. This nuanced understanding of mHealth's potential and limitations enriches the discourse, suggesting that while digital solutions offer significant advantages, their effectiveness is contingent upon broader societal and infrastructural contexts.

Comparatively, the study extends the findings of existing research by offering a specific examination of NHIS mobile renewals in Ghana through ITSA, providing empirical evidence of digital intervention efficacy in a regionally relevant context. This contribution not only enriches the existing body of mHealth literature but also prompts a deeper inquiry into the scalability and sustainability of such interventions across different settings.

In essence, the study's findings, while affirming the growing acceptance and effectiveness of mHealth interventions in LMICs, also highlight the complex interplay of factors that influence digital health solutions' success. By providing a nuanced analysis that bridges the gap between

intuitive expectations and counterintuitive realities, the research underscores the critical need for ongoing evaluation, adaptation, and targeted implementation strategies to maximize the benefits of digital health initiatives (Smith and Doe 2022). Through scholarly rigor and a keen insight into the dynamics of healthcare technology adoption, the study makes a significant contribution to the understanding of mHealth's transformative potential in improving healthcare access and outcomes.

4.4.1 Study's contributions and recommendations

This study adds to the relatively scant body of literature on mHealth interventions, particularly in the context of MRS for health insurance renewal. The findings affirm and build upon existing research by providing detailed empirical evidence of the acceptance of mHealth interventions (Oyeyemi and Wynn, 2014; Barrington et al., 2010; Diop and Lele, 2016). This is particularly significant given the earlier studies that pointed towards lower usage of such interventions. The findings suggest a shift in technology acceptance over time, possibly due to increased accessibility and familiarity with mobile technologies. The use of the ITSA technique also offered a methodological contribution to the field, showcasing the value of the technique in evaluating the longitudinal impact of mHealth interventions, an area that has been overlooked in existing research. Therefore, it is recommended that future research and evaluation efforts make use of this technique to provide robust empirical evidence on the effectiveness of mHealth interventions. Further, the study's findings about the demographic differences in the uptake of the mobile renewal system contribute to the theoretical understanding of the factors influencing mHealth adoption. The higher enrolment rate among women underscores the importance of considering demographic factors in the design and implementation of such interventions.

In addition to the methodological contributions, this chapter’s findings provide several practical implications for managers, policymakers, and implementers of mHealth interventions. Firstly, the broad acceptance of the NHIS MRS suggests that mHealth interventions can be effective tools for improving health service delivery and health system strengthening. This knowledge could inform the design and implementation of similar interventions in other contexts. Secondly, the finding about demographic differences in the uptake of the service highlights the need for policymakers and managers to consider these differences in their strategies. For instance, they might need to take targeted steps to increase awareness and enrolment in underutilised regions or among specific

demographic groups. Thirdly, the study provides evidence that targeted efforts to increase awareness and enrolment can be effective, even in regions with lower populations. This could help address health disparities in low-income areas of the country by informing strategies for promoting equity in access to healthcare services. This study contributes valuable insights to the field of mHealth interventions and offers practical guidance for decision-makers seeking to improve health service delivery and health system strengthening in Ghana and similar contexts.

4.4.2 Limitation of the study and future research direction

The study is limited to a specific timeframe (2016 - 2020), which may not fully capture the long-term effects and sustainability of MRS. A longer observation period could have provided more insight into trends, uptake, and the impact of the mobile renewal service over time, and how external events (such as technological advancements or changes in health policies) could affect these outcomes. While this chapter acknowledges a significant increase in the number of health insurance renewals using MRS, it does not provide empirical evidence on the factors impacting the use of the service. Understanding what influences the adoption and continued use of MRS is necessary to allow scalability. Therefore, this limitation is addressed in a subsequent chapter in this study to offer knowledge on the drivers of MRS adoption.

The study doesn't thoroughly investigate regional discrepancies in the acceptance and usage of mobile renewal services. The results indicated a higher renewal rate in Ashanti and Northern regions, but the reasons behind such regional variation aren't adequately explored. These could be due to factors such as varying levels of digital literacy, availability of mobile network, cultural factors, or differing effectiveness of regional awareness campaigns, which the study hasn't addressed in detail. Furthermore, the data used for the analysis was anonymised. Hence, there was no subscriber-specific information to aid in understanding individual preferences. Therefore, it is not sufficiently clear if the increase in policy renewals was purely due to the introduction of the MRS. This raises the question on whether the MRS is responsible for the increase in renewals. The next chapter investigates this question to offer a deeper understanding of MRS’s effectiveness.

This chapter acknowledges the use of an absolute measure of the outcome (number of renewals) as opposed to a relative measure. The choice of the absolute measure was guided by data availability, as the NHIA database, which is the data repository for NHIS renewals, offers absolute

data on the outcome. While this type of data does not provide a nuanced understanding of renewal trends per defined population sizes and for interpreting population-normalised outcomes, it provides the preliminary evidence to advance future research on relative measures for additional insights.

Finally, the chapter used the OLS model in the regression analysis. This decision was based on the literature and the assumption that the outcome variable, i.e., the number of renewals, is a normal distribution count variable. Given the potential limitation of this assumption, future studies could explore different distributions of this variable to advance the evidence around this research area.

4.5 Conclusion

The significant increase in the number of health insurance renewals using the NHIS's MRS suggests broad acceptance of the scheme, aligning with existing literature on mHealth interventions. Although early studies pointed towards low usage of mobile health interventions, more recent studies have shown a shift towards more positive acceptance, indicating changes in technology acceptance and potential access over time. While acknowledging that this chapter observed an increase in health insurance renewals with MRS, it could not completely attribute that increase to only MRS as MRS was run concurrently with the manual renewal approach. The next chapter of the thesis, therefore, conducted a dissimilarity analysis to assess the extent to which the increase in health insurance renewals could be attributed solely to MRS.

CHAPTER FIVE: COMPARISON OF MANUAL AND MRS INTERVENTION – DISSIMILARITY ANALYSIS

5.1 Introduction

The previous chapter evaluated the effectiveness of the MRS intervention using a single group trend analysis. The limitation with this analysis was that it could not sufficiently clear if the increase in policy renewals was solely as a result of the introduction of the MRS. It is essential to address this lack of clarity because the introduction of the MRS did not result in the manual renewal being stopped. To date, the two modes of renewal (manual vs. MRS) have been running concurrently. The concurrent availability of the two renewal platforms creates complexities in evaluating the impact of the MRS intervention. This chapter, therefore, addressed this complexity to establish whether the introduction of the MRS indeed influenced the increase in adoption or change in the NHIS renewal trends. The chapter builds upon the previous chapter's analysis by providing a more nuanced understanding of the differences between manual and mobile renewals.

The previous chapter was limited in accessing appropriate control group for the multiple group analyses. As a result, it could not establish with certainty whether the increase in overall renewal was due to the introduction of MRS, since both the manual and mobile renewal were running concurrently in the period under review. Could there have been a substitution effect? That is, did subscribers move from manual renewal to MRS? These questions warranted answers to understand the extent to which each renewal platform contributed to the overall NHIS renewal trends to collaborate the result of the ITSA in the previous chapter. To answer these questions, the study reviewed the existing literature, which suggests an alternative approach: comparing the time series of manual and mobile renewals using dissimilarity measures within the broad area of classification and clustering (Galeano and Pena, 2000). The study, therefore, employed various dissimilarity measures that do not rely on specific models to answer the questions around the extent to which the MRS intervention contributed to the NHIS's renewal trends. These measures are detailed in the methods section below.

5.2 Methodology

5.2.1 Dissimilarity measures

Based on the recommendations of Galeano and Pena (2000), Caiado et al. (2006), D'Urso and Maharaj (2009), and Piccolo (1990) and Maharaj (1996, 2000), autocorrelation-based, model-based and partial autocorrelation-based dissimilarity measures were used in this chapter. By adopting these dissimilarity measures, the study compared the characteristics and patterns of the time series for the manual and mobile renewals by quantifying the differences between their datasets in a rigorous and statistically robust manner (Han et al., 2011). Dissimilarity analysis aids in recognising patterns and possible outliners with renewals within datasets, which is crucial for determining whether the increase in renewals was due to the introduction of the MRS. Also, it allows for customisation and it is flexible. Further, its usage is flexible as it allows researchers choose which distance metric to use to assess the difference between the mobile and manual renewals based on the characteristics and needs of the NHIS membership data, allowing for a tailored approach to the analysis (Aggarwal and Reddy, 2014). These advantages of dissimilarity measures contributed to enhancing the understanding of how the MRS intervention influenced the NHIS renewal trends.

Notwithstanding the strengths, dissimilarity analyses could be hindered by sensitivity to outliners and inappropriate metrics. An inappropriate metric can lead to misleading interpretations, negating the outcome of the analysis (Theodoridis and Koutroumbas, 2008). Dissimilarity measures could also be sensitive to noise and outliers, which left unaddressed could distort the results of the analysis and lead to incorrect interpretation conclusions (Rousseeuw and Leroy, 2005). Therefore, the dissimilarity measures performed in this study were carefully selected to avoid misleading results and interpretation. Also, a Portmanteau test, which assessed whether the residuals of the models exhibit white noise characteristics, was conducted to address the noise limitations. The operationalisation of the dissimilarity measures used in the study is described below.

5.2.1.1 Autocorrelation and partial autocorrelation-based dissimilarity measures

Let X_T and Y_T be the time series of manual renewal and mobile renewal of the Ghana's NHIS respectively. The estimated autocorrelations for the two series are defined as

$\hat{\rho}_{X_T} = \left(\hat{\rho}_{1,X_T},...,\hat{\rho}_{L,X_T}\right)'$, and $\hat{\rho}_{Y_T} = \left(\hat{\rho}_{1,Y_T},...,\hat{\rho}_{L,Y_T}\right)'$, where L is such that $\hat{\rho}_{i,X_T} \approx 0$ and $\hat{\rho}_{i,Y_T} \approx 0$ for $i > L$. Galeano and Pena (2000) proposed a dissimilarity measure defined as follows:

$$d_{ACF}(X_T, Y_T) = \sqrt{\sum_{i=1}^{L} p(1-p)^i \left(\hat{\rho}_{i,X_T} - \hat{\rho}_{i,Y_T}\right)^2}, \quad (1)$$

Where $0 < p < 1$ is the geometric weights decaying with autocorrelation lags. This weighting scheme is more appropriate in adjusting for the effects of the various lags than the classical Euclidean distance measure that assumes constant weights. For the sake of brevity, partial autocorrelation-based dissimilarity measure in the spirit of Galeano and Pena (2000) was also considered as follows:

$$d_{PACF}(X_T, Y_T) = \sqrt{\sum_{i=1}^{L} p(1-p)^i \left(\hat{\rho}^*_{i,X_T} - \hat{\rho}^*_{i,Y_T}\right)^2} \quad (2)$$

The terms $\hat{\rho}^*_{i,X_T}$ and $\hat{\rho}^*_{i,Y_T}$ are the respective estimated partial autocorrelations for the manual and mobile renewals time series variables.

5.2.1.2 Model-based dissimilarity measures

Following the literature (Maharaj 1996; Shumway, Stoffer, and Stoffer, 2000), it is assumed that manual renewal and mobile renewal follow invertible autoregressive integrated moving averages (ARIMA). Hence, the parameters of these ARIMA models are estimated and used to measure the distance between these fitted models. The researcher further employed two of the most widely used measures, namely Piccolo distance and Maharaj distance measures. The Piccolo (1990) distance measure is defined as:

$$d_{PIC}(X_T, Y_T) = \sqrt{\sum_{j=1}^{k} \left(\hat{\pi}'_{j,X_T} - \hat{\pi}'_{j,Y_T}\right)^2}, \quad (3)$$

Where $k = \max\left(k_1, k_2\right)$, k_1 and k_2 are the orders of the AR model for X and Y.

Similarly, Maharaj (1996, 2000) proposed discrepancy measures based on the null hypothesis that the series have the same data-generating processes for stationary and invertible autoregressive moving averages (ARMA) models. Maharaj defined the distance of dissimilarity as follows:

$$d_{MAH}\left(X_T, Y_T\right) = \sqrt{T}\left(\hat{\pi}'_{X_T} - \hat{\pi}'_{Y_T}\right)' \hat{V}^{-1}\left(\hat{\pi}'_{X_T} - \hat{\pi}'_{Y_T}\right), \tag{4}$$

selecting k in the fashion of Piccolo distance measure, the terms $\hat{\pi}'_{X_T}$ and $\hat{\pi}'_{Y_T}$ are the parameter estimates of AR(k) of X_T, and Y_T, and $\hat{V}$ is an estimator of $V = \sigma^2_{X_T} R^{-1}_{X_T}(k) + \sigma^2_{Y_T} R^{-1}_{Y_T}(k)$, with $\sigma^2_{X_T}$ and $\sigma^2_{Y_T}$ representing the variances of the white noise of X_T, and Y_T, and R_{X_T}, and R_{Y_T} denote the sample covariance of the two series. The dissimilarity distance measures have three properties: (1) they are non-negative values, $d(X_T, Y_T) \geq 0$, (2) they are symmetric, $d(X_T, Y_T) = d(Y_T, X_T)$, (3) they obey $d(X_T, Y_T) \leq d(X_T, Z_T) + (Z_T, Y_T)$.

Pursuant to the model-based dissimilarity measures, the researcher parametrizes a *p* autoregressive order, *d* integration order, and *q* moving average order, ARIMA (*p, d, q*), as follows for the times series for both the manual renewal and mobile renewal:

$$renew_t = c + \sum_{i=1}^{p} \alpha * renew_{t-i} + \sum_{j=1}^{q} \theta * e_{t-j} + e_t \tag{5}$$

It should be noted that for a stationary time series the ARIMA (*p, d, q*) in equation (5) collapse to a standard autoregressive moving average (ARMA (*p, q*). The parameter estimation of equation (5) for the model-based approach of dissimilarity measures is done within the Box and Jenkins (1970) estimation procedure.

5.3 Results

5.3.1 Dissimilarity measures findings

The results of the model-free and model-based dissimilarity measures are presented in tables 5.1 and 5.2, respectively. Table 5.1 shows that the distance between the mobile and manual renewals is not equal to zero, and as such, they are classified as different time series. Therefore, the series

for both renewals are dissimilar. This outcome is augmented with the model-based approach for the classification of the two-time series variables in table 5.2, as it supports the conclusion drawn from the Autocorrelation Function (ACF) and Partial Autocorrelation Function (PACF) results in table 5.1.

Table 5. 1:Model-free dissimilarity measures

Dissimilarity measure	**Value**
Autocorrelation Function (ACF)	1.330
Partial Autocorrelation Function (PACF)	0.756

Within time series analysis, ACF typically has values ranging from -1 to 1, where +1 indicates perfect positive autocorrelation (each value is perfectly correlated with its predecessor); 0 indicates no autocorrelation (values are independent of each other); and -1 indicates perfect negative autocorrelation (each value is perfectly negatively correlated with its predecessor). The value of 1.330 should be interpreted with caution. A PACF value of 0.756 indicates that there a moderately strong positive correlation between the time series values and their corresponding lagged values, specifically for the lag in question. In the broader context of time series analysis, this outcome suggests that the past values of the series (up to this specific lag) have a significant influence on the current value, after accounting for the effects of earlier lags.

Table 5. 2:Model-based dissimilarity measures

Dissimilarity measure	**Value**	**P-value**
Piccolo distance	0.616	
Maharaj distance	0.984	0.321

Notes: The Piccolo distance measure does not produce p-value as compared to Maharaj distance measure. The p-value shows that the manual and mobile renewals come from the same class of models, but the distance value shows the dissimilarity between these variables.

A Piccolo distance value of 0.616 indicates a moderate level of dissimilarity between the two-time series. This suggests that while the autoregressive structures of the two series share some similarities, there are notable differences in how past values influence future values in each series. The literature (Maharaj 1996; Shumway, Stoffer, and Stoffer, 2000) suggests that Maharaj distance

ranges from 0 to 1, where 0 indicates that the two-time series are identical in terms of their underlying generating processes. 1 indicates maximum dissimilarity, meaning the series are very different. A Maharaj distance value of 0.984 is very close to 1, indicating a high level of dissimilarity between the two-time series. This suggests that the underlying processes generating the two series are substantially different. In the context of model-based dissimilarity measures, a p-value is used to determine whether the difference between two time series is statistically significant. A p-value of 0.321 means there is a 32.1% chance of observing the data under the assumption that the null hypothesis is true. This p-value of 32.1% is relatively high since it is greater than the commonly used significance level of 0.05 or 0.01.

In addition to the model-free analysis, an ARIMA model specification was imposed, and the dissimilarity measures were estimated to ensure the robustness of the analysis outcome. To proceed with the imposed model-based dissimilarity analysis, the time series for manual renewal which is the Biometric Membership System (BMS), and mobile renewal (MC_API) were subjected to a unit root test using both the Augmented Dickey-Fuller and Philips-Perron tests. The latter was more suitable for small sample size of the study. The results are presented in Table 5.3. The outcome reveals that, for both tests, the manual renewal (BMS) is stationary, while mobile renewal (API) attains stationarity at the first differencing level. Hence, for manual renewal (BMS), an appropriate autoregressive moving average (ARMA) model is estimated, while an autoregressive integrated (order one) moving average (ARIMA) model is estimated for mobile renewal (API). The MC_API is the formal renewal system used for membership renewal online.

Table 5. 3:Unit root test for manual renewal (BMS) and mobile renewal (API)

	Level			**First Difference**		
	Panel A:	**Augmented Dickey-Fuller test**				
	T-stat (Z(t))	**P-value**		**T-stat**	**P-value**	**Status**
Manual (BMS)	-4.126***	0.006				I(0)
Mobile (API)	-2.434	0.362		-4.178***	0.005	I(1)
	Panel B:	**Phillips-Perron test**				
	T-stat	P-value		T-stat	P-value	Status
Manual (BMS)	-4.062***	0.007				I(0)
Mobile (API)	-2.406	0.376		-4.068***	0.007	I(1)

*Note: P-value is the MacKinnon approximate probability value for test statistic (Z(t)). *** Significant at 1%. Panel A offers the Augmented Dickey-Fuller test for unit root, while Panel B presents the Phillips-Perron test for unit, which is more appropriate for small sample sizes*

Following the Box and Jenkins (1970) model selection approach, *p* (the AR portion) and *q* (the MA part) are identified using partial autocorrelation and autocorrelation functions, respectively. This enables the estimation of various models. The outcomes for manual renewal are presented in Figures 5.1 and 5.2, while those for mobile renewal are presented in Figures 5.3 and 5.4. The autocorrelation function in Figure 5.1 suggests that the optimal value for q is 1, while the optimal value for p in the partial autocorrelation function in Figure 5.2 is also 1.

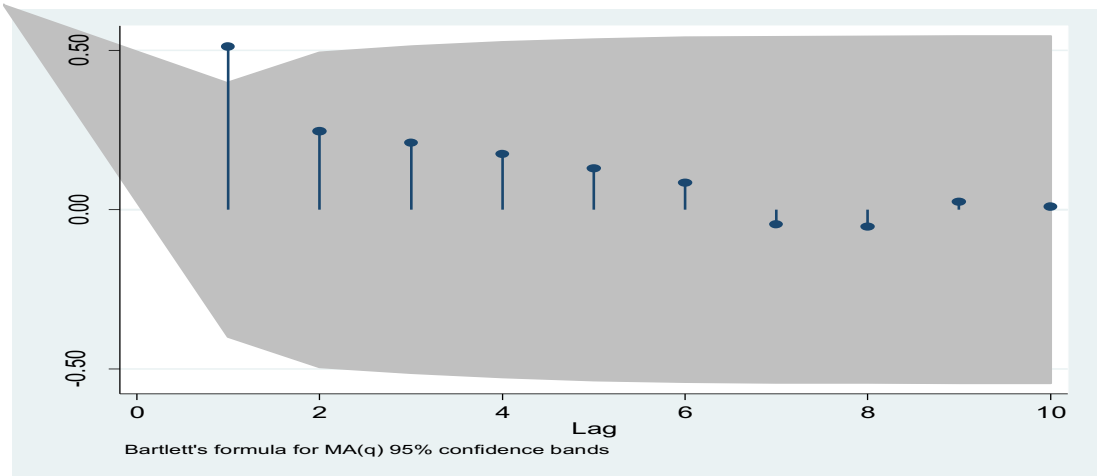

Figure 5. 1:Manual renewal autocorrelation.

The vertical axis represents the autocorrelation coefficients, which measure the correlation between the time series and its lagged values. These values typically range from -1 to 1. The horizontal axis represents the different time lags, with Lag 1 being the correlation between each value and the value immediately preceding it, Lag 2 being the correlation between each value and the value two steps earlier, and so on. The blue points indicate the autocorrelation values at each lag. The vertical bars (lines) extending from each point represent the 95% confidence intervals around the autocorrelation estimate. If the bars cross the horizontal line at zero, it suggests that the autocorrelation at that lag is not statistically significant. Also, in interpreting figure 5.1, the gray shaded area represents the confidence bands, usually based on Bartlett's formula for moving average models (MA). These bands help to determine whether the autocorrelation at a specific lag is significantly different from zero. Autocorrelation values that fall outside the gray shaded area as shown above are considered statistically significant, suggesting that the time series has some form of dependency at that specific lag. Therefore, the manual autocorrelation time series in figure 5.1 shows a significant positive autocorrelation at Lag 1, implying that there is a strong relationship between consecutive time points. However, as the lag increases, the autocorrelation reduces, indicating that the time series values become less dependent on past values as the lag increases. Thus, the influence of past values quickly diminishes after the first lag.

Figure 5.2 measures the correlation between the partial autocorrelation time series for the manual renewal and its lags, while controlling for the values of the intervening lags. From figure 5.2, the partial autocorrelation at Lag 1 is strong and positive, as shown by the value being above zero and outside the shaded area. This indicates a significant positive correlation between the current time series value and the value at Lag 1, after controlling for any intervening lags. However, from Lags 2 to 10 the partial autocorrelation values are smaller and mostly within the confidence bands, suggesting that they are not statistically significant. This means that after accounting for the effects of Lag 1, there is no significant correlation between the current value and these further lags. Therefore, from the figures 5.1 and 5.2, $p = 1$ and $q = 1$, and $d=0$ since the manual renewal variable is stationary at the levels. Hence, ARMA (1,1) (aka, ARIMA (1,0,1) is estimated.

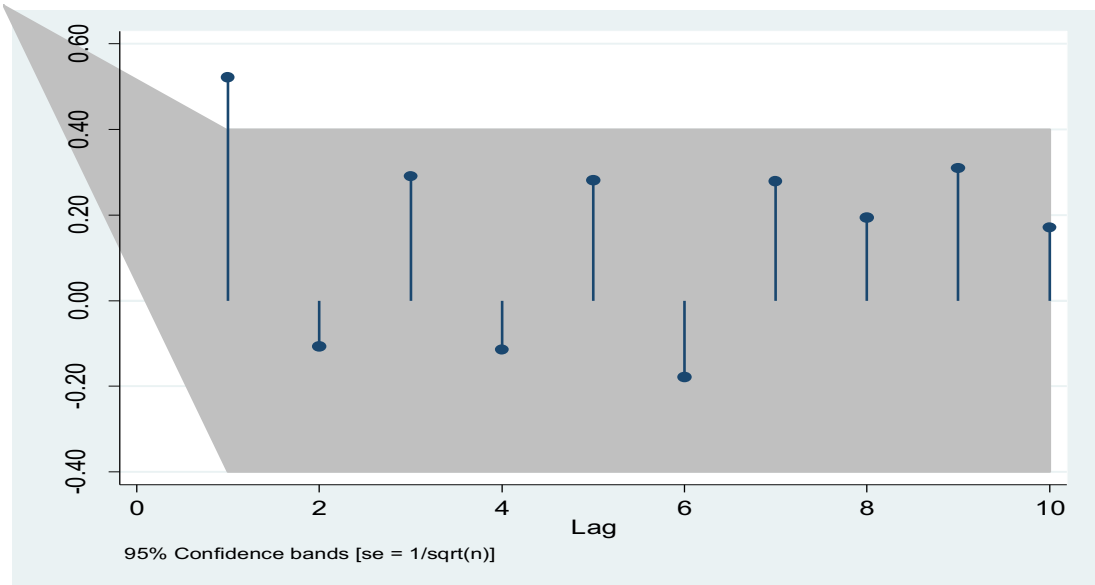

Figure 5. 2:Partial autocorrelation of manual renewal

In analysing the mobile renewal time series variable, the examination of Figures 5.3 and 5.4 revealed that the suggested value for q, representing the order of the moving average component, is 0, indicating no significant moving average effect. Conversely, the optimal value for p, representing the autoregressive component, is 7 based on the partial autocorrelation function. To ensure a comprehensive and in-depth analysis of the dissimilarity among the time series variables under consideration, the study further explored alternative specifications. This exploration involved considering different model configurations and assessing their potential impact on the dissimilarity measures to enhance the richness of the analysis, providing a more nuanced understanding of the relationships and patterns within the mobile renewal time series variable.

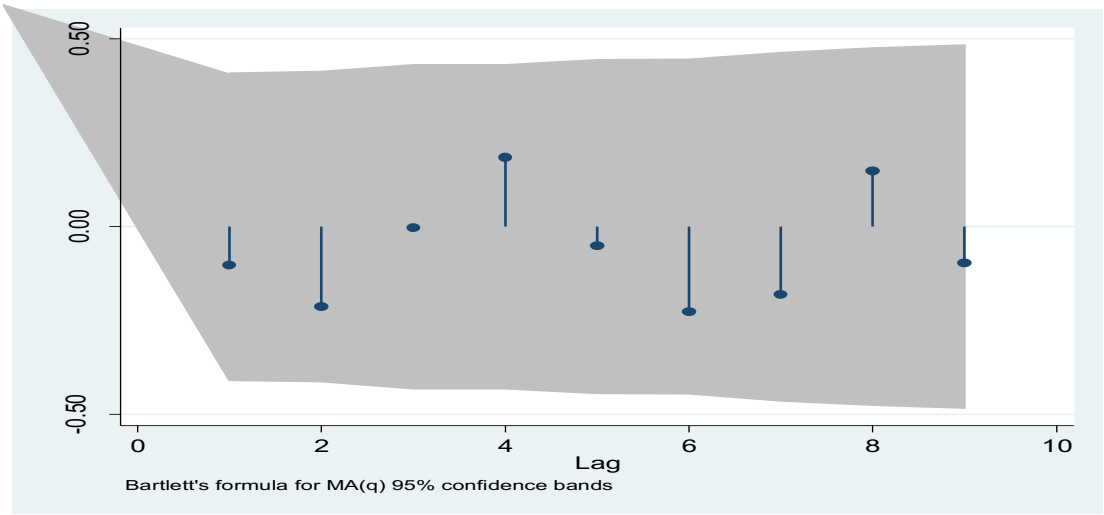

Figure 5. 3:Autocorrelation for mobile renewal

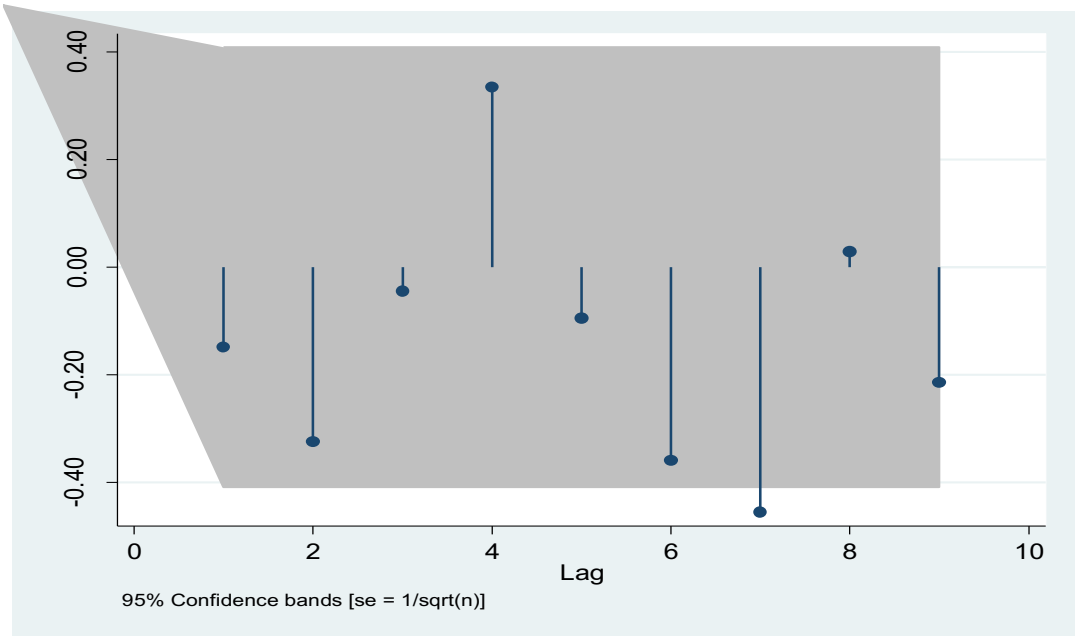

Figure 5. 4:Partial autocorrelation for mobile renewal

The study explored additional candidate models beyond the initial ARMA (1, 1) model. This approach allowed for a more comprehensive analysis of the data, considering potential alternatives. Table 5.4 presents the parameter estimates for the ARIMA models of the manual and mobile renewal intervention. The table displays the estimated coefficients for the autoregressive

(AR) and moving average (MA) parts of the models. The values in the table represent the parameter estimates, with their corresponding standard errors in brackets.

Table 5. 4:Parameter estimates ARIMA models of manual and mobile renewals.

Manual renewal						
ARMA						
	Autoregressive (AR) Part					
L.AR	0.869***	0.688***				
	(0.105)	(0.214)				
L2.AR				-0.314*		
				(0.165)		
	Moving Average (MA) Part					
L.MA		0.847**	0.912***		-0.471***	
		(0.336)	(0.294)		(0.201)	
L6.MA					-0.304	
					(0.303)	
L7.MA						-0.709**
L7.AR						-0.312
cons	268.159***	241.182***	225.844***	13.712	13.288**	
	(86.943)	(77.277)	(32.529)	(15.400)	(6.293)	
sigma	62.413***	54.985***	63.990***	81.348***	77.448***	72.647***
	(9.771)	(6.933)	(9.720)	(15.867)	(17.231)	-14.323
N	24.000	24.000	24.000	23.000	23.000	23.000
LLIKLI.	-133.970	-131.634	-134.752	-133.911	-133.221	-133.455
CHI2	69.077***	22.039***	9.637***	3.612**	6.113***	5.171**
DF_M	1.000	2.000	1.000	1.000	2.000	1.000
AIC	273.940	271.268	275.504	273.821	274.443	272.91
BIC	277.475	275.980	279.038	277.228	278.985	276.317
Model	AR (1)	ARMA (1,1)	MA (1)	AR (2)	MA (1)	MA (7)

Per table 5.4, the model types are AR (1): Autoregressive model of order 1; ARMA (1,1): Autoregressive Moving Average model of order 1 for both AR and MA components; MA (1): Moving Average model of order 1; AR(2): Autoregressive model of order 2 and MA (7): Moving Average model of order 7. The parameters in table 20 are *L.AR*: Coefficients for the lagged values of the dependent variable (autoregressive part); *L.MA*: Coefficients for the lagged errors (moving average part); *cons*: The constant term (intercept); *sigma*: The standard deviation of the residuals

(errors) from the model; *N*: The number of observations used in the model; *LLIKLI*: The log-likelihood value, which indicates how well the model fits the data (higher is better); *CHI2*: The Chi-square statistic for testing model fit; *DF_M*: Degrees of freedom for the model; *AIC*: Akaike Information Criterion, a measure of model quality considering both fit and complexity (lower is better); *BIC*: Bayesian Information Criterion, similar to AIC but with a stronger penalty for complexity (lower is better).

The results of the AR (1) Model is briefly explained as *L.AR (0.869)**: the coefficient for the first lag of the AR part is 0.869, which is highly significant (indicated by the ***). This suggests a strong positive relationship between the current value and the previous value of the series; *cons (268.159)**: the intercept is also significant, indicating a baseline level for the series; and *sigma (62.413)**: the standard deviation of the residuals is relatively small, suggesting a good fit. ARMA (1,1) model has the following results as indicated in table 20. *L.AR (0.688)**: the AR coefficient is 0.688, significant and indicating a moderate positive relationship; *L.MA (0.847)*: the MA coefficient is 0.847, significant at the ** level, indicating the presence of a significant moving average component; *cons (241.182)**: the intercept is significant and smaller than in the AR(1) model; *sigma (54.985)**: the residual standard deviation is smaller than in the AR(1) model, suggesting this model may fit the data better; *LLIKLI (-131.634)*: The log-likelihood is slightly better (higher) than the AR(1) model, indicating a better fit. The MA (1) model produced significant results in assessing the manual renewal. The MA coefficient of *L.MA (0.912)** is very strong and significant, suggesting that the current value is largely influenced by the error term from the previous period. The intercept value of *cons (225.844)** is also significant. The residual standard deviation is similar to the AR (1) model since it yielded a value of *sigma (63.990)**. In comparing the models, Log-Likelihood (LLIKLI), AIC and BIC are considered. Log-Likelihood (LLIKLI): The ARMA (1,1) model has the highest log-likelihood (-131.634), suggesting it fits the data best among the models compared. AIC and BIC: Lower AIC and BIC values indicate better models. The ARMA (1,1) model has the lowest AIC and BIC values, supporting it as the best fitting model.

Table 5.5 highlights the model selection criterion for the manual and mobile renewals. The table presents different models (labelled A to G) and evaluates their performance based on various

criteria such as log likelihood, Akaike information criterion (AIC), and Bayesian information criterion (BIC). The best model for each series is identified based on these criteria. For the best models, specifically models B and F, additional tests were conducted. These tests include the Portmanteau test, which assesses whether the residuals of the models exhibit white noise characteristics. Furthermore, the tests check whether the ARMA models are covariance stationary by examining if the AR model roots lie within the unit circle, and whether the models are invertible by ensuring that all MA roots lie within the unit circle. For the ARMA (1,1) model, the Portmanteau test yields a statistic value of 7.190 with a corresponding p-value of 0.707. Similarly, for the MA (7) model, the Portmanteau test in table 5.6 yields a statistic value of 5.551 with a p-value of 0.784. Based on the p-values, we fail to reject the null hypothesis, indicating that the residuals of both models exhibit white noise properties. The implication is that the residuals of both models, ARMA (1,1) and an MA (7) do not violate the conditions and assumptions of the models, hence are suitable for further analysis. These models, B (ARMA (1,1)) and F (MA (7)) in table 5.6 can now be used for further analysis, knowing they represent the data most effectively among the alternatives considered. For the best models, B and F, different tests were performed (i) Portmanteau test to determine if the residuals of the model are white noise; (ii) check if our ARMA models are covariance stationary, AR model roots must lie in the unit circle; (iii) investigate if our ARMA models are invertible, thus all the MA roots must lie in the unit circle.

Table 5. 5:Model selection criterion

Manual renewal					**Mobile renewal**				
Models					**Models**				
	Model A	**Model B**	**Model C**		**Model D**	**Model E**	**Model F**	**Model G**	
Criterion	AR(1)	ARMA(1,1)	MA(1)	**Best Model**	AR(2)	MA(1)	MA(7)	AR(7)	**Best Model**
C, AR and MA	2	3	2	A and C	2	2	2	2	D, E, F and G
Log Likeli.	-133.970	-131.634	-134.752	B	-133.911	-133.221	-133.455	-134.148	E
Akaike	273.940	271.268	275.504	B	273.821	274.443	272.910	274.296	F
Bayesian	277.475	275.980	279.038	B	277.228	278.985	276.317	277.702	F

Manual renewal					Mobile renewal				
Models					Models				
	Model A	Model B	Model C		Model D	Model E	Model F	Model G	
Overall Best Model				**B**					**F**

Note: Model A-C are the various ARMA models for the series of manual renewal, while Models D-F are those of mobile renewals. For AR(7) and MA(7) models, the significant coefficients are only selected

Table 5. 6:Portmanteau test

ARMA(1,1)	Value
Portmanteau (Q) statistic	7.190
P-value	0.707
MA(7)	
Portmanteau (Q) statistic	5.551
P-value	0.784

Notes: The null hypothesis is that the residuals of the model are white noise. Based on the p-values we failed to reject the null hypothesis.

The figures in table 5.6 above visually demonstrate that the ARMA models satisfy the conditions of covariance stationarity and invertibility, thereby confirming their suitability for further analysis. These results indicate that the selected models adequately capture the underlying patterns and dynamics of the time series data. Model B (ARMA (1,1)) is identified as the best model for "Manual renewal" because it has the highest log-likelihood, and the lowest AIC and BIC values. These metrics indicate that Model B fits the data better while balancing complexity. In comparison, Model F (MA (7)) is identified as the best model for "Mobile renewal" because it has the lowest AIC and BIC values, despite not having the highest log-likelihood. This suggests that Model F strikes the best balance between fitting the data well and not being overly complex.

The Portmanteau test is conducted to assess whether the residuals of these models exhibit white noise characteristics. The null hypothesis of the test is that the residuals do not display any serial correlation, indicating that they are random and resemble white noise. For both models, the Portmanteau test fails to reject the null hypothesis, implying that the residuals of the models can be considered as white noise, indicating randomness and lack of systematic patterns or correlation.

In addition, the resulting figures demonstrate that the ARMA models satisfy the conditions of covariance stationarity and invertibility. Covariance stationarity refers to the property where the statistical properties of a time series, such as mean and variance, remain constant over time. Invertibility refers to the property where the effects of past values on the current value of the time series can be completely represented by a finite number of lagged values. The satisfaction of these conditions indicates that the ARMA models are appropriate for further analysis and can be utilised to make valid inferences and predictions. Figures 5.5 and 5.6 presented below provides the results of the Portmanteau test for two models: the ARMA (1,1) model and the MA (7) model.

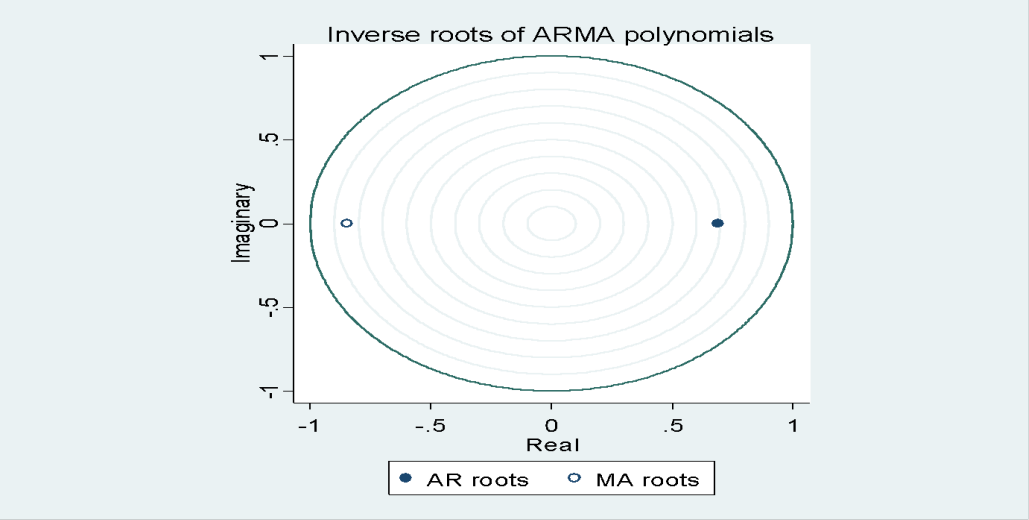

Figure 5. 5:Covariance stationary

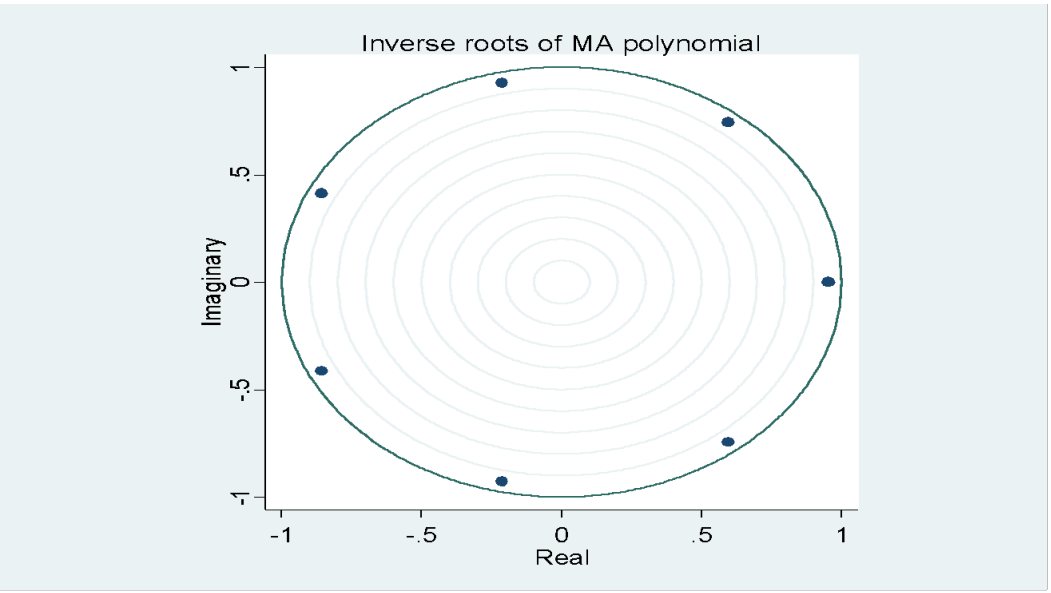

Figure 5. 6:Invertibility conditions

5.4 Discussion

This chapter conducted a dissimilarity analysis to understand whether the observed increase in the NHIS renewal rates post-December 2018 in Chapter 4 was directly attributable to the deployment of the MRS intervention. In ascertaining the differences between the manual renewal and MRS, the characteristics of the two renewal platforms were analysed using both model-free and model-based dissimilarity measures as tools for quantification. The findings from the model-free analysis showed a discernible variance between the time series of manual renewals and those conducted via MRS, suggesting a fundamental shift in user preference towards the mobile platform post-implementation. However, the absence of subscriber-specific data necessitates a cautious interpretation of these results. Without detailed insights into individual decision-making processes or a deeper understanding of the data's underlying relationships, attributing the increase in renewals solely to the introduction of MRS might oversimplify the dynamics at play.

Furthermore, the model-based analysis corroborated the distinctiveness of the renewal mechanisms, revealing that while the time series variables for both renewal methods stemmed from analogous models, the actual values pertaining to each renewal method diverged significantly. This analytical convergence underscores the transformative impact of the MRS on NHIS renewals, marking a departure from traditional manual processes.

The subsequent surge in renewals following the nationwide rollout of the mobile intervention in December 2018 serves as empirical evidence of this transformative impact. This uptick not only highlights a significant user migration to the mobile platform but also attests to the successful integration and acceptance of the MRS within the NHIS ecosystem. The sustained growth in mobile renewals through 2019 and 2020 further reinforces the enduring appeal and utility of the MRS among NHIS users, signifying a positive reception and continued reliance on the mobile platform for renewal activities.

This transition from manual to mobile renewals aligns with broader trends observed in mHealth research, where interventions leveraging smartphone technology have demonstrably enhanced healthcare accessibility. Studies by Brinkel and Owusu-Dabo (2017), Fatoye et al. (2019), Julia R. G. (2014), and Zakus and Moussa (2019) corroborate the potential of mHealth solutions to transcend the limitations inherent to manual health service processes, offering unprecedented ease and accessibility to users. These findings collectively validate the distinct advantages of the mobile renewal system over its manual counterpart, illustrating the pivotal role of digital interventions in modernizing healthcare delivery mechanisms. The results of the dissimilarity analysis underscore the necessity of nuanced interpretation and further investigation into the factors driving these outcomes.

5.4.1 Implications for theory and practice

The implications of an ITSA dissimilarity analysis in this study have both theoretical and practical significance. Theoretically, it contributes to a deeper understanding of temporal underlying dynamics in the sampled data and supports the development of new hypotheses and models. Based on the outcome of the statistical tests conducted in this study, ITSA dissimilarity analysis has the potential to help refine theories on causal relationships and the dynamics of intervention impacts such as that of the NHIS MRS. Practically, it informs the design, implementation, and evaluation of interventions, guiding decision-makers in optimizing the impact of their actions. The literature supports these assertions (Wagner et al., 2002; Bernal et al., 2017). Thus, the outcomes of such analyses are valuable tools in both advancing knowledge and improving real-world practices. Policymakers can use these findings to justify and support the continued review and expansion of mobile renewal service intervention within healthcare systems, potentially resulting in more efficient and streamlined operations.

5.4.2 Recommendations

The remarkable surge in renewals and continued growth observed after the nationwide implementation of the mobile intervention indicates widespread acceptance and utilisation by users. To capitalize on this positive response, it is recommended to further implement and expand mobile renewal systems within the NHIS and similar healthcare schemes in the sub-region. Additional efforts should be made to promote awareness and educate subscribers about the mobile system's benefits and functionality through various channels such as educational campaigns, mobile applications, and user guides. Continuous evaluation and improvement through user surveys, focus groups, and data analysis are essential to ensure alignment with subscribers' needs and expectations. These actions can maximize the benefits of the mobile system, contribute to enhanced healthcare processes, and potentially lead to increased enrolment and better healthcare outcomes.

5.4.3 Limitations of study

One limitation of the dissimilarity analysis is the lack of a comprehensive analysis of the perspectives of subscribers and policy implementers regarding the mobile renewal system. While the study indicates a moderately significant dissimilarity between the manual and mobile systems, it does not provide direct insights into the transition to the mobile renewal process from the viewpoint of subscribers and policy implementers. Understanding their level of satisfaction, perception of accessibility, and any barriers encountered during adoption and utilisation could shed light on the effectiveness of the design changes made and identify areas for improvement. Incorporating these perspectives in future studies could provide a more comprehensive understanding of the impact and effectiveness of the mobile renewal service, invaluable for refining the service, addressing potential limitations, and ensuring successful integration into the healthcare practices of Ghana’s NHIS and similar schemes in the West African Sub-region.

5.5 Conclusion

The findings of the analysis reveal a statistically significant dissimilarity between the manual renewal and the MRS intervention. The remarkable surge in renewals following the nationwide implementation of the MRS intervention in 2018 suggests a widespread acceptance and adoption of MRS by NHIS users. The consistent growth in renewals from 2019 to 2020 further emphasises

the acceptance and utilisation of the intervention. The positive response and growth observed in the MRS demonstrate the effectiveness of the intervention compared to the existing manual system. Previous research on mHealth interventions utilising smartphones validates the distinctiveness of the mobile intervention compared to the manual system (Brinkel et al., 2017; Zakus et al., 2019; Vogelsang et al., 2022). These studies consistently show that mHealth interventions enhance accessibility, aligning with the results of the dissimilarity analysis and further supporting the notion that the mobile renewal system is a valuable and effective tool for enhancing healthcare processes. The next chapter of the study examines NHIS's subscribers' perspectives on factors that could enhance the adoption of MRS.

CHAPTER SIX: ASSESSING THE BARRIERS AND FACILITATORS AFFECTING THE ADOPTION OF THE NHIS MOBILE RENEWAL SERVICE – SUBSCRIBERS PERSPECTIVE

6.1 Introduction

The rationale for including Chapter 6 arises from the critical need to address limitations identified in Chapters 4 and 5. While these earlier chapters provided valuable insights into the effectiveness of MRS, they fell short of exploring the behavioral and contextual factors that influence its adoption. The statistical evaluations presented in Chapters 4 and 5 demonstrated measurable impacts on renewal patterns but did not adequately explain the slower-than-expected uptake of the MRS among NHIS subscribers. This gap necessitated a deeper inquiry into the barriers and facilitators that shape user engagement with the MRS, thereby motivating the inclusion of Chapter 6. Chapter 4 utilised an ITSA to evaluate the impact of the introduction MRS for NHIS renewal trends. While the analysis revealed significant changes in renewal patterns, including a decline in manual renewals, it did not fully elucidate why the anticipated levels of MRS adoption were not achieved. The findings highlighted a discrepancy between the statistical impact of the intervention and its real-world uptake, raising questions about the underlying behavioral and contextual challenges. Similarly, Chapter 5 employed dissimilarity measures to compare manual and MRS renewals, offering insights into distinct trends and usage patterns. However, this chapter focused on statistical comparisons rather than examining the factors driving these trends, leaving an important aspect of the analysis unexplored.

The decision to pursue the research in Chapter 6 was further influenced by observations from Chapters 4 and 5 that hinted at potential barriers to adoption, such as technical limitations, socio-economic constraints, and resistance to change. These observations, however, were largely speculative, underscoring the need for empirical evidence to validate and expand upon these assumptions. Preliminary hypotheses suggested that challenges like limited network access, low digital literacy, and a lack of user familiarity with the MRS could be influencing its adoption. Addressing these questions required a shift from statistical analyses to a mixed-method approach, enabling a more comprehensive exploration of the factors at play.

Chapter 6 seeks to bridge the gap between quantitative analyses and the lived experiences of NHIS subscribers by focusing on both the barriers and facilitators of MRS adoption. The chapter examines the challenges hindering user engagement, such as technical difficulties and limited awareness, while also identifying enablers like targeted user education, cost reductions, and supportive policy frameworks. This dual focus ensures a well-rounded understanding of adoption dynamics, integrating both subscriber perspectives and broader systemic insights.

In addressing these questions, Chapter 6 complements the findings of earlier chapters, offering a deeper and more nuanced analysis of MRS adoption. The chapter contributes to the overall thesis by providing actionable insights into the behavioral and systemic factors influencing technology adoption in healthcare. This addition strengthens the empirical foundation of the study and informs practical recommendations for improving MRS implementation and uptake, thereby enhancing its overall effectiveness and impact.

6.2 Methods

6.2.1 Theoretical framework

This chapter adopts the UTAUT2 theoretical framework. This framework has been used in this study because its purpose aligns with this chapter's objective of evaluating the factors that influence the adoption of a technological intervention, i.e., MRS (Gupta et al., 2019). In addition, the literature supports UTAUT2 as a standard framework for evaluating the adoption of digital interventions, confirming its choice in this study (Gupta et al., 2019; Khechine et al., 2020; Nordhoff et al., 2020; Abubakari et al., 2021; Amankwaa et al., 2020; Asamoah et al., 2021). Other alternative frameworks, like the Health Belief Model (HBM) and Theory of Planned Behaviour (TPB), could have been used because they are also relevant theories for evaluating digital interventions. However, these frameworks were not deemed appropriate for this research because HBM does not account for the complexity of health behaviours among subscribers and has limited predictive power (Glanz et al., 2015; Jones et al., 2015). Like the HBM, TPB also helps to understand and predict human behaviour, but it also has limited predictive. It also focuses on intentions and neglects key constructs such as social influences and habits that could influence

intervention adoption, making it unsuitable for this chapter (Armitage et al., 2001; Hagger et al., 2015) since the analysis herein requires using a theoretical model that has predictive power and can provide insights into the beliefs and attitudes of subscribers. Therefore, comparatively, the UTUAT2 framework was a more appropriate option for this study due to its ability to offer a comprehensive list of constructs to predict the factors that influence subscribers' intention to adopt MRS (Venkatesh et al., 2012). UTAUT2 integrates the key constructs from several theories of technology acceptance and use, including the Technology Acceptance Model (TAM), the TPB, the Social Cognitive Theory (SCT), and the Model of PC Utilisation (MPCU), making it a robust evaluation framework. The UTUAT2 framework and its constructs or predictors are shown in Figure 6.1 and Table 6.1 respectively.

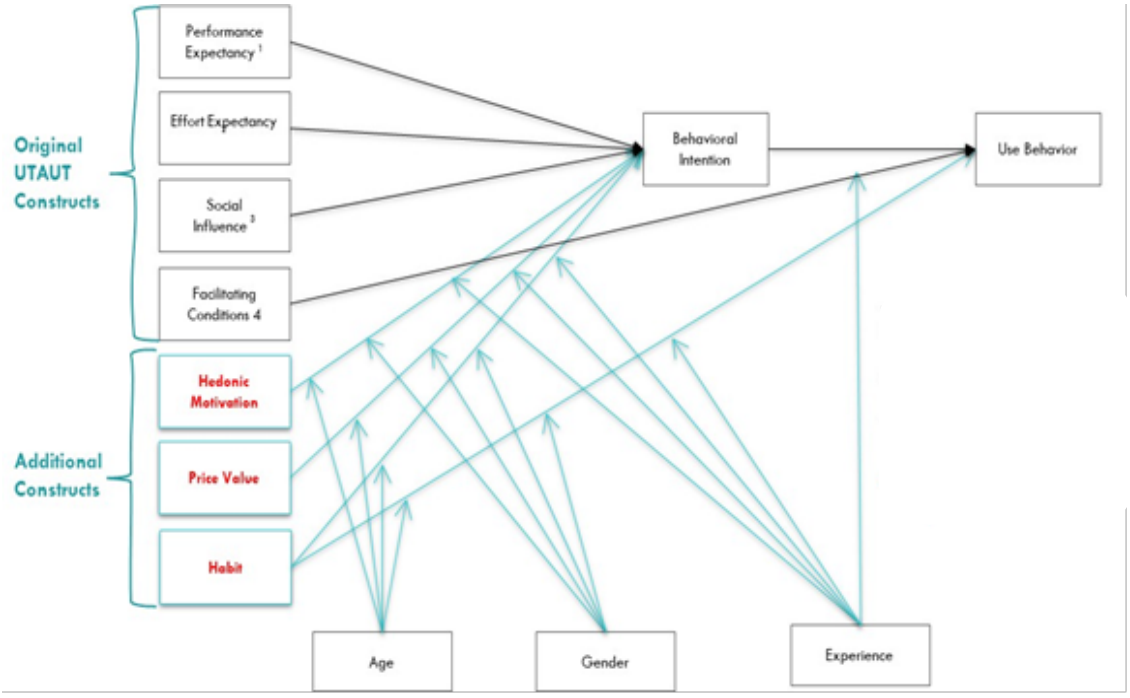

Figure 6. 1:UTAUT2 Framework by Venkatesh et al. (2012)

Table 6. 1:UTUAT2 constructs

Construct	Operational definition	Status
Performance Expectancy (PE)	The degree to which a subscriber believes that using the NHIS MRS will help them achieve gains in job performance. Measured by items such as: "I find the NHIS MRS useful in managing my health insurance." "The NHIS MRS enhances my efficiency in renewing health insurance."	Independent Variable
Effort Expectancy (EE)	The ease of use associated with the NHIS MRS. Measured by items such as: "Learning to operate the NHIS MRS is easy for me." "I find it easy to get the NHIS MRS to do what I want it to do."	Independent Variable
Social Influence (SI)	The degree to which an individual perceives that important others believe they should use the NHIS mobile renewal service. Measured by items such as: "People who influence my behavior think that I should use the NHIS MRS." "People who are important to me use the NHIS MRS."	Independent Variable
Facilitating Conditions (FC)	The degree to which an individual believes that an organisational and technical infrastructure exists to support the use of the NHIS MRS. Measured by items such as: "I have the resources necessary to use the NHIS mobile renewal service." "I have the knowledge necessary to use the NHIS MRS."	Independent Variable
Hedonic Motivation (HM)	The fun or pleasure derived from using the NHIS mobile renewal service. Measured by items such as: "Using the NHIS MRS is fun." "I enjoy using the NHIS mobile renewal service."	Independent Variable
Price Value (PV)	The subscribers' cognitive trade-off between the perceived benefits of the NHIS MRS and the monetary cost for using it. Measured by items such as: "The NHIS MRS is good value for the money." "The cost of using the NHIS MRS is reasonable."	Independent Variable
Habit	The extent to which people tend to perform behaviors automatically because of learning. Measured by items such as: "Using the NHIS MRS has become a habit for me." "I am used to renewing my NHIS subscription through the MRS."	Independent Variable
Behavioral Intentions (BI)	The degree of a person's intention to use the NHIS mobile renewal service. Measured by items such as: "I plan to continue using the NHIS MRS in the future." "I intend to use the NHIS MRS frequently."	Serial Mediator
Use Behavior (UB)	The actual use of the NHIS MRS. Measured by items such as: "In the past month, how often have you used	Independent Variable

Construct	Operational definition	Status
	the NHIS MRS?" "I use the NHIS MRS for renewing my health insurance whenever it is due."	
Moderating Factors	**Operational Definition**	**Status**
Age	The age of the subscriber could moderate the relationships between UTAUT2 constructs and use behavior. For example, younger users may find the service easier to use or more enjoyable than older users.	Moderator
Gender	The gender of the subscriber could moderate the relationships between UTAUT2 constructs and use behavior. For instance, men and women users might differ in their perceptions of ease of use or social influence.	Moderator
Experience	The amount of experience the subscriber has with the NHIS mobile renewal service could moderate the relationships between UTAUT2 constructs and use behavior. Subscribers with more experience might find the system easier to use and thus have a higher intention to use.	Moderator

6.2.1.1 Justification for the UTAUT2 theoretical framework

The exploration of technology adoption rates across various domains has leveraged numerous theoretical frameworks, with distinct studies highlighting different aspects of user acceptance and use. For instance, the research conducted by Al-Masri, Al-Ghassani, and Al-Kabi (2021) utilised the Technology Acceptance Model (TAM) to delve into the determinants shaping the adoption of mobile health (mHealth) services within Oman, illustrating TAM's utility in understanding technology acceptance in healthcare contexts. Similarly, an investigation by Kim, Kim, and Kim (2019) employed the Unified Theory of Acceptance and Use of Technology (UTAUT) to dissect the factors influencing the intention to utilise healthcare information systems in South Korea, showcasing UTAUT's applicability in healthcare information technology.

However, an evolving understanding of technology adoption necessitates a more nuanced framework. The UTAUT2, an extension of the original UTAUT model, has demonstrated enhanced predictive capability in elucidating technology adoption behaviors. A pivotal study by Khechine, Khechine, and Mellouli (2020) applied UTAUT2 to scrutinise the adoption factors of telemedicine in Tunisia, revealing its substantial explanatory power in accounting for telemedicine

adoption behaviours. This finding underscores UTAUT2's robustness in predicting technology adoption across different contexts.

Further emphasising the complexity of technology adoption, research by Scott, Alwashmi, and Abu-Ali (2021) via the Diffusion of Innovation (DOI) theory identified organisational culture and leadership as key facilitators in the adoption of mHealth technologies, suggesting that organisational dynamics significantly influence technology adoption. In a more focused inquiry into the influence of moderators on technology adoption, the work of Nordhoff et al. (2020) employed UTAUT2 to examine the adoption of electronic health records (EHRs) in German hospitals, highlighting age as a moderating factor that slightly but significantly affects the behavioral intention to use EHRs. This points to the nuanced role of individual differences in technology adoption. Notably, a common limitation in previous studies, as observed by Gupta, Bhardwaj, and Singh (2019), is the partial application of UTAUT2 constructs without incorporating moderating factors, which may overlook critical insights into how and why technology adoption varies among different user groups.

Given this backdrop, the UTAUT2 framework emerges as a comprehensive and empirically validated model that not only accounts for core determinants of technology adoption but also integrates the role of moderating factors, such as age, gender, and experience. This framework's holistic approach provides a solid foundation for investigating the barriers and facilitators influencing the adoption of Mobile Renewal Services (MRS), thereby offering a more complete understanding of user behavior in the context of technological advancements. This study seeks to leverage the full spectrum of UTAUT2 constructs along with moderators to enrich our comprehension of the dynamics at play in the adoption of technology, specifically within the domain of health insurance mobile renewal services. The theoretical framework adapted from Venkatesh et al. (2012) used for this research is provided in figure 6.2 below.

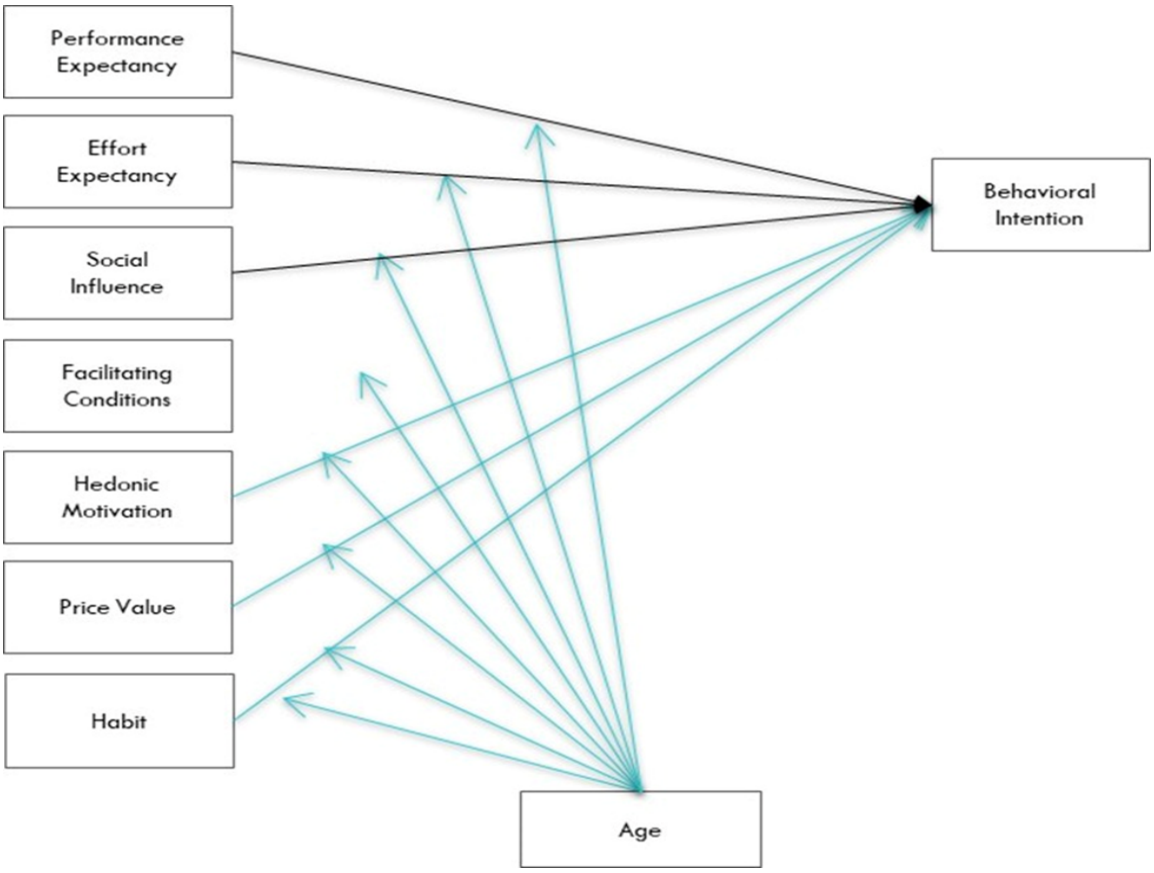

Figure 6. 2:UTAUT2 Theoretical Framework. Adapted from Venkatesh et al. (2012)

6.2.2 Research design

The research approach employed in this study was a quantitative non-experimental correlational research design. The primary objective was to examine the factors influencing the adoption of MRS by subscribers of the NHIA. Given that the research questions sought to establish correlations between variables and quantitatively assess the patterns, attitudes, and perspectives of the study participants, a quantitative methodology was deemed appropriate (Creswell, 2014). The use of quantitative research designs is crucial when investigating the impact of independent factors on dependent variables (Ivits et al., 2012). Considering the objectives of this chapter, ascertaining the barriers and facilitators of subscribers' intentions to engage in MRS, the adoption of a quantitative research design was a justified choice for this investigation because it allows the researcher to analyse the primary data collected from subscribers via online survey platforms using statistical

tools to identify relationships, patterns and trends to explore the barriers and facilitators of MRS adoption.

6.2.3 Research questions and hypothesis formulation

The hypotheses formulated in this study aim to investigate the relationships between different constructs of the UTAUT2 model and subscribers' intention to participate in mobile renewal service. The hypothesis formulation in this chapter effectively determines how the SEM is formulated. The available literature provides a comprehensive justification for each hypothesis. First, the literature suggests that performance expectancy (PE) plays a significant role in motivating individuals to adopt new technology, and it is the strongest predictor of behavioral intention (Tamilmani et al., 2020; Weeger et al., 2018). Additionally, the influence of performance expectancy may be more critical for individuals from individualistic cultures (Wang et al., 2017). The second hypothesis focuses on effort expectancy (EE), which refers to the perceived level of effort required to use technology. Research indicates that effort expectancy is the second strongest predictor of behavioral intention and can be influenced by factors such as compliance with corporate policies and configuration of security settings (Tamilmani et al., 2020; Weeger et al., 2018; Wang et al., 2017). Furthermore, the relationship between effort expectancy and facilitating conditions (FC) should be considered, as effort expectancy may impact the predictive strength of facilitating conditions on behavioral intention (Tamilmani et al., 2021).

The third hypothesis explores social influence (SI) and its impact on individual adoption intent. Social influence is influenced by cultural factors and the expectations of different individuals in the workplace (Venkatesh et al., 2003; Wang et al., 2017). The fourth hypothesis focuses on facilitating conditions (FC), which directly affect attitudes and significantly influence behavioral intention (Dwivedi et al., 2017; Ouattara, 2017). It is essential to consider the interplay between effort expectancy and facilitating conditions in predicting behavioral intention (Tamilmani et al., 2021). The fifth and sixth hypotheses examine hedonic motivation and price value, respectively. Hedonic motivation, derived from the enjoyment and happiness of using technology, is significant in determining adoption rates (Venkatesh et al., 2012; Ouattara, 2017). Price value, on the other hand, reflects the perceived tradeoff between the cost and benefits of adopting technology and predicts users' behavioral intention (Ouattara, 2017; Blut et al., 2022). Lastly, the study

acknowledges the moderating variable of age, which has shown varying effects on behavioral intention in different studies (Nordhoff et al., 2020; Munyoka and Maharaj, 2017; Ameen and Willis, 2018). Considering generational differences is crucial when examining technology adoption. Below are the hypotheses:

- Ha1: There is a statistically significant correlation between performance expectancy (PE) and subscriber's intention to participate in mobile renewal service.
- Ha2: There is a statistically significant correlation between effort expectancy (EE) and subscriber's intention to participate in mobile renewal service.
- Ha3: There is a statistically significant correlation between social influence (SI) and subscribers' intention to participate in mobile renewal service.
- Ha4: There is a statistically significant correlation between facilitating conditions (FC) and subscribers' intention to participate in mobile renewal service.
- Ha5: There is a statistically significant correlation between Hedonic motivation (HM) and subscribers' intention to participate in mobile renewal service.
- Ha6: There is a statistically significant correlation between price value and subscriber's intention to participate in mobile renewal service.
- Ha7: There is a statistically significant correlation between habit and subscriber's intention to participate in mobile renewal service.
- Ha8: There is a statistically significant correlation between performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, price value, and habit on subscriber's intention to participate in mobile renewal service, moderated by age.

6.2.4 Data collection

6.2.4.1 Design of survey instrument

A questionnaire was constructed by the researcher with the help of the survey builder tool in Microsoft Forms. The questionnaire was based on survey instrument designed and verified by Venkatesh (2012). The questionnaire for the survey was divided into three sections: an introduction and consent section, a screening question section, and a survey question section. Table 6.2 provides information on the survey instrument used in the study.

Table 6. 2: Survey instrument data

Section	Description	Number of questions
Introduction and Consent	Includes an introduction to the survey and a consent form	Yes/No
Survey Questions	Divided into nine distinct parts	40
Part 1: Demographic Information	Collects information on gender, age, educational level, number of years of mobile service use, and region	5
Part 2	Participants rate their level of acceptance on 5 Performance Expectancy Statements	5
Part 3	Participants rate their level of acceptance on 5 Effort Expectancy statements	5
Part 4	Participants rate their level of acceptance on 4 Social Influence statements	4
Part 5	Participants rate their level of acceptance on 4 Facilitating Conditions statements	4
Part 6	Participants rate their level of acceptance on 3 Hedonic Motivation statements	3
Part 7	Participants rate their level of acceptance on 4 Price Value statements	4
Part 8	Participants rate their level of acceptance on 6 Habits statements	6
Part 9	Participants rate their level of acceptance on 4 Behavioral Conditions statements	4

The introduction and consent section of the survey provides participants with a comprehensive overview of the study's objectives, ensuring they are well-informed about the research's purpose and scope. It also includes a consent form that outlines the confidentiality and voluntary nature of participation, which participants must agree to before proceeding with the survey. The survey questions section is methodically organised into nine parts, encompassing a total of 40 questions designed to capture a broad spectrum of data relevant to the study's aims. Part 1 is dedicated to gathering demographic information, an essential component in understanding the diversity of participants and contextualizing their responses within specific demographic segments. The selection of demographics—gender, age, educational level, years of experience with mobile or digital services, and region—was influenced by their potential impact on technology adoption behaviors and the necessity to analyse the adoption patterns across different demographic groups.

In determining which demographics to include, a strategic approach was taken to select variables that are most likely to influence technology adoption based on previous research and theoretical considerations. Gender and age are fundamental demographics that have been shown to affect technology use and adoption, potentially moderating the relationship between UTAUT2 constructs and user behavior (Venkatesh and Bala, 2008). Educational level provides insights into the users' ability to comprehend and interact with technology, influencing their Effort Expectancy and Performance Expectancy. The number of years' participants have used mobile or digital services offers a direct measure of experience, which is a crucial moderating factor in the UTAUT2 framework. Lastly, the inclusion of the region helps identify geographical variations in technology adoption, which can be attributed to differences in infrastructure, cultural factors, and access to technology.

However, other demographics such as income level, occupation, and marital status were not selected for inclusion in this study. The decision to omit these variables was driven by the study's specific focus on assessing the barriers and facilitators affecting the adoption of NHIS mobile renewal service from a subscriber's perspective. While these additional demographics could offer further insights into technology adoption patterns, the primary aim was to concentrate on variables with a direct and significant impact on technology use within the context of health insurance renewal services. Additionally, limiting the demographic variables helps streamline the survey, reducing the burden on participants and enhancing the response rate and data quality.

6.2.4.2 Population

The study participants were recruited from the pool of subscribers to the NHIS renewal program in each of Ghana's 16 regions. The study targeted individuals who met specific criteria, including being at least 18 years old, have access to a mobile or digital devices, living in Ghana, being registered with the NHIA, and working in either the formal or informal economy. The purpose of the study was to validate and evaluate the proposed hypothesis by aligning the target population of NHIS subscribers with the research questions. The total number of enrolled individuals among the target demographic was 16 million based on the subscriber's data collected from the NHIA. Therefore, the study population consists of 16 million NHIS subscribers who are at least 18 years old, work in either the formal or informal economy, have access to a mobile or digital device, and are registered members of the NHIS program.

6.2.4.3 Sampling size and technique

In the context of this study, understanding the significance of determining an appropriate sample size cannot be understated, as it is critical for achieving the research objectives effectively while maintaining scientific accuracy and integrity. An inadequately sized sample may not provide the statistical power necessary to identify true effects, leading to the potential for Type II errors where true associations are missed (Wen et al., 2018). Conversely, an excessively large sample size can inflate the risk of Type I errors, identifying false positives or spurious associations merely by chance (Fowler and Lapp, 2019).

Given the vast membership base of the National Health Insurance Scheme (NHIS) of Ghana, which stands at 16 million, selecting a representative sample size is imperative for drawing meaningful conclusions that can be generalised to the entire population of scheme members. This population reflects a significant portion of Ghana's roughly 30 million citizens engaged in both formal and informal sectors across the country's 16 regions. The criticality of sample size determination is further magnified by the constraints imposed by the COVID-19 pandemic, which necessitated adjustments to traditional data collection methodologies, leading to the utilisation of online survey platforms.

For this investigation, a calculated sample size of 1,536 was initially determined to ensure statistical validity at a 95% confidence level with a 2.5% margin of error, following guidelines by Research Advisors (2006). This calculation was designed to optimize the balance between precision of the results and feasibility of data collection, given the extensive reach of the NHIS in Ghana. However, to further enhance the robustness of our findings and account for potential non-response or incomplete responses, the study ultimately engaged 2,226 participants.

The selection and recruitment of participants were strategically conducted through a mixed-method approach, leveraging both email and WhatsApp communications. This approach was not only adaptable to the challenges presented by the pandemic but also enabled the study to reach a diverse group of participants who were at least 18 years old, Ghanaian, and had access to mobile or digital devices. The invitations contained detailed information about the research objectives and procedures, along with a direct link to the survey hosted on Microsoft Forms. Upon clicking the link, participants were greeted with a comprehensive description of the study, emphasising the

voluntary nature of their participation, and were required to consent before proceeding to the questionnaire.

This methodological framework, developed in line with ethical considerations outlined in the research ethics application, ensured that the sampling process was both inclusive and respectful of participant autonomy. It allowed for a thorough examination of the barriers and facilitators affecting the adoption of NHIS mobile renewal services, thereby contributing valuable insights from a significant segment of the Ghanaian population.

6.2.5 Method of data analysis

6.2.5.1 Descriptive analysis

This chapter employed descriptive statistics to gain insights into the characteristics of the participants, such as their age, gender, education level, experience with mobile devices, and residential region. Each construct in the survey instrument comprised multiple items, and responses from the survey were transformed into composite variables by summing the scores and dividing them by the number of relevant survey items (Hutchison, A. et al., 2011). Measures of central tendency, including frequencies, median scores, and standard deviations, were used to assess the demographic variables and composite variables. These central tendencies provided an understanding of the distribution and variability of the data (Amber, Aslam, and Bashir, 2016).

6.2.5.2 Multivariate analysis

This study leverages SEM to meticulously explore the relationships posited by the UTAUT2, encompassing constructs such as PE, EE, SI, among others. Through this analytical lens, we gained a nuanced perspective on the direct and indirect effects these factors have on subscriber attitudes and behaviors toward adopting the NHIS mobile renewal service. The process entailed a detailed path analysis for the measurement model, ensuring that each construct accurately captured the conceptual domain it was intended to measure. This step was crucial for validating the integrity of our measurement model, reinforcing the foundation upon which further SEM analysis was constructed. Subsequently, the path analysis component of our SEM framework was deployed to scrutinise the predictive model delineated by UTAUT2 constructs. This phase was instrumental in examining the hypothesized pathways through which the independent variables (e.g., EE, SI) exert influence on the dependent variables (notably, Behavioral Intention to use the NHIS mobile

renewal service). Such methodical investigation aligns with the strengths of SEM in confirming theoretical models, as underscored by Matsueda (2011), while adeptly navigating potential data quality and model fitness challenges. The meticulous confirmation of these hypothesized relationships underscores the empirical robustness of our findings, as elaborated in this thesis.

The nature of the SEM employed in this research was explicitly linear, reflecting a deliberate choice predicated on the preliminary analysis, which suggested a linear interconnection among the key constructs of the UTAUT2 framework and the adoption behavior of NHIS MRS users. This decision facilitated a clear interpretation of the model's coefficients, focusing on their magnitude and directional influence without the need to resort to marginal effects or odds ratios that a non-linear SEM approach might necessitate. Figure 6.3 illustrates the SEM model.

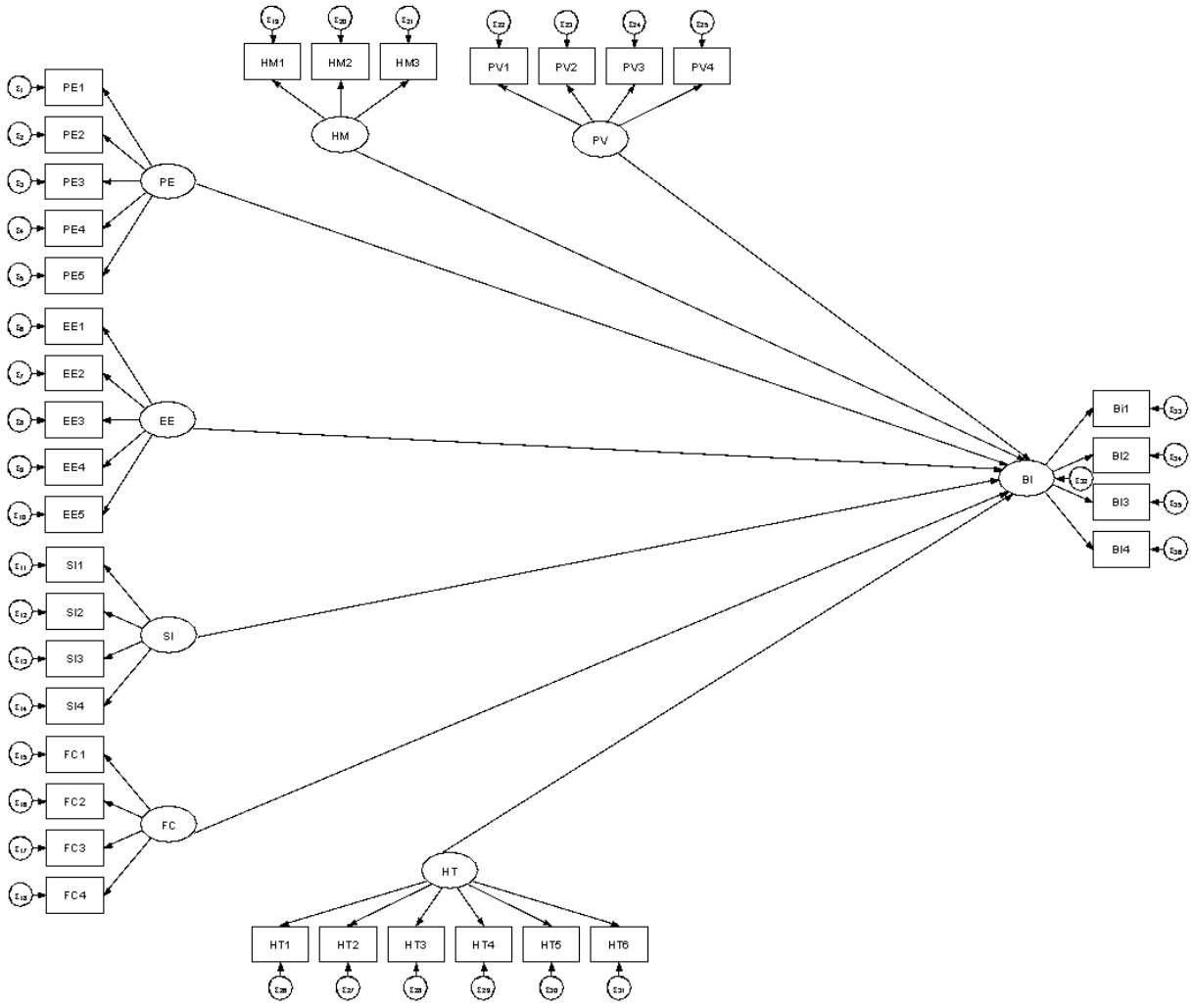

Figure 6. 3:Structural Equation Model (SEM)

6.2.5.3 Testing the psychometric features of the adapted questionnaire

To test the psychometric features of the adapted questionnaire, the research followed a systematic process that involved assessing the validity and reliability of the measurement instrument as discussed below:

6.2.5.3.1 Validity

In addressing the validity of the measurement instrument in this thesis, the study emphasises the rigorous process undertaken to ensure that the adapted UTAUT2 model accurately assesses the constructs of interest. Drawing upon the foundational work of Copper and Schinder (2014), the

researcher embarked on a comprehensive validation process tailored to the context of this research. The initial step involved the meticulous assessment of content validity. Content validity was accomplished in this study by convening a panel of experts within the field of Information Systems, leveraging their expertise to scrutinise the survey items for clarity, conciseness, and relevance to the measured constructs. This panel, comprising supervisors from the institution of study with extensive experience in technology adoption research, provided critical feedback that guided the refinement of the instrument, ensuring that each item precisely captured the essence of the construct it intended to measure.

To ascertain discriminant validity, we employed a series of statistical analyses to evaluate whether the constructs were distinct. The statistical analysis involved calculating each construct's average variance extracted (AVE) to ensure they met the minimum threshold of 0.70, indicative of strong discriminant validity. Furthermore, the study ensured that the squared correlations between constructs were lower than their respective AVE values, providing additional proof of the distinctiveness of the constructs. This step was crucial in confirming that the respondents could reliably differentiate between the constructs when responding to the survey items. Convergent validity for this study was assessed through Composite Reliability values, with a benchmark of $\alpha > 0.7$, following the guidelines by Hair et al. (2014) to ensure that the items grouped under each construct measured the same underlying phenomenon. To further support the instrument's validity, the Kaiser-Meyer-Olkin (KMO) test for sampling adequacy was conducted, with results exceeding the acceptable threshold of 0.7 across all variables. Bartlett's Test of Sphericity confirmed the appropriateness of the factor analysis, with significance levels well below 0.05, thereby verifying the suitability of our sample for conducting meaningful validity tests. Through these meticulous steps, the study directly validated the adapted questionnaire, ensuring its reliability and accuracy in measuring the constructs of interest within the specific research context. This approach aligns with best practices in research methodology and provides a robust foundation for interpreting and applying the findings in understanding technology adoption behaviours.

6.2.5.3.2 Reliability

This refers to the consistency and stability of measurements obtained from an instrument (Dubovik et al., 2019). In the context of the UTAUT2 instrument used in this study, reliability assessment is

important to ensure that the instrument consistently measures the intended constructs. Venkatesh et al. (2012) meticulously conducted a pilot test involving administering the instrument to a sample of participants and analysing the responses to assess the internal consistency reliability (ICR) values. This thorough process instils confidence in the reliability of the UTAUT2 instrument. Internal consistency reliability measures the extent to which the items within a construct consistently measure the same underlying concept. To ensure the consistency and reliability of the UTAUT2 instrument across different datasets, the results of the pilot test conducted by Venkatesh et al. (2012) were compared with the findings of comprehensive research. This comparison helps establish the instrument's generalisability and reliability across different populations and settings. By evaluating the internal consistency reliability and comparing the results with previous research, researchers can ensure that the UTAUT2 instrument provides consistent and reliable measurements of the constructs being examined. This enhances the confidence in the instrument's ability to accurately capture the intended constructs and facilitates meaningful analysis and interpretation of the data collected in this study (Venkatesh et al., 2012; Dubovik et al., 2019). A Cronbach alpha threshold of 0.7 was established for this study, ensuring the instrument's reliability.

The screening section of the questionnaire was presented to study participants using the survey instrument after they provided informed consent to participate in the investigation. The screening questionnaire included additional questions that were to be answered by participants to confirm that they met the eligibility criteria. Participants who did not meet the inclusion criteria or did not consent to participate ended their participation after reviewing the consent form. The explanation for why the survey was terminated can be found on the gratitude page. Participants who provided consent and met the inclusion criteria were allowed to proceed with the survey questions. Data collection covered started on 15th February 2023 and ended on 16 March 2023. On average, participants spent eight minutes completing the survey. We respected participants' rights to withdraw their consent at any point during the data collection period, ensuring the ethical considerations in our research process.

To further establish the reliability and interpretability of the SEM model, Convergent validity was evaluated using the following criteria: Cronbach's Alpha (CA), Composite Reliability (CR), and AVE. Additionally, the KMO measure and Bartlett's Test of Sphericity are used to confirm the suitability of the data for Structural equation modelling. These measures are commonly used in

the literature to assess the validity and reliability of constructs in a study Hair et al. (2010). In addition, Fornell-Larcker criterion was utilised to assess discriminant validity. In a discriminant validity result table, the diagonal values represent the square roots of the average variance explained (AVE) for each construct, while the off-diagonal values indicate the correlation coefficients between the constructs. The Fornell-Larcker criterion stipulates that discriminant validity is established when the square root of the AVE for each construct is greater than the correlation coefficients between that construct and all other constructs in the model.

6.3 Findings

The objective of this section is to present the outcomes of what subscribers perceive as the barriers and facilitators influencing the adoption of the MRS conducted on the survey data. It consists of three main parts. The first part focuses on the characteristics of the study's sample and provides descriptive statistics, including the chi-square test, for the collected variables. The second part delves into the measurement model, addressing aspects such as validity, reliability, model fitness, and the steps taken for hypothesis testing. It also discusses the findings from analysing how the study model aligns with the UTAUT2 theoretical framework. Research questions, hypotheses, and post hoc test analysis results are detailed in this section. The third part summarises the results of the hypothesis testing and acknowledges the limitations and implications of the study.

6.3.1 Demographic information

The survey garnered responses from 2,226 participants, with a slight majority being men (52.6%), demonstrating a balanced gender distribution with a significant representation from women (41.6%) as well. The age distribution indicates a younger demographic tendency among the participants, with the largest age group being 18-24 years (28%), followed closely by the 25-31 years' age group (23%). This suggests that the younger population segments are more engaged or interested in the NHIS MRS, which is pivotal for tailoring communication and outreach strategies. The participants predominantly held a college degree (44.6%), highlighting a highly educated sample pool. This was followed by those with secondary education (24.2%) and postgraduate education (22.4%), indicating a significant level of academic attainment among the survey

respondents. This demographic detail underscores the potential for a sophisticated understanding of and interaction with the NHIS MRS.

In terms of mobile phone usage experience, a substantial segment of the participants (28.1%) reported using mobile phones for a period of 11-15 years, suggesting a well-established familiarity with mobile technology. This experience with mobile technology is crucial for the adoption of mobile-based health services, indicating a potential readiness among the sample population to engage with such services. Regionally, the Upper West region saw the highest participation in the survey (22.9%), followed by the Northern and Upper East regions (15.6% and 13.9%, respectively), and the Greater Accra region (14.6%). This diverse geographical distribution demonstrates the wide-reaching interest and potential impact of the NHIS MRS across various parts of Ghana.

These distributions were compared to the broader NHIS subscriber data to evaluate representativeness and identify any deviations. A detailed analysis revealed some key differences. For instance, younger subscribers (ages 18–30) were slightly overrepresented in the survey compared to the overall NHIS demographic profile, where middle-aged subscribers dominate. Additionally, urban respondents accounted for a larger proportion in the survey sample than in the overall NHIS subscriber base, which has a significant rural representation.

The implications of these discrepancies are twofold. First, they suggest potential biases in the data collection process, where younger, urban, and more digitally literate subscribers may have been more accessible or willing to participate. This bias could influence findings related to MRS adoption, particularly in terms of perceived ease of use and adoption rates. Second, the underrepresentation of rural and older subscribers highlights the need for targeted strategies to ensure equitable access to and adoption of the MRS across diverse demographics. Addressing these gaps is crucial for designing interventions that cater to the needs of underrepresented groups, such as increasing outreach efforts in rural areas and tailoring MRS features to accommodate older, less tech-savvy users. Table 6.3 shows the demographic information for the 2,226 participants surveyed.

Table 6. 3:Demographic information

Variable	Category	Frequency	Percent
Gender	Men	1,171	52.6
	Women	926	41.6
	Prefer not to say	129	5.8
	Total	**2,226**	**100**
Age	18-24	624	28
	25-31	515	23.1
	32-38	395	17.7
	39-45	385	16.4
	46-52	1	0.0
	53-59	187	8.4
	60 and above	139	6.2
	Total	**2,226**	**100**
Education	Basic Level	195	8.8
	Secondary	539	24.2
	First Degree	993	44.6
	Post Graduate Degree	499	22.4
	Total	**2,226**	**100**
Experience in Using Mobile Phone	1-5	466	20.9
	6-10	565	25.4
	11-15	626	28.1
	16-19	252	11.3
	20 and above	317	14.2
	Total	**2,226**	**100**
Region	Ahafo	26	1.2
	Ashanti	18	8
	Bono	9	4
	Central	50	2.2
	Eastern	38	1.7
	Greater Accra	326	14.6
	North East	40	1.8
	Northern	347	15.6
	Oti	24	1.1
	Savannah	13	6
	Upper East	309	13.9
	Upper West	510	22.9
	Western	314	14.1
	Western North	33	1.5
	Volta	28	1.3
	Total	**2,226**	**100**

6.3.2 Descriptive statistics

6.3.2.1 Summary of measures of central tendency and percentile

Table 6.4 presents a summary of measures of central tendency and percentiles for the variables under investigation. The table details the descriptive statistics of six constructs: PE, EE, SI, FC, HM, and PV, as well as six items under the Behavioral Intention (BI) construct. The analysis of subscriber attitudes and behaviors towards the NHIS's MRS intervention, as presented in Table 6.4, is critical for understanding the factors influencing its adoption. This understanding is further enriched by the appropriate statistical summary of the collected data, which is especially tailored to the ordinal nature of the survey responses. The focus on median and interquartile ranges (IQR) for each variable, corresponding to different constructs like PE, EE, and others, provides a nuanced view of subscriber perceptions and interactions with the service.

For the MRS intervention, median values and percentiles offer invaluable insights into user satisfaction, perceived ease of use, and the influence of social and facilitating conditions on the adoption of the service. The predominance of median scores of 4 across various constructs suggests a generally favorable attitude towards the service. For instance, high median scores in PE and EE indicate that subscribers find the intervention both useful and easy to use. This is crucial for the NHIS administration to understand, as these factors are directly correlated with the likelihood of continued use and positive word-of-mouth promotion among the current subscriber base. The interquartile ranges, particularly where they narrow around higher median values, highlight a consensus among respondents regarding the positive attributes of the MRS intervention. Such consensus is particularly evident in constructs related to the service's utility and user interface simplicity, suggesting that efforts to enhance these aspects of the service are likely to be well-received by many users.

Table 6. 4: Descriptive results

Variable	Mean	Percentiles		
		25	50	75
PE1	3.987	4	4	5
PE2	3.8845	4	4	5
PE3	3.8648	4	4	4

Variable	Mean	Percentiles		
PE4	3.872	4	4	4
PE5	3.9991	4	4	5
EE1	3.929	4	4	5
EE2	3.9259	4	4	4
EE3	3.947	4	4	5
EE4	3.8607	4	4	4
EE5	3.863	4	4	4
SI1	3.7498	3	4	4
SI2	3.7035	3	4	4
SI3	3.7543	3	4	4
SI4	3.5319	3	4	4
FC1	3.8266	4	4	4
FC2	3.9254	4	4	5
FC3	3.8014	3	4	4
FC4	3.8949	4	4	4
HM1	3.5063	3	4	4
HM2	3.5889	3	4	4
HM3	3.5234	3	4	4
PV1	3.7282	3	4	4
PV2	3.7745	3	4	4
PV3	3.7448	3	4	4
PV4	3.8028	3	4	4
HT1	3.5382	3	4	4
HT2	3.3603	3	4	4
HT3	3.6559	3	4	4
HT4	3.6788	3	4	4
HT5	3.4519	3	4	4
HT6	3.8419	3	4	4
Bi1	3.8351	4	4	4
BI2	3.8553	4	4	4
BI3	3.8535	3	4	4
BI4	4.0562	4	4	5

6.3.3 Measurement model

Table 6.5 describes the measurement model used to assess the convergent validity of the study constructs, including PE, EE, SI, PV, FC, HM, HT, and BI. In this case, the results indicate that the constructs in the study are both valid and reliable. When the KMO values are higher than the 0.5 threshold, the sample is considered adequate for analysis. In the same vein, when Bartlett's Test of Sphericity scores have a p-value of less than 0.05 (p-value < 0.05), it suggests that the data

is suitable for the analysis. Also, when the Total Variance Explained values are relatively high, it indicates that the constructs explain a substantial portion of the variance in the data. AVE values meet the 0.5 threshold for all constructs, suggesting that the constructs explain enough variance in the data. CR scores exceed the 0.7 threshold for all constructs, further confirming their reliability. Finally, CA values are higher than 0.7 for all constructs, indicating good internal consistency and reliability.

Table 6. 5:Measurement model (validity and reliability)

Constructs	**KMO**	**Bartlett's Test of Sphericity**	**Total Variance Explained**	**AVE**	**Composite Reliability**	**Cronbach Alpha**
PE	0.873	0.001	72.518	0.725	0.929	0.905
EE	0.874	0.001	75.471	0.754	0.939	0.918
SI	0.815	0.001	72.864	0.729	0.914	0.868
FC	0.832	0.001	75.967	0.760	0.927	0.894
HM	0.750	0.001	83.195	0.832	0.937	0.899
PV	0.825	0.001	77.040	0.770	0.931	0.900
HT	0.890	0.001	69.985	0.695	0.932	0.913
BI	0.850	0.001	80.054	0.800	0.941	0.917
Weighted Average	0.838625	0.001	75.88675	0.758125	0.93125	0.90175

Table 6.6 displays the findings of the discriminant validity analysis conducted for the constructs in the study, including PE, EE, SI, FC, HM, PV, HT, and BI. The results demonstrate that all constructs satisfy the Fornell-Larcker criterion. The diagonal values are greater than the corresponding off-diagonal values, indicating that the examined constructs are distinct from each other. This confirms that the observed relationships between the constructs are genuine and not influenced by measurement issues. The achieved discriminant validity in this study supports the theoretical foundation of the UTAUT2 model and contributes to the existing literature on

technology acceptance. It provides compelling evidence that the constructs within the UTAUT2 model can be reliably differentiated in empirical research. This differentiation enables meaningful comparisons of the effects of different constructs on technology acceptance and facilitates comparisons with findings from other studies employing the UTAUT2 model or similar frameworks. The results show that the correlation coefficient between PE and EE is 0.791 and that of PE and BI is 0.674, suggesting adequate discriminant validity. Threshold for discriminant validity is that correlation below 0.70 or 0.80 is indicative of adequate discriminant validity. The results in table 6.6 suggests that most of the correlation between the constructs are below 0.70 or 0.80, suggesting good discriminant validity. The correlations between each construct and itself are not relevant considerations for assessing discriminant validity, hence ignored.

Table 6. 6:Results for discriminant validity analysis

	PE	EE	SI	FC	HM	PV	HT	BI
PE	0.526							
EE	0.791	0.570						
SI	0.673	0.720	0.531					
FC	0.737	0.805	0.732	0.577				
HM	0.549	0.603	0.634	0.658	0.692			
PV	0.668	0.710	0.708	0.752	0.642	0.594		
HT	0.613	0.668	0.636	0.696	0.686	0.710	0.490	
BI	0.674	0.700	0.638	0.731	0.574	0.722	0.744	0.641

6.3.4 Goodness of fit test

Table 6.7 presents the overall results of the goodness-of-fit test conducted on the operational model.

Table 6. 7:Overall Goodness of fit test

Fit statistic	**Value**	**Threshold**
Probability RMSEA	0.001	<0.05 (Hair, et al., 2010)
Comparative fit index (CFI)	0.758	>0.95 (Kline, 2011)
Tucker–Lewis index (TLI)	0.740	>0.9 (McDonald et al., 2002)

In the literature, a model is often considered to have an acceptable fit if the RMSEA is below 0.08 and ideally below 0.05 (Hair et al., 2010). The Probability RMSEA is the p-value for the test of close fit (or p-value). It provides additional evidence about whether the fit is close enough to consider whether the model adequately represents the data. A value of 0.001 is deemed a close fit of the model. Therefore, it suggests that the model fits the data well. Hence, the hypothesis that probability RMSEA of ≤ 0.05 cannot be rejected. The CFI helps to assess how well a proposed model fits the data compared to a null model. CFI is less sensitive to sample size than other fit indices, such as the chi-square test, and provides a reliable measure for evaluating model fit. An acceptable model fit is expected to have a CFI of at least 0.90, with values of 0.95 or higher preferable (Kline, 2011). A value of 0.758 obtained in this study is deemed undesirable and, therefore, does not fit the data well and may require adjustment. In SEM, TLI is a statistical measure used to evaluate a model's overall goodness of fit. The TLI compares the fit of the target model to a baseline model, usually the null model. In literature, to assess the goodness of fit using TLI, values above 0.90 are generally acceptable, with values above 0.95 indicating a strong fit (Hu and Bentler, 1999; McDonald et al., 2002). Values below 0.90 generally suggest that the model does not fit the data well and may require re-specification. Therefore, the value of 0.740 does not meet the appropriate cutoff criteria of a TLI value of 0.90 or higher. Nevertheless, equation level goodness of fit was conducted to check how the predictors in the model explain the dependent variable.

6.3.4.1 Equation level goodness of fit

Table 6.8 presents the equation-level goodness of fit for the dependent variable, BI, in the context of the UTAUT2 model. The equation-level goodness of fit yielded an R2 value of 0.539. The R2 of 0.539 suggests that 53.9% of the variation in BI can be attributed to the predictors, including PE, EE, SI, FC, HM, PV, and HT. The remaining 46.1% of the variation in BI cannot be attributed to the predictors. The R2 value is a valuable indicator of how well the predictors in the model explain the dependent variable.

Table 6. 8: Equation Level Goodness of Fit

Construct	Fitted	Predicted	Residual	R-squared
BI	0.417	0.225	0.192	0.539

Construct	Fitted	Predicted	Residual	R-squared
Overall				1

6.3.5 Model results

The path analysis results for the hypothesized model are presented in Figure 6.4 and Table 6.9. The path coefficients indicate the strength and direction of the relationships between the UTAUT2 constructs and BI to adopt MRS.

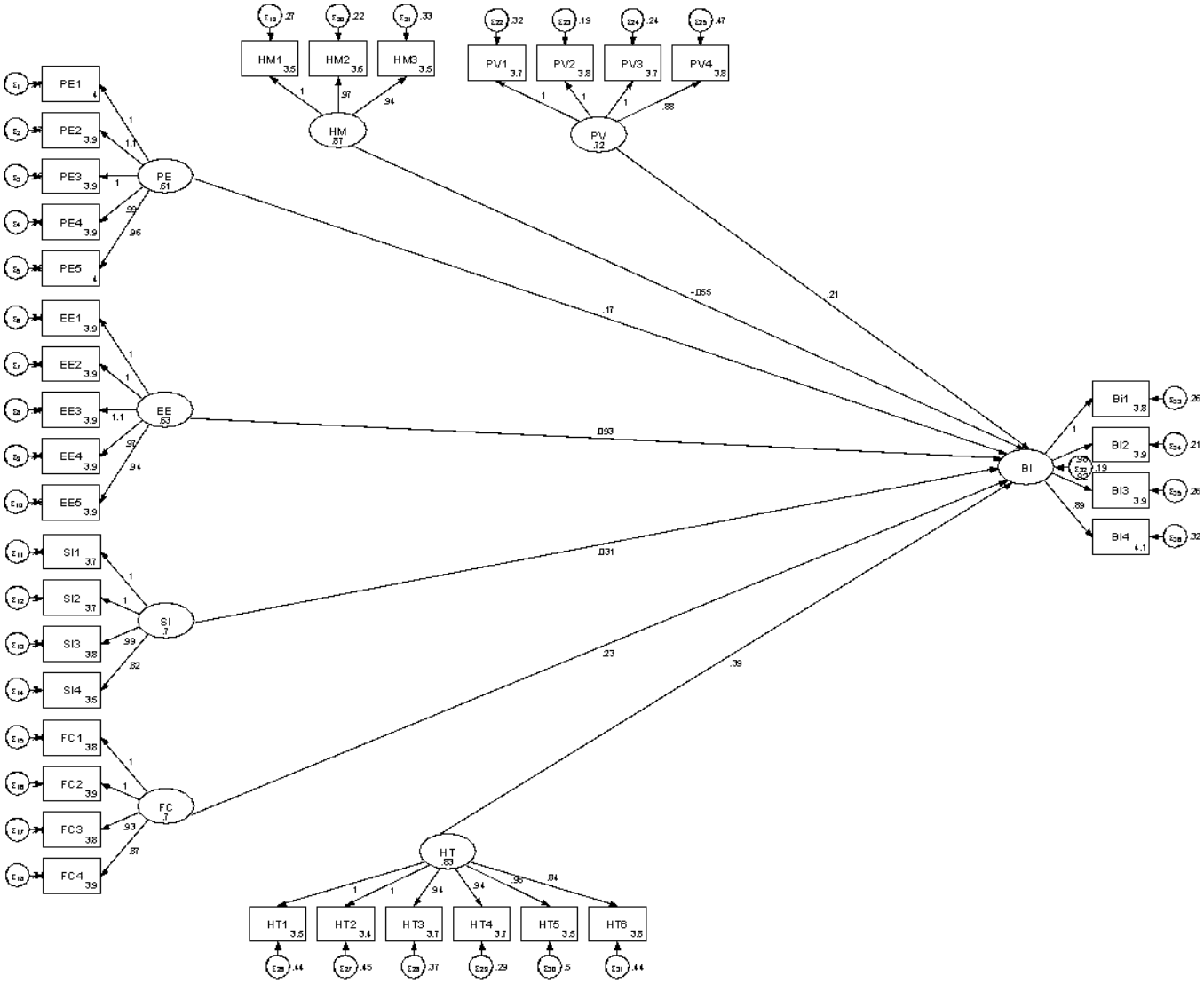

Figure 6. 4:Hypothesised model

(a) Barriers

One of the key findings from the hypothesized model is the role of Hedonic Motivation (HM) as a barrier to the adoption of MRS. The analysis revealed a significant negative relationship between HM and BI to adopt MRS (β=-0.59, p<0.004). This indicates that an increase in HM, or the pleasure and enjoyment derived from using the service, unexpectedly correlates with a decrease in the intent to adopt MRS. This counterintuitive finding suggests that users who seek pleasure or entertainment from the NHIS mobile app may not view the MRS as satisfying these needs, thus acting as a barrier to its adoption.

(b) Facilitators

In this study, several factors emerged as facilitators for the adoption of NHIS MRS, as indicated by their positive effects on BI. PE and EE were found to positively influence BI, with coefficients of 0.169 (p<0.001) and 0.093 (p<0.001), respectively. The results imply that enhanced users' perceptions of the MRS's usefulness (PE) and ease of use (EE) are associated with enhanced intentions to adopt MRS. Additionally, FC and PV significantly enhance BI to adopt MRS, with increases of 23.1% (β=0.231, p<0.001) and 21.4% (β=0.214, p<0.001), respectively. The model shows that HT is the most potent facilitator of NHIS MRS adoption, with a 39.3% increase in HT linked to an increase in BI (β=0.393, p<0.001). It is noteworthy that while Social Influence (SI) showed a positive relationship with BI (β=0.031), this effect was not statistically significant (p = 0.201), suggesting that the perceptions of others do not significantly drive the decision to adopt MRS. See table 6.9 for these results

Table 6. 9:Path coefficients of hypothesised model

Construct	β (Coefficient)	Standard Error	P>[z]	95% Conf. Interval		Remarks
PE=>BI	0.169	0.026	0.001	0.118	0.221	Fail to reject
EE=>BI	0.093	0.029	0.001	0.036	0.151	Fail to reject
SI=>BI	0.031	0.024	0.201	-0.016	0.077	Reject
FC=>BI	0.231	0.028	0.001	0.176	0.286	Fail to reject
HM=>BI	-0.59	0.019	0.004	-0.092	-0.017	Fail to reject
PV=>BI	0.214	0.024	0.001	0.168	0.260	Fail to reject

Construct	β (Coefficient)	Standard Error	P>[z]	95% Conf. Interval		Remarks
HT=>BI	0.393	0.022	0.001	0.349	0.437	Fail to reject

6.4 Discussions

This chapter examined NHIS members/subscribers' perspectives on barriers and facilitators influencing MRS adoption. The findings are discussed below:

6.4.1 Barriers

The study found that SI, FC and HM are non-significant or negatively influencing. These findings are inconsistent with the literature regarding technology adoption (Hoque et al., 2017; Dorsey and Topol, 2016; Gagnon et al., 2016). Specifically, the identification of SI and HM as negatively influencing B) towards MRS adoption raises several points for discussion. Traditionally, SI and FC have been regarded as pivotal in driving the adoption of technological innovations. The fact that these constructs were not found to be significant predictors in this study suggests a unique context or set of circumstances influencing NHIS scheme members' adoption decisions. This departure from findings by Weeger et al. (2018), Tamilmani et al. (2021), Dwivedi et al. (2017), and Ouattara (2017) might be attributed to the specific nature of health insurance services, which are perceived not just as a technological solution but as a critical, needs-based service. Therefore, the decision to use MRS could be influenced more by individual needs and perceptions of utility rather than social pressure or the influence of others. Furthermore, the non-significance of FC as a driver for BI indicates that simply having the necessary resources and support may not be sufficient to motivate use, especially if the service's perceived relevance or benefits are not clearly understood by the users.

Equally counterintuitive is the finding that Hedonic Motivation (HM) negatively impacts BI, contradicting the expectations set by Ouattara (2017), Nikolopoulou and Lavidas (2020), and Gharaibeh et al. (2020). This suggests that the enjoyment or pleasure derived from using MRS

does not play a conventional role in influencing adoption intentions among NHIS members. One possible justification for this could be the nature of MRS as a utilitarian service, where the primary motivation for use is based on necessity rather than entertainment or enjoyment. In such a context, the hedonic aspects may not only be secondary but could potentially detract from the service's perceived seriousness or reliability as a healthcare-related application. This perspective challenges the usual application of hedonic motivation in technology adoption models, suggesting a need for more nuanced understanding within specific service contexts like healthcare.

Regarding the moderator analysis, the absence of age as a significant moderator in the relationship between UTAUT2 constructs and BI is another intriguing aspect of the findings. Contrary to the suggestions by Nordhoff et al. (2020), Chang et al. (2019), Munyoka and Maharaj (2017), and Ameen and Willis (2018), this study's results imply that age may not have a uniform effect on technology adoption intentions across different contexts. The finding that age does not play a significant role in influencing BI towards MRS adoption among NHIS members could reflect a broader trend of increasing digital literacy and technology acceptance across all age groups, particularly in contexts where the technology addresses fundamental needs such as health insurance. Alternatively, it may suggest that factors specific to the NHIS context, such as the universal necessity of health insurance, outweigh the differences in technology adoption behavior typically observed among different age groups. This observation underscores the importance of contextual factors in technology adoption studies and cautions against the uncritical application of theoretical models across different settings and services.

6.4.2 Facilitators

The study showed that the Behavioral Intentions (BI) of scheme members towards adopting the MRS are facilitated by PE, EE, PV, and HT. PE, or the belief in the benefits and effectiveness of MRS, has a directly positive impact on BI. This resonates well with existing literature (Nikolopoulou and Lavidas, 2020; Niehaves et al., 2012; Wang et al., 2017; Doargajudhur and Dell, 2019), highlighting the universally acknowledged role of perceived usefulness in the decision to embrace new technologies. This intuitive finding underscores the importance of users' perceptions regarding the tangible benefits a service can offer, reinforcing the notion that the more beneficial a service is perceived to be, the more likely individuals are to adopt it. Similarly, Effort

Expectancy's significant positive relationship with BI suggests that the ease of use and user-friendly nature of MRS are crucial for its acceptance. This aligns with findings from Ouattara (2017) and Chen et al. (2020), echoing the broader technology adoption narrative where ease of use significantly reduces the barrier to entry for new users, thus facilitating adoption.

Moreover, the positive influence of PV on BI further affirms the intuitive understanding that individuals weigh the costs against the benefits of adopting new technologies. Supported by studies such as those by Tamilmani et al. (2020) and Blut et al. (2022), this aspect highlights that when users perceive they are getting value for their money, their willingness to adopt the service increases. This finding reflects the rational decision-making process of potential adopters who consider the economic benefits before committing to a new service. Lastly, the role of Habit as a significant facilitator is particularly intriguing. The study's observation that the habitual use of MRS significantly bolsters BI suggests an important, though somewhat counterintuitive, insight into human behavior concerning technology adoption. While habit formation is typically viewed as a byproduct of adoption, this study (Hu et al., 2020; Nikolopoulou et al., 2020) suggests that existing habits regarding the use of similar services can indeed foster a predisposition towards adopting new services. This underscores the nuanced nature of technology adoption, where past behaviors and routines can significantly influence future adoption decisions.

These facilitators collectively paint a comprehensive picture of the factors that encourage the adoption of MRS among NHIS scheme members. The intuitive aspects, such as the influence of perceived benefits, ease of use, and economic value, are consistent with well-established theories in technology adoption literature. Conversely, the significant role of habit in influencing behavioral intention offers a slightly counterintuitive angle, suggesting that not only does adoption foster habituation but also that pre-existing habits can predispose individuals towards new technologies. Understanding these dynamics is crucial for policymakers and service designers aiming to increase the uptake of MRS. By enhancing the perceived benefits, simplifying the user experience, emphasising the value for money, and leveraging existing user habits, NHIS can strategically increase the adoption rates of its mobile renewal services.

6.4.3 Implications for theory, literature, policy relevance, practice, and social impact

6.4.3.1 Theoretical implications

The current study fills these literature gaps both theoretically and empirically. Theoretically, it brings an understanding of the UTAUT2 framework in the unique context of NHIS subscribers. The outcome of this study has shaped the operational model, including constructs like Performance Expectancy (PE), Effort Expectancy (EE), Facilitating Conditions (FC), Hedonic Motivation (HM), Price Value (PV), and Habit (HT), in the context of National Insurance Policy renewal. The hypothesized SEM may be used as a guide in predicting Behavioral Intention (BI) in adopting MRS. Thus, it provides a guide for researchers to extend this model to other jurisdictions.

6.4.3.2 Empirical and practical implications

The discussion in this chapter, while grounded in a robust theoretical framework, needs to be complemented with actionable, practical recommendations to address barriers to the adoption of the Mobile Renewal Service (MRS). Insights from the study indicate a clear need for strategies that bridge theoretical findings and real-world implementation.

One critical area of focus is improving accessibility. The analysis identified technical barriers, such as inconsistent network coverage, particularly in rural areas. To address this, the NHIS could collaborate with telecom providers to enhance network infrastructure in underserved regions. Moreover, integrating offline functionalities into the MRS, such as SMS-based renewal options, could serve as a practical alternative for users in areas with limited connectivity. Such interventions would ensure that rural subscribers are not excluded from the benefits of the system.

Another significant issue is the lack of awareness and digital literacy, which emerged as a major barrier to adoption. To overcome this, targeted educational campaigns should be designed to demonstrate the functionality of the MRS. Community health workers can play a pivotal role in these efforts by providing hands-on guidance to potential users. Additionally, instructional materials should be made available in local languages to cater to diverse demographics. Leveraging traditional media channels like radio and television can further amplify awareness, particularly in rural and underserved areas.

The study also highlighted usability challenges, such as complex navigation and limited support systems. Simplifying the user interface and incorporating features like multilingual options can enhance user experience and encourage wider adoption. Establishing a dedicated helpline to address user concerns and provide technical assistance would also be a valuable support mechanism, particularly for older and less tech-savvy users.

Socio-economic barriers, including cost sensitivity, also hinder MRS adoption. To address this, policymakers could introduce incentives, such as reduced renewal fees for subscribers using the MRS platform. Subsidies for low-income subscribers could also be considered, ensuring that financial constraints do not limit access to healthcare services. These measures would promote equity and increase adoption rates across socio-economic groups.

Strengthening policy support is another vital aspect. Policymakers could integrate MRS adoption metrics into the broader performance targets of the NHIS. Incentivizing NHIS staff and agents to actively promote the use of the MRS could create a more supportive environment for its implementation. Regular training sessions for NHIS personnel would also ensure they are equipped to assist users effectively.

Finally, establishing monitoring and feedback mechanisms is essential for continuous improvement. Providing subscribers with avenues to report issues and suggest improvements would create a feedback loop that ensures the MRS evolves in response to user needs. Regular updates to the system, informed by user feedback, would enhance its functionality and relevance.

These practical solutions align with the theoretical insights of the study, addressing barriers and facilitators identified through empirical analysis. By integrating these actionable strategies into the broader discussion, the thesis offers valuable guidance for policymakers, implementers, and stakeholders seeking to optimize MRS adoption and improve healthcare access in Ghana.

6.4.3.3 Implications for public services and technology adoption

The findings of this research have practical implications for public services and technology adoption. Policymakers and implementers should focus on the factors influencing the non-predictability of certain constructs, providing guidance for MRS rollout. Opportunities exist for

the government to leverage critical factors for technology adoption in the public sector, considering the unique challenges and needs of the Ghanaian context.

6.4.3.4 Research and policy implications

The non-predictability of certain constructs (SI and Age) offers an opportunity for further research. The findings add to the ongoing debate and contrasting results regarding the influence of these predictors (SI and HM) and the moderator (Age) on MRS adoption. By identifying these gaps and acknowledging the differences in findings, the study emphasises the need for additional research to comprehend the reasons behind the non-prediction of these factors. These results can serve as a foundation for future research investigating the factors influencing MRS adoption among NHIS subscribers and other populations. In addressing literature gaps and contributing valuable empirical evidence, this study advances the understanding of factors influencing MRS adoption. This enhanced understanding can aid policymakers and practitioners working to promote MRS adoption both in Ghana and beyond. Future research can further help identify significant predictors and provide actionable recommendations, possibly leading to the development of targeted interventions, policies, or strategies to support the successful implementation of MRS programs in various settings.

6.4.4 Recommendations

The conclusions and interpretations derived from this study pave the way for several strategic recommendations aimed at both advancing academic research and refining practical applications related to the adoption of MRS within the Ghanaian context. There's a compelling need to delve deeper into the cultural dimensions that influence technology acceptance and usage. Ghana's rich cultural diversity might play a pivotal role in shaping the attitudes and behaviors of scheme members towards MRS. By incorporating cultural factors into future research, we can uncover the nuanced ways in which cultural beliefs, norms, and practices either facilitate or hinder the adoption of mobile renewal services. This exploration could offer critical insights into designing culturally sensitive and more user-friendly MRS platforms that resonate with the diverse user base in Ghana.

Moreover, expanding the scope of investigation to include additional moderating variables, such as "Use Behavior," could significantly enhance our comprehension of the adoption process. While this study focused on the predictive strengths of various exogenous variables on behavioral

intentions, incorporating "Use Behavior" as a moderating variable might reveal deeper insights into the actual usage patterns and the complexities surrounding the sustained use of MRS. Such an analysis would provide a more detailed picture of the dynamics at play, enabling stakeholders to devise strategies that not only encourage enrollment into MRS but also promote its long-term utilisation.

Another critical avenue for future research is the in-depth examination of specific variables like social influence, facilitating conditions, hedonic motivation, and price value. The findings of this study highlighted these variables as not significantly contributing to the intention to enroll in MRS in Ghana. However, understanding the underlying reasons for this lack of significance could uncover potential areas for enhancing the design and marketing of MRS, thereby improving its adoption rates. Investigating these variables further could lead to targeted interventions that address the barriers and leverage the facilitators more effectively. Lastly, extending UTAUT2 framework to the West African sub-region, particularly within Ghana, could yield invaluable insights into the framework's applicability and relevance. This exploration is crucial for academics and practitioners aiming to understand the unique cultural and technological challenges present in the sub-region that may influence behavioral intentions towards technology adoption. Leveraging the UTAUT2 framework in this context can significantly contribute to the development of more robust models that accurately capture the intricacies of technology adoption in Ghana and similar settings

6.4.5 Limitations and future research direction

The research environment, the inclusion criteria, the online application used to capture data, the measurement instrument employed in the study and the UTAUT2 theory all presented limitations. The scope of the study was restricted to 16 regions in Ghana and NHIS subscribers only. The inclusion criteria for this study required participants to be at least 18 years old, to have access to computer or mobile device, and to be a registered member of NHIS. As stated, the inclusion criteria limit potential participants who are temporarily located outside the country's borders but who subscribe to the NHIS service using their mobile devices. Conducting this research within the context of Ghana entails the possibility of cultural influences on the findings. This study did not

include any cultural dimension constructs that could have influenced the effect of performance expectancy, effort expectancy, social influence, facilitating conditions, hedonic motivation, habit, and price value on behavioral intention to adopt MRS.

Since the online tool was not self-administered, it was difficult for the researcher to determine whether or not all participants comprehended the queries. Participants who do not understand the inquiries or their context may provide incomplete or inaccurate responses. The study was limited by two factors: (a) the exclusion of two moderating variables (gender and experience) and (b) the exclusion of the actual use behavior of the UTAUT2. The theory limitation precluded the "Use Behavior" dependent variable as well as the moderating variables of gender and years of experience from the UTAUT2 theoretical framework. This study omitted the two moderating variables and the "Use Behavior" variable because its emphasis was on predicting behavioral intention to engage in MRS while controlling for age. Scheme members' genuine participation in MRS would have corresponded to the "Use Behavior" variable of the UTAUT2 framework. Even though the study was conducted in all Regions of Ghana, the theoretical framework was limited to individual behavior constructs only. As a result, the study lacked predictors that could have measured the impact of organisational, environmental, and technological factors that may also influence the behavioral intention to partake in MRS. The next chapters discuss the barriers and facilitators of the adoption of MRS from the perspective of policy makers and implementers.

6.5 Conclusions

In conclusion, the findings emphasise the critical role of PE in shaping the intention of NHIS members to participate in MRS. The study demonstrated a statistically significant correlation between PE and subscribers' intention to participate in MRS, with a change in PE leading to a 16.9% increase in BI. These results align with previous research (Venkatesh et al., 2003; Wang and Butler, 2007), highlighting the significance of PE in influencing individuals' intentions to adopt new technologies. Cultural perspectives were found to play a vital role, with the impact of PE likely being more significant for people from individualistic cultures. The study also revealed various insights into the influence of EE, SI, FC, PV, HM, and HT on scheme members' intentions. Contrasting perspectives were found in previous research, and the study contributes to the ongoing debate on these factors, emphasising the need for a nuanced understanding and further exploration,

especially within different cultural contexts. The study employed the Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) model and identified additional factors influencing scheme members' behavioral intention, providing valuable insights for organisations and policymakers seeking to promote the adoption of new technologies in healthcare settings.

CHAPTER SEVEN: ASSESSING THE BARRIERS AND FACILITATORS INFLUENCING THE ADOPTION OF NHIS MOBILE RENEWAL SERVICE - POLICY MAKERS PERSPECTIVE

7.1 Introduction

Chapters 4 and 5 indicated specific adoption challenges, such as regional disparities in MRS usage and a lack of infrastructure. These findings highlighted the need to explore these issues further from the perspectives of users (subscribers) – Chapter 6 and policy implementers (Chapter 7). By grounding the motivation in the gaps identified earlier, the thesis demonstrates that the examination of these barriers was not based on assumptions but rather on empirical evidence and the logical progression of the research.

The lack of evidence on the critical drivers of adoption/adherence to MRS was identified as a research gap in the literature review (Chapter 2). The need to address this gap from the perspective of NHIS subscribers and policy implementors is established in chapter two. The previous chapter assessed the barriers and facilitators influencing the adoption of MRS from the subscribers' perspective. By understanding the subscribers' viewpoint, the study gained valuable insights into the factors that shape their intentions to adopt MRS. Within this context, several barriers and facilitators were identified, shedding light on the adoption process's complexities. Given the importance of understanding the barriers and facilitators identified from the subscribers' perspective, it is crucial to broaden our perspective by considering the viewpoint of policymakers and implementers. By doing so, the study would gain valuable insights into the challenges they face during the implementation process and the strategies they employ to ensure the successful adoption of the MRS intervention (Nathan et al., 2018). Therefore, this chapter explored the barriers and facilitators influencing the adoption of the MRS from the policy implementers' perspective. By examining their experiences and perspectives, the current chapter gains a deeper understanding of the challenges they face and the strategies they employ to overcome these challenges. This understanding will contribute to developing effective implementation strategies and policies that align with subscribers' expectations while considering the feasibility and practicality of implementation.

The choice of stakeholder engagement in this study through the Delphi study is premised on the grounds that it promotes buy-in and supports the acceptance of the research outcomes (Oliver et al., 2014; Boaz et al., 2018). Stakeholder engagement also enhances the credibility and legitimacy of the research. Stakeholder engagement in this chapter refers to interactions with key actors directly interested in the MRS implementation process, such as district managers, regional managers and NHIA head office staff (Boaz et al. 2019). To the best of the researcher's knowledge, no research ascertaining the barriers and facilitators affecting the implementation of MRS in Ghana has involved stakeholders with direct roles to play in the implementation process. The use of stakeholder engagement in this study is important because there is a paucity of its use in the West African Subregion and other low-middle-income countries (Kapririri, 2018). This study hopes to add to the existing literature by ascertaining the barriers and facilitators affecting the implementation of MRS in Ghana through stakeholder engagement.

7.2 Methods

7.2.1 Research design

A Delphi study was conducted among key policy implementers of the MRS to identify the barriers and facilitators influencing the implementation of the intervention in Ghana. The choice of the Delphi technique in this study lies in its widespread use and acceptance in achieving consensus on experts' views to draw conclusions (Okoli and Pawlowski, 2004; Powell, C., 2003; Adler and Ziglio, 1996). Several questionnaires are submitted to participants to collect data to address the identified research gap (Hsu and Sandford, 2007). The Delphi technique is known for effectively controlling the feedback process (Adler and Ziglio, 1996).

The rationale for the Delphi technique was to achieve consensus on critical barriers and facilitators influencing the adoption of the NHIS MRS to direct targeted interventions that could enhance the service's uptake (Cheung et al., 2017). The Delphi technique is an accepted and widely used approach to answer research questions that require experts' nuanced perspectives (Barrett D, Heale, 2020). It helps build consensus through iterative processes that allow the experts to reflect and assess their previous responses (Cheung et al., 2017). The level of engagement among

participants and the stability of responses meant that reaching an appreciable level of consensus was possible in a limited number of predefined rounds. Three iterative processes are often considered sufficient to achieve consensus (Cheung et al., 2017). However, converging in experts' opinions was achieved in two iterative rounds in this study, suggesting that consensus is also possible in two iterative rounds.

Other factors, such as time and resource constraints and convergence of opinions by participants, were instrumental in the decision to restrict the Delphi study to two rounds. Ultimately, the number of iterations in a Delphi study considered enough to collect the needed information for a consensus is guided by the specific objectives of the study and other considerations such as the research question under investigation and resource and time constraints (Powell, C., 2003; Hasson et al. 2000).

Participants in this study were recruited from the National Health Insurance Authority, managers of the National Health Insurance Scheme. These included the top management of NHIA and key head office staff, Regional Managers and all District Managers of the scheme. This sampling frame was informed by the need to get informed data from experts directly involved in implementing the MRS. The researcher adopted a purposive sampling approach to select participants for the study. Table 7.1 below shows the sampling frame for the selection of the stakeholders who participated in this study.

Table 7. 1:Sampling frame

Participant	Rationale for inclusion
NHIA/ NHIS Head Office Staff (Top Management, key staff such Data Centre and Operational Staff etc.)	Supports the Ministry of Health in policy formulation in the health sector. Introduced the MRS intervention and responsible for its implementation and overall quality basic health care provision in Ghana
NHIA/ NHIS Regional Managers	Responsible for the implementation of the MRS and other health interventions in their regional jurisdictions. Supervises all district managers in their respective regions
NHIA/ NHIS District Managers	Directly deal with NHIS members and involved in implementing the MRS at the district level and are

Participant	Rationale for inclusion
	the initial point of call when there are implementation challenges.

The inclusion criteria included:

1. Individuals who are directly involved in the MRS implementation process, hence, possess the necessary experience, know-how and expertise relevant to the study.
2. Individuals who can commit to participating and completing all the Delphi processes and fall within the sampling unit.
3. Aged 18 years and above.
4. Resident of Ghana

The exclusion criteria are:

1. Individuals who are not directly involved in the MRS implementation, hence, do not possess the necessary experience, know-how and expertise relevant to the study.
2. Individuals within the sampling unit who are unable to commit to participating and completing all the Delphi process.
3. individuals below the age of 18 years; and
4. Non-residents of Ghana.

7.2.2 Data collection

A two-round Delphi approach was used to collect data from the participants to address the research question in this chapter. In both rounds, questionnaires were designed to explore the study participants' opinions on the barriers and facilitators influencing mobile renewal service implementation and acceptance (Hsu and Sandford, 2007; Rubin and Rubin, 2012). The questionnaires were refined through an iterative process (Linstone and Turoff, 2002). Further, a pilot survey was conducted to ensure the validity and reliability of the questionnaire, allowing for refinement of questions and response options before the final survey (Bryman and Bell, 2015). The pretesting and refining process was crucial to the quality and accuracy of the data collected.

7.2.2.1 First round

Data was collected in two Delphi rounds. In the first round, 139 respondents were provided with detailed information about the purpose of the interview. They were then asked to identify possible barriers, facilitators, and interventions to address the barriers to the adoption of MRS through open-ended questions. Box 1 contains the questions that were posed to them through an open-ended questionnaire on Qualtrics.

Box 7. 1: Open-ended questions used in round 1

Q1. What are the challenges/barriers affecting the delivery of the mobile renewal intervention, specifically in your district or region?

Q2. What in your view are the factors that encourages people to use the mobile renewal service?

Q3. What in your opinion can be done at the district, regional and national levels to improve on the delivery of the mobile renewal service?

The participants were provided with a Qualtrics URL link to access the study's questionnaire. The researcher did not provide a list of barriers, facilitators and mobile renewal service improvement measures to the participants to avoid introducing bias into the study. Instead, the participants were asked to indicate their possible responses to the questions provided in the questionnaire. After collecting the responses, the researcher conducted a thematic analysis. The first step involved familiarizing himself with the extracted data by reviewing and interpreting responses from each respondent. Common phrases and sentences were identified, and data coding was done to generate common themes. Sixteen common themes were identified as the final themes. The themes were then reviewed to ensure that they reflected the responses and views of all participants. The final themes were discussed with two independent reviewers to reach a consensus on the final list of barriers, facilitators and mobile renewal service improvement measures for each of the questions. The questionnaire for round 2 was then based on the agreed common themes. Due process was followed to ensure that the responses obtained were analysed in a rigorous and unbiased manner, and the final list of themes represented the views and perspectives of the participants.

7.2.2.2 Second round

In the second round, the experts were presented with the responses from round 1 on the barriers, facilitators and improvement measures for the adoption of MRS in Ghana. The respondents for this round were 138, as 1 of the initial 139 respondents did not participate in this round. This round was conducted online using Microsoft Forms. Participants were presented with the generated themes on barriers, facilitators and MRS improvement measures to determine which factors are important to understanding the factors that enhance MRS implementation and acceptance by subscribers and what inhibits implementation. They were asked to rate the importance of the generated themes using a 5-point Likert scale ranging from 1 – not important; 2 – not very important; 3 – neutral; 4 – important to 5 – very important. Their ratings were analysed descriptively using median and IQR to assess the dispersion of responses and examine how they prioritize each identified response from round 1 (Cheung et al., 2017). Responses with median scores ≥4 indicated that the experts considered the responses important. A >70% agreement or disagreement among the experts was used to establish consensus on the importance of a response (Vogel et al., 2019). Data for this round was collected via Microsoft forms.

7.2.3 Ethics approval

Ethics considerations included informed consent, data protection, and the use of pseudonyms and de-identification to ensure participants' anonymity and confidentiality (Polit and Beck, 2017; Creswell and Poth, 2018). Ghana National Health Insurance Authority and Brunel University College of Health and Life Sciences gave ethics approval for this study.

7.3 Results

7.3.1 Findings from the first round

7.3.1.1 Demographic characteristics

One hundred and thirty-eight (139) respondents participated in this round. Of this, 137 (98.56%) were men and two (1.44%) were women. Many of them were aged 46 – 52 years (n = 58; 41.73%) and are predominantly NHIS District Managers (n=120; 86.33%) and Regional Directors (n=10; 7.19%). The Ashanti Region of Ghana had the most respondents (n=28; 20.14%). The responses

highlighted six barriers and five facilitators influencing the adoption of MRS in Ghana. Also, five MRS adoption improvement measures were mentioned by respondents. 'Network connectivity' and 'convenience and comfort' were the commonly reported barrier (n = 42)' and facilitator (n = 38) of MRS adoption, respectively. The experts' opinions on measures to improve MRS adoption included mobile network connectivity improvement (n = 31) and public education (n = 20).

The study acknowledged the significant gender imbalance in the sample, where 99% of participants were men. This was compared to national workforce data, which similarly showed men dominance in managerial roles within the NHIS. The implications of this imbalance were discussed, including the potential bias in the perspectives gathered, as women implementers may have provided different insights. The chapter emphasised the importance of inclusive recruitment policies within the NHIS to ensure diverse representation in future research and policy formulation. Table 7.2 below summarizes the characteristics of the respondents.

Table 7. 2: Demographic characteristics of respondents

Variable	Category	Frequency	Percentage
Gender	Women	2	1.44
	Men	137	98.56
	Total	**139**	**100.00**
	39 - 45	51	36.69
	46 - 52	58	41.73
	53 – 59	25	17.99
	Other Age Groups	5	3.60
	Total	**139**	**100.00**
Job Title	District Manager	120	86.33
	Regional Director	10	7.19
	Other Job Titles	9	6.47
	Total	**139**	**100.00**
Region	Ashanti	28	20.14
	Central	20	14.39
	Eastern	20	14.39
	Greater Accra	23	16.55
	Oti, N, NE, UW, Savannah, NP	16	11.51
	Western	11	7.91
	Western North	10	7.19
	Volta	11	7.91

Variable	Category	Frequency	Percentage
	Total	**139**	**100.00**

Note: N – Northern Region, NE – Northeast, UW – Upper West, NP – Region Not provided

7.3.1.2 Responses on MRS adoption barriers and facilitators

Table 7.3 and Figure 7.1 below present the respondents' responses on the barriers, facilitators, and improvement measures for MRS adoption. Among the themes included illiteracy, network connectivity, and convenience and comfort.

Table 7. 3: Responses and Themes -Round 1

Theme	Respondents' ID	Frequency
Barriers		
Network connectivity	02, 03, 04, 06, 07, 08, 09, 010, 011, 012, 013, 014, 015, 016, 017, 018, 019, 020, 021, 022, 023, 024, 025, 026, 027, 028, 030, 031, 032, 035, 037, 038, 039, 040, 041, 042, 043, 044, 045, 047, 048, 049	42
Illiteracy	02, 03, 07, 08, 09, 010, 018, 025, 026, 029, 030, 033, 036, 046	14
Poverty	05, 029, 033	3
Lack of Sensitisation	01, 02, 05,06	
Mobile Renewal platforms, including Fraud and E-Levy	06, 010, 034	3
Resistance to Change	015, 030	2
Facilitators		
Convenience and Comfort	050, 051, 052, 053, 054, 055, 056, 057, 058, 059, 060, 062, 063, 064, 065, 066, 069, 070, 071, 072, 073, 074, 076, 081, 083,084, 085, 086, 087, 088, 089, 091, 091, 092, 093, 094, 095, 097	38
Saves Time and prevents Queuing	055, 058, 059, 063, 064, 066, 067, 068,072, 077, 082, 089, 090, 092, 096	15
Cost effective and offers Savings on transportation	050, 051, 052, 053, 054, 055, 057, 059, 060, 062, 066, 067, 068, 073, 075, 077, 078, 079, 080, 081, 087, 089, 091, 096	24
Readily Accessible	051,068, 069, 079	4
Easy to use	069, 070, 077	3
Improvement Measures		
Improve mobile network connectivity	099, 0100, 0103, 0104, 0106, 0107, 0108, 0109, 0110, 0111, 0113, 0116, 0118, 0119,	31

Theme	Respondents' ID	Frequency
Barriers		
	0121, 0123, 0124, 0125, 0128, 0129, 0130, 0132, 0133, 0135, 0136, 0137, 0138, 0141, 0145, 0146, 0147	
Sensitisation/ Publicity/ Public Education	098, 099, 0100, 0101, 0102, 0103, 0104, 0112, 0114, 0115, 0120, 0122, 0127, 0128, 0131, 0134, 0139, 0140, 0143, 0144	20
Enhance and Expand Network Coverage	0100, 0110, 0142	3
Send Reminders	0112, 0117, 099, 0103	4
Leap Beneficiaries	0126	1

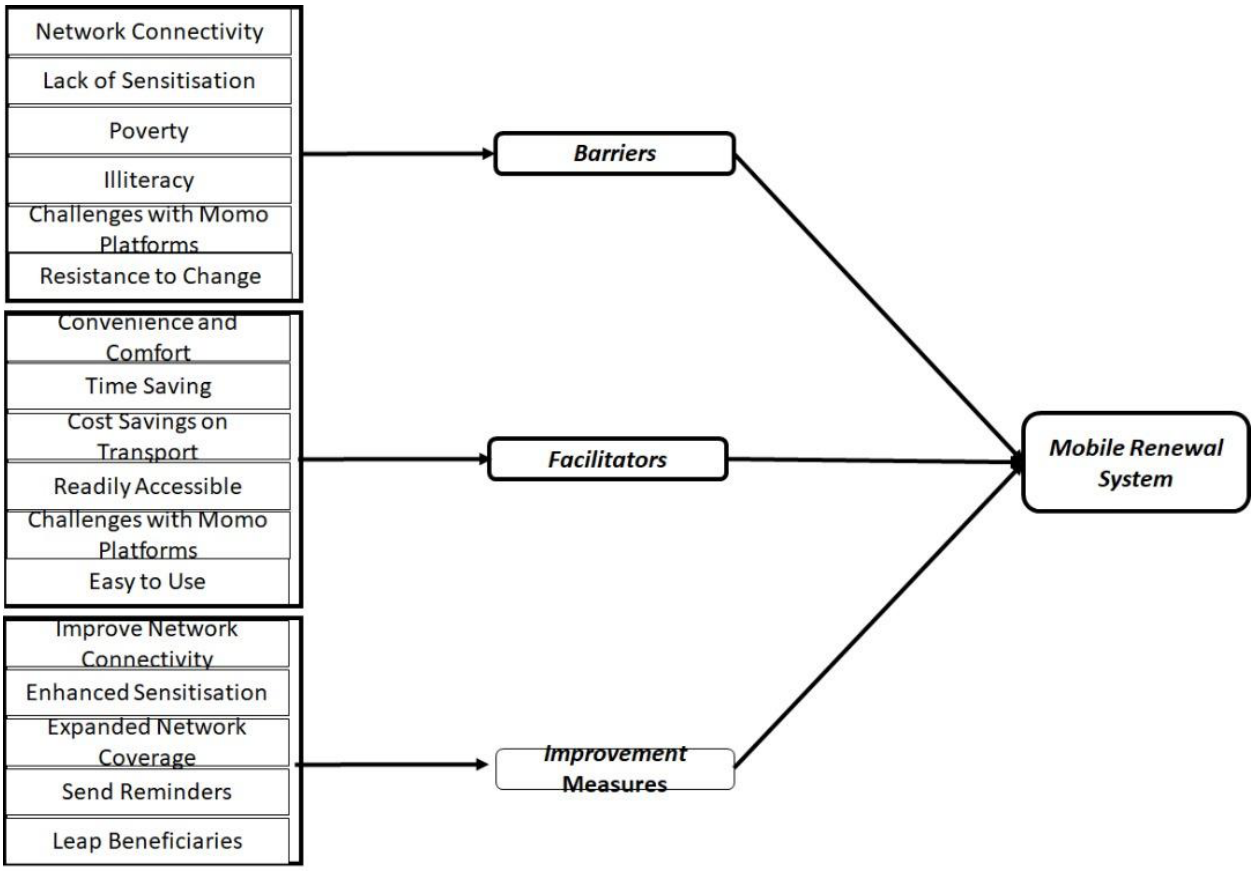

Figure 7. 1:Barriers, facilitators and improvements measures for MRS

7.3.2 Findings from the second round

One hundred and thirty-eight (n = 138) of the 139 respondents in round 1 participated in round 2, showing a 99% response rate. There was consensus (>70% strongly agree/agree) that all the factors

mentioned in round 1 were important (Median ≥ 4) barriers, facilitators and improvement measures for enhancing the uptake of the NHIS's MRS adoption in Ghana, except for providing free MRS access to LEAP beneficiaries as a measure to improve MRS adoption. These findings are summarised in table 7.4 and detailed in the texts thereafter.

Table 7. 4:Importance and consensus on barriers, facilitators and adoption of MRS

Barriers, facilitators and improvement measures	**Median score (IQR)**	**% strongly agree/agree**	**% strongly disagree/disagree**
Barriers			
Network connectivity is a challenge to the adoption of mobile renewal service	5 (.00)	97.1	2.9
Illiteracy among subscribers in the rural areas and city slumps is a barrier to mobile renewal service adoption	5 (.00)	99.2	0.7
The level of poverty among subscribers in the low-income bracket is a barrier to mobile renewal adoption	5 (.00)	94.9	1.4
Lack of sensitisation about the existence and benefits of mobile renewal service affects the adoption of mobile renewal service	4 (.00)	96.9	2.3
Challenges with mobile money platforms, including fraud and e-levy has a negative effect on mobile renewal adoption	5 (.00)	93.5	4.3
Resistance to change is a challenge to mobile renewal adoption	5 (.00)	90.6	7.2
Facilitators			
The mobile renewal service offers convenience and comfort. Members can renew their membership from the comfort of their homes	5 (.00)	100	0
Usage of the mobile renewal service saves time and prevents queuing	5 (.00)	100	0
Mobile renewal service is cost effective and offers savings on transportation	5 (.00)	99.3	0.7
Mobile renewal service is readily accessible	4 (.00)	96.4	2.9
The mobile renewal service is easy to use	5 (.00)	96.4	2.2
Improvement measures			
Improve mobile network connectivity, especially in rural communities to improve adoption of mobile renewal service	5 (.00)	98.6	0.7

Barriers, facilitators and improvement measures	Median score (IQR)	% strongly agree/agree	% strongly disagree/disagree
Enhance sensitisation/ publicity/ public education with the view to creating awareness of mobile renewal service	5 (.00)	99.3	0
NHIA should liaise with telecommunication companies in Ghana to enhance and expand network coverage across the country	5 (.00)	97.8	0
Send reminders to members of the scheme upon expiry of membership	5 (.00)	98.6	0.7
Include LEAP beneficiaries in mobile renewal service to enable the extreme poor and vulnerable in Ghana to freely access mobile renewal service	3 (.00)	23.9	1.4

7.3.2.1 Barriers to adoption

1. **Network Connectivity**: A critical barrier identified is the poor mobile network connectivity, which significantly hampers the usability of mobile-based renewal services, especially in rural areas. All policymakers agreed (with a median score of 5.0000 and minimal variance) that enhancing network connectivity must be a priority to ensure the service's effectiveness.
2. **Illiteracy and Poverty**: Both illiteracy and poverty are significant barriers, receiving a unanimous median score of 5.0000. These factors limit the ability of potential users to engage with digital services. Illiteracy complicates the understanding and navigation of mobile platforms, while poverty restricts access to necessary technological resources like smartphones and data plans.
3. **Lack of Sensitisation**: There is a notable deficit in public awareness and understanding of the mobile renewal service. This is reflected in a lower median score of 4.0000, indicating a slightly lesser consensus compared to other barriers but still pointing towards a significant impact. Enhanced public education and targeted sensitisation campaigns are essential to bridge this gap.
4. **Mobile Money Platform Challenges**: Issues such as fraud and the imposition of electronic levies (E-Levy) also deter users, reflecting a unanimous concern among policymakers

(median of 5.0000). Addressing these issues could increase trust and user engagement with the service.

5. **Resistance to Change**: Resistance to adopting new technologies is a natural human tendency and is seen as a significant barrier with a median score of 5.0000. Overcoming this requires strategic communication and the demonstration of tangible benefits to the users.

7.3.2.2 Facilitators of adoption

1. **Convenience and Comfort** - The ability to renew insurance from the comfort of one's home is a strong facilitator, scored uniformly at 5.0000. This feature enhances user satisfaction and is likely to drive adoption rates.
2. **Time-Saving and Cost-Effectiveness** - Similarly, the service's ability to save time and reduce costs related to transportation to physical offices received a top score of 5.0000. These economic and practical benefits are crucial for widespread adoption.
3. **Accessibility and Ease of Use** - While the general accessibility of the service scored slightly lower (4.0000), indicating room for improvement, the ease of use of the mobile platform received a high score (5.0000). Making the service more accessible to a broader audience, especially in underserved areas, could further enhance its effectiveness.

Several strategic actions were highlighted as necessary to overcome barriers:

- **Improving Mobile Network Connectivity -** Recognising the essential role of robust network infrastructure, policymakers unanimously suggest that enhancing connectivity, especially in rural areas, is imperative.
- **Enhancing Sensitisation and Public Education -** To combat the lack of sensitisation, a unanimous score underscores the need for aggressive public education campaigns.
- **Collaboration with Telecommunication Companies -** A strategic partnership with telecom companies could facilitate wider network coverage and better service delivery, a notion that received a top consensus score.

7.4 Discussions

The findings suggest that there are several barriers to the adoption of MRS in Ghana, including network connectivity, illiteracy, poverty, lack of sensitisation, challenges with mobile money

platforms, and resistance to change. These findings are consistent with previous studies that have identified similar barriers to the adoption of mobile health services in LMICs (Ahmed et al., 2018; Tamrat and Kachnowski, 2012). For instance, network connectivity has been identified as a significant barrier to the adoption of mobile health services in LMICs due to the limited availability and quality of mobile network infrastructure in these settings (Tamrat and Kachnowski, 2012). On facilitators, the study found factors such as convenience, timesaving, cost-effectiveness, accessibility, and ease of use as facilitators of MRS adoption. These findings are consistent with the literature on the adoption of MRS, as it also illustrated that that convenience, cost-effectiveness, and ease of use are essential factors in promoting the adoption and sustained use of MRS (Ahmed et al., 2018; Tamrat and Kachnowski, 2012).

The improvement measures identified in this chapter, such as enhancing network connectivity and public education, are also consistent with previous studies on the adoption of mobile health services in LMICs. For example, a systematic review of mobile health interventions in LMICs found that successful interventions often involved partnerships with telecommunications companies to enhance network coverage and targeted public education campaigns to increase awareness and understanding of mobile health services (Ahmed et al., 2018). The findings suggest that there is a need to address the barriers to mobile renewal service adoption in Ghana, including network connectivity, illiteracy, poverty, lack of sensitisation, challenges with mobile money platforms and resistance to change. At the same time, efforts should be made to leverage the facilitators of mobile renewal service adoption, including convenience, time-saving, cost-effectiveness, accessibility, and ease of use. Improvement measures such as enhancing network connectivity and public education campaigns could help to promote the adoption and sustained use of mobile renewal service in Ghana.

These findings are consistent with previous research, which suggests that these factors hinder the adoption and use of Mobile Renewal services in low-income communities. Moreover, the study highlights the importance of facilitators such as convenience, time-saving, cost-effectiveness, accessibility, and ease of use, which have been identified as critical factors in promoting the adoption and sustained use of mobile health services in NHIA. The findings also indicate that improving mobile network connectivity, sensitisation and public education, enhancing and

expanding network coverage, sending reminders, and leaping beneficiaries are critical measures to improve Mobile Renewal adoption in the study area, which is consistent with previous studies. Policymakers and Mobile Renewal service providers should take into consideration these barriers and facilitators in designing interventions to promote the adoption and sustained use of MRS. In particular, efforts should be made to address the identified barriers to mobile renewal service adoption in Ghana, such as network connectivity, illiteracy, poverty, lack of sensitisation, and challenges with Mobile Renewal platforms, while leveraging the facilitators to promote adoption and sustained use of mobile renewal services.

7.4.1 Implication for theory and practice

The study's findings make a significant contribution to the growing body of research on barriers and facilitators to the adoption of mobile health services in Ghana and West Africa. Their alignment with prior studies lends support to the generalisability of these factors across diverse settings and populations. The evidence demonstrates that network connectivity, illiteracy, poverty, lack of sensitisation, and resistance to change stand as significant barriers to the adoption of Mobile Renewal services. Conversely, factors such as convenience, time-saving, cost-effectiveness, accessibility, and ease of use serve as key facilitators. When designing interventions to encourage adoption and sustained use of mobile health services, including Mobile Renewal services, these aspects must be given due consideration.

7.4.2 Policy relevance and social impact

The study highlights essential policy directions to overcome the identified barriers and enhance the facilitators of Mobile Renewal services. Policymakers may consider strategies that improve network connectivity, particularly in underserved areas, and target interventions to address illiteracy and poverty, which hinder adoption. Sensitising the population about the benefits of Mobile Renewal services, overcoming resistance to change, and addressing specific challenges with the mobile platforms are also critical. Inclusion of beneficiaries from social programs like LEAP, without burdening them with additional fees, ensures that the services reach those who need them most, potentially reducing poverty and increasing financial inclusion.

7.4.3 Recommendations

Based on the findings, the study offers the following recommendations:

Improving Mobile Network Connectivity and Expanding Network Coverage - Improving mobile network connectivity is vital for overcoming barriers in network accessibility, especially in low-income communities where connectivity is often inadequate or absent. To facilitate the usage of Mobile Renewal services, service providers can collaborate with telecommunication companies. This collaboration may involve installing additional base stations, providing network extension services, or employing alternative network technologies. Moreover, expanding network coverage ensures that Mobile Renewal services reach all individuals, including those in low-income communities. This expansion may require investment in infrastructure such as mobile network towers to provide consistent and reliable coverage. By enhancing mobile network connectivity and coverage, Mobile Renewal service providers can reduce barriers, enabling more accessible services for low-income individuals.

Enhancing sensitisation through public education campaigns - To overcome the barrier of lack of sensitisation, policymakers should develop targeted public education campaigns focusing on the benefits and practicalities of Mobile Renewal and related services. These campaigns can be designed for low-income communities where adoption rates are low, and they can take the form of community outreach programs, town hall meetings, or targeted media advertisements. By emphasising the convenience, time-saving attributes, and cost-effectiveness of Mobile Renewal services, and addressing misconceptions or concerns, these campaigns can foster greater acceptance and sustained usage among low-income populations.

Making platforms user-friendly to overcome illiteracy barriers - Mobile Renewal service providers should prioritize making their platforms more user-friendly to ensure accessibility across all literacy levels. Strategies may include using simplified language, employing graphics or images to clarify instructions, and offering voice-guided features. Collaboration with community organisations or local government to provide technology literacy training or support is also advisable. By addressing these barriers and enhancing accessibility, providers can boost adoption rates and improve essential healthcare access within low-income communities.

Providing reminders and incentives to encourage usage - Reminders and incentives can serve as effective strategies to overcome resistance to change and promote sustained usage of Mobile

Renewal services. Service providers can utilise SMS or other communication channels to remind users of important deadlines or available services. Offering incentives, such as discounts or other benefits for regular use, can further enhance the perceived value of the service. Careful design, implementation, and ongoing evaluation of these reminders and incentives are crucial to ensure their effectiveness and relevance over time.

7.4.4 Limitations and future research direction

These limitations provide avenues for future research:

- Conducting studies with larger and more diverse samples would enhance the generalisability of the findings. Researchers should consider involving different regions, industries, and demographics to capture a more comprehensive view of the factors influencing mobile renewal adoption.
- Longitudinal studies that track the adoption of mobile renewal services over time would help in establishing causal relationships between the identified barriers, facilitators, and adoption rates. This approach could shed light on how specific factors directly impact the uptake of mobile renewal services.
- Investigating the adoption of mobile renewal services in contexts other than the NHIA would broaden the understanding of the phenomenon. Comparative studies across different industries or countries could reveal commonalities and differences in the factors influencing mobile renewal adoption.

7.5 Conclusions

This chapter highlights critical barriers and facilitators that influence the adoption of MRS for health insurance renewals. It identifies network connectivity, illiteracy, poverty, lack of sensitisation, challenges with mobile money platforms, and resistance to change as significant barriers to adoption, and convenience, time-saving, cost-effectiveness, accessibility, and ease of use as key facilitators for adopting MRS. These findings are consistent with those identified in Chapter 6, where adoption rates were lower in areas with limited digital infrastructure. To overcome these barriers, the study proposed actionable solutions, such as conducting targeted public awareness campaigns to educate NHIS members about the benefits and functionalities of MRS. Additionally, collaboration with telecommunications providers to expand network coverage

was recommended. The justification for these solutions was based on their potential to enhance equitable access to the MRS and increase overall adoption rates, addressing disparities observed in rural areas. Leveraging the identified facilitators and barriers to the adoption of MRS could promote the sustained use the NHIS's MRS for health insurance renewal. The next chapter, which is the final chapter of this thesis, outlines the new knowledge gained from this study, discusses the policy implications of the new knowledge and directs the next direction of travel of this research area.

CHAPTER EIGHT: SUMMARY OF KEY FINDINGS, RECOMMENDATIONS AND CONCLUSIONS

8.1 Introduction

The empirical studies of this thesis demonstrated the effectiveness of MRS for health insurance renewals and the perceived barriers and facilitators influencing the adoption of the MRS from the perspective of the NHIS members and the managers of the scheme. This chapter provides an overview of the thesis's objectives, summarises its key findings, and discusses its contributions to literature and how it compares to the Ghanaian and global literature. It also reflects on the thesis's methodological approaches and limitations and provides policy and practice recommendations, future research directions, and conclusion comments.

8.2 Overview of objectives

The aim of this thesis was to enhance understanding of the effectiveness of MRS for health insurance renewal in Ghana. Empirical evidence of MRS effectiveness is expected to inform policy directions for improvement in areas such as the design and coverage of the MRS intervention and the development of similar interventions in the future. To achieve this aim, the researcher explored three key objectives:

1. The effectiveness of the MRS intervention was examined using the NHIS subscribers' membership data. The number of renewals per annum served as the evaluation outcome measure.
2. Subscribers' perspectives on the barriers and facilitators influencing the adoption of NHIS's MRS were explored to offer insight into the factors influencing the adoption of MRS.
3. The factors influencing the implementation and adoption of the NHIS's MRS were investigated from Ghana's NHIS policy implementers perspectives.

The objectives and their corresponding research findings are summarised in Table 8.1 below:

Table 8. 1: Research objectives, questions and findings

Research Objective	Research Question
Examine the effectiveness of the NHIS's MRS.	Is MRS effective for renewing health insurance? ?
Investigate the perspective of NHIS's scheme members on the barriers and facilitators of MRS adoption	What factors influence NHIS sunscribers/users' adoption of MRS?
Investigate the perspective of scheme implementers on the barriers and facilitators of MRS adoption	What are the barriers and facilitators to the adoption of MRS from the perspectives of NHIS's policy implementers

8.3 Summary of the study's key findings

The study showed that NHIS subscribers' members have widely accepted the MRS. More scheme members use the MRS to renew their membership than the option of going to the district office. It also demonstrated that the adoption of MRS was facilitated by the ease of use, accessibility, convenience, cost savings on transportation, and the prevention of queuing, which are the main facilitators of the adoption of MRS. Bad network connectivity, lack of sensitisation, poverty, illiteracy, challenges with mobile money platforms and resistance to change were identified as barriers to adopting MRS. Further, it revealed that improving mobile network connectivity, enhancing sensitisation, sending reminders to scheme members and expanding mobile network coverage can help improve MRS adoption. Figure 8.1 summarises the new knowledge from this thesis and the texts after details this summary per each chapter.

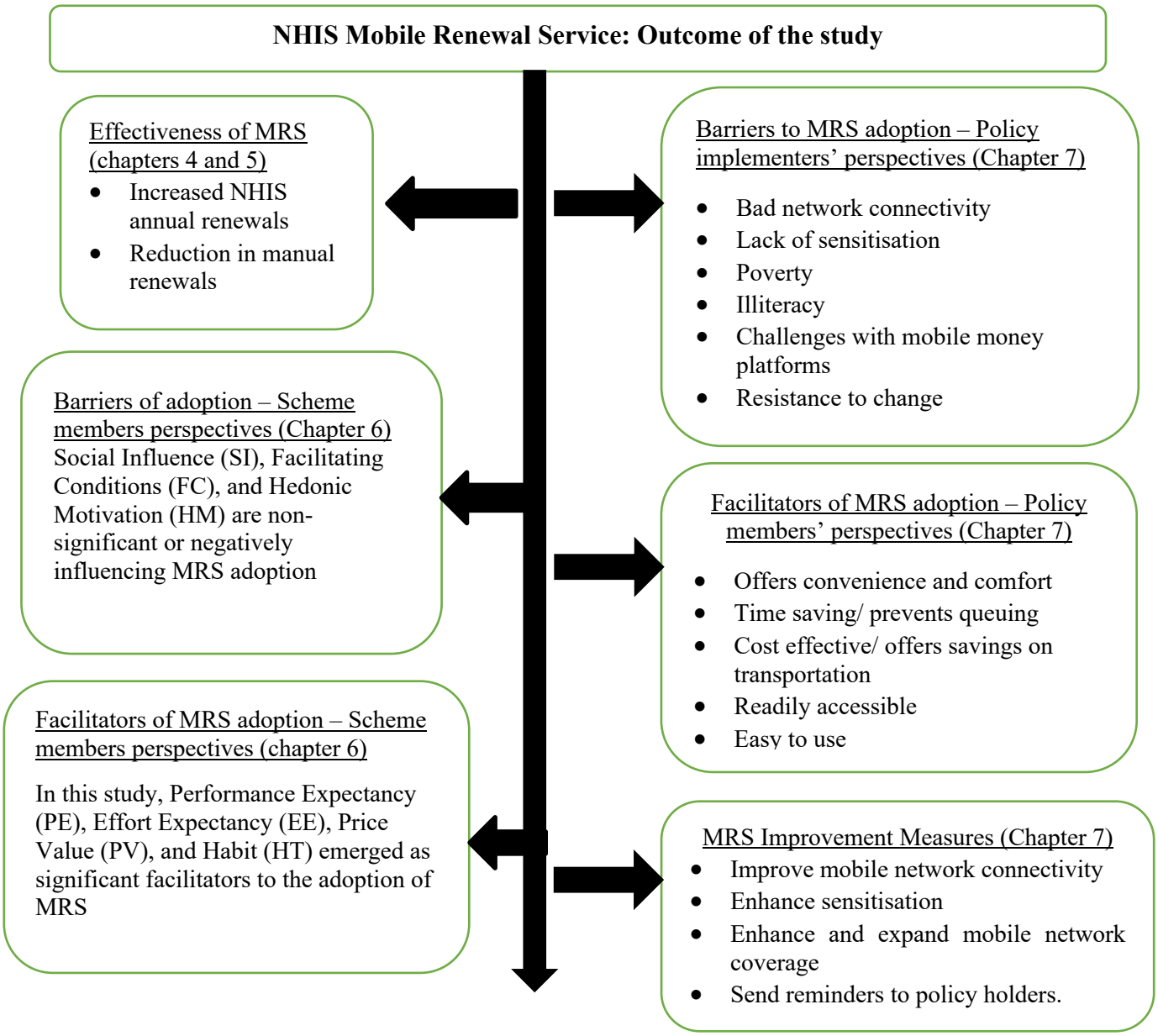

Figure 8. 1:Summary of the study's key findings

Literature review on evaluation of mHealth interventions in healthcare delivery – The literature review examined mHealth interventions in West Africa, mainly focusing on their effectiveness and challenges. Key findings indicated that while mHealth interventions generally improved healthcare access and quality, network unreliability, limited digital literacy, and infrastructural deficits frequently undermined their efficacy. The review highlighted a critical gap in context-specific evaluations, particularly regarding the effectiveness of mHealth and the economic impacts of its implementations, which informed the subsequent empirical analyses.

Framework for empirical analysis - This thesis outlined the methodological frameworks for evaluating the mobile renewal service. It introduced the UTAUT2 framework for assessing behavioural intentions towards technology adoption and ITSA model to quantify changes attributable to the introduction of the mobile renewal service. The framework established a structured approach to address the research questions in this thesis, focusing on effectiveness and the factors influencing the adoption from both user and implementer perspectives. This study is the first to have used ITSA and UTAUT2 to assess the effectiveness and user acceptance of MRS in Ghana.

Effectiveness of MRS - Findings demonstrated a significant increase in NHIS renewals post-introduction of the mobile service, attributed to enhanced accessibility and user convenience. ITSA results indicated a clear positive shift in renewal trends, affirming the mobile platform's impact. These chapters validated the mobile renewal service as an effective strategy for increasing health insurance coverage among Ghanaians.

Barriers and facilitators of MRS adoption from subscribers' perspective - The research in Chapter 6 explored factors influencing the adoption of the mobile renewal service from the subscribers' perspective. Key facilitators included the mobile platform's perceived ease of use, cost-effectiveness, and time efficiency. However, significant barriers such as lack of awareness, limited digital literacy, and distrust in digital transactions were noted. These factors influenced subscribers' willingness to adopt the mobile renewal service, suggesting areas for targeted improvements.

Barriers and facilitators from policy implementers' perspective - The final empirical chapter delved into the perspectives of NHIS managers and other stakeholders involved in implementing the mobile renewal service. The findings highlighted that while implementers strongly supported the mobile platform, challenges such as infrastructural limitations and periodic technical glitches hindered optimal service delivery. Nevertheless, solid collaborative efforts with telecommunication companies and continuous stakeholder engagement were identified as critical enablers for the successful adoption and scaling of the service.

8.4 Contributions of the thesis

This thesis significantly contributes to the evolving discourse on mHealth interventions, explicitly focusing on Ghana's NHIS's MRS. Generally, the perceived usefulness of mHealth and overall digitalisation in healthcare access and utilisation has been well documented in the literature (Labrique et al., 2013; Bali and Singh, 2018; Kawakatsu et al., 2020; Nsiah-Boateng et al., 2023). However, this thesis's systematic review demonstrated a paucity of literature specific to Ghana and West Africa in this area (Annan et al., 2017; Amponsah et al., 2020; Oppong-Twene et al., 2021). For example, it showed that much of the evidence on the effectiveness of mHealth interventions is from settings outside West Africa (Lee et al., 2018; Nystrom et al., 2019; Müller et al., 2016; Garg et al., 2020). Further, it observed that while mHealth interventions are becoming modern stay in West Africa, and their advantages of enhancing health accessibility are touted, there have been few investigations on what drives their adoption to inform scalability decisions (Marcolino et al., 2018; Laar et al., 2019; Zhou et al., 2019). This thesis, therefore, leveraged these literature gaps to contribute new knowledge on mHealth interventions in Ghana, a West African country, to stimulate conversations around improving and enhancing the adoption of mHealth in Ghana.

It first employed robust statistical methodologies, including the ITSA and dissimilarity analyses, to assess the effectiveness of the NHIS MRS, one of Ghana's mHealth interventions, using data from over 40 million NHIS membership records. This methodological advantage allowed the study to offer comprehensive evidence on the effectiveness of MRS. The findings from that analyses not only provided novel evidence of the intervention's effectiveness but further affirmed a significant shift from manual to mobile options for health insurance renewals, underscoring a potential for scaling MRS to improve healthcare access (Adongo et al., 2014; Aranda-Jan et al., 2014). It also bolsters the argument for broader adoption of mobile health technology, highlighting its potential advantages in enhancing health outcomes.

Furthermore, the analyses added new knowledge by empirically confirming through statistical analysis that the MRS and manual renewal systems are statistically different. Specifically, the dissimilarity measures assessment in the thesis helped contribute to the broader field of time series analysis by offering new ways to quantify and interpret differences between the time series of

manual and digital interventions. To the best of the researcher's knowledge, no study on mHealth in Ghana, and by extension, West Africa, has applied dissimilarity measures to quantify, attribute and interpret the time series differences between the MRS and the manual renewal system for health insurance renewals. Therefore, using these measures in this thesis offered preliminary evidence for robust analysis of mHealth interventions in West Africa to offer precise estimates of their effectiveness.

Further, the empirical evidence from the thesis regarding barriers to adopting MRS among NHIS members presents a deviation from established literature on technology adoption (Hoque et al., 2017; Dorsey and Topol, 2016; Gagnon et al., 2016). The assertion that constructs such as SI and FC were not significant predictors in this study suggests a unique context or set of circumstances influencing NHIS scheme members' adoption decisions. This departure from findings by Weeger et al. (2018), Tamilmani et al. (2021), Dwivedi et al. (2017), and Ouattara (2017) might be attributed to the specific nature of health insurance services, which are perceived not just as a technological solution but as a critical, needs-based service. An equally counterintuitive is the finding which suggests that HM negatively impacts BI, contradicting the expectations set by Ouattara (2017), Nikolopoulou and Lavidas (2020), and Gharaibeh et al. (2020). The literature highlights the barriers and facilitators to the adoption and effectiveness of mHealth, such as user engagement, technology infrastructure, user trust, accessibility, and technological literacy (Whittaker, 2012), suggesting that the findings of this study are an addition to available knowledge. Also, this study added to the literature by utilising SEM to examine how independent variables such as EE, SI, and PE, among others, influence one's BI (dependent variable) when using the NHIS MRS. To the best of the researcher's knowledge, previous research on the barriers and facilitators of mHealth in Ghana had yet to use SEM to investigate the factors influencing one's BI to adopt mHealth within the broader context of technology adoption.

Finally, the thesis filled a gap in the literature by examining the barriers and facilitators of MRS implementation and adoption from the perspective of Ghana's NHIS policy members. The literature focused on barriers and facilitators from the perspective of mHealth (MRS) adoption from the perspective of scheme members within the broader context of technology adoption

(Mechael, 2009; Whittaker, 2012; Adongo et al., 2014; Hoque et al., 2017). This study provided empirical evidence which suggests that poor mobile network connectivity, illiteracy and poverty, lack of sensitisation, mobile money platform challenges, and resistance to adopting new technologies are the barriers to the implementation and adoption of MRS from the perspective of the managers of the NHIS. The study further provided evidence on the improvement measures necessary to enhance MRS implementation and adoption from the perspective of the NHIS within the Ghanaian context. These measures include improving mobile network connectivity, enhancing sensitisation and publicity education, enhancing and expanding mobile network coverage, especially in rural communities and sending reminders to NHIS members when annual renewal is due. The available literature (Agarwal et al., 2010; Whittaker, 2012; Gagnon et al., 2016; Wang et al., 2019) on the measures to improve mHealth adoption from the perspective of Government institutions such as the NHIS were mainly conducted outside Ghana, hence may not be context specific.

8.5 Methodological approach revisited

The thesis employed a comprehensive methodological framework combining empirical data analysis, theoretical insights, and stakeholder feedback. First, it utilised the Extended Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) as its conceptual framework. The UTAUT2 framework was used to explore the factors that impact the adoption of the MRS (Venkatesh et al., 2012; Tamilmani et al., 2021). The model has gained widespread recognition and has been extensively supported by empirical evidence in different situations, giving it a robust framework for analysing the acceptance of technology (Marikyan and Papagiannidis, 2021; Parhamnia, 2022). Nevertheless, the model's extensive scope also provides a disadvantage, as it encompasses numerous factors that can potentially complicate evaluating the MRS research and interpretation. Furthermore, the suitability of UTAUT2 may differ in various cultural and contextual environments, necessitating meticulous adjustment (Duarte and Pinho, 2019). More precisely, there are several possible disadvantages when using this approach to evaluate subscribers' intention to engage in the mobile renewal service. A significant limitation is that UTAUT2 needed to encompass all the context-specific aspects that influence subscribers' intentions in the distinct setting of mobile renewal services. Furthermore, UTAUT2 primarily

concentrates on favourable aspects that impact behavioural intention and fails to sufficiently consider potential adverse influences such as perceived dangers, privacy concerns, or reluctance to change.

In identifying the facilitators and barriers to NHIS renewal, the researcher adopted the Structural Equation Modelling (SEM) to assess the UTAUT2 components' validity and reliability. SEM, a statistical technique that enables the investigation of many interactions among variables simultaneously, was employed thoroughly. SEM is particularly suitable for testing complex models such as UTAUT2 (Lowry and Gaskin, 2014). Nevertheless, the model posed some limitations for this study. First, the study's sample size of 2,226, albeit significant, can present certain constraints. In ascertaining the barriers and facilitators of MRS adoption, the SEM model includes variables such as perceived ease of use, comfort, digital literacy, and network reliability. Estimating the relationships among these variables requires a substantial number of observations to ensure the results are not due to random chance. Sample sizes and how well they represent the target population are likely to influence the results of the SEM. If the sample is not a sufficient representation of all NHIS subscribers in Ghana, it may undermine the generalisability of the findings. However, the sample size was carefully chosen to represent the population.

Furthermore, although the model fit indices indicated a satisfactory match, it is essential to note that these indices alone do not confirm that the model is the most accurate representation of the data (Herting and Costner, 2017). Nevertheless, a goodness of fit test was performed to demonstrate the model's resilience. Three fit indices were examined: Root Median Square Error of Approximation (RMSEA), Comparative Fit Index (CFI), and Tucker-Lewis Index (TLI) (Fadyl et al., 2010; Afe et al., 2020).

Subsequently, the research study utilised the before-after quasi-experimental research approach, and the data was analysed using interrupted time series analysis, Prais-Winsten, and Newey-West regression models. This approach is feasible in real-life situations where introducing randomness is impossible. (Dal-Ré et al., 2018). Interrupted time series analysis is a valuable method for evaluating the effects of interventions across time. It allows for the examination of patterns and changes in behaviour (Penfold and Zhang, 2013). Nevertheless, given the absence of randomisation, confounding variables could affect the outcomes, making it difficult to ascribe any changes exclusively to the intervention (Dal-Ré et al., 2018). Furthermore, the findings may be

limited to the particular timeframe examined and not apply to other periods. The analysis of ITSA can be influenced by concurrent events or interventions that take place during the implementation of the mobile renewal service. For example, the concurrent implementation of health policy changes, economic fluctuations, or public health campaigns may impact the intent of subscribers, complicating the isolation of the impact of the mobile renewal service. Interrupted time series analysis often requires a substantial observation period before and after the intervention to get reliable outcomes (Bernal et al., 2017). Suppose the duration of the study was relatively brief, as may be the case in this study. In that case, it may not have adequately captured the enduring impacts of the mobile renewal service on subscribers' intentions. The immediate effects may not accurately represent the actual influence, which may develop over a longer duration (Bernal et al., 2017).

In addition, a dissimilarity metric was employed to compare the time series of manual and mobile renewals and confirm whether the increase in renewal was due to the MRS intervention. This methodology offers a quantitative method for comparing renewal options, emphasising distinctions and patterns (Woolley et al., 2017). The method quantifies disparities between time series, allowing for in-depth examination (Walther et al., 2016). Nevertheless, it necessitates comprehensive time series data, which may not consistently be accessible or precise. Moreover, the interpretation of the data might be intricate, particularly for individuals needing a solid foundation in statistics (Woolley et al., 2017).

The utilisation of dissimilarity measurements in this work had few constraints. First and foremost, the issue at hand is interpretability. Although dissimilarity measurements can quantitatively evaluate disparities, they do not inherently provide insights into the underlying causes of these discrepancies. Comprehending the reasons behind the varying objectives of specific subscriber groups may necessitate using qualitative methods or further statistical research. Furthermore, it is crucial to recognise the dynamic nature of subscriber behaviour, which is not effectively captured by static dissimilarity measurements. Subscribers' intentions might be influenced by a range of factors, including new knowledge, policy changes, or personal experiences, and these factors can change over time. Dissimilarity metrics usually offer a static representation that may only partially encompass the temporal changes. The Delphi study and statistical models have resolved these

issues and provided more profound insights into the elements that affect the acceptance of the NHIS mobile renewal service.

Finally, a Delphi study was carried out among influential policy implementers to pinpoint the obstacles and enablers that impact the execution of the MRS. The Delphi method is a comprehensive approach that elicits expert insights, thereby facilitating a comprehensive comprehension of intricate issues (Jorm, 2015). The iterative nature of the Delphi approach facilitates the improvement of ideas and the establishment of agreement (Naisola-Ruiter, 2022). Nevertheless, the Delphi method can be lengthy, necessitating numerous iterations of surveys and research. Moreover, the conclusions could be affected by the experts' subjective assessments, which may introduce bias (Naisola-Ruiter, 2022; Jorm, 2015).

Furthermore, the choice of experts in a Delphi study could be a constraint. The panel members' competence and representativeness greatly influence the results' quality and relevancy. If the chosen experts lack adequate expertise or a range of viewpoints on adopting MRS, the resulting insights may be biased or incomplete. Nevertheless, the panel of this study is extensive and pertinent to the topic. In addition, obtaining consensus may occasionally result in disregarding minority ideas (Xu et al., 2015). The significance of insights provided by a limited number of specialists may be undervalued in favour of more broadly accepted views. There was consensus among participants on the identified themes in this study.

The study employed a methodological approach that thoroughly integrated the advantages of many approaches to assessing the NHIS's Mobile Renewal Service. Each strategy possessed distinct benefits. Nevertheless, these methods also had constraints. Although faced with several obstacles, incorporating numerous methodologies ensured a robust and detailed analysis, providing significant insights into the existing body of research on mHealth interventions in Ghana, particularly the NHIS MRS.

8.6 Comparison of research findings to the literature

The findings of this thesis align with existing literature. For instance, Bhavnani et al. (2015) discovered that convenience and accessibility play crucial roles in encouraging the acceptance of digital healthcare services. Bhavnani et al. (2015) findings are consistent with the study's results,

which indicate a notable increase in mobile renewals. The findings suggest that consumers perceived the mobile service as more convenient and readily available than manual renewals. Alam et al. (2020) found in their study on the adoption of mHealth services in Bangladesh, using the UTAUT model, that performance expectancy, social influence, facilitating conditions, and perceived reliability have a positive impact on the behavioural intention of respondents to adopt mHealth services. The facilitators found in the Delphi survey, such as convenience, time-saving, cost-effectiveness, accessibility, and ease of use, align with these characteristics.

Addae-Nketiah (2022) discovered that the Technology acceptability Model (TAM) comprehensively explains subscribers' acceptability and use of the Mobile Renewal Service. The study determined that accessibility and perceived ease of use are crucial elements that positively impact perceived usefulness. The study indicated that accessibility is vital to subscribers' acceptance of the Mobile Renewal Service. This assertion aligns with the present study's findings on the significant change in user preference towards the mobile platform. Similarly, Morgan et al. (2024) showed that students who perceived the mobile platform as advantageous and easy to use were more inclined to utilise it for NHIS renewals. This position corroborates the present study's discovery that there was a substantial rise in mobile renewals, suggesting that consumers consider the mobile platform advantageous and easy to use.

The results regarding barriers and facilitators align with existing research. Aranha et al. (2021) conducted a systematic study. They found that technology adoption is influenced by multiple factors, which may be categorised into three main themes: dispositional barriers, usability aspects of mobile devices, and social impact. Dispositional obstacles, such as a lack of confidence in one's abilities and skepticisms towards technology, result in anxiety around adopting mHealth. The findings are consistent with the difficulties highlighted in the current study, including illiteracy and reluctance to change.

Moreover, research conducted by Nsor-Anabiah et al. (2019), Khatun et al. (2016), and Peprah et al. (2020) has emphasised that the lack of literacy, societal barriers, and an insufficient number of skilled healthcare professionals provide substantial obstacles to the effectiveness of mHealth in developing nations. The barriers identified in this study are similar to those mentioned, encompassing problems related to network connectivity, poverty, and difficulties with mobile money systems. In their research, Cajita et al. (2018) found that the adoption of mobile technology

among patients is facilitated by two main factors: ease of use and the provision of helpful features. The outcome of this study is consistent with the facilitators identified in this study, including convenience, time efficiency, cost efficiency, accessibility, and user-friendliness. The acceptance and continuous usage of Ghana's NHIS mobile renewal service depend on several crucial elements.

According to a study conducted in Kenya, using mobile money, M-Pesa, to pay health insurance premiums do not lead to a substantial rise in membership in the National Health Insurance Fund (Chemin, 2018). This finding was consistent with this study, as it also discovered that introducing the mobile renewal platform for NHIS renewal in Ghana did not significantly impact the overall number of renewals throughout the specified analysis time. These data indicate that although mobile platforms provide convenience and accessibility, they may not be enough to significantly improve health insurance adoption. The divergent results observed between Ghana and Kenya underscore the complex obstacles to adopting mobile health technologies, as the adoption could be influenced by multiple variables, such as insufficient awareness, trust in digital payment systems, technological literacy, and persistent socio-economic hurdles.

Overall, the study's results are consistent with previous research, highlighting the significance of criteria such as convenience, accessibility, performance expectancy, and ease of use in the acceptance of digital healthcare services. Furthermore, the barriers and facilitators revealed in this study align with the findings in previous research. Dispositional obstacles, usability characteristics, social impact, illiteracy, sociocultural issues, and the need for more competent healthcare professionals are significant impediments to the adoption of mHealth. The alignment with prior studies underscores the complex and varied factors influencing technology adoption. It also emphasises the need to address both obstacles and enablers, as this comprehensive approach is crucial to improving the acceptance of mHealth services.

8.7 Public health significance of the research findings

The findings of this study have key public health significance, which are discussed in the key areas below:

Improved access to healthcare services - The observed significant use of MRS for health insurance renewals suggests that more people can maintain active health insurance, reducing financial

barriers to healthcare access. Health insurance continuity is essential for timely access to medical care and reducing out-of-pocket expenditures, which are key factors in achieving universal health coverage (WHO, 2021). This assertion is supported by studies that have shown that digital health interventions improve health insurance enrollment and utilisation (Adjei et al., 2020). Similar mobile health interventions in low-resource settings have enhanced access to essential healthcare services (Mechael et al., 2018).

Reduction in financial and transportation barriers - The study found that MRS adoption was driven by convenience, cost savings on transportation, and prevention of long queues. These findings confirm that reducing indirect costs (e.g., travel expenses) improves healthcare utilisation (Kuunibe and Domanban, 2019). Studies have established that financial constraints are a leading cause of delayed or forgone healthcare (Giedion et al., 2013). Also, mobile-based health services have effectively reduced geographical and financial access barriers (Lemaire, 2011). Therefore, the introduction of MRS in Ghana has shown how geographical and financial barriers to healthcare access may be addressed.

Addressing health inequities and vulnerable populations - MRS helps marginalised populations, including those in rural areas and low-income groups, by making NHIS renewal more accessible. However, barriers like poverty, illiteracy, and mobile money platform challenges indicate the need for inclusive digital health strategies (WHO, 2022). Evidence from similar interventions shows that mobile health services can improve health equity when tailored for vulnerable populations (Bullen, 2013). Addressing network issues and digital literacy is essential to prevent digital exclusion (Chib et al., 2015).

Strengthening health system efficiency - By reducing congestion at NHIS district offices, MRS allows health workers to focus on service delivery rather than administrative tasks. This is consistent with research showing that mobile health interventions improve healthcare system efficiency (Agarwal et al., 2016). Digital health services have reduced waiting times and administrative burdens and improved patient satisfaction in similar settings (Labrique et al., 2018).

Enhancing public health interventions through digital health - The study suggests that sending reminders and sensitisation campaigns can improve MRS adoption. Evidence shows that SMS

reminders and community awareness programs enhance the uptake of health services (Lund et al., 2012). For example, in Ghana, text message reminders have improved maternal healthcare attendance (Der et al., 2015). Digital communication strategies are cost-effective tools for improving health service utilisation (Free et al., 2013).

8.8 Limitations of thesis

Certain limitations in the study need to be considered when interpreting its results. First, the data utilised in this thesis covers the period from 2016 to 2020, with only two years of data available after the deployment of the mobile renewal system. The short duration of this time frame may not comprehensively represent the long-term patterns and effects of the mobile renewal service on NHIS renewals. The limited duration of the post-implementation phase hinders the ability to accurately assess lasting changes in behaviour and long-term impacts. This limitation may fail to recognise delayed adoption patterns or the progressive resolution of early obstacles.

Also, although the sample size of more than 2,000 individuals is significant, it constitutes only a tiny proportion of the entire NHIS subscriber population, around 16 million. This disparity raises issues regarding the sample's representativeness. The findings may need complete generalisability to the total population of NHIS subscribers because the sample may not sufficiently represent the diverse range of experiences and opinions among the broader subscriber base.

Furthermore, employing an online self-administered questionnaire as the primary approach for gathering data poses possible biases. Online surveys frequently omit those with a poor internet connection or digital literacy, leading to a sample bias towards more technologically proficient participants. This method is susceptible to self-selection bias, wherein persons with strong opinions or experiences regarding the mobile renewal service are more inclined to participate, possibly resulting in an overrepresentation of specific positions. Moreover, the cultural environment in which the conceptual model is accepted may restrict the extent to which the findings can be used. The conceptual model employed in this study could be impacted by cultural and environmental characteristics exclusive to Ghana, which may not apply entirely to other environments. Cultural variations in technology uptake, health service use, and views of mobile services could influence the generalisability of the results to different nations or areas.

Despite the constraints, the study implemented a comprehensive approach to ensure the accuracy and dependability of its findings. The findings were validated using rigorous data analytic techniques, and a broad and representative sample was obtained through deliberate efforts. By employing proven measuring tools and embracing a thorough conceptual model, the study's reliability and validity are further enhanced. The study's triangulated approach, which combines both quantitative and qualitative data, offers a comprehensive understanding of the factors that influence the uptake of the NHIS mobile renewal service. This wealth of knowledge can significantly inform the intervention implementing agency and the government for policy direction and further research, underlining the importance of the study's findings.

8.9 Recommendations for future research

Future research could explore longitudinal impacts, broader demographic variables, and comparative studies across different regions and countries within West Africa to understand the diverse impacts of multiple factors on mHealth services. This exploration could be done through:

- Conducting studies with more extensive and diverse samples in Ghana. The findings of such analysis could be essential to enhance the external validity of the study. In such analysis, researchers could consider involving different regions, industries, and demographics to understand the factors influencing mobile renewal adoption comprehensively.
- Conducting longitudinal studies that track the adoption of mobile renewal services over time. This analysis could be invaluable in establishing causal relationships between the identified barriers, facilitators, and adoption rates.
- Investigating the adoption of mobile renewal services in sectors/contexts other than the NHIA. Such analysis could reveal commonalities and differences in the factors influencing mobile renewal adoption, broadening our understanding of the phenomenon.
- An in-depth examination of specific variables such as social influence, facilitating conditions, hedonic motivation, and price value.

8.10 Recommendations for policy and practice

This study advances the understanding of factors influencing MRS adoption. This enhanced understanding can aid policymakers and practitioners in promoting MRS adoption in Ghana and other countries. For example, the NHIA and the Government of Ghana could develop and implement tailor-made publicity campaigns in the predominant local languages of each of the 16 regions through visual television commercials, short documentaries, and social media platforms. This approach could significantly impact MRS adoption since it tends to have broader coverage. Furthermore, given the stakeholders' findings on trust challenges associated with MRS adoption, the Government of Ghana could take steps to build trust in digital transactions on these platforms. Building trust in digital interventions can be achieved by enhancing security protocols to protect users' personal and health information, ensuring transparency in data handling practices, and communicating these practices to users. The importance of trust in the security and privacy of the mobile platform cannot be overstated, as it is an essential factor in enhancing and sustaining user adoption. Increasing awareness through clear communication and robust security measures will help alleviate user concerns and build confidence in the MRS. These recommendations are summarised below to offer a crisp, and clear recommendations plans for the NHIA:

Improve the reliability of the MRS platform: The NHIA could upgrade the mobile renewal platform (USSD, mobile app) to minimise transaction failures

Enhance Network Connectivity: The NHIA could consider collaborating with telecom providers to expand network coverage to underserve rural communities in Ghana

Introduce Multilingual Support: The NHIS MRS platform currently only transmits in English language. Therefore, the NHIA could consider ensuring that mobile renewal messages and interfaces are available in key local languages across the length and breadth of Ghana to increase accessibility.

Community Sensitisation: Both the subscribers and policy implementers emphasised the need for continuous awareness and public education campaigns across the country. Accordingly, the NHIA could consider this suggestion by making creating awareness of the MRS platform through radio, TV, and various social media platforms to educate users about the benefits of the MRS. They could

further use officers at the various district offices to educate the public on the renewal processes and the benefits of the MRS.

Removal of convenience fee: The NHIA could consider removing the convenience fee to enhance adoption of the MRS, especially for poor and marginalised populations.

24/7 Call Center: It may be prudent for the NHIS to set up a dedicated helpline for MRS support, including artificial intelligence (AI) chatbots for instant assistance. This could help with increasing and retaining NHIS's subscribers.

User Feedback and System Improvement: The NHIA could normalise a practice of gathering user feedback through SMS surveys and subscriber engagements, especially in deprived communities to improve service delivery. Such feedback should be incorporated into future updates of the MRS platform. It should also consider developing a clear process for resolving issues related to failed transactions or incorrect deductions. This will encourage subscribers to continue to use the service and increase uptake.

By implementing these strategic actions, NHIA can enhance the uptake of MRS, leading to enhanced health accessibility, and enhance overall public health coverage through an efficient, tech-driven MRS. In summary, this chapter has proposed specific implementation plans for the NHIS based on the study's findings. The recommendations include enhancing user support systems, ensuring affordability of the mobile renewal process, and scaling up digital literacy programs to encourage widespread adoption. The absence of a cost-effectiveness analysis in the thesis was also addressed. The exclusion was justified by the lack of granular cost data for both mobile and manual renewal systems. The chapter recommended that future research prioritise the economic evaluation of MRS to understand its financial implications fully. This ensures a comprehensive assessment of the system's sustainability and impact.

8.11 Reflection on the achievement of research objectives

This section synthesises the conclusions of all the chapters to determine whether the research objectives have been achieved. The research aimed to evaluate the effectiveness of MRS in three core dimensions: its impact on NHIS membership retention and accessibility, user adoption and satisfaction, and policy-level barriers and facilitators.

8.11.1. Effectiveness Evaluation

The evaluation of the MRS's effectiveness was thoroughly addressed in Chapters 4 and 5. Using ITSA, the research assessed trends in NHIS membership renewals before and after the implementation of the MRS. The findings revealed a significant increase in renewal rates post-implementation, indicating that the service positively impacted NHIS membership retention and accessibility. By demonstrating that mobile renewal improved convenience and expanded access, particularly in urban areas, this objective was clearly achieved. However, disparities in adoption between urban and rural areas were identified, highlighting a need for targeted interventions to address contextual challenges such as connectivity and awareness gaps.

8.11.2. User Perspectives

Chapters 6 and 7 addressed the factors influencing user adoption and satisfaction with MRS. The application of the UTAUT2 framework revealed that constructs like performance expectancy, effort expectancy, social influence, and facilitating conditions were significant predictors of user behavior. Hedonic motivation and price value also influenced user intentions, underscoring the importance of both functional and emotional drivers in technology adoption. Satisfaction was found to be high among users who valued the ease of use and time savings provided by the service. Thematic analysis also identified barriers such as a lack of awareness and digital literacy, particularly in rural areas. These insights provided a nuanced understanding of user behavior, fulfilling this objective and paving the way for strategies to improve user engagement.

8.11.3. Policy Perspectives

Chapter 7 also explored the perspectives of NHIS implementers and policymakers, identifying structural barriers and facilitators in the implementation of the MRS. Key barriers included

inadequate infrastructure, lack of training for staff, and limited outreach to underserved communities. Facilitators included strong organisational support, and the perceived cost-effectiveness of the mobile system compared to manual processes. The study proposed practical recommendations, such as expanding training programs for NHIS staff and improving network connectivity in rural areas. These findings reflect a comprehensive exploration of the policy landscape, achieving the objective of understanding institutional and systemic dynamics.

8.11.4. Overall reflection

The conclusions from all chapters collectively demonstrate that the research objectives have been achieved. The study provided empirical evidence of the MRS's effectiveness, insights into user adoption behaviors and satisfaction, and a thorough analysis of policy-related challenges a opportunities. While the objectives were met, the findings also highlighted areas for future improvement, such as addressing rural-urban disparities, enhancing user awareness, and fostering policy frameworks that support sustainable implementation. These reflections underscore the study's contribution to advancing knowledge on mHealth interventions and guiding the strategic evolution of the NHIS mobile renewal initiative.

8.12 Conclusion

The NHIS's MRS represents a transformative approach to healthcare delivery in Ghana, effectively increasing insurance coverage and accessibility. To meet evolving healthcare demands and technological advancements, continuous improvement and adaptation of mHealth strategies are necessary. The research underscores the potential of mobile platforms in enhancing healthcare outcomes in Ghana and similar settings globally. Through focusing on continuous improvement, mHealth interventions like the MRS can transform healthcare accessibility and outcomes across diverse communities. The key highlights and implications include:

1. *Successful Implementation of Mobile Platforms* - The research underscores the potential of mobile platforms in enhancing healthcare outcomes in Ghana. The successful implementation and subsequent increase in NHIS renewals affirm the viability of such platforms, aligning with international research on the benefits of mobile health (mHealth)

interventions (Akinfaderin-Agarau et al., 2012; Brinkel and Owusu-Dabo, 2017; Fatoye et al., 2019; Julia, 2014; Zakus and Moussa, 2019).

2. *Necessity for Promotion and Expansion* - Mobile renewal systems urgently need additional promotion and expansion to extend the reach and efficacy further. Educating subscribers about the convenience and time-saving attributes of the MRS can encourage broader adoption.
3. *Ongoing Assessment and Iterative Implementation* - Consistent with iterative program implementation principles, the continual and rigorous assessment of mobile renewal systems is not just important but vital to making necessary improvements and enhancing healthcare outcomes (Bernal, Cummins, and Gasparrini, 2017).
4. *Inclusion of Various Perspectives* - Future research should prioritize including user and policy implementer perspectives. Their experiences and insights will foster a more holistic understanding of the impact and efficacy of mHealth interventions, aiding the development of user-centred healthcare technologies (Johnson et al., 2023).
5. *Implications for Low-Income Communities* - By examining the primary barriers and facilitators affecting the acceptance of mobile renewal services in low-income communities in Ghana, the study provides urgent and actionable insights for policymakers and service providers. These findings directly affect designing and executing interventions that can enhance healthcare accessibility and quality within the Ghanaian context and potentially in similar settings globally.

In conclusion, this study marks an important step in unravelling the complexities of mHealth interventions such as MRS in a specific socio-cultural setting. It validates the practicality of such interventions and builds a foundation for future research and policymaking to achieve equitable and efficient healthcare delivery. By embracing the lessons learned and focusing on continuous improvement and user-centricity, mHealth interventions like the mobile renewal service in Ghana can transform healthcare accessibility and outcomes across diverse communities.

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APPENDICES

Appendix 1: Pilot Review

AN EVALUATION OF MOBILE RENEWAL SERVICE IN HEALTHCARE DELIVERY: CASE STUDY OF NATIONAL HEALTH INSURANCE AUTHORITY, GHANA

Introduction

This pilot review was conducted to ascertain the appropriate research methods to be used for the main literature review, identify datasets and search terms frequently used by systematic reviews that evaluate effectiveness (general effectiveness and process) and cost effectiveness of mHealth.

Methods

Search Strategy

The search was conducted on Scopus, which is a comprehensive database containing more than 20,000 titles in the fields of medicine, technology, and social sciences. The search was conducted between November 9th and November 13th, 2020, specifically targeting relevant systematic reviews. Scopus was chosen as the search engine due to its extensive coverage of citations and reliable and consistent results (Bosman, 2006). Additionally, Scopus provides a wide range of journals and offers the ability for citation analysis, making it a suitable choice for this research (Falagas et al., 2007). This pilot review used the following search terms: (“mobilehealth" OR ehealth OR mHealth OR "digitalhealth") AND (evaluation OR effectiveness OR cost) AND PUBYEAR > 2012. Table 1 demonstrates the search result from Scopus.

Table 1: Search Term

Database	Initial Hits	Filters Used	Final Results
Scopus	1,037 – systematic reviews	Systematic reviews based on subject area – 93	Systematic reviews based on relevance - 18
Total			18

Eligibility criteria

A predetermined eligibility criterion was used to determine whether a systematic review can be included in the pilot review. To identify and select current articles related to this study, the search was limited to papers that were published between the year 2010 and 2020. The ten-year period was chosen as it captures the emergence of mHealth use in Ghana. The Ministry of Health (MoH) in Ghana adopted a National e-Health Strategy in 2010 (Ghana Health Service, 2010). Table 2 below shows the eligibility criteria that was used in this study.

Table 2: Eligibility Criteria

INCLUSION CRITERIA	EXCLUSION CRITERIA
Systematic reviews examining effectiveness of mHealth	Reviews examining the effectiveness of General eHealth
Systematic reviews must be in English	Systematic reviews in any other language apart from English
Full text of the systematic review must be available and accessible	Full text not available
Systematic reviews published between 2010 and 2020	Systematic reviews published before the year 2010.

Data extraction

A developed data extraction question was used to extract data from the selected systematic reviews. Five main questions were used to extract the relevant data from the selected systematic reviews. The questions were:

- What database/databases were used in the studies or reviews?
- What search terms were used in the studies?
- Who are the authors?
- What year did they publish the reviews?
- What were the main findings of the study?

Quality appraisal

After extracting the relevant data, the Critical Appraisal Skills Program (CASP) tool for systematic reviews was used to appraise the quality of the selected studies. This was to ensure that the quality of the study met the required standard of a systematic review to avoid potential bias (Harris et al., 2014).

Results

Overall, ninety-three (93) reviews were identified and selected from Scopus database after the database specific filters were applied. The titles of these papers were then screened to ensure their relevance to the topic under study. After screening, two (2) were removed because they did not meet the English language eligibility criteria. A further screening of the remaining ninety-one (91) resulted in the removal of seventy-five (78) reviews because the search engines used for some of them were not indicated, whereas some did not relate to the topic under study and did not meet the search criteria. The abstracts of the thirteen (13) remaining reviews were screened to ensure they met the eligibility criteria. A final screening resulted in the elimination of one (1) more review that did not meet the inclusion criteria. Consequently, twelve (12) systematic reviews met the eligibility criteria for the pilot review. The Prisma diagram below has been used to demonstrate the selection process.

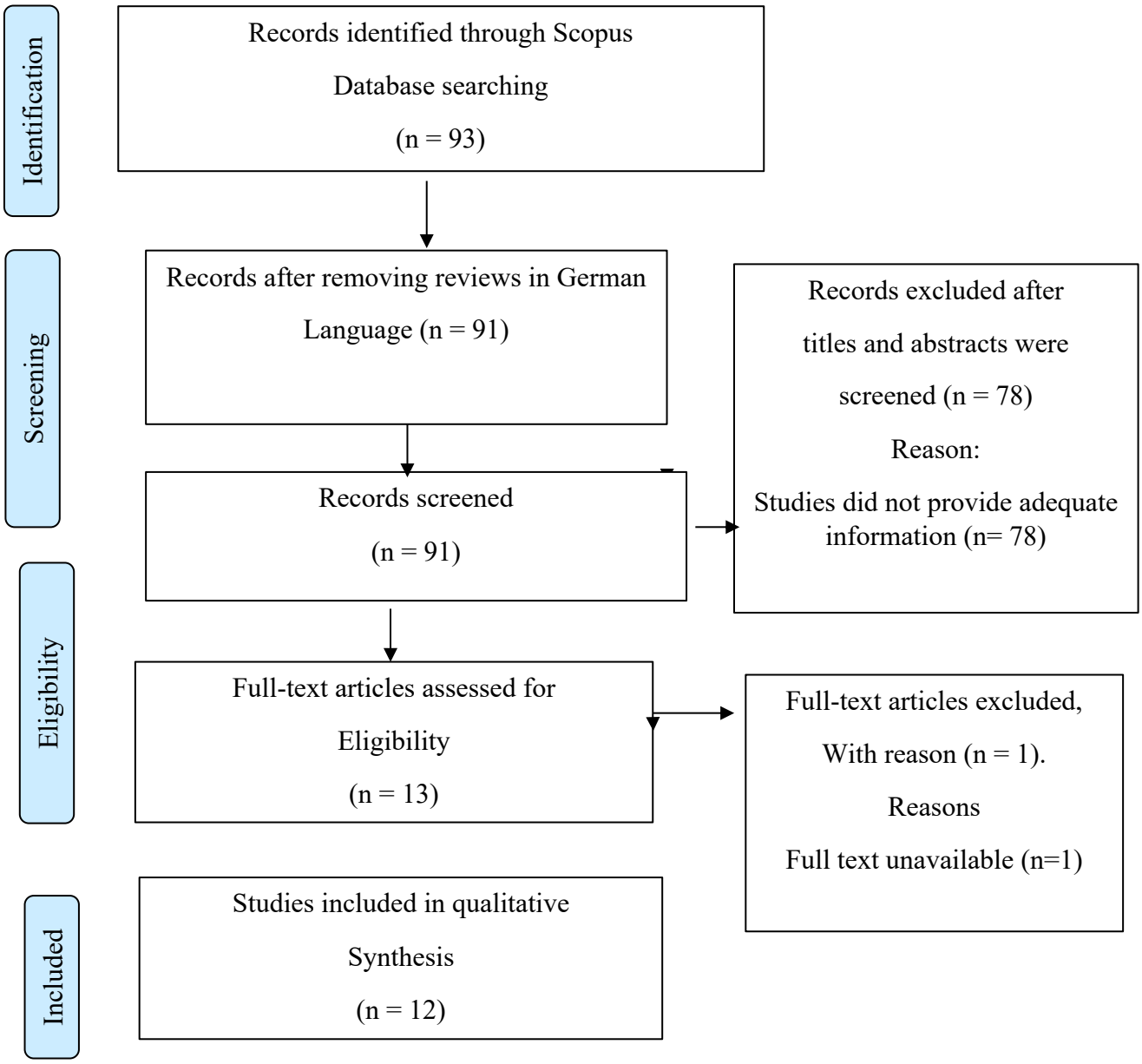

Figure 1: Results of Search

Data Extraction

Data extracted from the reviewed papers included the research topics, authors, year of publication, database and search terms as shown in 3 below:

Table 3: Extracted Data

REVIEWS	AUTHOUR/YEAR	DATABASE	SEARCH TERMS
The Cost-Effectiveness of Mobile Health (mHealth) Interventions for Older Adults: Systematic Review	Zartashia Ghani et al., (2020)	Pubmed, Scopus, and Cumulative Index of Nursing and Allied Literature (CINAHL), Google Scholar	'age', 'cost-benefit analysis', 'economic evaluation', 'gerontechnology', 'telemedicine'
Influences on the Uptake of and Engagement with Health and Well-Being Smartphone Apps: Systematic Review	Dorothy Szinay et al., (2020)	MEDLINE, EMBASE, CINAHL, PsycInfo, Scopus, Cochrane library databases, DBLP, and (ACM)	mHealth; health app; engagement; uptake; systematic review; COM-B; TDF; digital health; mobile phone; smartphone; smartphone app
Effectiveness of Mobile Health Interventions on Diabetes and Obesity Treatment and Management: Systematic Review of Systematic Reviews	Youfa Wang et al., (2020)	PubMed, IEEE Xplore Digital Library, and Cochrane	"mhealth[Title/Abstract] AND (obesity[Title/Abstract] OR diabetes*[Title/Abstract]) AND review[Title/Abstract]."
Digital health professions education on chronic wound management: A systematic review	Laura Martinengo et al., (2019)	MEDLINE, Embase, Web of Science, ERIC, PsycINFO, CINAHL, CENTRAL, and ProQuest Dissertation and Theses Database	Digital education, E-learning, Healthcare professionals, Nurses, Chronic wounds, Pressure ulcers, Venous leg ulcers, Continuous medical education, Systematic review

REVIEWS	AUTHOUR/YEAR	DATABASE	SEARCH TERMS
Health workers' perceptions and experiences of using mHealth technologies to deliver primary healthcare services: qualitative evidence synthesis	Willem A. Odendaal et al., (2020)	MEDLINE, Embase, CINAHL, Science Citation Index, Social Sciences Citation Index in January 2018 and Global Health in December 2015	Cell Phone, Delivery of Health Care [*methods], Developing Countries, Health Personnel, Health Services, Perception, Primary Health Care, [*methods], Qualitative Research, Rural Health Services, Telemedicine [*methods], Text Messaging
Mobile health app usability and quality rating scales: a systematic review	Peyman Azad-Khaneghah et al., (2019)	Medline, CINAHL, PsycINFO, IEEE Explore databases	Mobile applications, quality evaluation, rating scales, E-health, mobile health, systematic review
Mobile apps for increasing treatment adherence: Systematic review	Virtudes Perez-Jover et al., (2019)	Scopus, Cochrane Library, ProQuest, and MEDLINE	mobile health, medication alert systems, medication adherence
The cost-effectiveness of digital health interventions on the management of cardiovascular diseases: Systematic review	Xinchan Jiang et al., (2019)	Medline, Embase, Cumulative Index to Nursing and Allied Health Literature Complete, PsycINFO, Scopus, Web of Science, Center for Review and Dissemination, and Institute for IEEE Xplore between 2001 and 2018	telemedicine; cardiovascular diseases; stroke; heart failure; myocardial infarction; heart attack; cost-effectiveness; medical economics; decision modelling; systematic review
mHealth interventions	Naomi J. Saronga et al., (2019)	MEDLINE, EMBASE,	MHealth, mobile phones, dietary intake,

REVIEWS	AUTHOUR/YEAR	DATABASE	SEARCH TERMS
targeting pregnancy intakes in low and lower-middle income countries: Systematic review		CINAHL, Cochrane, Web of Science, Scopus, Global Index Medicus, and Maternity and Infant Care	maternal health, nutrients intake, pregnancy
Economic evaluations of eHealth technologies: A systematic review	Chiranjeev Sanyal et al., (2018)	MEDLINE, EMBASE, CINAHL, NHS EED, and PsycINFO	'assistive technology', 'socially assistive robots', 'mobile health', 'mobile robot', 'smart home system', 'telecare', 'telehealth', 'telemedicine', 'wander prevention systems', 'mobile locator devices', 'gps', 'location based technology', 'mobile apps', 'mobile application', 'cell phone', 'web based', 'internet', 'mhealth', 'm health', 'eHealth' or 'e health' cross referenced with 'older adult', 'elderly', 'seniors', or 'older patient' and 'cost effective', 'cost utility', or 'economic evaluation'.
Evidence on feasibility and effective use of mHealth strategies by frontline health workers in developing countries: Systematic review	Smisha Agarwal et al., (2015)	MEDLINE, EMBASE, Global Health, Google Scholar and Scopus	mHealth, community health workers, health personnel, mobile health
mHealth in sub-Saharan Africa	Thomas J. Betjeman et al., (2013)	PubMed	"mHealth"

Databases

The common databases used by the selected reviews were Medline, Embase, CINAHL, Scopus, PsycInfo, PubMed, the Cochrane Database of Systematic Reviews, Web of Science and Google Scholar. Even though there were other databases, these are the ones that were frequently used. Table 4 below shows the databases and the frequency of use across the selected reviews.

Table 4: Databases and frequency of use

S/NO.	DATABASE	NUMBER OF REVIEWS THAT USED IT
1	Medline	9/12
2	Embase	7/12
3	CINAHL	7/12
4	Scopus	6/12
5	PsycInfo	5/12
6	PubMed	3/12
7	COCHRANE	3/12
8	Web of Science	3/12
9	Google Scholar	2/12

Search terms

The following keywords 'mHealth', 'telemedicine', 'systematic review', 'mobile health', 'economic evaluation', 'review', 'health personnel', cost-effectiveness', and 'mobile phones' were the most frequent search terms used by the selected systematic reviews. The search terms and frequency of use has been demonstrated in table 5 below:

Table 5: Identified search terms and frequency of use

S/NO.	SEARCH TERMS	NUMBER OF REVIEWS THAT USED IT
1	mHealth	6/12

S/NO.	SEARCH TERMS	NUMBER OF REVIEWS THAT USED IT
2	Telemedicine	4/12
3	Systematic Review	4/12
4	Mobile Health	4/12
5	Economic Evaluation	2/12
6	Review	2/12
7	Health Personnel	2/12
8	Cost-Effectiveness	2/12
9	Mobile Phones	2/12
10	Cost-benefit Analysis	1/12
11	Health App	1/12
12	Digital Health	1/12
13	Delivery of Healthcare	1/12
14	Developing Countries	1/12
15	eHealth	1/12

Quality appraisal

All the selected systematic review papers, except one answered 'YES' to the appraisal questions. This suggested that they were of high-quality with regards to the CASP tool quality requirement (CASP, 2020). In addition, all the other eleven (11) studies showed the systematic processes they used to select and assess the quality of their selected primary studies in accordance with the principles of systematic reviews (Akobeng, 2005). Hence, this additional quality made the selected review papers reliable. The results of the quality appraisal are demonstrated in table 6 below:

Table 6: Results of Quality Appraisal

S/NO.	AUTHOUR/YEAR	APPRAISAL QUESTIONS									
		Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
1	Zartashia Ghani et al., (2020)	Yes	Yes	Yes	Yes	Yes			Yes	Yes	Yes
2	Dorothy Szinay et al., (2020)	Yes	Yes	Yes	Yes	Yes			Yes	Yes	Yes
3	Youfa Wang et al., (2020)	Yes	Yes	Yes	Yes	Yes			Yes	Yes	Yes
4	Laura Martinengo et al., (2019)	Yes	Yes	Yes	Yes	Yes			Yes	Yes	Yes
5	Willem A. Odendaal et al., (2020)	Yes	Yes	Yes	Yes	Yes			Yes	Yes	Yes
6	Peyman Azad-Khaneghah et al., (2019)	Yes	Yes	Yes	Yes	Yes			Yes	Yes	Yes
7	Virtudes Perez-Jover et al., (2019)	Yes	Yes	Yes	Yes	Yes			Yes	Yes	Yes
8	Xinchan Jiang et al., (2019)	Yes	Yes	Yes	Yes	Yes			Yes	Yes	Yes
9	Naomi J. Saronga et al., (2019)	Yes	Yes	Yes	Yes	Yes			Yes	Yes	Yes
10	Chiranjeev Sanyal et al., (2018)	Yes	Yes	Yes	Yes	Yes			Yes	Yes	Yes
11	Smisha Agarwal et al., (2015)	Yes	Yes	Yes	Yes	Yes			Yes	Yes	Yes
12	Thomas J. Betjeman et al., (2013)	No	Can't Tell	Can't Tell	Can't Tell	Can't Tell			Can't Tell	Can't Tell	Yes

Conclusion

In conclusion, Medline, Embase, CINAHL, Scopus, PsychINFO, PubMed, COCHRAINE, Web of Science and Google Scholar were the most common databases used by the selected systematic reviews examining mHealth evaluation and effectiveness. In addition, ‘mHealth’ was the frequent search term used by the identified systematic reviews. Therefore, these databases and search terms will inform the search strategy in the literature review of this thesis.

Appendix 2: CASP and Drummond quality appraisal checklists

1. CASP checklist

Number	Question
Q1	Was there a clear question for the study to address?
Q2	Was there a comparison with an appropriate reference standard?
Q3	Did all patients get the diagnostic test and reference standard?
Q4	Could the results of the test have been influenced by the results of the reference standard?
Q5	Is the disease status of the tested population clearly described?
Q6	Were the methods for performing the test described in sufficient detail?
Q7	What are the results?
Q8	How sure are we about the results? Consequences and cost of alternatives performed?
Q9	Can the results be applied to your patients/the population of interest?
Q10	Can the test be applied to your patient or population of interest?

2. Drummond et al (2015) economic evaluation appraisal checklist

Number	Question
Q1	Was a well-defined question posed in an answerable form?
Q2	Was a comprehensive description of the competing alternatives given?
Q3	Was the effectiveness of the programs or services established?
Q4	Were all the important and relevant costs and consequences for each alternative identified?
Q5	Were costs and consequences measured accurately in appropriate physical units?
Q6	Were costs and consequences valued credibly?
Q7	Were costs and consequences adjusted for differential timing?
Q8	Was an incremental analysis of costs and consequences of alternatives performed?
Q9	Was allowance made for uncertainty in the establishments of costs and consequences?
Q10	Did the presentation and discussion of study results include all issues of concern to users?

Appendix 3: Summarised characteristics of reviewed studies

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings
Babalola et al. 2019	*Assessment of mHealth Projects*	To assess mobile digital health tool piloted in Kaduna City, Nigeria	Quantitative	Mobile phone (*one way SMS)*	Contraceptive usage (Maternal health)	NA	Considerations for desired family size Perceive self-efficacy for communicating with a family planning provider, Spousal communication about family size	The intervention was efficacious in improving relevant ideational and behavioral outcomes.
Brinkel et al.2017	*Assessment of mHealth Projects*	To investigate and determine the factors that enhanced or constituted barriers to the acceptance	Qualitative	Mobile phone (*Assess disease symptoms and provide health education*)	Care for the sick children	NA	Adherence to IVR system System Usability Score (SUS)	Majority of participants (n = 33; 89.2%) followed the system's recommendations. Participants rated the IVR system with a

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings
		of an mHealth system which was piloted in Asante-Akim North District of Ghana to support healthcare of children						medium acceptability SUS score of 79.3 (SD 7.4) indicating a good usability.
Downs et al.2019	*Assessment of mHealth Projects*	To design an mHealth voice messaging intervention delivered to mothers and fathers targeting IYCF practices and examine its implementation and impact in	Quantitative	Mobile phone (*one way SMS*)	Infant and young child feeding behaviors	NA	Minimum dietary diversity Minimum acceptable diet scores.	There was a significant increase in the number of children that consumed various kinds of food fish (60% vs. 94%; p = .008) as measured by the 24-hr recall after the completion

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings
		households with children 6–23 months in three rural villages in Senegal						of the intervention.
Fatoye et al. 2020	*Assessment of mHealth Projects*	The study sought to evaluate the clinical and cost-effectiveness of tele-rehabilitation compared with a clinic-based intervention for people with NCLBP in Nigeria	Quantitative	Mobile phone (*program software + telemonitored through enhanced caregiver support)*	Management of chronic low back pain	Cost comparative analysis	Movement Standing Lying positions	The changes of health outcomes from baseline to week 4 and week 8 have shown a significant difference ($P<.001$) within the CBMT and TBMT groups
Friedman et al.2015	*Assessment of mHealth Projects*	The objective is to assess the	Quantitative	Mobile phone (*One way SMS)*	Management of childhood diarrhea	NA	Self-reported practices (provider survey) actual	There are discrepancies between recommendations made

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings
		findings from an experiment that seeks to encourage licensed chemical sellers (LCS) in Ghana to recommend ORS and zinc for the managemen t of childhood diarrhea					Recommendati ons (mystery client)	and actual action taken by the members of the control group. For example, 88.6% of recommende d ORS, only 78.5% actually provided it to the mystery client. 9.7% of LCS in the control group recommende d anti-microbials but 47.8% provided it to a mystery client.
LeFevre et al.2017	*Assessment of mHealth Projects*		Quantitati ve	Mobile phone (*automated reminders and alerts*)	Utilisation of MNCH services		Rates of active listening amongst message recipients	25% or less of expected messages were received by

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings
								pregnant women, despite the majority (>77%) owning a private mobile phone. Over 80% of messages received by pregnant women were listened to. Postpartum rates of listening declined over time.
Modrek et al. 2014	*Assessment of mHealth Projects*	The objective of the REMEDI study was to evaluate the	Quantitative	Mobile phone (*One way SMS)*	Treatment of malaria	NA	Adherence to RDT	Adherence to RDT results was 14.3 percentage points (P-val <0.001) higher in the treatment

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings
		acceptability of RDTs among people seeking malaria drugs from private sector drug retailers						group who were sent the SMS.
Mohammed et al.2019	*Assessment of mHealth Projects*	The aim of this study was to assess the effect of a theory-driven mHealth intervention on the prevalence of malaria among children under-five living in rural	Quantitative	Mobile phone *Automatically deliver a one-way voice SMS*	Malaria prevention	NA	Reduction in malaria prevalence, perceived severity, perceived susceptibility, self-efficacy	A higher reduction in the prevalence of malaria among children under-five in the intervention group compared with the control group at end line. The overall impact of the intervention

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings
		districts of Ghana						revealed a statistically significant reduction of malaria prevalence (DiD: −0.154; p = 0.043) among children whose caregivers received the intervention
Nelissen et al. 2018	*Assessment of mHealth Projects*	The objective here is to: 1) assess patient retention in the pilot program and reasons for dropping-out, 2) changes in blood	Mixed method	Mobile phone *Record routine patient data*	Enhancement of medical care	NA	Retention in care Medication adherence Quality of care	Overall among patients with mHealth activity the median duration of activity was 3.3months (IQR: 2.2–5.4) and a median of five pharmacy visits (IQR:

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings
		pressure during the pilot program and determinants for blood pressure on target or improvement, and 3) the quality of and satisfaction with pharmacy-based care including mHealth						3–6) was recorded by the pharmacy staff.
Olajubu et al.2020	*Assessment of mHealth Projects*	This study aimed to evaluate the effect of a mobile health intervention on PNC attendance	Quantitative	Mobile phone (*One way SMS)*	antenatal care (ANC)	NA	The rate of utilisation of postnatal care services. The total number of PNC visits utilised.	About one-third (30.9%) of respondents in the intervention group had four postnatal care visits

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings
		among mothers in selected primary healthcare facilities in Osun State, Nigeria						while only 3.7% in the control group had four visits ($p < 0.001$)
Raifman et al.2014	*Assessment of mHealth Projects*	The aim of this study was to assess the impact of text message reminders on adherence to ACT regimens.	Quantitative	*Mobile phone* *(automated reminders and alerts)*	Treatment of malaria	NA	Adherence to the prescribed treatment Impact of text reminders on self-reported treatment completion.	Among individuals in the control group, 61.5% took the full course of treatment. The simple text message reminders increased the odds of adherence (adjusted OR 1.45, 95% CI [1.03 to 2.04], p-value 0.028). Receiving an additional message did

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings
								not result in a significant change in adherence
Rokicki and Fink, 2017	*Assessment of mHealth Projects*	The study aimed to assess the degree to which mHealth programs reach target adolescent subpopulations who may be at higher risk of poor SRH outcomes	Quantitative	*Mobile phone* *(Two-way Instruction/Education SMS)*	Reproductive health	NA	Reproductive health knowledge, Self-reported pregnancy	Higher levels of engagement were associated with higher knowledge scores both at 3 (linear slope estimate 0.11, 95%CI 0.08 to 0.14) and at 15 months (linear slope estimate 0.07, 95%CI 0.02 to 0.13). The mHealth program was effective at significantly increasing knowledge

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings
								for every subgroup.
Velez et al. 2014	*Assessment of mHealth Projects*	This study sought to present midwives working in rural Ghana with an mHealth application known as mClinic and asked them to evaluate its usability and applicability in their practice	Qualitative	Collect form-based data and transmit to an EHR *mClinic*	Improving Primary health services	NA	Identifying usability issues Applicability Checks	Identified usability problems related to 4 of 8 usability categories. Support the applicability of mClinic to midwives' work and identified the need for additional functionality.
Ebenso et al., 2018	*Assessment of mHealth Projects*	To evaluate the impact of eHealth tools on health system functions	Quantitative	Clinical Patient Administration Kit (CliniPAK)	Enable health administrators increase productivity and improve patient	NA	Reduce maternal and child morbidity and mortality. Adoption of the eHealth tool	The application of CliniPak shows the effectiveness of eHealth approaches

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings
		and health outcomes.			clinical experience.			for improving quality and efficiency of health systems functions and client outcomes.
Zakus et al.2019	*Assessment of mHealth Projects*	The primary research question focused on whether the use of a specially equipped smartphone (or mHealth intervention) could make a difference in the diagnosis and treatment	Quantitative	Smartphones *an application to support quality case management and provide good timely clinical data.*	Diagnose and treat diarrhea, malaria and pneumonia	NA	Quality of care provided by RCom, RCom motivation and retention.	The QoC per RCom was significantly higher for the intervention group than the control group (P=0.009) indicating that use of the smart phone and mHealth application improved QoC, and this was attributable

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings
		by RCom of malaria, pneumonia and diarrhea in children aged 2 to 59 months.						to better assessment.
Bowser et al. 2018	Cost Effectiveness Ratios	This study sought to address this gap in the literature by examining the cost effectiveness of an mHealth intervention in two regions of Nigeria	Quantitative	mHealth applications	ANC interventions with minimal demand-side interventions linking women to facility births	Cost Ratio Analysis	Disability Adjusted Life Years Cost Effectiveness Ratios	The cost-effectiveness ratio of this program for antenatal care and no demand-side generation for facility delivery is US$13,739 per life saved as compared US$9,806 per life saved when implementing a mobile health program for antenatal care

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings
Adewuya et al., 2019		To evaluate the effectiveness and acceptability of adding mHealth to a Collaborative Stepped Care intervention for primary care management of depression.	RCT	Mobile Device	Primary care management of depression.	Cost comparative analysis	Cost Effectiveness Ratios	Cost comparative analysis find that for every $1 spent on mCSC, $1.50 or more may be saved in the long-run through fewer healthcare costs,
Kawakatsu et al 2020	Incremental cost-effectiveness analysis	The objective is to confirm whether mHealth largely contribute to increasing the coverages	Quantitative	Mobile Device	SMS text reminders in clients' return visits to the health facilities for child vaccinations	Start-up and Recurring Cost Assessment	Incremental cost-effectiveness analysis	Return rates for child vaccinations in the intervention group were significantly higher ($p < 0.001$) by 4.8%-6.0% than those in

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings
		of key maternal and child health services or not						the control groups, consistently across all the five different timings.
Nsiah-Boateng et al.2017	Not reported	This paper assesses claims adjustment rate of the paper- and electronic-based claims reviews of the National Health Insurance Scheme (NHIS) in Ghana.	Quantitative	NA	electronic-based claims reviews of the NHIA	Comparative Cost Assessment	Difference in cost adjustment rate between the paper and electronic-based reviews	The electronic-based review made overall adjustment of 17.0% from GHS10.09 million (USD2.64 m) claims cost whilst the paper-based review adjusted 4.9% from a total of GHS57.50 million (USD15.09 m) claims cost received, and the difference

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings
								was significant ($p < 0.001$).
Willcox 2018	incremental costs and effects	This study aims to forecast the incremental cost-effectiveness of the Mobile Technology for Community Health (MOTECH) initiative at scale across 170 districts in Ghana	Quantitative	NA	ANC interventions with minimal demand-side interventions linking women to facility births	Comparative Cost Analysis	Cumulative lives saved over the 10-year analytic time horizon Disability Adjusted Life Year	Estimated 59,906 lives at total cost of $32 million. The incremental cost per Disability Adjusted Life Year averted ranged from $174 in year 1 to $6.54 in the 10th year of implementation, and $20.94 (95% CI: $20.34-$21.55) over 10 years.
Fadekem et al. 2012	NA	To examine adolescent girls and	Quantitative	NA	NA	NA	Access and use of mobile phones	High mobile phone access but limited

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings
		young women's access to and use of mobile phones, as well as the perceived and actual barriers and limitations to using their mobile phones to seek SRH information and services.					Perceived and Actual limitations to utilisation mHealth in	use of phones to access SRH information and services. Barriers to use of these services include cost of service for young women clients, request for socio-demographic information that could break anonymity, poor marketing and publicity, socio-cultural beliefs and expectations of young girls, individual

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings
								personality and beliefs, as well as infrastructural/network quality
LeFevre et al.2017		To assess the acceptability of an mHealth intervention among PLHIV in three countries of West Africa.	Quantitative	NA	NA	NA	Overall rate of mHealth acceptability	The overall rate of mHealth acceptability was 98.8% with no variation by country. Financial acceptability was 50.1% (n=322), 88.7% (n=212), and 92.8% (n=231) of PLHIV in Côte d'Ivoire, Togo, and Burkina Faso, respectively

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings
Mbuagbaw et al.2014	NA	To investigate acceptability and readiness for ownership of a text message program among a community of clients living with human immunodeficiency virus (HIV) in Yaoundé, Cameroon and to develop a framework for implementation.	Mixed method	NA	NA	NA	Acceptability and readiness for ownership of a text message program	Both qualitative and quantitative strands showed high levels of acceptability and readiness despite low rates of participation in other community-led projects.
Ngozi, Ogochukwu and Allen, 2015	NA	To explore the extent to which	Quantitative	NA	NA	NA	The use of e-health resources	60% of Nigerian undergraduat

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings
		undergraduate students are exposed and utilised e-health resources.					Dependence on e-health resources	e students rely on e-health to take proactive health actions.
Peprah et al.2019	NA	To provides a snapshot and baseline evidence on knowledge, attitude and use of mHealth among university students in Ghana	Quantitative	NA	NA	NA	non-use or use of mHealth technology	Results revealed statistically significant difference between genders in awareness of use of mobile phones for accessing healthcare information (53.8% vs. 46.2%; $p < 0.011$). 74% of the respondents used mHealth at irregular intervals

Author(s)	Category	Objective of the study	Research methods	Type of mHealth/ Features of app	Type of Intervention	Type of Cost Assessment	Outcome variables	Findings

Appendix 4: Quality appraisal results for the twenty studies appraised with CASP

Study	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10	Score
Babalola et al.2019	Yes	Yes	Yes	Yes	?	No	Yes	Yes	Yes	Yes	17/20
Brinkel et al.2017	Yes	Yes	Yes	Yes	Yes	?	Yes	Yes	Yes	Yes	18/20
Downs et al.2019	Yes	Yes	Yes	Yes	Yes	No	Yes	?	Yes	Yes	17/20
Fadekem et al. 2012	Yes	Yes	Yes	Yes	Yes	No	?	?	Yes	Yes	16/20
Fatoye et al. 2020	Yes	Yes	Yes	Yes	Yes	No	Yes	?	?	Yes	16/20
Friedman et al.2015	Yes	Yes	Yes	Yes	Yes	No	Yes	?	Yes	Yes	17/20
LeFevre et al.2017	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	20/20
Lepère et al.2019	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	18/20
Mbuagbaw et al.2014	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	18/20
Modrek et al. 2014	Yes	Yes	Yes	Yes	Yes	?	Yes	Yes	Yes	Yes	19/20
Mohammed et al.2019	Yes	Yes	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	18/20
Nelissen et al. 2018	Yes	Yes	?	Yes	Yes	No	Yes	Yes	Yes	Yes	17/20
Ngozi, Ogochukwu and Allen, 2015	Yes	Yes	Yes	Yes	?	No	Yes	Yes	?	Yes	16/20
Olajubu et al.2020	Yes	Yes	Yes	Yes	?	?	Yes	No	No	?	13/20
Peprah et al.2019	Yes	Yes	Yes	Yes	Yes	?	Yes	?	Yes	Yes	18/20
Raifman et al.2014	Yes	Yes	?	Yes	Yes	?	Yes	Yes	?	?	16/20
Rokicki and Fink, 2017	Yes	Yes	Yes	Yes	Yes	?	Yes	Yes	Yes	Yes	19/20
Velez et al. 2014	Yes	Yes	Yes	Yes	Yes	No	No	Yes	?	Yes	15/20
Ebenso et al., 2018	Yes	Yes	Yes	Yes	Yes	No	No	Yes	?	?	14/20
Zakus et al.2019	Yes	Yes	Yes	Yes	Yes	No	No	Yes	Yes	Yes	15/20

CASP questions scoring: Yes =2 Can't Tell (?) = 1 No = 0

Appendix 5: List of clinical outcomes

Author(s)	Outcome Variables
Babalola et al. 2019	Considerations for desired family size Perceive self-efficacy for communicating with a family planning provider Spousal communication about family size
Brinkel et al.2017	Adherence to IVR system System Usability Score (SUS)
Downs et al.2019	Minimum dietary diversity Minimum acceptable diet scores
Fatoye et al. 2020	Movement Standing Lying positions
Friedman et al.2015	Self-reported practices (provider survey) actual Recommendations (mystery client
LeFevre et al.2017	Rates of active listening amongst message recipients
Modrek et al. 2014	Adherence to RDT
Mohammed et al.2019	Reduction in malaria prevalence perceived severity, perceived susceptibility, self-efficacy
Nelissen et al. 2018	Retention in care Medication adherence Quality of care
Olajubu et al.2020	The rate of utilisation of postnatal care services The total number of PNC visits utilised
Raifman et al.2014	Adherence to the prescribed treatment Impact of text reminders on self-reported treatment completion.
Rokicki and Fink, 2017	Reproductive health knowledge Self-reported pregnancy
Velez et al. 2014	Identifying usability issues Applicability Checks
Ebenso et al., 2018	Reduce maternal and child morbidity and mortality. Adoption of the eHealth tool
Zakus et al.2019	Quality of care provided by RCom RCom motivation and retention
Bowser et al. 2018	Disability Adjusted Life Years Cost Effectiveness Ratios
Adewuya et al., 2019	Cost Effectiveness Ratios
Kawakatsu et al. 2020	Incremental cost-effectiveness ratio
Nsiah-Boateng et al.2017	Difference in cost adjustment rate between the paper and electronic-based reviews
Willcox 2018	Cumulative lives saved over the 10-year analytic time horizon Disability Adjusted Life Year

Fadekem et al. 2012	Access and use of mobile phones Perceived and Actual limitations to utilisation of mHealth
LeFevre et al.2017	Overall rate of mHealth acceptability
Mbuagbaw et al.2014	Acceptability and readiness for ownership of a text message program
Ngozi, Ogochukwu and Allen, 2015	The use of e-health resources Dependence on e-health resources
Peprah et al.2019	non-use or use of mHealth technology