AN EVALUATION OF COMMUNITY HEALTH CARE SERVICE IN GHANA; A CASE OF THE COMMUNITY-BASED HEALTH AND PLANNING SERVICE (CHPS) COMPOUNDS IN GHANA

BY

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Abstract

Background: Ghana implemented the Community-based Health Planning Services (CHPS) as a primary healthcare initiative designed to provide essential health services to underserved rural communities in Ghana. To date there is paucity of evidence on the effectiveness of the CHPS initiative in Ghana. In addition to the limited evidence on the initiative's effectiveness, there is also limited understanding on the determinants of the positioning of the CHPS compounds in Ghana. Such knowledge is critical to inform the initiative's continuous operation and improvement. The general aim of the study is to evaluate the effectiveness and implementation of primary health service centres in Ghana, to inform policy making and enhance health service delivery through optimised location, positioning, and operational efficiency, along the CHPS Zones.

Methods: A review of 39 studies identified knowledge gaps on CHPS's effectiveness and influencing factors. An Interrupted Time Series Analysis (ITSA) assessed CHPS effectiveness using metrics such as Family Planning (FP) visits, Antenatal Care (ANC) visits, Maternal Deliveries, and Outpatient Department (OPD) attendance. Secondary data from the Ghana Health Service supported these analyses. Three Logistic Regression models examined factors determining CHPS positioning, and a Generalized Linear Model assessed disease outbreak distances relative to CHPS facilities across 216 districts. Additionally, a Discrete Event Simulation modelled CHPS operations to suggest service delivery improvements.

Results: The ITSA indicated significant improvements in maternal and child health outcomes, particularly maternal deliveries and ANC visits, since 2016. However, OPD visit effectiveness requires further strengthening. Analysis showed that out of 117 districts, 68 had at least one CHPS facility within 8 km, but 83 did not meet the mandated threshold. Districts with no CHPS facilities were 12% more likely to be closer to disease outbreaks. Districts with 6-11 CHPS facilities were farther from disease outbreaks, while those with over 11 facilities were closer to outbreaks. Simulation results revealed lengthy wait times as a major challenge, suggesting an increase in staff and assessment rooms to boost efficiency.

Conclusions: The study revealed that districts with CHPS facilities were more distanced from disease hotspots compared to those without such facilities, underscoring the pivotal role of primary healthcare in disease prevention and control. Additionally, the simulation of CHPS operations highlighted significant issues related to lengthy wait times, which can adversely affect healthcare demand and utilization. The findings advocate for interventions to streamline patient flow and improve service delivery efficiency, emphasizing the importance of staff training and flexible staffing schedules. The implications for policy are many-fold. Firstly, there is a clear need for a strategic and equitable expansion of CHPS facilities across Ghana, prioritizing underserved, and remote districts. Policymakers should consider a strategic increase in the number of CHPS facilities to ensure they are adequately staffed, equipped, and integrated into the community's already existing healthcare system. Moreover, continuous monitoring and assessment of these facilities are essential to maintain their effectiveness and adapt to evolving healthcare needs.

Declarations

I, Prince Edward Nii Amarkai Okine, 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 for which it is now submitted.

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Glossary

CHPS – Community -Based Health Planning and Services

GHS – Ghana Health Service

MOH – Ghana Ministry of Health

WHO - World Health Organization

GSS – Ghana Statistical Service

NHIS – National Health Insurance Scheme

PHC – Primary Health Care/Centre

CHS – Community Health Services

LMICs – Low- and Middle-Income Countries

UN – United Nations

CHC – Community Health Centre

JICA - Japan International Cooperation Agency

ITSA – Interrupted Time Series Analysis

Chapter 1

1.1 Introduction

Community-based health planning and services (CHPS) is a primary healthcare initiative designed to provide essential health services to underserved rural communities in Ghana (Elsey et al., 2023). CHPS aims to promote equitable access to healthcare by strengthening community involvement in the planning, delivery, and management of health services. The CHPS program has been in operation in Ghana since its inception in 1994 (Nyonator, et al., 2005) and has been implemented in various regions of the country. The CHPS initiative is a national strategy geared towards reducing barriers to geographical access to healthcare.

The purpose of this thesis is to evaluate Community-based Health Planning and Services (CHPS) in Ghana, in improving the health status of the population and to identify areas for further research and improvement. This chapter provides a brief overview and organisation of the study, research problem, research objectives and questions, and relevance of the study.

This study is important because it will provide valuable insights into the strengths and weaknesses of the CHPS program in Ghana. The findings of the study will help policymakers and healthcare providers to identify areas for improvement and to develop strategies for strengthening the program. Moreover, the study will contribute to the body of knowledge on community-based healthcare delivery and will inform similar initiatives in other countries.

1.2 Background to the study

Ghana is one of the low-income countries in West Africa with a population of about 30 million spread in all the 16 regions (Ghana Statistical Service 2020). Though the country has an abundance of natural resources, the country's gross national income (GNI) is approximately $2500 per capita which is below average for low-income countries (WHO, 2006). Just as is the case for most countries, growth is not only dependent on wealth but also depends on social services including improvement in the healthcare delivery system (Peters et al. 2008). This suggests that human resource cannot function to its fullest in a country with an inadequate healthcare delivery system. With all these natural resources, Ghana is still challenged in the provision of functional health facilities, proper nutrition and sanitation, enforcement of laws on health and occupational hazards (MOH, 2005).

Unlike developed countries where many alternatives present themselves, developing countries like Ghana are still faced with various and multiple challenges. They therefore lag in terms of acceptability of health care facilities to areas that actually need it (Ashiagbor et al., 2020). For instance, the doctor-to-patient ratio in Ghana stands at 1:6355 patients according to the Ghana Minister of Health, a situation that has fallen short of the World Health Organisation (WHO) recommended ratio of 1:1000 patients (WHO, 2018). This has made preventable deaths resulting from poor sanitation become difficult to control (MOH, 2018).

These health hazards are more prevalent in remote areas in Ghana where geo-political and financial power predicts the likelihood for the citizenry to gain access to basic healthcare facilities. The major hurdles restraining rural population from gaining access to health facilities are the unusual distribution of health facilities. This leads to longer duration of travel, financial constraints in covering such distances as well as inadequate health personnel at the health facilities (Evans et al., 2022). This points to the inherent issue of inequality within the healthcare delivery service. To buttress this assertion, a structural review in relation to healthcare delivery was carried out by Durrani (2016). In his findings, he unveiled that generally, individuals that are healthy and financially sound, have a lower mortality rate when compared to their similar status individuals in the past 30 years. The study further indicated that the child mortality rate also reduced from 12.7 million to 6.3 million. However, these rates are still high in most Asian and African countries. During the 30-year period, the world population nearly doubled (4.8 billion in 1985 to 7.2 billion in 2015) with a majority of the population from developing countries (3.6 billion to 5.33 billion) suggesting that, by the year 2035, the world will be short of approximately 12.9 million healthcare providers (WHO, 2020). These findings are however based on a structural review that includes grey studies that need to be further peer reviewed to validate the numerical conclusions. However, the included peer reviewed studies confirm the general trends of the stated findings.

In the next 30 years, there is a high likelihood of a high increase in population growth in urban cities of developing countries like Ghana which will contribute significantly to the global population growth (Seto et al. 2012). From Durrani (2016), the deficit in health investment in developing countries will make urban areas the focal points for future health catastrophes. This means it is expected most of future investments in health to focus in urban areas, which raises questions about the future of health facilities and access to health to residents of rural areas. The weak healthcare delivery system, unequal distribution of healthcare facilities in developing countries will continue to exacerbate the health hazards in these areas (WHO, 2017).

One of the core aims of the introduction of the Community-based health planning and Services (CHPS) is to achieve equal distribution of healthcare facilities irrespective of geographical location to minimise some of these negative health outcomes. The study thus seeks to emphasise the spatial distribution of the CHPS zones/compounds in Ghana as a case study.

1.3 Rationale of the study

The evolution of Ghana's Community-based Health Planning and Services (CHPS) over the last 30 years presents a laudable narrative of healthcare transformation. Originating as a trial in Navrongo in the 1990s, CHPS's integration into the national health policy in 1999 was a key moment in the health history of Ghana. This study seeks to unravel the complex layers of this evolution, exploring its impact on healthcare delivery and policy in Ghana (Adongo et al., 2014; Nyonator et al., 2005).

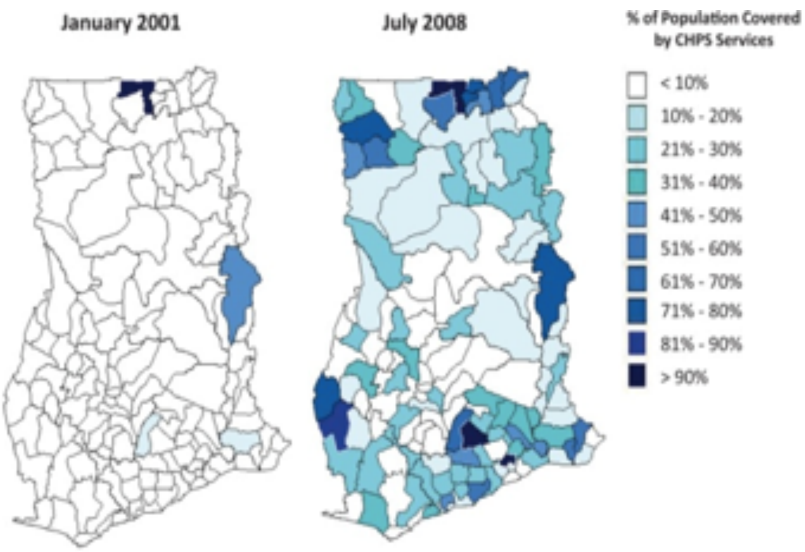
Equally praiseworthy is Ghana's journey towards universal health coverage, especially with the introduction of the National Health Insurance Scheme (NHIS) in 2005. This research aims to illuminate how these policy initiatives have intersected with CHPS to enhance healthcare accessibility and equity, providing valuable insights for policymakers.

The implementation of NHIS saw a rise in demand for health services as studied in a systematic review by Aduo-Adjei et al (2016) where they found that both in-patient and outpatient services have seen a rise with the introduction of the NHIS. However, the study does not indicate if there are spatial differences in the rise in demand particularly arising from the proximity or access to healthcare facilities. Therefore, though their study reports an association between the increase in demand for health services and reduction in maternal mortality, this study will explain how the distribution of CHPS compounds impacts the differences in demand for maternal health services.

Similarly, Elsey et al (2023) concluded that the CHPS initiative has been effective in reducing under-5 mortality particularly for the rural poor. From their systematic review of 58 studies, they found that the presence of a CHPS zone in addition to a health facility resulted in increased odds of skilled birth attendant care by 56%. However, there is an overwhelming geographical concentration of the majority of the studies reviewed in the Upper East Region. This research will be particularly significant for policymakers, as it will offer evidence-based insights into the CHPS initiative over a broader geographical spread. This study's findings will thus be more robust and generalizable.

The CHPS+ initiative, launched in 2017, was aimed at revitalising the CHPS's goal of community-level health care. This study will critically analyse CHPS+ in the context of the challenges faced by CHPS that necessitated CHPS+. Bassoumah et al (2021) used in-depth interviews of community health officers, volunteers and women receiving post-natal care to assess such challenges in Yendi, covering four CHPS zones. They surmise that poor road networks and a lack of transportation among other things are the key challenges to the effectiveness of CHPS compounds. Kaburu et al (2023) also find that disputes over the location of CHPS facilities between competing communities also impacts effectiveness from their study of the Jirapa municipality. This makes the inquiry into the spatial distribution of the CHPS compounds, one of the main focuses of this study, very important for policy makers if they are to draft policies that make healthcare more accessible and scalable. Such insights are crucial in contexts like Ghana, where geographical accessibility is a significant determinant of healthcare service utilisation (Delamater et al., 2012; Gao et al., 2021).

In sub-Saharan Africa, where health outcomes are often suboptimal, the equitable distribution of healthcare facilities is vital. This study, using Ghana's CHPS initiative as a case study, aims to offer insights that could improve healthcare delivery. By exploring CHPS's objectives and strategies, this research will contribute to enhancing healthcare systems in Ghana and similar settings, significantly impacting the lives of communities. (Nyonator et al., 2005; Ghana Health Service, 2018).



Reference: (Awoonor-William, et al., 2016)

The study's exploration of community health services, as highlighted by Howard et al., (2017), aligns with the WHO's emphasis on expanding pre-hospital care in LMICs. Investigating how

CHPS, in the face of resource limitations and emerging health threats, can improve health outcomes has profound social implications. It can lead to strategies that enhance access to healthcare for the most vulnerable, thereby improving overall community health and well-being (World Health Organization, 2005; Jewkes, 2004).

1.4 Research Aim and Objectives

The general aim of the study is to evaluate the effectiveness and implementation of primary health service centres in Ghana, to inform policy making and enhance health service delivery through optimised location, positioning, and operational efficiency, along the CHPS Zones.

The specific objectives of the study are as follows:

1. To identify the determinants and key drivers associated with CHPS facilities location and positioning by the Ghana Health Service to achieve maximal outcomes.
2. To analyse the effectiveness of the implementation strategies of the CHPS initiative on Health Service delivery in the Ghanaian setting.
3. To determine the level of operational effectiveness of CHPS compounds using the core mandates of CHPS facilities in Ghana as a measurement variable.
4. To determine how to improve the operational efficiency of CHPS compounds to line with their core mandates.

The study is attempting to measure the overall effectiveness of the plan to use CHPS compounds to bridge the health delivery gaps that currently exist within Ghana (Ghana Health Service, 2000). To do this, the study first assesses the key determinants of the positioning of these CHPS compounds as distance to healthcare centres is one of the main determinants of healthcare access for underserved populations, the main target demographic of CHPS compounds (Awoonor-Williams et al., 2016: Peters et al., 2008). This leads the study to its second objective to assess the efficacy of the various strategies adopted to ensure productive operation of CHPS compounds (Adjei et al., 2008). At the inception of the CHPS initiative, certain benchmarks related to operational effectiveness were set (Ghana Ministry of Health, 2013). These benchmarks are periodically evaluated and reset to maintain its relevance to the needs of the target demography (Ghana Health Service, 2014). The study consequently aims to determine the levels of operational effectiveness CHPS facilities are operating at. Finally, the assessment of operational efficiency leads to the final objective of the study, which is aimed at providing suggestions on how CHPS compounds can improve their overall efficiency to meet their set targets and mandates (Asante et al., 2017).

1.5 Research Questions and Research Contribution

1. What are the determinants and key drivers with CHPS facilities location and positioning by the Ghana Health Service to achieve maximal outcomes?
2. How effective are the implementation strategies of the CHPS initiative on Health Service delivery in the Ghanaian setting?
3. What is the level of operational effectiveness of CHPS compounds if the core mandates of CHPS facilities in Ghana are used as a measurement variable?
4. How can the operational efficiency of CHPS compounds be improved to line up with their core mandates?

With the current distribution of healthcare facilities in Ghana, proximity to disease hotspots of CHPS facilities is a crucial determinant of health outcomes and a sign of the well-being of the healthcare system as a whole (Ghana Health Service, 2014). The study analyses and contributes valuable insights to this distribution based on GIS data from the Ghana Health Service to underscore how vital primary care access is to the entire health care system (Awoonor-Williams et al., 2016). The Ghana Health Service mandates an 8-kilometer radius as the catchment area for functioning CHPS compounds and the communities they serve (Ghana Health Service, 2014). However, due to resource constraints, strict adherence to this policy guideline remains moderate. This is compounded by other issues of access such as the income and total surface area of the communities allocated a CHPS compound (Adjei et al., 2008). The study uses key proxy measures such as antenatal visits and maternal deliveries recorded at CHPS compounds to determine how effective the distribution of CHPS compounds have been to improving child and maternal health outcomes; two of the most important variables related to the establishment of the CHPS initiative (Awoonor-Williams et al., 2016).

Within the existing CHPS compounds, allocation of resources in a timely and efficient manner remains central to the success or otherwise of the CHPS initiative. The study aims to investigate how patient wait times at CHPS facilities and staff allocation influence each other in the health delivery process. The findings of the discrete event simulation analysis conducted on the selected CHPS facilities will contribute to the discussion on proximity being a vital factor in healthcare access. This is based on the assumption that patients who are sensitive to distance in their evaluation of attending a CHPS facility or not will be sensitive to wait times (Jun, Jacobson & Swisher, 1999). The study leverages on the findings of the analysis to provide suggestions on how to improve operational efficiency at CHPS facilities in the areas of facility layout, staff allocation and technology adoption.

1.6 Research Methods

The literature that serves as the foundation for the study was thoroughly searched for using a scoping review (Arksey & O'Malley, 2005). Prior to the scoping review, a pilot review was conducted to identify if the related papers for the study are available in the databases used. The pilot review identified Scopus, Web of Science and PubMed as the most relevant databases to be used for the subsequent scoping review. Keywords that are relevant for searching for studies related to the effectiveness of health facilities are then utilized in the scoping review to retrieve the appropriate literature. The selected studies are appraised with the Agency for Healthcare Research and Quality (AHRQ) checklist and the Methodological Index for Non-Randomized Studies (MINORS) checklist for the observational studies and interventional-based non-randomised control trials, respectively (Slim et al.,2003). The data collected on the attendants as well as attendance at the CHPS facilities were analysed for their statistical characteristics including various measures of central tendency. Regression and Difference-in-Differences (DiD) approaches were used to investigate the effect of the CHPS intervention on the outcomes of interest; OPD attendance, antenatal attendance and maternal visits (Angrist & Pischke, 2009). The DiD approach used matched samples to make a better evaluation of causality in terms of analysing if CHPS intervention caused the effects calculated with the regression. Randomized Control Trials are ruled out as a choice of analytical tool because of the impracticality of doing so for health-based studies using real patients. Thus, the study largely depends on a quasi-experimental design (Shadish, Cook & Campbell, 2002).

Generalized Linear Models are then fitted on the data due in order to accommodate the skewed nature of the dependent variable data (McCullagh & Nelder, 1989). The linear model is used to calculate the key determinants of disease outbreak distance from the districts with CHPS compounds. The paper then uses Discrete Event Simulator (DES) to model patient visits to a typical Primary Health Care facility to evaluate patient wait times using data gathered on time estimates of the patient care processes at the facilities. This simulation of patient flows offers clues into how to improve processes at CHPS compounds to improve their efficiency.

1.7 Roadmap of Thesis

To achieve the research aim, the following roadmap is adopted:

1. **Identifying Literature Gaps (Chapter 2);**
    - A systematic review was conducted to identify gaps in existing research on CHPS effectiveness, facility placement and operational challenges.
    - Provides a foundation for formulating research questions and objectives.

2. **Methodological Framework (Chapter 3):**
    - The research approach and methodological choices are defined
    - The use of time series analysis, GIS based facility mapping and simulation modelling is justified.

3. **Effectiveness of CHPS (Chapter 4):**
    - An Interrupted Time Series (ITS) analysis is utilised to assess the impact of CHPS interventions on healthcare accessibility and service delivery.
    - Measurements of key performance indicators, such as maternal deliveries, OPD visits and family planning uptake.

4. **Determinants of CHPS Facility Placement (Chapter 5):**
    - The Chapter uses GIS and logistic regression models to evaluate factors influencing the geographical distribution of CHPS facilities.
    - The chapter also examines socioeconomic, demographic and political determinants.

5. **Determinants of CHPS Facility Placement (Chapter 6):**
    - This chapter analyzes the relationship between CHPS facility locations and disease outbreak flashpoints.
    - The chapter also utilizes spatial analysis techniques to assess how CHPS facilities contribute to disease prevention.

6. **Operational Challenges – Patient Waiting Times (Chapter 7):**
    - A simulation model was employed to evaluate patient flow and waiting times in CHPS facilities.
    - The chapter also suggest strategies for optimizing resource allocation and service efficiency.

7. **Discussion and Policy Implications (Chapter 8):**
    - This chapter synthesizes findings from previous chapters.
    - Proposes policy recommendations for optimizing CHPS implementation.
    - It highlights the main contribution of the study to health policy and planning.

1.8 Structure of Thesis

The thesis starts with an introductory chapter. Here, the groundwork is laid, revealing the significance, purpose, and broader context of community health care services in Ghana, with a specific spotlight on the CHPS (Community-based Health Planning and Services) compounds. Moving on to the second chapter, there's a thorough dissection of existing literature on community healthcare facilities. This part crucially bridges historical perspectives with contemporary realities, particularly emphasizing the dynamics in developing countries like Ghana. It sets the stage for a deeper understanding of the evolution, state, and impacts of these community healthcare facilities.

The third chapter introduces a robust framework for empirical analysis. This is where the thesis begins to meld theory with practice, outlining the models and methodologies that underpin the study. It's a critical segment that shapes how data is interpreted, and findings are extracted, specifically in the realm of CHPS facilities.

In the fourth chapter, the focus shifts to understanding the strategic positioning of CHPS facilities. It's an exploration into how these facilities align—or sometimes, misalign—with national and international healthcare guidelines. The determinants guiding these decisions are scrutinized, offering insights into the planning and execution phases of health service delivery.

Chapter five takes a geographic and socio-economic lens to disease occurrence in relation to CHPS facilities. It's an analytical dive into how the location and surrounding factors of these facilities influence health outcomes in communities.

The methodology, detailed in the sixth chapter, is the backbone of the research. It transparently outlines how the study was conducted, detailing the data collection methods and analytical techniques. This chapter is foundational in ensuring that the research is grounded in robust empirical methods.

Patient waiting times and the logistics of patient movement within CHPS compounds are the focal points of chapter seven. This analysis is pivotal in understanding the operational efficiency of these facilities and their impact on patient experience.

Chapter 2: Literature Review

2.1 Introduction

Chapter 1 provided the rationale for this thesis and presented its aims and objectives. This chapter conducted an in-depth, systematic review of the literature on community healthcare facilities to understand what (and how) has been done with a view to addressing the following questions:

- What is the evidence on the effectiveness of community healthcare facilities?
- What are the factors affecting the effectiveness of community healthcare facilities?
- Which methods have been used in the literature to assess community healthcare facilities?

In Ghana, CHPS facilities provide frontline care for the majority of the rural poor, supplying them with essential preventive care as well as some curative care (Bassoumah et al., 2021). The scale of coverage and the value the CHPS initiative provides in serving the most vulnerable populations within Ghana necessitates a better understanding of the underlying factors affecting its successes and failures. The rationale for using a systematic review approach in this chapter to understand what is known and what gaps exist in the current literature was informed by the study's design rigour and lower probability of bias compared to the other designs. It was also informed by the paucity of evidence synthesis on the effectiveness of community healthcare facilities in the current literature (Katikireddi et al., 2014). For example, the existing literature is inundated with several primary research/studies on the effectiveness of community healthcare facilities (Smith et al., 2016). However, while helpful, these primary studies present fragmented evidence, which limits appreciating the critical knowledge needs in the research area and establishing the validity of the existing evidence to inform the best interventions or policy (Moja et al., 2005). Relying on the fragmented evidence to provide research direction for this thesis could, therefore, imply producing redundant evidence with no meaningful conclusion (Snyder, 2019). These reasons justified the systematic review approach in this chapter to allow integration of available evidence to address not only the scarcity in the literature on synthesised evidence on the effectiveness of community health facilities but, most importantly, to provide research direction for this study to ensure incremental understanding of the research area.

Arguably, a scoping review approach could have also sufficed in this context; however, unlike systematic reviews, scoping reviews do not incorporate screening the quality of the available evidence (Munn et al., 2018). The lack of screening could result in the inclusion of poor-quality evidence, which could inadvertently limit the quality of the synthesised evidence (Kane et al., 2016), justifying the choice of the systematic review approach over the scoping review approach.

The literature review will be presented in the following order: Methods of the literature review, followed by the results of the literature review, discussions of the findings of the literature review, the gaps identified from the literature review, the strengths, and limitations of the literature review, then finally the conclusion.

2.2 Methods

This section provides an overview of the search strategy, the process for selecting, reviewing, and data extraction of the relevant papers. The systematic review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines (Moher et al. 2009).

2.3 Literature Search Strategy

The search strategy in this study was informed by a prior pilot review (Appendix 1) conducted to identify databases and keywords frequently used by systematic reviews in this research area. The rationale for the pilot review approach was to ensure a targeted search, as the frequent use of specific databases and keywords by previous reviews in this research area could suggest that the relevant/required papers for this study are more likely to be identified in these databases with these search terms. This reasoning for a pilot review approach is corroborated by other theses in the literature (Agyemang et al., 2022) and (Mansour et al., 2023). In ensuring a targeted literature search, the pilot review also saved time that could have been spent on using keywords and searching databases that could not produce the papers of interest. To corroborate this assertion, a search was conducted in a database (CINAHL) different from the ones identified in the pilot review, and the search did not yield papers relevant to this study. The pilot review was conducted in May 2020 using Scopus, the largest bibliography database for peer-reviewed journals (Team, 2018). In addition to its size, Scopus was employed for the pilot review because it also contains records from other large databases such as EMBASE and Medline (Burnham, 2006).

The pilot review identified Scopus, Web of Science, and PubMed as the databases most frequently used by previous systematic reviews in the defined research area. Although Web of Science has a much more extensive coverage of research papers going back into the middle of the 20th century, that did not provide a unique advantage over Scopus in this literature search. This is because most literature on the CHPS initiative are recent and thus captured within the timeframe of the research papers also available within Scopus. However, Scopus covers a wider journal range in terms of keyword search and citation, with approximately 20% more coverage than Web of Science (Falagas et al., 2007). PubMed is also a valuable database for biomedical electronic research, but Scopus has a wider database in terms of scope (Alryalat et al., 2019). This informed the choice of Scopus as the database of choice for the review. Google Scholar also has an equally wide database in terms of relevance for such studies but was not chosen for two main reasons. The first reason is the preponderance of grey studies on Google Scholar (Harzing & Alakangas, 2016). While grey studies can be useful for systematic reviews (Bramer, Giustini, Kramer & Anderson, 2016) but have limited utility in such studies related to effectiveness of medical centres due to the necessity to include statistical data in such evaluations. This means peer reviewed studies are preferred for this study to ensure such studies dependent on statistical analyses had been thoroughly reviewed. Additionally, Scopus uses CiteScore, which is a rating index that rates and assesses how impactful the studies being reviewed have been by providing the number of citations on each study (Elsevier, 2016). That aids in the selection of higher quality studies and justifies the usage of Scopus rather than Google Scholar for the systematic review.

In addition, it also showed that keywords like ‘community’, ‘asses’, ‘monitor’, ‘effect’ and ‘primary health care’ are commonly used search terms to identify studies evaluating the effectiveness of community healthcare facilities. These keywords were, therefore, developed into search terms using the Boolean operators’ ‘OR’ and ‘AND’ to ensure a sensitive and exhaustive literature search (Johnson & Hennessy, 2019). For example, the ‘OR’ operator widened the search’s scope by allowing the combination of words that are synonyms to the identified keywords (Elston, 2020). This widening allowed the identification of relevant papers that did not use the exact keywords from the pilot review. The 'AND' operator also helped narrow the search to the specific articles of interest (Levan, 2001). For example, it directed the search to papers that have not just done evaluation but have specifically evaluated community healthcare facilities/interventions. The identified keywords and developed search terms are illustrated in Table 1.

The term "community" is essential because CHPS compounds operate primarily at the community level. This term enables the search to capture studies emphasising the community-based approach in healthcare delivery, which is central to the assessment of CHPS compounds' effectiveness. This term helps to ensure that the studies retrieved are relevant to settings where CHPS facilities typically operate and are thus more likely to discuss elements directly related to the implementation. "Assess" and "monitor" are important terms to include because they guide the search toward studies that employ evaluation and tracking operational performance and impact. "Assess" aligns the search with studies focusing on the systematic evaluation of the types of services provided by CHPS compounds, while "monitor" captures ongoing efforts to track service delivery and health outcomes over time. The term "effect" is crucial for identifying research that discusses the outcomes and impacts of CHPS facilities. Studies using this term often focus on changes in health indicators, service usage, community health awareness and other metrics all of which are central to determining whether CHPS compounds achieve their intended health outcomes.

"Primary health care" is the main term of search because CHPS compounds are part of the primary health care framework in many countries, especially in rural and underserved areas.

Including this term ensures that the search captures studies situated within the primary health care paradigm, where CHPS compounds contribute to basic, accessible healthcare. This term helps locate research that contextualises CHPS services within broader health system goals and examines how these facilities address essential health needs in alignment with primary care objectives.

Other potential search terms, such as “rural health,” “health outcomes,” “health services,” “public health programs,” or “preventive care,” could have also been used. However, these alternatives lack the specificity and direct relevance to CHPS compounds compared to the chosen terms. For example, while “rural health” might yield some relevant studies, it does not exclusively focus on community-based facilities or CHPS compounds specifically and may encompass other unrelated rural health programs and also, some CHPS compounds exist outside of rural areas, making such studies not entirely relevant for CHPS compounds. Similarly, “health outcomes” is too broad and could capture a wide range of health impacts not necessarily tied to community healthcare facilities. “Health services” and “public health programs” may introduce studies that discuss general health initiatives without the targeted focus on community-based primary healthcare, thus diluting the relevance of the results.

Following the pilot review, a literature search was conducted from June to July 2020 to identify papers to include in this systematic review. The search terms were modified to suit the respective features of the individual databases. Search alerts were activated in the respective databases to monitor relevant articles published post-hoc to ensure current evidence generation. The identified papers from the literature search were uploaded into reference management computer software i.e., RefWorks, to facilitate the management of duplicates and ease of referencing.

Table 1: Search Terms

Keywords	Search Terms
Community Health Centre	Community OR communit* OR health OR centre OR center OR “primary health care” OR dispensary OR clinic* OR “neighbourhood health cent*” OR “community health care” OR “nurse managed cent*”
AND	
Evaluation	“Monitor*” OR “effect*” OR assess* OR efficien* OR perform* OR success*

2.4 Eligibility Criteria

The eligibility criteria approach used in this review was informed by the recommendations of Rees, (2009) to utilise a robust framework to select papers pertinent to the objectives of a review. As such, this review used the Setting, Population/Perspective, Intervention, Comparison, and Evaluation (SPICE) framework to guide the selection of eligible studies for this review (Riesenberg & Justice, 2014). SPICE is a robust tool that uses specific indicators/parameters to enhance the inclusion of studies tailored to address research questions in a systematic review (Riesenberg & Justice, 2014). Implementing the SPICE framework in this review enhanced the review’s rigour as it promoted the relevance and comparability of the selected studies and bolstered the potential for generalising the findings of this review to the target population (Green & Higgins, 2008).

The SPICE framework is not without its limitations, however. Although CHPS facilities predominantly serve rural areas, they also serve some peri-urban areas (Nwameme et al., 2018). They also serve a diversity of patients, from maternal patients to adult men. This means the CHPS initiative operates in a diversity of settings for diverse populations which inherently limits the applicability of the SPICE framework.

Another potential limitation for using the SPICE framework, like similar frameworks, in this thesis was its possibility of inadvertently excluding studies relevant to this review. Therefore, to mitigate this limitation, the review's population and intervention of interest were operationalised to encompass their broader definitions to avoid the potential risk of excluding eligible studies that could contribute to the evidence. This approach was consistent with suggestions in the literature (Tricco et al., 2018; Moher et al., 2009). In addition, the broader definitions of the parameters in the SPICE framework were complemented with the comprehensive literature search strategy, informed by the pilot review, to increase the probability of including all studies pertinent to this review. Lastly, the choice of the Scopus database which contains the EMBASE and Medline allowed for a wider range of studies that mitigate the limitations.

In practice, the SPICE framework was specified as below:

S: Setting (sub-Saharan Africa)

P: Population (The focus was on the general population in any defined community).

I: Intervention (community health facilities – defined as any community healthcare facility implemented to offer primary healthcare/clinical services to defined communities)

C: Comparison (No comparisons were considered)

E: Evaluation (studies that assessed the effect/impact/effectiveness of community healthcare facilities per defined outcomes, e.g., reduced mortality and increased healthcare accessibility)

In addition to the SPICE framework, other indicators, such as study design, were used to select studies for this review. For example, review papers, commentaries and discussion papers were excluded from this review. Additionally, studies not published in English were not considered due to logistical constraints. Grey literature was also excluded from this study to avoid including unsubstantiated evidence that could bias the generated evidence (Sailors & Hoffman, 2019). Other frameworks could have been employed, each offering unique approaches to framing research criteria. These alternatives include the PICO, PICOS, PEO, and even the PRISMA frameworks, though each has limitations compared to SPICE in the context of this study.

PICO, which stands for Population, Intervention, Comparison, and Outcome, is widely used in clinical and healthcare research, particularly for studies evaluating treatment efficacy (Richardson et al., 1995). While it is a robust framework for well-defined clinical comparisons, PICO is somewhat restrictive for community-based healthcare research such as CHPS, because this study does not involve specific intervention as the population served by CHPS compounds is broad and diverse, and as such, the interventions may encompass many comprehensive primary care activities rather than a single one. SPICE, by contrast, allows for a broader examination of Settings and Perspectives, which are essential in community healthcare research, where context heavily influences outcomes (Daly & Jones, 2013).

PICOS builds on PICO by adding Study design, which can help refine search results based on the methodological rigor of the studies included (Higgins & Green, 2011). However, SPICE's flexible structure, with an emphasis on context through Setting and Perspective, captures these varied study designs and perspectives, enabling a more inclusive literature base.

The PEO framework, which stands for Population, Exposure, and Outcome, is typically applied to qualitative research questions exploring experiences or attitudes toward a specific exposure. While PEO might have relevance when examining community health, it lacks a structured approach to comparing different community settings or interventions, which is key to assessing CHPS effectiveness across diverse contexts (Dixon-Woods et al., 2005). SPICE is better suited for studies that may need to contrast outcomes across different communities or models within CHPS.

PRISMA, or the Preferred Reporting Items for Systematic Reviews and Meta-Analyses, is not strictly a framework for defining search eligibility but rather a set of guidelines for reporting systematic reviews (Moher et al., 2009). Though useful for organising and transparently reporting systematic reviews, its main value lies in improving reporting quality after studies have been selected, rather than guiding the criteria for selecting studies.

The SPICE framework has several advantages that make it particularly suitable for evaluating CHPS compounds. Its focus on Setting allows for a tailored approach that emphasizes community-level healthcare delivery, where local contexts and environments influence healthcare accessibility and efficacy. The inclusion of Perspective enables the analysis of CHPS from the viewpoints of various stakeholders, including patients, healthcare workers, and community leaders. These elements facilitate a comprehensive understanding of CHPS effectiveness that other frameworks might overlook. Additionally, SPICE allows for comparisons across different community contexts or intervention models, an essential feature when examining a diverse range of CHPS compounds across rural and urban settings.

2.5 Data Extraction

Table 2 below depicts a set of predetermined questions used to extract relevant data from the literature-identified studies. The questions were informed by the parameters in the SPICE framework and those observed in the systematic reviews identified from the pilot review (Appendix 1). The questions are outlined under two key themes, i.e., general information and methodology, to allow easy comparisons and synthesis of similar data from the studies. According to standard data extraction checklists, like the PRISMA checklist, data extraction is best done by two reviewers to enhance the extracted data's transparency, rigour, quality, and reliability (Page et al., 2021). However, given the requirement of this thesis, the extraction was conducted by only the reviewer. However, to dimmish potential limitations associated with a single person's extracted data and to enhance the quality and reliability of the extracted data (Higgins et al.), an independent assessor (SC) reviewed the data extraction questions and assessed the extracted data from randomly selected studies (50%). The review resulted in an agreement to extract data on the evaluation types and outcomes included in the study's evaluation.

Table 2: Data Extraction Template

Headings	Review Questions
General Information	1. Authors 2. Year 3. Aim 4. Country
Methodology Used	5. What was the study design? 6. What was the study setting? 7. Was the study in a rural or urban area? 8. What type of community healthcare facility was studied? 9. How is the community healthcare facility described and operationalised? 10. Are the community healthcare facilities compared to other facilities? 11. If so, how are the comparators described? 12. What indicators/parameters were used to evaluate the effectiveness of the community healthcare facility? 13. What are the outcomes used in the study? 14. How were the outcomes measured? 15. What analytical estimators were used to assess the intervention's influence on the outcomes to estimate its effectiveness? 16. What were the findings of the study? 17. What were the author's stated limitations? 18. What were the author stated strengths? 19. What type of evaluation was performed?

The Review Questions provides a focus through which to assess each study, ensuring that the extracted data aligns closely with the specific objectives of the research (Liberati et al., 2009). This step is crucial for maintaining consistency and relevance in the information gathered. The "General Information" section includes details on authors, publication year, study aim and country, offers a foundational understanding of the study's context. This information is critical for understanding variations in healthcare outcomes based on regional and socio-political factors (Moher et al., 2009).

In the “Methodology Used” section, key methodological details are captured, including the study’s design and setting which together reveal the structure and approach of each study included, identifying whether the study was conducted in a rural or urban area provides insights into how the health facilities included in the study operate across different environments. This distinction is particularly important, as CHPS compounds often function in rural areas where healthcare access can be limited (Peters et al., 2008). By noting the type of community healthcare facility studied, the health facilities included in the retrieved studies are understood, ensuring that comparisons and conclusions remain relevant to the CHPS framework.

The template aids delving into how each community healthcare facility is described and operationalized. This is valuable because health facilities may vary in their structure and services, influenced by local needs and resources (Dixon-Woods et al., 2005). This comparative information is essential for identifying specific features of CHPS compounds that contribute to their unique impact, particularly when contrasted with other healthcare delivery models.

For evaluating CHPS effectiveness, the template focuses on the indicators and parameters used, such as health outcomes, service utilization and patient satisfaction. These parameters provide measurable evidence of how well CHPS compounds fulfil their objectives (Campbell & Graham, 2006). Similarly, the template specifies the types of outcomes used and how they were measured. This information is essential for determining whether CHPS compounds achieve desired health improvements in the communities they serve, as well as for comparing outcomes across studies to identify common patterns or variations.

The template also captures the analytical estimators or statistical tools or estimators used to assess the intervention's impact on outcomes in those studies. This information is crucial in understanding the rigor of each study's analysis and the validity of its findings (Higgins & Green, 2011). Lastly, the template includes sections for "Findings," "Limitations," "Strengths," and the "Type of Evaluation." Documenting each study's limitations and strengths highlights the scope and potential biases within each study. Finally, identifying and documenting the evaluation type further clarifies the study's purpose, helping to distinguish between research focused on program improvement and those aiming to assess long-term impact.

2.6 Quality Appraisal

The quality of the selected studies was appraised with the Agency for Healthcare Research and Quality (AHRQ) checklist and the Methodological Index for Non-Randomized Studies (MINORS) checklist for the observational studies and interventional-based non-randomised control trials, respectively. The choice of these checklists was informed by the recommendations of a recent systematic review that juxtaposed the strengths and limitations of quality appraisal tools to inform robust systematic reviews (Xiantao Zeng, 2014). The AHRQ is an eleven-item checklist that uses 'yes', 'no' and 'not applicable (NA)' responses to assess the methodological quality of observational studies. Therefore, in the assessment, studies that met the items on the checklist were marked 'yes' and those that did not meet or addressed the items were marked 'no' or 'NA'. Accordingly, and per the AHRQ guidelines, studies with ≥8 'yeses' were considered high quality, those with ≤4 were regarded as low quality, and those between 4 and 8 were deemed moderate quality. Similarly, the quality of the studies assessed with the MINORS tool was rated on a 24-item checklist. Studies meeting ≥18 of the item requirements was rated high quality, and those meeting ≤10 were rated low quality.

To reduce potential bias in the assessment of the studies, roughly half of the extracted studies were independently assessed by a second reviewer. This mechanism is accepted to increase the reliability of the data extraction (Haywood et al., 2004)

2.7 Data Synthesis and Analysis

A narrative synthesis approach was used to describe the methods, operationalisation of the methods and the findings in the studies. The descriptions were captured under key themes/headings emanating from the selected studies. For example, themes, like interventions and outcomes characteristics, were used to describe the characteristics of the community healthcare facility/intervention identified in the studies. Tables and graphs were also utilised to summarise and compare the characteristics of the studies per a defined theme. Where applicable, quantitative findings from studies that used similar analytical estimators and assessed similar outcomes were compared to understand the magnitude and direction of the effect of the intervention on the outcome. The operationalisation of the narrative synthesis approach in this review was guided by the recommendations of Popay et al. (2006).

2.8 Results

A total of 3,200 studies were identified from the database searches. After removing duplicates, the titles, and abstracts of 2,309 articles were screened for eligibility. After the titles and abstracts screening, 225 of the literature remained. Out of the 225 papers, 185 of them were excluded for not meeting eligibility criteria. 85 of the studies were excluded from the review, as they focused on non-primary healthcare facilities and as such did not align with the review. A total of 39 research papers remained and were used in this review. The PRISMA diagram below (Figure 2) illustrates how the selection process was conducted.

2.9 Chapter Summary

A systematic review approach was selected for this study due to its structured and rigorous methodology. A detailed search strategy was employed to locate relevant studies. A preliminary review identified Scopus, Web of Science, and PubMed as the primary databases, as they were the most frequently used sources for studies in this area. The search terms were crafted based on keywords commonly associated with the assessment of community health interventions. The chapter also discusses the Boolean operators 'AND' and 'OR,' which expanded and narrowed the search to capture relevant studies accurately. The identified studies were stored and managed through RefWorks to handle duplicates and simplify referencing, further ensuring the review's rigour.

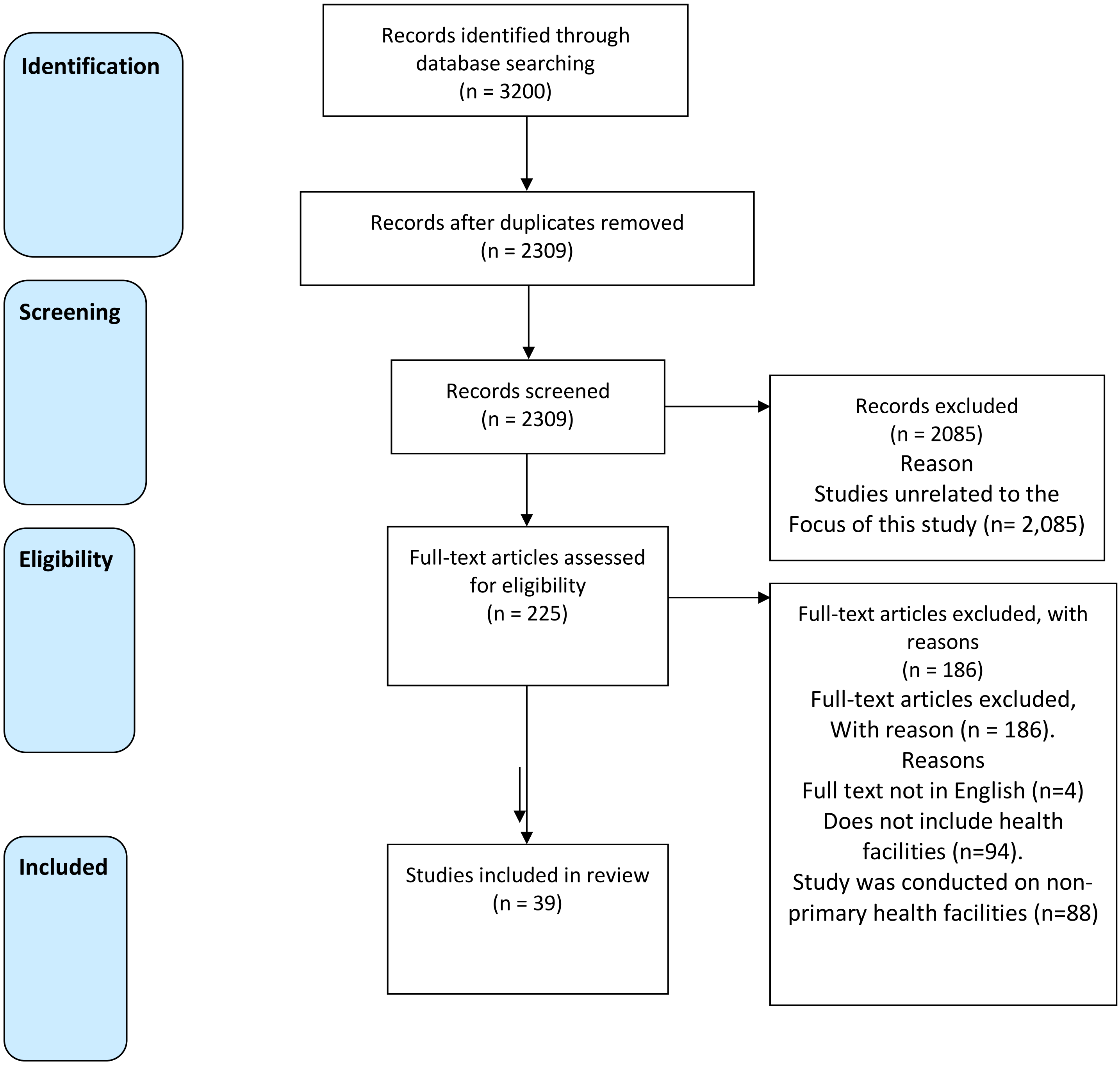
The review employed the Setting, Population, Intervention, Comparison, and Evaluation (SPICE) framework to set eligibility criteria, facilitating the selection of studies directly relevant to the research questions. This framework was selected because it supports a structured selection process, enabling the review to focus on studies with similar populations and intervention characteristics.

Data was extracted using a template with headings inspired by the PRISMA framework. Key themes included study design, type of healthcare facility, evaluation parameters, and outcomes. Quality appraisal was conducted using the AHRQ checklist and the Methodological Index for Non-Randomized Studies (MINORS) checklist, ensuring only high-quality studies were included in this review.

Quantitative findings were compared across studies with similar methods to identify trends in effectiveness measures. This approach provided a structured presentation of findings, making it possible to analyse complex data patterns and outcomes associated with the CHPS model. From a total of 3,200 studies initially identified, 39 studies were selected based on their relevance and alignment with the eligibility criteria. Notably, a large portion of relevant studies emerged from the United States and Australia, underscoring the global interest in community healthcare interventions, which present valuable insights for Ghana's CHPS initiative. The studies examined covered a range of countries, with the majority stemming from high-income regions like the United States, where extensive data on community health models exists. Studies from countries like Australia highlighted culturally competent healthcare as a factor influencing healthcare effectiveness. These findings emphasize the need to adapt the CHPS model to local cultural contexts, which can significantly affect the acceptance and effectiveness of community health initiatives.

In Africa, studies from Uganda and other sub-Saharan regions provide insights into low-resource settings that face similar challenges as Ghana. These studies focus on healthcare accessibility, workforce challenges, and patient education, all of which are highly relevant to the CHPS initiative. The quality appraisal revealed that most studies included were high to moderate quality, with only a small portion rated as low quality based on AHRQ and MINORS criteria. This quality assessment highlights the strength of the evidence base on community healthcare facilities, although there remain some gaps in methodological rigour, particularly in studies focused on rural Africa.

PRISMA 2009 Flow Diagram



PRISMA checklist available at: http://prisma-statement.org/PRISMAStatement/Checklist

2.10 Overview of the selected studies

The selected papers spanned seventeen countries (see Figure 3). Of these, United States had the highest number of studies (n = 13 studies) (Abrams, 2006), (Ameh et al., 2021), (Babalola & Moodley, 2020), (Cheadle et al., 2008), (Chen et al., 2019), (Chrisman et al., 2002), (Dwinnells & Misik, 2017), (Glick et al., 1999), (Hardy et al., 2013), (Henly et al., 1998), (Islam et al., 2015), (Maurana & Rodney, 2000), (Weinstein et al., 2013). The United States provides an abundance of data regarding community healthcare interventions. Studies such as those conducted by Islam et al. (2015) and Abrams (2006), for instance, centre on the application of technology in healthcare delivery and integrated community health models. The findings hold significant relevance for Ghana, as the incorporation of technology and training for community health workers can enhance the effectiveness and scope of service delivery. It is followed by Australia (D'Abbs et al., 2008), (Lawless et al., 2014), (Rendalls et al., 2019). Studies conducted in Australia, including those by D'Abbs et al. (2008) and Lawless et al. (2014), place a strong emphasis on culturally competent health interventions and community involvement. These factors are especially important for Ghana, where a variety of cultural traditions and beliefs have a big influence on the acceptance and efficacy of healthcare. As these studies show, implementing culturally appropriate health education programmes can increase the effectiveness of the CHPS project. In third place is Uganda (Di Giorgio et al 2016) (Mujasi et al. 2016) (Mujasi & Kirigia, 2016).

Research from Uganda, like that of Di Giorgio et al. (2016) and Mujasi et al. (2016), emphasise how crucial decentralisation and community involvement are to the provision of health services. These results underline the necessity for robust community health worker (CHW) programmes and local health committees in Ghana by supporting the CHPS model's emphasis on community engagement and local health care delivery.

Research from Ghana (Alhassan et al.2015), (Jehu-Appiah et al. 2014), (Nonvignon, 2017) with (n= 3 studies each) already pose inherent relevance to the Ghanaian context of primary healthcare.

From the United Kingdom, the relevant research was from (Davison et al., 1999) and (Matheson et al., 2020). Research from the United Kingdom provides valuable information about how community health services might be integrated with primary healthcare systems.

According to these papers, successful integration may result in improved health outcomes and more economical resource usage. By improving coordination between CHPS and other primary healthcare services, Ghana can gain from these findings and guarantee a smooth transition of care. The studies conducted in Ethiopia (Sebastian & Lemma, 2010; Ali et al., 2017) and Kenya (Di Giorgio et al., 2016; Omondi Aduda et al., 2015) highlight the importance of mobile health (mHealth) technologies and the involvement of community health volunteers. These strategies have improved mother and child health outcomes and increased access to healthcare. By utilising mobile technologies to assist CHWs and increase healthcare access in rural regions, Ghana can implement comparable tactics. Similarly, in the case of Nigeria, (Sede & Ohemeng, 2012; Ichoku et al., 2014) emphasise the significance of long-term financial sources and health financing for community health initiatives. These findings can help establish more sustainable financial methods to support the long-term survival of the CHPS initiative in Ghana, given the funding problems it faces. The research from China (Wang et al., 2017), Pakistan (Ohly et al., 2018), and Turkey (Ates et al., 2020) focuses on novel models of health interventions and the application of data analytics to track and enhance health outcomes. Similar data-driven techniques can be used in Ghana to monitor CHPS effectiveness, pinpoint gaps, and guide policy choices that will improve healthcare delivery.

Studies conducted in Zambia (Di Giorgio et al., 2016), Togo (Atake, 2019), and Israel (Epstein et al., 2002) offer proof of the efficiency of community-based health insurance plans as well as the contribution of community involvement to better health outcomes. These studies can help Ghana improve community involvement in the planning and execution of health programmes and fortify community health insurance programmes. Angola (Kirigia et al., 2014), Burkina Faso (Marschall, 2011) and South Africa (Ngobeni et al., 2020) had a study each. Robust health infrastructure and government support being critical for the effectiveness of community health programmes were the focal point of these studies. To support the CHPS project in Ghana, these insights highlight the necessity of a strong government commitment and investment in health infrastructure.

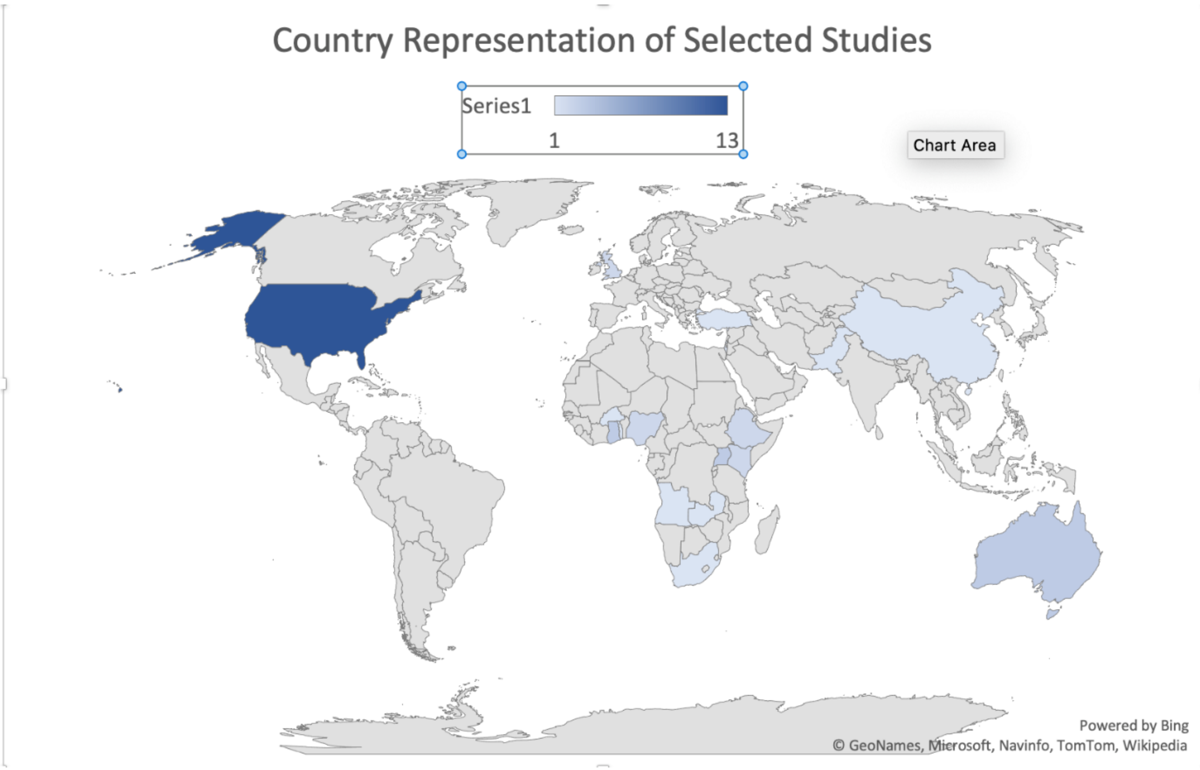


Figure 3: Country Representation

2.11 Characteristics of included studies

The studies included in the review are around those that feature interventions in primary and community health services as well as evaluation methods in primary health care delivery. From the review, 6 studies aimed at discussing or presenting innovative programs in the primary and community health service delivery of various countries, 18 aimed at discussing the various research methodologies that are used in studies of community primary health care services. The remaining 15 studies aimed at the various evaluations done on different primary health care innovations and interventions in varied communities.

Innovative programmes that incorporate technology into primary and community health services were provided by a number of the review's studies. For instance, telemedicine and mobile health (mHealth) apps can be used to enhance healthcare delivery and accessibility.

Similar technology advancements can be used in the CHPS model to improve communication between health institutions and community health workers (CHWs), provide remote consultations, and educate communities about health issues.

Numerous studies highlight the value of Community Health Workers (CHWs) and highlight programmes that train CHWs to provide basic healthcare services, lead health education sessions, and encourage preventative care practices. This is in line with the CHPS concept, which provides decentralised healthcare primarily through the use of CHWs. By putting these studies' best practices into practice—like ongoing training and support for CHWs—the CHPS project can function more effectively.

The effectiveness of the CHPS effort depends on programmes that use culturally sensitive approaches to healthcare delivery, as the evaluated research have shown. CHWs can improve health outcomes by encouraging better community acceptance and involvement in health programmes by customising health interventions to accord with local cultural practices and beliefs.

The examined research' cost-effectiveness assessments offer valuable insights into the long-term financial viability of health interventions. By integrating these analyses with the CHPS model, it will be possible to determine the most economical methods of providing basic healthcare services while guaranteeing that resources are allocated effectively in order to maximise health benefits.

2.12 Quality Appraisal Results

The scores of the studies assessed with the AHRQ ranged from three (3) to six (6), indicating low to moderate quality, while those appraised with the MINORS checklist ranged from five (5) to twenty-two (22), suggesting low to high methodological quality Three of the studies (Chen, 2020; d'Abbs, 2008; Ken-Opurum, 2019) that scored five and above on the AHRQ checklist faced a common methodological challenge; they did not indicate how missing data were handled in the analysis.

The validity of the study's findings may be weakened by bias introduced by failing to disclose how missing data were handled. If missing data is not properly managed, it might distort results and lead to incorrect conclusions regarding the efficacy of initiatives. Reliance on such data for the CHPS model could lead to the adoption of tactics that are not as successful as they seem or the neglect of potentially beneficial treatments.

Also, the studies that scored below six on the checklist faced methodological limitations such as no summaries on patient response rates and completeness of data collection. Such erroneous or overestimated intervention effects may result from incomplete data collection and summaries of patient response rates. Results may be skewed if important trends or outcomes are missed due to incomplete data. This could lead to CHPS adopting treatments based on insufficient evidence, which could result in less-than-ideal health results.

Others were due to a lack of control of confounding factors such as comorbidities, socioeconomic status, and other external factors. In the context of CHPS, failing to address confounders may result in the recommendation of ineffective treatments because the underlying factors influencing health outcomes may not be fully understood.

Further, for the MINORS checklist, eighteen studies that scored below fifteen did not adequately report follow-up periods, resulting in potential bias. Short follow-up times might only record short-term impacts, omitting long-term advantages or disadvantages. This could cause CHPS to accept treatments too soon that might be helpful in the short term but less effective or even harmful in the long run.

Tables 3 and 4 below show the number of studies that met the AHRQ and MINORS checklists, respectively.

Table 3: Number of studies that met the AHRQ checklists.

AHRQ Checklist	Number of studies (N) that met it	Studies' reference
1) Define the source of information (survey, record review)	4	(Chen et al., 2019), (Ken-Opurum, 2019), (D'Abbs et al., 2008), (Wang et al., 2017)
2) List inclusion and exclusion criteria for exposed and unexposed subjects (cases and controls) or refer to previous publications	2	(Chen et al., 2019), (Ken-Opurum, 2019),
3) Indicate time period used for identifying patients	3	(Chen et al., 2019), (Ken-Opurum, 2019), (D'Abbs et al., 2008),
4) Indicate whether or not subjects were consecutive if not population-based	1	(D'Abbs et al., 2008),
5) Indicate if evaluators of subjective components of study were masked to other aspects of the status of the participants	1	Sebastian & Lemma, 2010)
6) Describe any assessments undertaken for quality assurance purposes (e.g., test/retest of primary outcome measurements)	3	(Chen et al., 2019), (Ken-Opurum, 2019), (D'Abbs et al., 2008),
7) Explain any patient exclusions from analysis	0	
8) Describe how confounding was assessed and/or controlled.	0	
9) If applicable, explain how missing data were handled in the analysis	0	
10) Summarize patient response rates and completeness of data collection	4	(Chen et al., 2019), (Ken-Opurum, 2019), (D'Abbs et al., 2008), (Kirigia et al., 2014)
11) Clarify what follow-up, if any, was expected and the percentage of patients for which incomplete data or follow-up was obtained	0	

Table 4: Number of studies that met the MINORS checklists.

Minors Checklist	Number of studies (n) that met it	Studies' reference
1. A clearly stated aim: the question addressed should be precise and relevant in the light of available literature	19	(Gullo et al., 2016), (Dwinnells & Misik, 2017), (Davison et al., 1999), (Lawless et al., 2014), (Ohly et al., 2018), (Matheson et al., 2020), (Cheadle et al., 2008), (Rendalls et al., 2019), (Henly et al., 1998), (Islam et al., 2015), (Hardy et al., 2013), (Babalola & Moodley, 2020), (Sede & Ohemeng, 2012), (Ates et al., 2020), (Zúñiga et al., 2006), (Glick et al., 1999), (Ichoku et al., 2014), (Epstein et al., 2002), (Kirigia et al., 2014)
2. Inclusion of consecutive patients: all patients potentially fit for inclusion (satisfying the criteria for inclusion) have been included in the study during the study period (no exclusion or details about the reasons for exclusion)	17	(Dwinnells & Misik, 2017), (Davison et al., 1999), (Lawless et al., 2014), (Ohly et al., 2018), (Matheson et al., 2020), (Cheadle et al., 2008), (Henly et al., 1998), (Hardy et al., 2013), (Jehu-Appiah et al. 2014), (Alhassan et al. 2015), (Babalola &

Minors Checklist	Number of studies (n) that met it	Studies' reference
		Moodley, 2020), (Rendalls et al., 2019), (Sebastian & Lemma, 2010), (Zúñiga et al., 2006), (Epstein et al., 2002), (Glick et al., 1999), (Islam et al., 2015)
3. Prospective collection of data: data were collected according to a protocol established before the beginning of the study	17	(Gullo et al., 2016), (Dwinnells & Misik, 2017), (Davison et al., 1999), (Lawless et al., 2014), (Ohly et al., 2018), (Matheson et al., 2020), (Cheadle et al., 2008), (Rendalls et al., 2019), (Henly et al., 1998), (Hardy et al., 2013), (Babalola & Moodley, 2020), (Weinstein et al., 2013)
4. Endpoints appropriate to the aim of the study: unambiguous explanation of the criteria used to evaluate the main outcome which should be in accordance with the question addressed by the study. Also, the endpoints should be assessed on an intention-to-treat basis.	12	(Dwinnells & Misik, 2017), (Davison et al., 1999), (Lawless et al., 2014), (Ohly et al., 2018), (Zúñiga et al., 2006), (Henly et al., 1998), (Islam et al., 2015), (Hardy et al., 2013), (Glick et al., 1999), (Matheson et al., 2020), (Sebastian & Lemma, 2010),

Minors Checklist	Number of studies (n) that met it	Studies' reference
		(Babalola & Moodley, 2020)
5. Unbiased assessment of the study endpoint: blind evaluation of objective endpoints and double-blind evaluation of subjective endpoints. Otherwise, the reasons for not blinding should be stated	8	(Dwinnells & Misik, 2017), (Davison et al., 1999), (Lawless et al., 2014), (Ohly et al., 2018), (Cheadle et al., 2008), (Zúñiga et al., 2006), (Henly et al., 1998), (Hardy et al., 2013),
6. Follow-up period appropriate to the aim of the study: the follow-up should be sufficiently long to allow the assessment of the main endpoint and possible adverse events	2	(Ohly et al., 2018), (Zúñiga et al., 2006),
7. Loss to follow up less than 5%: all patients should be included in the follow up. Otherwise, the proportion lost to follow up should not exceed the proportion experiencing the major endpoint	0	
8. Prospective calculation of the study size: information of the size of detectable difference of interest with a calculation of 95% confidence interval, according to the expected incidence of the outcome event, and information about the level for statistical significance and estimates of power when comparing the outcomes	12	(Dwinnells & Misik, 2017), (Davison et al., 1999), (Lawless et al., 2014), (Ohly et al., 2018), (Zúñiga et al., 2006), (Henly et al., 1998), (Islam et al., 2015), (Hardy et al., 2013), (Glick et al., 1999), (Matheson et al., 2020), (Sebastian & Lemma, 2010), (Babalola & Moodley, 2020)
Additional criteria in the case of comparative study		

Minors Checklist	Number of studies (n) that met it	Studies' reference
9. An adequate control group: having a gold standard diagnostic test or therapeutic intervention recognized as the optimal intervention according to the available published data	5	(Dwinnells & Misik, 2017), (Lawless et al., 2014), (Ohly et al., 2018), (Zúñiga et al., 2006), (Hardy et al., 2013)
10. Contemporary groups: control and studied group should be managed during the same time period (no historical comparison)	2	(Dwinnells & Misik, 2017), (Davison et al., 1999)
11. Baseline equivalence of groups: the groups should be similar regarding the criteria other than the studied endpoints. Absence of confounding factors that could bias the interpretation of the results	5	(Ohly et al., 2018), (Matheson et al., 2020), (Zúñiga et al., 2006), (Hardy et al., 2013), (Weinstein et al., 2013)
12. Adequate statistical analyses: whether the statistics were in accordance with the type of study with calculation of confidence intervals or relative risk	6	(Davison et al., 1999), (Matheson et al., 2020), (Cheadle et al., 2008), (Hardy et al., 2013), (Babalola & Moodley, 2020), (Weinstein et al., 2013)

Table 5: The number of moderate and high-quality studies per the AHRQ and MINORS checklist.

MINORS Checklist		AHRQ Checklist	
High quality	Moderate quality	High quality	Moderate quality
N = 15	N = 8	N = 11	N = 5

2.13 Methodological Features

2.13.1 Study/Sample Characteristics

Seventeen papers in this review used observational studies (n=17 papers); n=16 papers used non-randomised experimental interventional studies; the rest used quasi-experimental models and a longitudinal approach. The studies are listed in Table 7 below. Regarding the types of data used by the selected studies, the majority used primary data (n=21), while the other studies (n=18) used secondary data. The dominant instrument used in collecting data was structured questionnaires (n=10), with a sample population ranging from as low as 30 to 643,223. The majority of the structured questionnaires were administered as structured interviews. On the other hand, three (3) studies used secondary data from three primary sources, further described in Table (6) below. The sample size for the secondary data ranged from 600 to 1,225,816. The reported sample population of the included studies were primarily adults aged 18 years and above.

However, one study (Elif Ates, 2020) reported the use of infants due to the study's focus on postpartum evaluation of the mother and infant in the home environment. Most studies used a simple random sampling approach to select the sample size. Few studies reported the use of simple stratified and quota methods. The health facilities type identified in the selected studies were grouped into four major categories: primary healthcare centres, secondary or district hospitals, tertiary, specialist and teaching hospitals, and others (mainly health posts and voluntary medical male circumcision facilities).

Table 6: Description of secondary datasets

Dataset	Description	Content
Local school nurses, geographic information systems-based mapping of food and recreation accessibility, census demographics, income and employment data, educational attainment, housing quality indices, availability of quality childcare, and crime statistics.	Provided a valuable analysis of the health status and accompanying social determinants within the chosen community	BMI data on adults aged 18 years and older from within the neighbourhood and city of study.
Youngstown Community Health Centre (YCHC).	Draws data from a target population of 20,000 patients.	Basic demographic information including age, sex, marital status, drug & alcohol usage, family characteristics, and household size & economic measures
Wang Fang Database, China National Knowledge Infrastructure (CNKI), China's Ministry of Health and the Chinese Centre for Disease Control and Prevention	Longitudinal data of all CHCs after the first year of the 2009 New Health Reform	Financial investment and Health practitioners in CHCs from 2010 to 2015.

Table 7: Studies included in review and study designs utilized.

Observational Studies	Non-Randomised Interventional Experimental Studies	Quasi-Experimental Studies	Longitudinal Studies
(Abrams, 2006)	(Cheadle et al., 2008)	Ken-Opurum, 2019	(Epstein et al., 2002)
(Ameh et al., 2021)	(Chen et al., 2019)	(Dwinnells & Misik, 2017)	
(Babalola & Moodley, 2020)	(Glick et al., 1999)	(Ates et al., 2020)	
(Chrisman et al., 2002)	(Hardy et al., 2013)	(Nonvignon, 2017)	
(Di Giorgio et al 2016)	Henly et al., 1998)	(Weinstein et al., 2013)	
(Mujasi et al. 2016)	(Islam et al., 2015)		
(Alhassan et al. 2015)	(Maurana & Rodney, 2000)		
(Jehu-Appiah et al. 2014)	(D'Abbs et al., 2008)		
(Omondi Aduda et al., 2015)	(Lawless et al., 2014)		
(Sebastian & Lemma, 2010)	(Rendalls et al., 2019)		
(Ali et al. 2017)	(Davison et al., 1999)		
(Ichoku et al., 2014)	(Matheson et al., 2020)		
(Sede & Ohemeng, 2012)	(Wang et al., 2017)		
(Atake, 2019)	(Ohly et al., 2018)		
(Kirigia et al., 2014)	(Gullo et al., 2016)		
(Marschall, 2011)	(Zúñiga et al., 2006)		
(Ngobeni et al., 2020)			

2.13.2 Characteristics of interventions

This review gathered studies on interventions for delivering community primary health services. The distinct features of these interventions are discussed as follows.

Interventions assessed by reviews were heterogeneous. The heterogeneity was confined to three main dimensions: components, mode of delivery, and personnel delivering or facilitating the support. However, interventions across each category shared common characteristics. Across the thirty-nine studies which assessed the effectiveness of CHPs interventions, most interventions included one or more of the following components related to disease management: action plans, goal setting, decision-making, self-monitoring, self-efficacy, and problem-solving. Also, the educational components of the interventions varied with the target population. However, the educational programs included two or more components: disease general education and medication. The mode of delivery of interventions included individual or group-based delivered face-to-face or/and via telephone with follow-up. On the other hand, personnel mainly were health care professionals (HCPs), including general practitioners, nurses, and physicians. Physicians and nurses worked as multidisciplinary team members or in pure consultancy or nurse-led interventions.

2.13.3 Primary health care in poor, remote and marginalised communities

Four of the interventions were characterised by non-governmental partnerships in community-based primary healthcare service delivery among the studies reviewed. For instance, the study by (Cheadle et al., 2008) looks at the Partnership for the Public's Health (PPH). This comprehensive community initiative featured a central role for local health departments with their community partners. Another study that is characterised by private or non-governmental partnerships towards community health care delivery is (Beery et al., 2005).

Another feature of research works on interventions of primary health services in community health is the approaches and involvement of students in the community aspects of the medical fields (Davison et al., 1999) (Ates et al., 2020). Studies such as (Zuniga et al., 2006) evaluate the training of health delivery personnel to be effective in culturally distinctive areas. Other characteristic features in community primary health care are those studies that describe public policy implementations (Wang et al., 2017).

Studies from (Davison et al., 1999), (Epstein et al., 2002), (Ohly et al., 2018), (Zhaoxin et al., 2017), (Dwinnells, Misik. 2017), (Henley et al., 1998), (Islam et al., 2015) were all focused on primary healthcare in poor and marginalised communities but not in West Africa and by extension Ghana.

The third distinct characteristic of the literature reviewed is the feature that describes and reports on the varying evaluation methods of assessing the quality and outcomes of community primary health care; this was found in studies such as (Matheson et al., 2020) (Rodney et al., 1998; Gullo et al., 2016 and Lawless, et al., 2014). Other studies, such as (Chrisman et al., 2002), also use qualitative approaches in evaluating Community Health care services and initiatives.

2.13.4 Intervention categories

The included studies used two main categories to classify community health centres: 1) Community-Based and 2) Community-Based Partnerships. The categories have been itemised and briefly explained below.

2.13.4.1 Community-Based

A summary of the community-based category and an overview of the specification and frequency of use are outlined below.

The community-based system is defined by the delivery of medical care and education, it is made distinct by its setting. This can be in varying forms. A typical approach is a facility outside a trusted and identified community centre. The community-based systems do not simply expand or increase access to health services but instead deploy communities to direct health initiatives.

2.13.4.2 Community-based partnerships

The community-based partnerships are characterized by the partnership of indigenous groups and organizations in the community of interest for the purpose of altering health outcomes.

The community-based partnerships hinge on the input and expertise of community members. Healthcare organisations partner with these indigenous groups within the community to deliver important educational messages to high-risk populations who ordinarily do not trust the healthcare organisations or do not visit the healthcare facilities.

2.14 Empirical Findings

The findings were synthesized in three themes, revealing a variety of dimensions associated with healthcare facilities. The themes included the 1). Input Output Variables, 2). Output Variables, 3). factors influencing hospital efficiency and technical efficiency.

2.14.1 Input Variables

Individual-level healthcare system inputs data from the selected studies are summarised on table 8 below. Generally, all the studies reported a varied number of input variables. These variables consist of various occupations that have different effects on the production of the health care service. The input variables are very important in the healthcare facilities ability to deliver quality service and meet customer expectations.

Table 8: Input Variables from the Selected Studies

Variables	Measurement
Inputs	**(Individual-level data)**
Human Resources *Clinical staff* Doctor/dentists Nurse/midwife Pharm. /pharm. Tech Physiotherapist Public health/CHO Radiographer Technician/paramedics Other (non-specified clinical staff) *Nonclinical staff* Administrative staff Counsellor and educator Health attendants Other support staff	Clinical staff: Total number of doctors, nurses, pharmacists, medical assistants, physiotherapists etc. Nonclinical staff: Total number of administrators, orderlies, accountants, nutrition officers etc.
Financial Recurrent expenditure Expenditure on drugs and supplies	Total recurrent expenditure inclusive of salaries of personnel, expenditure on drugs and expenditure on other goods and services.

Structure No of consulting rooms No of wards Size of facility Bed	Total number of beds/ consulting rooms/ wards/
Others Drug supplies. Equipment Power/energy supply Total operating time	

2.15 The Output Variables

The basic service of a health facility is the course of treatment that the patient receives, so the quantity of these treatments is defined as output. The selected studies measured outputs by grouping hospital outputs based on inpatient discharges and outpatient visits or by diagnostic categories (e.g. medical/surgical, obstetrics, paediatric care etc.) as shown on table 9 below. These variables were used in the calculation of the efficiency of hospitals.

These output variables have over time been benchmarked, and meeting and exceeding these targets are indicators of quality of care and efficiency of the hospital.

Table 9: Output Variables from the Selected Studies

Variables	Measurement
Outputs	**(Individual-level data)**
Consultation visits Outpatient visits Inpatient visits Dental care visits Emergency cases Special care visit	Annual total number of outpatient visits (inpatients, emergency cases, special care, dental etc...)
Maternal and child health services Antenatal care visits Delivery Immunization visits Postnatal visits Family planning visits Other MCH visit.	Annual total number of deliveries, immunization, etc...
Others Procedure/surgery Tests and observation Patient death New births discharged alive. Patients' days	Annual total number of other specialized services

2.16 Factors Influencing Hospital Effectiveness and Technical Effectiveness

Effectiveness literatures emphasized that the performance of healthcare facilities is influenced not only by the internal factors but also by external factors beyond the control of hospital management, and this has an impact on efficiency of the healthcare facilities. These factors are represented by environmental variables that are related to management, demographic characteristics of the catchment area of the hospitals, and organizational structure. The influence of these variables on the effectiveness of healthcare facilities was investigated by some of the selected studies. Of the 39 selected studies, only 7 (20%) investigated the impact of these external variables on the effectiveness of healthcare facilities. The list of the external variables reported in the selected studies are summarised in Box 1 below.

Box 1 External Variables

1. Catchment population
2. Distance
3. Location (urban/rural)
4. Ownership (profit/not-for-profit)
5. Teaching status
6. Payment source (out-of-pocket/health insurance)
7. Occupancy rate
8. Average length of stay
9. Patient waiting time.
10. Outpatient visits as a proportion of inpatient days
11. Quality

The most common factor identified by the studies was “facility ownership”. This is followed by “facility location” and “catchment population.”

Table 10: Characteristics of selected papers

Serial Number	Study	Study Setting	Intervention	Study Design	Main/Common Outcome Measures
1	Elizabeth Chen, Cristina Leos, Sarah D. Kowitt, Kathryn E. Moracco,	Durham, North Carolina,	Community-Based Participatory Research Through Human-Centred Design Strategies	Cross-sectional Design	HCD's primary purpose is to actively test and build solutions intended to scale across a larger user base, far beyond participants in the original project. In contrast, CBPR emphasizes generating research findings and uncovering highly localized, contextual insights for and with the participating community. While CBPR may contribute to a solution, it is essentially a research process and, as such, its primary goal is to generate new knowledge that can inform future action.

2	Lisa Jane Hardy, Kyle David Bohan, Robert Talbot Trotter	USA	Synthesizing Evidence-Based Strategies and Community-Engaged Research	Non-randomised intervention	Hermosa Vida research and planning resulted in the selection of multiple strategies for enhancing the safety net and addressing the SDH in one U.S. city.
3	Doris F. Glick, Karen Macdonald Thompson, Richard A. Bridge	USA	The Foundation for Development, Management and Evaluation of Community Nursing Centre	Cross-Sectional	1. The use of population level data is important for the development of public health needs. 2. Aggregate data that portray the features of the entire population studied usually serves as the base line of the planning and development of health programs that promote and protect the health needs of the communities.

					3. Knowing the populations in the study has helped in the choice of programs and health services to plan and deliver to each distinct population.
4	Abrams, 2006)	USA	LCA methodology to address programmatic and evaluation challenges associated with implementing a municipal-based wellness intervention program across a large number of heterogeneous communities.	Non-randomised intervention	The prevention and wellness community typology derived from the analysis serves as a basis for 1) establishing proper evaluation benchmarks, 2) establishing efficient-yet-tailored communications campaigns, 3) facilitating knowledge exchange across peer communities, and 4)Using cost-effective, context-specific intervention selections and staff training.

5	(Rendalls et al., 2019)	Australia	Health service engagement with consumers and community in Australia for issue Engagement and accountability with your community	Cross-Sectional	As an outcome of the first-year evaluation, the PHN is engaging in a co-design process with the contracted service provider, staff, consumers, and other key stakeholders including local hospital services and other community service providers. Based on the programme logic, the assessment and triage criteria, SMART activity output and outcome measures will be defined. The inclusion of external stakeholders in the co-design process will facilitate the development of measures to assess the cross-agency collective impact of the programme on the demand for other services.

6	Lara Carson Weinstein, Marianna D. LaNoue, James D. Plumb, Hannah King, Brianna, Stein and Sam Tsemberis, PhD	USA	A Primary Care–Public Health Partnership Addressing Homelessness, Serious Mental Illness, and Health Disparities	Non-randomised intervention	1. The outcome was that the success of this model program relies largely on the extension of the existing academic PCMH.
7	Peter d'Abbs, Barbara Schmidt, Kathryn Dougherty, and Kate Senior	Australia	Process evaluation involved health centre staff in both communities; clinical audits used random samples from the adult population (each sample n = 30); ethnographic fieldwork was conducted with resident population.	Non-randomised intervention	On almost all indicators, implementation of NQICDS had progressed further in Community A than in Community B; however, some common issues emerged, especially lack of linkages between health centres and other groups, and lack of support for client self-management.

8	Allen Cheadle, Clarissa Hsu, Pamela M. Schwartz, David Pearson, Howard P. Greenwald, William L. Beery, George Flores, and Maria Campbell Case	USA	Involving Local Health Departments in Community Health Partnerships: Evaluation Results from the Partnership for the Public's Health Initiative	Non-randomised intervention	1. Out of the 37 partnerships funded continuously throughout the 5 years of the initiative, between 25% and 40% were able to make a high level of progress in each of the Initiative's five goal areas. 2. health departments able to work effectively with community groups had strong, committed leaders who used creative financing mechanisms, inclusive planning processes, organizational changes, and open communication to promote collaboration with the communities they served.

9	Nadia Islam, Smiti Kapadia Nadkarni, Deborah Zahn, Megan Skillman, Simona C. Kwon and Chau Trinh-Shevrin,	USA	Integrating Community Health Workers Within Patient Protection and Affordable Care Act Implementation	Cross Sectional Study	1. The Integration of Community health workers in the program has proven that community health workers play a vital role in administering health care that is cultural appropriate as patient and family centred as well. 2. That the Community health workers can also health in the coordination of access to health services and programs such as disease prevention programs in the communities. 3. The study also found that the community health workers also function very much in the management of support care and

					health promotion in their various communities.
10	Susan J Henley, Elizabeth A. Tyree, Deborah L. Lindsey, Sharon O. Lambeth, Christine M. Burd	USA	Innovative Perspective on Health Services for Vulnerable Populations	Non-randomised intervention	1. Health care professionals who are educated with this vision of practice will become extremely useful as 21st century leaders in planning for and meeting the unique health needs of rural populations.
11	Ronald Dwinnells and Lauren Misik	USA	An Integrative Behavioural Health Care Model Using Automated SBIRT and Care Coordination in Community Health Care	Non-randomised intervention	1. It was found that A fully integrated, efficient, and effective BH program promotes the success of the chronic care or disease management model of primary health care

					delivery. This brought about early direction and treatment for the patients.
12	Zhaoxin Wang, Jianwei Shi, ZhiguiWu Huiling Xie, YifanYu, Ping Li, Rui Liu, and Limei Jing	China	Introduction of CHCs staff to manage CDs	Non-randomised intervention	Evaluating the longitudinal changes of CHCs' ability for chronic disease prevention and treatment at both the macrolevel and microlevel
13	Hilary Davison, Simon Capewell, Jane Macnaughton, Scott Murray, Phil Hanlon, and James McEwen	UK	Community-Oriented Medical Education in Glasgow, Developing a community Diagnosis Exercise	Non-randomised intervention	This innovative community-oriented teaching programme gave students some insight into how health, morbidity and mortality are measured, why these might vary between different communities, and how different community members' perspectives might differ regarding perceived health and social needs.

14	Leon Epstein, Jaime Gofin, Rosa Gofin and Yehuda Neumark	Israel	The Jerusalem Experience: Three Decades of Service, Research, and Training in Community-Oriented Primary Care	Cross Sectional Design	1. The community health service education has been categorised into areas such as community diagnosis, Reassessments, evaluation, and Intervention planning
15	Heather Ohly, Helen Bingley, Nicola Lowe, Rashid Mehdi, Zia Ul Haq, Mukhtiar Zaman.	Pakistan	Developing health service delivery in a poor and marginalised community in Northwest Pakistan	Non-randomised intervention	The evaluation assessed the efficiency and effectiveness of project implementation, including a survey of maternal and child health indicators.
16	Ken-Opurum, 2019	USA	Transdisciplinary Approaches to Understanding and Eliminating Ethnic Health Disparities: Are We on the Right Track?	Cross Sectional	1. Intervention and community engagement outcomes have received less attention than more process-oriented research outcomes. 2. A renewed focus on the ultimate products of transdisciplinary approaches, namely effective

					multilevel interventions, specific health outcome improvements, and greater community involvement, will aid this promising research paradigm in carrying out its philosophical commitment to ending population health disparities
17	William L. Beery, Sandra Senter, Allen Cheadle, Howard P. Greenwald, David Pearson, Ruth Brousseau and Gary D. Nelson	USA	The Health Improvement Initiative of the California Wellness Foundation is a partnership based non-governmental initiative that concentrates on activities such as the provision of direct health services, improving the environment and institutions into	Non-randomised intervention	1. That the elements of the initiative such as partnerships, their main activities and other capacity building initiatives can be sustained effectively. 2. That the scope of activities can be broadened or become less depending on the findings

			more healthy ones as well as advocate for policy changes in the health sector		
18	Elif Ates, Bahire Ulus, and Azize Karahan	Turkey	Simulation Experience in Community Health Nursing: Postpartum Evaluation of the Mother and the Infant at Home Environment	Quasi-experimental	1. a statistically significant difference between the self-confidence subscale of the SCLS after the simulation activity and the actual home visits ($p < 0.05$). 2. Comparison of the scores obtained from the satisfaction subscale of the SCLS after the simulation activity and the actual home visits reveals no

					statistically significant difference (p > 0.05
19	Anna Matheson, Mat Walton, Rebecca Gray, Kirstin Lindberg, Mathu Shanthakumar, Caroline Fyfe, Nan Wehipeihana, Barry Borman	UK	Evaluating a community-based public health intervention using a complex systems approach	Non-randomised intervention	1. the study found that framing social systems as complex helps in coming out with the right methods to evaluate issues liked public health initiatives. 2. While using existing methods, the combination of approaches within a frame of social complexity offers an innovative approach to public health evaluation.
20	Marilyn Rodney, Carla Clasen Gloria Goldman, Ronald	USA	Three evaluation methods of a community health advocate program	Non-randomised intervention	1. The study found that; from the indications of the results, the CHA program can be considered a success.

	Markert and Donna Deane,				2. The CHAs generally decided that the training program adequately prepared them for their roles and functions. 3. It studies also showed that there were t systematic frustrations and barriers that made it more difficult for health service professionals to do their jobs well.
21	Marıa Luisa Zuniga, Dean E Sidelinger, Gregory S Blaschke, Frank A Silva, Shelia L Broyles, Philip R Nader & Vivian Reznik	USA	Evaluation of residency training in the delivery of culturally effective care	Non-randomised intervention	Data for evaluation of the residency programme was drawn from 4 locally developed measures. Measures were based on an existing survey and findings from the original block rotation in community paediatric.

22	Sara Gullo, Christine Galavotti1 and Lara Altman		Using care international's score cared models to evaluate social accountability in Health care	Non-randomised intervention	1. After the review of the CSC, it was found that there were a lot of important impacts of the framework for instance the range of outcomes, suggests that the CSC is contributing to significant changes.
23	Angela Lawless Toby Freeman, Michael Bentley, Fran Baum, and Gwyn Jolley	Australia	Comprehensive Primary Health Care	Non-randomised intervention	Using the logically causal pathway progress toward these 'big picture' outcomes can be tracked through achievement of more proximal outcomes such as increased individual knowledge and skills; increased health enhancing behaviour; improved quality of life for individuals; slowed progression of conditions; decreased rates of preventable conditions and issues; increased supportive environments for health;

					increased social capital; increased planned, managed care; and decreased acute, episodic care.
24	Noel Chrisma, Kristen Santuria, Gary Tang and Bookda Gheisar	USA	Qualitative Process Evaluation of Urban Community work: A preliminary view	Evaluation Model	1. Designs for community-oriented projects vary from grassroots endeavours in which local activists organize to solve local problems to programs led by public health specialists to promote population health. 2. Leadership structure similarly varies but often includes an advisory committee, a coalition, or other organizational means to seek broad participation

25	Di Giorgio et al 2016	Kenya; Uganda & Zambia	Expansion of antiretroviral therapy health facility	Cross-sectional *(Quantitative*	Facility Efficiency
26	Atake, 2019	Togo	Primary post-natal consultation	Cross-sectional *(Quantitative*)	*Technical efficiency*
27	Alhassan et al.2015	Ghana	Acceptance of National Health Insurance scheme in primary health care facilities	Cross-sectional *(Quantitative)*	Technical Efficiency
28	Jehu-Appiah et al. 2014	Ghana		Cross-sectional *(Quantitative)*	Technical And Scale Efficiency

29	Novignon & Nonvignon, 2017	Ghana	Increase in operational resources for primary healthcare facilities	Cross-sectional *(Quantitative)*	Efficiency Of Health Facilities
30	Kirigia et al., 2014	Angola	Increase in financial budget of primary healthcare facility	Longitudinal (Quantitative)	Technical Efficiency
31	Mujasi et al. 2016	Uganda	Improved treatment referral program	Cross-sectional (Quantitative)	Technical Efficiency
32	Marschall & Flessa, 2011	Burkina Faso	Increased financial budget for primary healthcare facility	Cross-sectional (Quantitative)	Technical Efficiency

33	Mujasi & Kirigia, 2016	Uganda	Change in hospital referral scheme	Longitudinal (Quantitative)	Technical Efficiency
34	Sebastian & Lemma, 2010	Ethiopia	Extension of primary healthcare capacity and boundary	Cross-sectional (Quantitative)	Technical Efficiency
35	(Babalola & Moodley, 2020)	Nigeria	Increase in staffing and operational resources	Cross-sectional (Quantitative)	Technical Efficiency
36	Ngobeni et al., 2020	South Africa	Training and sensitization of primary healthcare staff to reduce negligence	Cross-sectional (Quantitative)	Technical Efficiency

37	Ali et al. 2017	Ethiopia	Improved doctor to patient ration in primary healthcare facilities	Longitudinal (Quantitative)	Technical Efficiency
38	Omondi Aduda et al., 2015	Kenya	Implementation of in clinic Voluntary medical male circumcision	Longitudinal (Quantitative)	Technical Efficiency
39	Sede & Ohemeng, 2012	Nigeria	Increased financial resources	Cross-sectional (*Quantitative*	Technical Efficiency

2.17 Discussions

This review synthesised available evidence on the effectiveness of community healthcare facilities. As part of the synthesis, it also explored factors that influence the effectiveness of these community healthcare facilities and the methods used by prior studies in the effectiveness. In addition to providing integrated evidence on the performance of community health facilities, the review's core objective was to identify related and relevant literature gaps in this research area to inform the empirical analyses in this thesis. Findings from the syntheses are summarised and discussed below:

2.17.1 Effectiveness of Community Healthcare Facilities and Influencing Factors

The review showed that nearly 13% and 47% of the community healthcare facilities investigated in the selected studies were effective and ineffective, respectively. For the ineffective facilities, widespread human and financial resource misallocation or underutilisation issues were argued to be contributory factors. This argument raises a critical concern: many health facilities are not operating at total capacity, potentially due to inadequate resource management or systemic inefficiencies (Brown & Watson, 2020). This concern is also echoed in similar studies from sub-Saharan Africa, reporting low effectiveness due to resource concerns (Calderón, 2021). These studies prompt a look into the implementation strategies employed at community healthcare facilities in the present study. This is because for this study to adequately answer the effectiveness question on CHPS compounds, the resource allocation from the central, local as well as health governing authorities (Ghana Health Service) have to be investigated. Additionally, any bottlenecks in administrative procedures are investigated since the reviewed literature suggests systemic inefficiencies are a key factor in the effectiveness of the implementation process. As these concerns could limit meeting health policy targets, such as the Sustainable Development Goals (SDGs), they must be prioritised in national health policies.

In addition to resource concerns, the review found the effectiveness of community healthcare facilities to be influenced by an interplay of myriad factors from the reviewed literature. These factors include catchment population, bed occupancy rate, average length of stay, facility ownership, location, funding source, and the ratio of outpatient visits to inpatient days. The investigation of this current study focuses on the operational efficiency of CHPS facilities to determine how facility management and treatment practices contribute to overall effectiveness of the CHPS compounds. More importantly, it highlighted that facility ownership is the most significant factor influencing the effectiveness of community healthcare facilities. However, the reported evidence regarding this factor varied considerably based on factors like geographic location, structure, financing schemes, and assessment methodologies (Colombi et al., 2017; Dervaux et al., 2004). That makes it imperative for the current study to investigate the determinants of location decisions by the Ghana Health Service and its impact on the overall effectiveness of the CHPS initiative. The conflicting findings, where some studies indicate private (for-profit) hospitals as more effective than private (non-profit) ones (Rosko & Mutter, 2010), while others suggest the contrary (Jehu-Appiah et al., 2014), highlight the complexity of determining a clear-cut relationship between ownership types and community healthcare facilities' effectiveness.

This inconsistency suggests that the operational effectiveness of these healthcare facilities may be influenced more by management practices and operational efficiencies than by ownership per se. For example, delivering high-quality healthcare services depends on the intricate management, collaboration and coordination among many organisations and providers (Jehu-Appiah et al., 2014), and these intricate characteristics could significantly impede the effectiveness of the facilities (William et al., 2015).

Moreover, the claim that for-profit hospitals potentially achieve better profits through increased effectiveness (Rosko et al., 2018) is arguable. This is because the assertion overlooks the possibility that profit motives might lead to cost-cutting measures that could compromise patient care quality. It may also overlook that for-profit facilities may be strategically positioned in areas with higher income. Therefore, the current study will investigate effectiveness of CHPS facilities that are not for-profit in conjunction with its positioning to control for profit incentivized positioning. Furthermore, the suggestion that government/public hospitals are more technically effective than private (non-profit) hospitals and that hospitals enhance their operational effectiveness under financial stress (Tiemann et al., 2012) raises questions about the impact of financial pressures on healthcare quality and accessibility. Therefore, the review concludes that various factors, from hospital-level characteristics to external economic conditions, influence associations between community healthcare facility ownership and effectiveness. This conclusion acknowledges the multifaceted nature of healthcare delivery and performance within communities. It also aligns with evidence from previous literature (Ackerberg et al., 2001; William et al., 2015). Therefore, the interplay of varied factors, including ownership, operational efficiencies, and external economic conditions, must be considered in nuanced approaches to developing, implementing, and enhancing healthcare facility effectiveness.

2.18 Gaps identified in the literature.

2.18.1 Limited evidence on the effectiveness of community health facilities in Ghana

The review identified three studies that have evaluated community healthcare facilities in Ghana (Alhassan et al.2015), (Jehu-Appiah et al. 2014), (Nonvignon, 2017). However, they all focused on secondary and tertiary healthcare facilities, including district hospitals, highlighting literature gaps on the effectiveness of primary healthcare facilities in Ghana, specifically the Community-based Health Planning and Services (CHPS) facilities. This gap requires research attention because CHPS facilities are arguably the only service delivery centres for persons in underserved and rural communities in Ghana; therefore, their effectiveness is critical to addressing healthcare disparities and geographic healthcare inaccessibility in Ghana (Ganle, 2014). More importantly, they offer the crucial primary health intervention to sustain life in emergencies, and in the hierarchy of health service delivery in Ghana, they are usually the conduit for transitioning patients to secondary and tertiary facilities (Ayanore et al., 2023). Therefore, evaluating their effectiveness is critical to position the healthcare service delivery in Ghana to meet the United Nation's Sustainable Development Goal (SDG) 3. Accordingly, this thesis addressed this gap in the first empirical chapter to ensure a comprehensive capture of the effectiveness of Ghana's healthcare facilities.

Based on the literature analysis, it is recommended that the operating capacities of CHPS facilities be strengthened as a priority for practice. This entails upgrading infrastructure, guaranteeing there are enough medical supplies, and giving community health workers proper training. Furthermore, putting in place strong frameworks for monitoring and assessment can assist in tracking CHPS facilities' performance and pinpointing areas in need of improvement. Another practical implication is to include community feedback in the review process. By including local populations in the evaluation of CHPS facilities, important insights into their unique requirements and preferences can be gained, making healthcare services more accessible.

The effectiveness and reach of CHPS services can also be improved by utilising technology, such as telemedicine and mobile health apps. Improved health education, improved patient-provider communication, and remote consultations—particularly in rural locations—can all be facilitated by these technological treatments.

2.18.2 Limited evidence on the determinants related to the distribution or siting of healthcare facilities.

The evidence synthesis demonstrated that resource concerns are vital to the effectiveness of community healthcare facilities. While useful, these present broader determinants. As such, they do not provide granular evidence on factors that influence these resource concerns, particularly the allocation of the limited available resources, including the distribution and positioning of even healthcare facilities as a resource. Therefore, examining the determinants of healthcare facilities' positioning and distribution is essential to avoid the inequitable distribution of critical resources (Jehu-Appiah et al., 2014). More importantly, understanding the factors that determine how healthcare facilities are distributed and positioned is necessary to meet the WHO's requirements on healthcare facility position to prevent lopsided healthcare service and the consequences of uneven health service distribution (Wang et al., 2023). Meeting this requirement is particularly important for countries like Ghana, where socioeconomic and health inequality already exists (Jehu-Appiah et al., 2014;

Alegana et al., 2020). The reviewed literature showed scarce evidence on factors that could determine healthcare facilities' distribution and positioning in Ghana, and as argued earlier, given Ghana's socioeconomic inequalities, addressing this gap is essential to curtail its pervasive health inaccessibility concerns. Therefore, the second empirical chapter examined the determinants of community healthcare facilities to address the related literature gaps, stimulate conversations around Ghana meeting the WHO's requirements and contribute to mitigating health inequalities.

Understanding these variables is vital in fulfilling the World Health Organization's (WHO) mandate regarding healthcare facility placement, with the goal of halting inequitable healthcare service allocation and the consequent adverse outcomes. This prerequisite is especially important for nations like Ghana, where socioeconomic disparities and poor health are common. The analysis of the literature found little information about the variables influencing the location and distribution of healthcare facilities in Ghana. Closing this gap is essential to reducing widespread problems with health accessibility associated with the nation's socioeconomic inequality.

Examining the factors that influence the placement and distribution of healthcare facilities is thus essential for guaranteeing equitable access to medical treatment, especially in light of Ghana's current socioeconomic disparities. This thesis's second empirical chapter fills in the gaps in the literature by concentrating on these determinants. By doing this, it hopes to start a conversation about how Ghana might fulfil WHO guidelines and lessen health disparities. This analysis is crucial to enhancing the distribution of health services and guaranteeing that all areas—especially rural and underserved ones—have access to sufficient medical facilities.

2.18.3 Limited consideration of disease occurrences contexts in the location of healthcare facilities

As explained by location theorists, there must be a rationale for locating/establishing facilities in defined areas or settings (Ghosh, 2013). For example, businesses are typically located in areas with more economic activity to impact their delivery, optimal functioning, and profits. By extension, it is also essential for health facilities to be located in areas that require critical health service delivery to achieve its core mandate and again reduce the possibility of health inequalities. For example, it may be necessary to have healthcare facilities predominantly situated in areas with high disease occurrences to provide timely health interventions and enhance disease surveillance (Luz et al., 2012). Also, for countries like Ghana, with endemic diseases like malaria, a condition that contributes significantly to mortalities in children (Sicuri et al., 2013), it is prudent that primary healthcare facilities are located in areas with high incidences of malaria to enhance prevention and early management strategies. In evaluating the effectiveness of community healthcare facilities, none of the selected studies considered the importance of health facility location relative to disease occurrence points to assess how they could effectively mitigate and address these issues. As argued earlier, accounting for this gap in the literature is important to inform the strategic position of community healthcare facilities. Therefore, the third empirical chapter explored disease occurrence points in relation to CHPS facilities in Ghana to inform policies around future locations of CHPS facilities.

It makes sense to site basic healthcare facilities near high malaria occurrences in nations like Ghana, where endemic diseases like malaria considerably increase child mortality. By optimising prevention and early management techniques, this placement can improve health outcomes in the long run. Nevertheless, the significance of health facility location in relation to illness occurrence was not taken into account while evaluating the efficacy of community healthcare facilities in the chosen research. This gap indicates a serious weakness in the analysis of the potential mitigation and treatment of certain health risks by strategically positioned institutions.

2.18.4 Limited rigour in examining the influence of patients waiting time on the uptake of community healthcare facilities.

The literature review identified several factors, such as patient waiting time, distance, quality of service delivery and facility ownership, that could affect the effectiveness and consumption of community healthcare facilities. The studies thoroughly assessed these factors with robust approaches, except for the patient waiting time analyses (Rendalls et al., 2019). The analysis of that factor was conducted by only one study and was limited to a descriptive analysis of perceptions of waiting time on the uptake of community healthcare facilities. Therefore, while the findings were useful, they were limited in increasing our understanding of the magnitude and extent of the relationship between patient waiting time and consumption of community healthcare facilities. More specifically, they limit appreciation of the dose-response relationship of varying waiting time on the performance, output, and use of community healthcare facilities. The fourth empirical chapter, therefore, addressed this gap to provide evidence that could help optimise the efficiency of primary healthcare delivery.

The evidence could contribute to facilitating the formulation of policies on acceptable minimum waiting times to meet the patient's health needs while preventing burnout in healthcare workers.

This gap is particularly important because it makes it more difficult to create plans for improving the effectiveness of primary healthcare delivery. In order to create minimum acceptable waiting times regulations that satisfy patients' health demands without driving healthcare professionals into burnout, it is necessary that this issue be addressed.

2.19 Strengths and Limitations of the Review

The review explored the effectiveness of community healthcare facilities from a global perspective, increasing its findings' generalisation to broader contexts. However, it was limited by the methodological challenges of the included studies. For example, some studies used dated data (before 2010). Much has happened since 2010, notably regarding a country's socioeconomic and health development. Therefore, their results, and by extension, the findings of this review, should be taken only partially to reflect the current condition but rather to illustrate the potential usefulness of such efficiency analyses. In addition, the synthesised evidence is derived from observational designs without adjustment for confounders or consideration of interactions among factors. Hence, the review is limited in demonstrating causal relationships between factors associated with the effectiveness of community healthcare facilities. Further, the designs of the included studies varied considerably, preventing the presentation of findings as might be obtained through meta-analysis.

2.20 Conclusion

This literature review has demonstrated vital gaps in the evidence base on the effectiveness of CHPS compounds. Key among these gaps is the need for more complementary approaches to evaluate the effectiveness of CHPS compounds and the need to examine determinants of distribution of community healthcare facilities. As already stated, the subsequent empirical chapters of this thesis will address these gaps.

The distribution, placement, and allocation of resources all have a significant impact on how well community healthcare institutions function. Research has shown that there is a substantial knowledge vacuum regarding the allocation of resources and how it affects health outcomes. For CHPS facilities, which are the main healthcare providers in underprivileged areas, this is essential. In Ghana, CHPS compounds are critical in providing healthcare access to rural populations who often have limited options for medical care(Ghana Health Service, 2020). However, to better understand the CHPS initiative's value and limitations, it is necessary to investigate the determinants of its effectiveness, as well as the methods through which its impact has been assessed (Peters et al., 2008; Kruk & Freedman, 2008).

A systematic review approach was selected due to its structured and rigorous methodology, which minimises biases and provides a clearer synthesis of evidence than primary studies alone (Higgins & Green, 2011; Moher et al., 2009). Systematic reviews consolidate multiple research findings, allowing for a more comprehensive understanding of a research area (Liberati et al., 2009). From these studies, it is gleaned that the use of community healthcare facilities is influenced by a number of important factors, including patient waiting times, facility ownership, service delivery quality, and distance to facilities (Campbell & Graham, 2006; Peters et al., 2008). Unfortunately, little of the available study has been devoted to the effects of patient waiting periods and the positioning of health facilities relative to disease hotspots. This has limited our knowledge of how different waiting times and facility positioning affect the use of healthcare services. Closing this knowledge gap is crucial to creating rules that strike a balance between the demands of patients and the productivity of medical staff.

The importance for a fair allocation of healthcare resources to guarantee that all populations, especially those in underserved and rural areas, have access to critical health services is a recurrent subject in the literature found.

From a total of 3,200 studies initially identified, 39 studies were selected based on their relevance and alignment with the eligibility criteria. Notably, a large portion of relevant studies emerged from the United States and Australia, underscoring the global interest in community healthcare interventions, which present valuable insights for Ghana's CHPS initiative.

The studies examined covered a range of countries, with the majority stemming from high-income regions like the United States, where extensive data on community health models exists. In Africa, studies from Uganda and other sub-Saharan regions provide insights into low-resource settings that face similar challenges as Ghana. These studies focus on healthcare accessibility, workforce challenges, and patient education, all of which are highly relevant to the CHPS initiative.

Optimising the delivery of healthcare requires efficient resource allocation, which includes planning the locations of healthcare institutions and controlling patient wait times. It is possible to increase CHPS facilities' efficacy in delivering primary healthcare services by making sure they are well-resourced and positioned. Access to and results from health services are strongly impacted by socioeconomic differences. These differences must be taken into account in research and policy in order to create treatments that reduce health disparities and enhance the equity of the healthcare system as a whole.

Chapter 3: Framework For Empirical Analysis

3.1 Introduction

The aim of this thesis was to evaluate the effectiveness of community healthcare facilities in Ghana; a case of the CHPS compounds. The preceding chapter (Chapter 2) reviewed the current literature on primary and community healthcare facilities in sub-Saharan Africa and identified key gaps in literature to guide the empirical chapters in this study. The current chapter outlines the specific research questions to address each research gap from Chapter 2. After this, the chapter discussed the methodological approaches to explore the research questions and, by extension, the research gaps. Table 11 summarises the identified literature gaps, their related research questions, and the thesis chapter that addressed them. The following texts explain how each thesis chapter investigated the research gaps and questions in table 11.

Long wait times, insufficient resources, and operational inefficiencies still exist in the CHPS system despite major efforts and investments. The World Health Organisation has stated that ensuring healthy lives and fostering well-being for all ages is a sustainable development goal that must be addressed. This study aims to evaluate the efficacy of CHPS Compounds in order to pinpoint areas that require improvement and offer evidence-based suggestions that can guide Ghanaian healthcare policy and practice. Long wait times, insufficient resources, and operational inefficiencies still exist in the CHPS system despite major efforts and investments. Achieving the sustainable development aim of guaranteeing healthy lives and promoting well-being for all ages depends on addressing these concerns.

First and foremost, the goal of community healthcare institutions is to increase the accessibility of healthcare for those living in rural and underdeveloped areas. By assessing their performance, we can be sure that these facilities are doing their part to close the gap in health and advance fair access to healthcare. Second, efficient evaluation guarantees that the little resources are used effectively by pointing out areas that require the greatest attention. This may result in increased service delivery in CHPS compounds, better infrastructure, and more manpower. The subsequent subsections will detail the methodological approaches used to answer the research questions.

Table 11: Summary of Identified Literature gaps

Literature gap	Research questions	Thesis Chapter
Limited evidence on the effectiveness of community health facilities in Ghana	What is the level of operational effectiveness of CHPS compounds according to the outlined core mandates by the Ghana Health Service?	Chapter 4 – this was evaluated using interrupted time series analysis.
Limited evidence on the determinants related to the distribution or siting of healthcare facilities.	What are the determinants and key drivers associated with CHPS facilities location and positioning in Ghana?	Chapter 5 – this was investigated using GIS and regression models.
Limited consideration of disease occurrences contexts in the location of healthcare facilities	What is the relationship between CHPS compounds related factors and disease outbreak points in Ghana?	Chapter 6 - this was investigated using GIS and regression models.
Limited rigour in examining the influence of patients waiting time on the uptake of community healthcare facilities.	How can the CHPS compounds be improved to achieve their core mandates?	Chapter 7 – this was assessed using simulation models.

3.2 Justification of Research Questions

Each question addresses a crucial aspect of CHPS effectiveness and its alignment with the Ghana Health Service's goals for improving healthcare access and outcomes at the community level (Ghana Health Service, 2020; Peters et al., 2008). The first research question assesses how well CHPS compounds fulfil their fundamental objectives, which typically include providing accessible healthcare, reducing travel time for patients, and enhancing preventive and curative services at the community level (Campbell & Graham, 2006). Examining operational effectiveness against core mandates is essential for understanding the extent to which CHPS compounds deliver on their intended mission. This foundational question is valuable because it allows for a structured, mandate-focused assessment that captures both the strengths and areas for improvement within existing CHPS operations.

The second question inspires investigation into the factors that determine CHPS compound location helps to clarify why certain areas have more facilities than others. This inquiry is vital in Ghana where geographic and socioeconomic disparities affect healthcare access, particularly in underserved or remote communities (Guagliardo, 2004; Peters et al., 2008). This research question aims to reveal patterns that could improve the strategic positioning of CHPS facilities by identifying key drivers, such as population density, economic activity or proximity to disease-prone areas. This question justifies the importance of an equitable distribution model for CHPS facilities, in order for the CHPS initiative as a whole to approach a level of effectiveness.

The third question investigates the link between CHPS presence and disease prevalence, which is pivotal to evaluating the preventive and surveillance roles of these facilities. This question is designed to explore whether CHPS compounds help reduce the frequency or spread of disease outbreaks by providing timely, community-level interventions (Tatem et al., 2012). Analysing this relationship can highlight how CHPS facilities contribute to disease control and identify any potential gaps in coverage that may leave certain areas vulnerable to outbreaks. Such insights could guide enhancements in healthcare infrastructure aimed at reducing disease risk through improved CHPS interventions.

Lastly, the final question is oriented toward solution-building and policy recommendations. This question seeks to bridge any identified gaps between current performance and core mandate fulfilment by exploring ways to strengthen CHPS operations. This question supports the practical goal of the study, as it translates research findings into actionable strategies for better healthcare delivery at the community level (Kruk & Freedman, 2008).

3.3 Methodological Approaches

The methodological approaches used to investigate the fundamental research questions underlying this study are detailed in this chapter. They will introduce the health framework used in the overarching analysis and evaluate each research question as a gap in this subsection.

3.3.1 Gap 1: Limited evidence on the effectiveness of community health facilities in Ghana

The research questions for this identified gap in literature were answered using secondary data. The data was sourced from Ghana's health service and supplemented by the Geocoded Community-based Management of Severe Acute Malnutrition (CMAM) database. These databases, containing relevant pre-and-post CHPS intervention data from 2012 to 2019, provide an overview of healthcare delivery metrics, including patient service numbers, health professional staffing levels, and the outcomes of interest. These databases were also chosen because they were comprehensive and longitudinal, two qualities that are crucial for assessing the efficacy of CHPS interventions over time. These datasets were useful for evaluating changes linked to CHPS interventions because they provided comprehensive records of healthcare delivery and outcomes. The use of these reputable databases is consistent with the data collection techniques applied in earlier studies that have been reviewed in the literature, guaranteeing coherence and comparability with current research.

The use of secondary data to address this gap identified from the literature was also consistent with the data collection of the papers reviewed in the literature review section of this thesis. Concerning data analyses, the statistical estimators were informed by the literature review and the dependent variables in the research questions informed the data analysis techniques. STATA 17 SE was used to analyse the data.

The first steps in the analysis were to create frequency distributions, mean, median, standard deviation, and other descriptive statistics to provide an overview of the data. This stage helped find any anomalies or missing data points in the dataset and gave a basic grasp of its properties.

The effectiveness of CHPS methods was then assessed using a Difference-in-Differences (DiD) approach because pre- and post-intervention data were available. With this strategy, confounding factors that do not vary over time are successfully controlled for by comparing changes in outcomes over time between groups exposed to the intervention and those not exposed. DiD's resilience in causal inference—especially in quasi-experimental settings where randomised control trials are impractical—justified its adoption.

PSM was used in conjunction with DiD to generate matched samples of the intervention and control groups with comparable baseline characteristics in order to mitigate any potential selection bias. By improving group comparability, this method reinforces the causal interpretation of the data. The DiD method makes the assumption that the treatment and control groups would have gradually followed similar trajectories in the absence of the intervention. The estimated treatment impact could be skewed if this assumption is broken.

Regression models that were fitted to investigate this gap were predicated on assumptions of accurate specification, which included the lack of multicollinearity and linearity. Although diagnostic tests were performed to verify these hypotheses, any infractions might still have an impact on the outcomes. DiD, regression analysis, and PSM together provided a sophisticated understanding of the interventions' effects. Together, they took potential biases and confounding variables into consideration. Although DiD and PSM bolster the causal arguments, the possibility of unidentified confounding variables skewing the results is still there. Since the findings are context-specific, it's possible that they can't be applied to other contexts with dissimilar healthcare systems and starting points.

3.3.1.1 Data Envelopment Analysis Framework

There has been a proliferation of several relevant frameworks to provide a contextual explanation for factors associated with evaluation of primary healthcare facilities in the previous centuries.

In the literature two principal approaches are used to measure efficiency of firms (including health facilities) namely: Data Envelopment Analysis Model (DEA) and stochastic frontiers (Coelli et al., 1996). The DEA model approach is used to benchmark performance and the relative efficiency of each production unit among a set of fairly homogeneous Decision-Making Units (DMUs), such as clinics and health centres that use similar inputs to produce service outputs. DMUs deemed optimally efficient among their peers (based on available inputs and outputs) are assigned an efficiency score of 1.0 which is equivalent to 100 % in percentage terms. A health facility is described as fully efficient among its peers when it attains an efficiency score of 1.0 and completely inefficient when it attains an efficiency score of 0.0 (equivalent to 0 % in percentage terms). It must be emphasised that facilities estimated as optimally efficient among peers might not necessarily be efficient in absolute terms. There is therefore the need to interpret results of the DEA in the context of relative efficiency of facilities under assessment. Measurement of efficiency can be technical or allocative and the orientation can be input-orientated or output-orientated.

In a study published in 2017, researchers used DEA to evaluate the effectiveness of primary healthcare interventions in rural areas of Ghana (Mensah, 2018). The study found that interventions that focused on community involvement and education were more effective than those that relied solely on clinical interventions and that factors such as availability of medical supplies and staffing levels were crucial determinants of success.

The Data Envelopment Analysis (DEA) model generally provides a theoretical framework for evaluating primary healthcare facilities’ efficiency and effectiveness, which serves as an underlying theory of change within the context of healthcare (Charnes, Cooper & Rhodes, 1978; Ozcan , 2008). By focusing on efficiency as a key indicator, DEA offers a structured means to identify which facilities or interventions use resources most effectively to achieve desired health outcomes. The theory behind DEA provides a systematic approach to analyse how well healthcare facilities transform inputs (like staff, supplies and infrastructure) into outputs (such as patient consultations, treatments and health education efforts) (Charnes et al., 1978).

DEA allows healthcare stakeholders to visualise and assess the transformation process—how resources at the input level directly affect healthcare outputs. For example, in primary healthcare settings in Ghana, as Mensah's study (2018) showed, facilities that incorporate community involvement and educational activities tend to be more effective, demonstrating that a holistic use of inputs can lead to better health outcomes. DEA, in this way, promotes the idea that by understanding and optimising resource use, healthcare facilities can drive positive patient outcomes, indicating that it can be consistently applied as an underlying principle of a theory of change (Ozcan, 2008). Thus, in this study, while the DEA model does not directly constitute a theory, it functions as a structured model for testing theories on healthcare efficiency and resource optimization that emerge from qualitative research.

One potential challenge of using DEA in the context of primary healthcare interventions in Ghana is data availability and quality (Emrouznejad & Yang, 2011; Worthington & Dollery, 2001). In some cases, data on key inputs and outputs may need to be completed or reliable, making it difficult to conduct a meaningful analysis. However, efforts to improve data collection and analysis are underway in many countries, including Ghana, and using DEA may help identify areas where further improvements are needed.

In conclusion, using Data Envelopment Analysis as a conceptual framework for evaluating a primary healthcare intervention in Ghana can provide a valuable tool for assessing the effectiveness of the intervention and identifying areas for improvement. By taking into account multiple inputs and outputs and providing a comparative analysis of different interventions, DEA can help healthcare providers allocate resources more effectively and improve overall healthcare outcomes. While there are some challenges to using DEA in this context, the method has been successfully applied in various healthcare settings worldwide, including Ghana. It can potentially be a powerful tool for improving healthcare delivery and outcomes.

3.3.2 Gap 2: Limited evidence on the determinants related to the distribution or siting of healthcare facilities.

This gap in the literature was addressed by providing data on the determinants/drivers of CHPS compound location within Ghanaian districts to understand whether they are within the Ghana Health Service recommended guidelines of 8km (Ghana Health Service, 2014). The data sources and the method for analysing the data are presented below. The data set used in this chapter's analyses was obtained from the Ghana Health Service as part of a larger dataset for future analysis. Geospatial Information Systems (GIS) data collection was a core part of this chapter's assessment; the goal was to highlight each community's assets and health needs. GIS data collection was essential to this study because it filled in a knowledge vacuum about the factors that influence healthcare facility siting by offering insights into the resources and health needs of each town.

Due to resolution limitations of remote sensing technology, GPS data collecting issues, or outdated mapping, geospatial data may have errors. In-depth data cleaning procedures were developed to find and fix mistakes, fill in missing information, and guarantee consistency between datasets. To guarantee consistency in reporting and measurement, the variables were standardised. Advanced analytical approaches and various verification stages improved the accuracy of geospatial data.

Throughout, it was assumed that the GIS data accurately reflected the actual locations of CHPS compounds and community centres. However, potential geocoding errors may have impacted the precision of the analysis. The regression models were built on key assumptions, including linearity for continuous variables and appropriate categorization for categorical ones, which were thoroughly checked using diagnostic tests to address issues such as multicollinearity. Despite imputation for missing values, it was acknowledged that data gaps could still skew results. Therefore, caution must be applied in interpreting the findings and extrapolation to contexts outside Ghana even if similarly situated economically, geographically or politically.

The analyses were conducted in two main stages. In order to confirm the accuracy of the created GIS dataset and characterise the attributes of the variables, the initial step of the process required a descriptive analysis of the data. To summarise the data, descriptive statistics were computed, including mean, median, standard deviation, and frequency distributions. Before moving on to further in-depth investigations, this assisted in locating any anomalies or inconsistencies in the dataset that needed attention.

Second, regression models were fitted to investigate associations between the dependent and independent variables. STATA 17 SE was used for the data analysis.

To separate the impacts of each variable on the siting of CHPS compounds and account for relevant confounders, multiple regression models were used. The link between continuous independent variables and the separation between CHPS compounds and community centres was investigated using this model. It made it easier to measure how socioeconomic status and population density affected the location of facilities. Logistic regression was used for categorical outcomes, such as whether a CHPS compound is within the 8km guideline. Based on a number of variables, this model assisted in estimating the probability that CHPS compounds will meet the siting requirements.

It was considered that the locations of the CHPS compounds and community centres were accurately reflected by the GIS data. However, any geocoding mistakes could have an impact on the analysis. For continuous variables, linearity, and proper categorization for categorical variables, the regression models assumed accurate specification. Although multicollinearity and other possible problems were checked thoroughly with diagnostic tests, any infractions could affect the outcome. The information was thought to be comprehensive and representative of all CHPS compounds in Ghana. As such the results could be skewed by missing data and that is factored into any conclusions even though imputations were done to fill in missing data.

3.3.3 Gap 3: Limited consideration of disease occurrences contexts in the location of healthcare facilities

After evaluating the effectiveness of the CHPS compounds and the determinants/drivers related to the siting of healthcare facilities, the study addressed the gap regarding the limited consideration of disease occurrences contexts in the location of healthcare facilities. The rationale for addressing this gap was to explore the complexities of the positioning of CHPS facilities, which requires a holistic approach to critically understand the arguments associated to the positioning of CHPS facilities. The data for the analysis was obtained from the Ghana Health Service, as discussed in the previous chapter (Chapter 5). Geospatial data from the Ghana Health Service was used for this investigation as it was especially well-suited for the analysis. This is because it was necessary to understand the spatial distribution of CHPS facilities in connection to disease incidences. In order to ensure accuracy in the geographic information on the locations of CHPS facilities and illness occurrence points, the GIS data was carefully cleaned, processed and categorised for use as dependent variables.

The data was then analysed using the Poisson family of the Generalised Linear model (GLM), which was fitted to investigate the key determinants of distance to disease outbreaks from a district among 216 districts. The rationale for this analysis was because the dependent variable was a count variable with a skewed distribution (Sellers et al. 2010). The assumptions for GLM, such as correct distribution of residuals and correct specification of variance structure were checked before fitting the Poisson model (Sellers et al. 2010). The Poisson model was also based on the premise that the dependent variable's variance was equal to its mean, which was also verified and validated throughout the investigation. Finally, all the independent variables were included in the model to unmask actual determinants of disease outbreak distance from a district. STATA SE/17.0 was used for the data analysis.

The accuracy and completeness of the GIS data and other demographic information was presumed. Errors in the data may thus cause bias in the outcomes. Additionally, although the findings are insightful for Ghana, it's possible that they won't apply as well in other situations where the healthcare systems and patterns of disease prevalence differ.

The study addressed a critical gap in the literature by exploring the limited consideration of disease occurrence contexts in the siting of healthcare facilities, specifically CHPS compounds. This gap was significant, as understanding the spatial distribution of disease outbreaks and their proximity to healthcare services is crucial for optimizing the positioning of healthcare resources. The rationale for investigating this gap was to provide a comprehensive, holistic approach to the placement of CHPS facilities, recognizing that the positioning decisions must not only account for general access and demographic factors but also for patterns of disease occurrences. In this regard, the study aimed to critically evaluate the geographical placement of CHPS compounds, considering how their proximity to disease outbreak points might impact the effectiveness of healthcare delivery.

To address this, the study utilized geospatial data from the Ghana Health Service, as discussed in Chapter 5, which proved to be a particularly apt choice for this analysis. The use of GIS data was essential, as it provided precise information about the locations of CHPS compounds and the points of disease outbreaks, allowing for an in-depth understanding of how healthcare facilities' positioning influences their responsiveness to public health threats. This geographic data was rigorously cleaned, processed, and categorized to ensure its suitability for analysis as dependent variables, ensuring that disease incidences and CHPS locations were accurately mapped and ready for further exploration.

The analysis was conducted using the Poisson family of the Generalized Linear Model (GLM), a method selected for its ability to handle count data with a skewed distribution, as described by Sellers et al. (2010). The Poisson model is particularly appropriate for this type of analysis because it accounts for the nature of the dependent variable—disease outbreak occurrences—by assuming that the variance of the dependent variable is equal to its mean. This assumption was thoroughly verified during the data analysis process, and the correctness of residual distributions and variance structures was checked to ensure the robustness of the model. The decision to include all independent variables in the GLM model allowed for a comprehensive understanding of the factors influencing the distance between disease outbreaks and the CHPS compounds. By doing so, the study aimed to isolate and identify the most significant determinants that shape the spatial relationship between healthcare facilities and disease outbreaks.

The analysis was conducted using STATA SE/17.0, a widely respected statistical software that provided the tools necessary for implementing the Poisson GLM and ensuring rigorous checks for model accuracy. Throughout the study, it was assumed that the GIS data and demographic information were accurate and complete, though the potential for errors in these datasets was acknowledged. Such errors could potentially introduce biases that would affect the conclusions drawn from the analysis, which was a limitation of the study that was carefully considered in the interpretation of the results.

While the findings from this study provide valuable insights into the effectiveness of CHPS compound positioning in Ghana, it was also recognized that the results may not be universally applicable. The healthcare systems and disease prevalence patterns in other countries or regions may differ significantly from those in Ghana, meaning that the conclusions drawn from this study might not directly translate to different contexts. This limitation is an important consideration for any future attempts to apply these findings beyond Ghana's borders.

3.3.4 Gap 4: Limited rigour in examining the influence of patients waiting time on the uptake of community healthcare facilities.

Chapter 4 of the thesis evaluated the effectiveness of the CHPS compounds since its inception, the next two chapters (Chapters 5 & 6) then examined the positioning of CHPS compounds and the various determinants that influence them. The final chapter sought to explore the influence of patient waiting times on the uptake of the CHPS compounds. The ultimate goal is to contribute empirical data that could guide the ongoing discussions on the operation of the CHPS program and further have implications for the policy's sustenance and improvements in Ghana. This is all in an attempt to align with the Sustainable Development Goal (SDG) 3.8's universal health coverage goal (WHO, 2016).

The data used for the analysis in the chapter stemmed from the larger dataset obtained from the Ghana Health Service. The dataset comprised the clock in times of health personnel allocated to a CHPS facility, their rank and job titles, as well as the duration of their shifts. The data was then analysed by importing it into Arena Simulation V16.1, a Discrete Event Simulation model was then built to replicate the real-world scenario. The selection of a DES model was justified because of its ability to accurately replicate intricate healthcare processes and yield valuable insights. DES is a great tool for researching how waiting times affect service uptake since it works especially well in situations where patient flow and resource allocation are important factors.

After being loaded into Arena Simulation V16.1, the dataset underwent cleaning and modelling preparation. This involved checking that all pertinent data points were included and confirming the accuracy of clock-in times and shift durations. To mimic the CHPS facilities' actual activities, a preliminary DES model was built. Multiple models were then built after that and ran on the real-world scenario and continuously modified using the findings from the initial run to improve the model efficiency.

The analysis and simulation however were subject to a few assumptions. It was assumed that the documented clock-in times and shift lengths correctly reflected the real work schedules of the medical staff. It is crucial that the shift lengths and clock-in times were complete and accurate. The outcomes of the simulation could be impacted by any insufficient reporting of important parameters, mistakes in data entry, and missing data. Also, it was assumed that the reporting and clocking-in practices were uniform across all facilities. As such, inconsistencies may be introduced by differences in the ways that data were recorded and reported amongst facilities. Variations in the procedures and training of data entry staff may have an impact on how reliable the recorded information is.

There are some limitations to the applicability of the simulation, however. The data only covers the years 2012 through 2019, therefore it may not reflect more current trends or changes in CHPS operations and healthcare provision in Ghana. Also, although the results offer insightful information about the CHPS compounds in Ghana, it's possible that other healthcare environments with distinct operational dynamics won't be able to immediately benefit from the findings.

The results of this analysis nonetheless have important ramifications for CHPS programme strategy and implementation. Policymakers can devise tactics to optimise staff schedules and patient flow thereby decreasing waiting times and enhancing service delivery. This has the potential to improve patient happiness, boost CHPS facility utilisation, and help Ghana attain universal health coverage.

The final subsection draws on the current chapter to provide useful highlights on the methodologies adopted to answer the research questions.

3.4 Conclusion

This chapter outlined the methodological approaches to address the research questions for the literature gaps identified in Chapter 2. The next chapter, Chapter 4, examined the first literature gap, i.e., the limited evidence on the effectiveness of community health facilities in Ghana.

The first significant research gap addressed in this chapter pertains to evaluating CHPS facilities' operational effectiveness since their inception. This examined the degree to which CHPS compounds fulfil their primary functions and meet the healthcare needs of their communities (Ghana Health Service, 2020; Peters et al., 2008). In response to this gap, the analysis provided a baseline for understanding how effectively CHPS facilities are performing their roles and where improvements might be needed to maximize their impact. Current literature, while robust on secondary and tertiary healthcare facilities, lacks sufficient examination of primary healthcare facilities like CHPS in relation to their geographic distribution and resource allocation. This gap is crucial given the inequitable healthcare access in Ghana, particularly in rural and underserved areas (Guagliardo, 2004; Marmot, 2005).

The second research question, examining the effectiveness of the CHPS initiative's implementation strategies on health service delivery, is rooted in the findings of the first research question-limited evidence regarding primary healthcare delivery effectiveness in Ghana. While a few studies have assessed general healthcare service effectiveness, they do not focus on primary facilities like CHPS (Kruk & Freedman, 2008). Investigating implementation strategies of CHPS provides insight into how well CHPS facilities fulfil their mandate and address healthcare accessibility gaps in support of Ghana's progress toward SDG 3, which seeks to ensure healthy lives and promote well-being for all. Following this, Chapters Five and Six addresses the gap in literature concerning the determinants influencing the positioning of CHPS facilities and the drivers of siting decisions. Using geospatial analysis, the study reveals how the distance of CHPS facilities from communities relates to healthcare accessibility. This analysis is essential, as it unveils the complexities involved in CHPS facility siting—factors that extend beyond logistical considerations to include socioeconomic and demographic variables (Tatem et al., 2012). Through this, the thesis contributes to a more nuanced understanding of how CHPS placement can either enhance or hinder access to healthcare, emphasising the importance of adhering to Ghana Health Service's recommended proximity guidelines (Ghana Health Service, 2020).

The third research question evaluates the operational effectiveness of CHPS compounds based on their core mandates. It aims to measure how well CHPS compounds function against their defined roles and how effectively they meet the urgent health needs of the populations they serve. Given the criticality of CHPS as a link to higher-level health services, understanding their operational effectiveness is key to sustaining a reliable healthcare system that can support timely interventions, particularly in high-disease-incidence areas (Campbell & Graham, 2006). Employing GIS data to analyse the relationship between facility location and disease occurrences, the study provides insights into the spatial dynamics between CHPS facilities and community health needs. This analysis highlights that the placement of CHPS compounds must not only meet proximity guidelines but also be informed by disease prevalence patterns to improve preventative care and rapid response capabilities (Tatem et al., 2012). It highlights how situating CHPS facilities closer to high-need areas, could potentially enhance CHPS's capacity to address localized health challenges effectively.

Finally, the fourth question probes how the operational efficiency of CHPS compounds could be enhanced to meet their core mandates more effectively through designing policies that optimise efficiency and reduce patient wait times. Using Discrete Event Simulation (DES) to model the real-world scenarios of patient flows, the study illustrates how patient wait times correlate with facility utilization (Law, 2015). Other factors such as staffing schedules and resource allocation provides actionable insights for reducing service delays. This study seeks to contribute meaningful policy implications centred around improving effectiveness of CHPS facilities by potentially informing guidelines on acceptable waiting times and resource allocation to ensure that CHPS compounds can fully serve Ghana's healthcare needs without compromising quality (Kruk & Freedman, 2008).

Together, these analyses comprehensively address key dimensions of the CHPS program that are essential for evaluating and enhancing its effectiveness. This knowledge is invaluable for policymakers and practitioners seeking to strengthen the CHPS program, suggesting practical pathways to improve facility siting, operational efficiency, and service accessibility. In so doing, the findings contribute directly to the broader goal of achieving universal health coverage in Ghana, laying a foundation for sustained improvements in community health and well-being.

Chapter 4: Effectiveness Of CHPS Compounds in Ghana: An Interrupted Time Series Analysis.

4.1 Introduction

The previous chapters highlighted the critical knowledge gaps on the effectiveness of community healthcare facilities (Chapter 2) and argued the robust methodological approaches to address the highlighted gaps (Chapter 3). This Chapter operationalised one of the methodological approaches in Chapter 3, i.e., the quasi-experimental design, to evaluate the effectiveness of community healthcare facilities, i.e., CHPS compounds, in Ghana. As discussed in Chapter 1, CHPS is a flagship program by Ghana to provide primary healthcare services to underserved populations in remote/rural communities in Ghana (Elsey et al., 2023). The overarching objective of this program is to address healthcare disparities between rural and urban communities in Ghana by ensuring the availability and accessibility of primary healthcare services in rural Ghana (Agyepong et al., 2012; Agyepong & Kodua, 2012).

However, as demonstrated in Chapter 2, the program's effectiveness has been scantily explored since its inception to ascertain whether it is meeting its core objectives. This scarcity, resulting in the lack of relevant data, possibly accounts for the ongoing debates regarding the program's efficacy in addressing healthcare disparities in Ghana (Addi et al., 2022; Assan et al., 2018).

4.1.1 Brief Literature Review on the Effectiveness of CHPS in Ghana

4.1.1.1 Introduction

Ghana's Community-based Health Planning and Services (CHPS) initiative represents a significant policy effort to decentralise primary healthcare and address health disparities between urban and rural areas. Launched in the late 1990s, CHPS aims to bring essential health services closer to underserved populations by deploying trained community health officers (CHOs) to live and work within rural communities (Nyonator et al., 2005). This literature review assesses the effectiveness of CHPS compounds, focusing on empirical evidence derived from various methodological approaches, including the interrupted time series (ITS) analysis, to determine the program's impact on health outcomes in Ghana.

4.1.1.2 Early Evaluations on CHPS Effectiveness

Early studies on the CHPS initiative indicated promising outcomes in enhancing healthcare access and improving health indicators. The Navrongo Experiment, a pilot for CHPS, demonstrated significant improvements in child immunisation rates and antenatal care coverage (Phillips et al., 2006). Similarly, Awoonor-Williams et al. (2013) reported reductions in maternal and child mortality rates in CHPS zones, attributing these improvements to the increased accessibility of healthcare services facilitated by the program.

4.1.1.3 Challenges and Mixed Outcomes

Despite these positive early results, subsequent research has highlighted challenges that have impeded the program's widespread success. Agyepong et al. (2012) identified issues such as inconsistent funding, inadequate infrastructure, and variable levels of community engagement as significant barriers to effective implementation. The variability in CHPS outcomes across different regions suggests that local context and implementation fidelity play crucial roles in determining the program's success (Agyepong & Kodua, 2012).

4.1.2 Methodological Approaches

4.1.2.1 Cross-Sectional and Observational Studies

Many initial Community-based Health Planning and Services (CHPS) program evaluations utilised cross-sectional and observational study designs. These methodologies provided critical early insights into the program’s impact and helped establish a foundation for understanding the relationship between CHPS implementation and health outcomes in rural Ghana. Cross-sectional studies, which involve analysing data from a population at a specific point in time, were instrumental in identifying immediate associations between CHPS presence and health indicators such as immunisation rates, antenatal care attendance, and maternal health outcomes. For example, studies by Nyonator et al. (2005) and Phillips et al. (2006) documented improvements in child health services and reproductive health in areas where CHPS was operational. These studies reported higher immunisation coverage and increased usage of antenatal services compared to non-CHPS areas, suggesting a positive impact of the program.

Observational studies further contributed to understanding the program by tracking health outcomes over a period without manipulating variables. Awoonor-Williams et al. (2013) provided evidence of reduced maternal and child mortality rates in CHPS zones, attributing these improvements to enhanced healthcare accessibility and utilisation. Similarly, Agyepong et al. (2012) highlighted improvements in maternal and child health outcomes in regions with active CHPS implementation. However, while these cross-sectional and observational studies were valuable in highlighting potential benefits, they were inherently limited in establishing causality. As Elsey et al. (2023) pointed out, these designs could demonstrate associations but were insufficient to definitively attribute changes in health outcomes directly to the CHPS intervention due to potential confounding variables and lack of temporal sequencing.

4.1.2.2 Interrupted Time Series (ITS) Analysis

In contrast to cross-sectional and observational designs, the Interrupted Time Series (ITS) analysis offers a more robust methodological approach for evaluating the impact of public health interventions like CHPS. ITS is a quasi-experimental design that assesses longitudinal data to identify outcome changes following an intervention, controlling for pre-existing trends and other confounding factors (Bernal et al., 2017). ITS analysis involves collecting data at multiple time points before and after the implementation of the intervention. This method helps isolate the intervention's effect from other external influences by examining the 'interruption' caused by the intervention in the existing trend of the outcome variable. ITS can provide stronger causal inferences about the intervention's effectiveness by comparing the pre- and post-intervention periods.

For example, Addi et al. (2022) used ITS analysis to evaluate the impact of CHPS on under-five mortality rates in Ghana. Their study revealed a significant decline in mortality rates following the introduction of CHPS, indicating that the program likely contributed to improved child survival rates. The strength of ITS lies in its ability to control for time-related confounding variables, such as seasonal variations and underlying health trends, thus offering more reliable evidence of the program’s impact. Similarly, Assan et al. (2018) employed ITS analysis to assess changes in maternal health outcomes, including skilled birth attendance rates and pre- and post-CHPS implementation. Their findings indicated a notable increase in skilled birth attendance in CHPS zones, further supporting the program's effectiveness in enhancing maternal healthcare services. By controlling for pre-intervention trends and examining the data over an extended period, ITS analysis addresses many of the limitations inherent in cross-sectional and observational studies. This methodological rigour makes it a preferred approach for evaluating health interventions' long-term impacts and causal effects like CHPS.

In this study, the interrupted time series (ITS) analysis was carefully employed to investigate the outcomes associated with the core healthcare goals of CHPS facilities in Ghana. By focusing on specific key performance indicators (KPIs) such as the number of maternal deliveries, Outpatient Department (OPD) attendance, Family Planning (FP) visits, and Antenatal Care (ANC) visits, ITS provided a structured, time-based approach to assess the operational effectiveness of CHPS compounds (Wagner, Soumerai, Zhang & Ross-Degnan, 2022; Bernal, Cummins & Gasparrini, 2017). These indicators are central to the CHPS mission, as they directly reflect the service delivery and health outcomes prioritized by the Ghana Health Service (Ghana Health Service, 2014).

The ITS approach was well-suited to capture the shifts in these KPIs because of its capacity to detect changes over time, which may occur gradually or immediately following health system interventions or policy changes (Penfold & Zhang, 2013). In this context, ITS allowed for examining whether the delivery of maternal and child healthcare services at CHPS facilities improved over time especially as these services are essential to promoting health equity in underserved communities. By comparing KPI trends before and after specific interventions or operational adjustments, ITS provides a robust framework to detect patterns of change that might suggest improvements in the quality, accessibility, or reach of healthcare services at CHPS facilities.

One of the primary characteristics that makes ITS analysis especially effective in this study is its ability to analyse longitudinal data and track trends across different time points. With multiple data points collected over a period of time, ITS can reveal whether any observed changes are part of an ongoing trend, or a significant shift tied to specific interventions. For example, in the case of maternal deliveries, ITS allows researchers to track if there was a sustained increase in deliveries following the implementation of CHPS-specific programs focused on maternal care (Bernal et al., 2017).

Another essential feature of ITS that makes it ideal for analysing CHPS performance is its capacity to isolate the effect of the intervention from other underlying trends. In remote regions with dynamic healthcare demands, changes in service usage may occur due to various unrelated factors, such as seasonal population changes or economic shifts. By establishing a clear "interruption" point ITS separates the effect of that change from other variables. This characteristic is critical in a setting like Ghana's, where external factors often influence healthcare utilization. For instance, if a new outreach initiative was launched to promote family planning services at CHPS facilities, ITS analysis could reveal whether this initiative directly correlated with an increase in FP visits, or if any uptick was merely part of a pre-existing trend (Wagner et al., 2002).

Moreover, ITS not only evaluates immediate changes post-intervention but also assesses long-term trends, making it the appropriate tool for understanding the sustained impact of CHPS interventions. By focusing on ANC visits, ITS can reveal not only immediate increases following a new ANC-focused program but also if these gains were maintained over time, indicating the program's lasting effectiveness. This long-term perspective is particularly valuable in the context of CHPS facilities, where a sustained increase in ANC visits may correlate with broader improvements in maternal health outcomes (Penfold & Zhang, 2013). In addition, ITS analysis accommodates complex, non-linear trends that may emerge from interventions. In rural and underserved settings, CHPS facilities may implement gradual, resource-driven changes such as gradually increased staffing, expanded clinic hours, or enhanced community education programs. These changes do not always yield immediate, linear increases but may contribute to gradual, compounding growth in indicators like OPD attendance. ITS enables the analysis to capture these nuances.

The choice of ITS analysis is further justified by its flexibility in handling varying baseline trends across the different KPIs studied for this thesis. Given that each indicator—such as OPD attendance, maternal deliveries, FP visits, and ANC visits—responds uniquely to interventions and local health conditions, ITS accommodates such variability in baseline trends and detects different intervention effects across these service areas. In the case of FP visits, for instance, an ITS model could reveal a more gradual upward trend if community awareness efforts had to overcome cultural barriers, whereas maternal deliveries might show a more immediate effect if services such as obstetric services were expanded.

4.1.3 Recent Findings from ITS Analyses

Recent studies utilising ITS analysis have provided more compelling evidence regarding the effectiveness of CHPS. Addi et al. (2022) conducted an ITS analysis on under-five mortality rates. They found a significant decline associated with the implementation of CHPS, indicating the program's potential in reducing child mortality. Similarly, research by Assan et al. (2018)

demonstrated improvements in maternal health outcomes, including increased rates of skilled birth attendance, following the introduction of CHPS.

The evidence from recent ITS analyses underscore the importance of sustained and adequately resourced CHPS interventions. To enhance the effectiveness of CHPS, policymakers should focus on addressing the identified challenges, such as improving funding mechanisms, strengthening health infrastructure, and fostering community participation (Agyepong & Kodua, 2012). Additionally, ongoing monitoring and evaluation using rigorous methodologies like ITS are crucial for adapting and refining the program to ensure it meets its objectives of reducing health disparities and improving primary healthcare access in rural Ghana (WHO, 2016).

The CHPS initiative holds significant promise for improving health outcomes in rural Ghana. While early studies and recent ITS analyses provide evidence of the program's positive impact, challenges must be addressed to realise its potential fully. Continued investment in and evaluation of CHPS are essential to ensure its alignment with Ghana's health policy goals and the broader objective of achieving universal health coverage as outlined in Sustainable Development Goal 3.8 (WHO, 2016).

Ensuring the availability and accessibility of primary healthcare services in rural Ghana is the program's main goal, which aims to alleviate healthcare inequities between Ghanaian rural and urban areas (Agyepong et al., 2012; Agyepong & Kodua, 2012). This chapter aims to provide empirical data that could inform ongoing discussions about the efficacy of the CHPS programme and have implications for the continuation and enhancement of the policy in

Ghana. This assessment will pay particular attention to important outcomes such service utilisation rates, healthcare accessibility, and patient health outcomes.

Evaluating these results is essential to knowing if CHPS compounds are successfully addressing underprivileged people' healthcare requirements, lowering healthcare inequities, and enhancing health indicators in rural locations. The evaluation seeks to offer a thorough appraisal of the influence and efficacy of the CHPS programme by concentrating on these particular results.

Cohort studies, quasi-experimental designs, and Randomised Controlled Trials (RCTs) are a few of the methodological techniques used in public health research to examine the effectiveness of health interventions (Handley et al., 2018).

4.2 Methods

This chapter used the quasi-experimental design to assess the efficacy of CHPS compound interventions in Ghana. This is to its competitive advantage of providing a more robust estimation of the intervention's influence on defined outcomes compared to observational designs, given their increased tendency to account for potential confounders. (Kontopantelis et al., 2015).

The choice to use a quasi-experimental technique, which enabled the accounting of counterfactuals in evaluating the effectiveness of the CHPS intervention, was guided by the availability of comparable data. Randomised controlled trials (RCTs) were not relevant in this chapter because randomization was impractical for the evaluation's setting, given the impracticality and unethical nature of arbitrarily assigning intervention and control groups for the purposes of this study. It is however acknowledged that RCTs offer similar benefits and may have been a more rigorous option given their robustness in accordance with the evidence hierarchy order established by previous studies. (Kontopantelis et al., 2015).

For example, because the CHPS intervention was not originally intended for evaluation study reasons and its selection and implementation were influenced by real-life factors, it was not practical to consider randomly assigning communities to "intervention" and "control" groups. More significantly, denying a control group access to potentially helpful services would have been immoral. The Interrupted Time Series Analysis (ITSA), one of the quasi-experimental methods, was used in this investigation because of its capacity to evaluate the effects of treatments over time while taking shifting trends into consideration (Hategeka et al., 2020).

This chapter's use of longitudinal data to evaluate pre- and post-CHPS intervention outcomes in individual communities made this very crucial. By using the longitudinal data, the researcher was able to investigate whether and how certain outcome variables were affected by evolving patterns over time, both before and after CHPS interventions, and how the CHPS intervention responded to those trends (Bryman, 2016). Empirically, given their inflexibility to time-dependent changes, one-time point data, such as cross-sectional data, could not have been used to obtain this benefit (Bryman, 2016). This study did not experience attrition, despite the fact that longitudinal data research is typically associated with significant time and financial expenses. This was because the study used retrospective longitudinal data from the Ghana Health Service (GHS) database. (Abbott et al., 2016; Ruspini, 2003)

This application was critical since this chapter used longitudinal data to assess the outcomes of the CHPS intervention before and after it was implemented in certain communities. The researcher, by utilising the longitudinal data, was able to examine whether and how changing patterns over time, both before and after CHPS treatments, affected certain outcome variables, and how the CHPS intervention responded to those trends. (Bryman, 2016).

Because of the way the CHPS intervention was implemented, other quasi-experimental approaches, such controlled before-and-after trials, were judged unsuitable for this study. It is usually necessary to clearly distinguish between the intervention and control groups in controlled before-and-after investigations. As previously pointed out, the distinguishing between intervention and control groups are not practical in the context of healthcare access studies. Nevertheless, the CHPS intervention was simultaneously deployed across the country among the demographics of interest in this study. Therefore, there was no way to have a control group for comparison purposes. Finding an adequate control group that did not receive the intervention at the same time was not possible due to this broad deployment.

Furthermore, because ITSA focuses on trends over time within the same population, it can better account for confounding variables that vary between groups and can change over time, which can lead to biases in controlled before-and-after studies. To fit the characteristics of the CHPS intervention, the researcher modified the traditional ITSA approach, which usually entails comparing intervention and control groups (Kontopantelis et al., 2015). Due to the simultaneous nationwide implementation of the CHPS intervention, the prospect of having a non-intervention group for a comparison study was eliminated, necessitating this adjustment.

But in order to properly identify changes, ITSA needs a significant enough number of data points both before and after the intervention. This study was able to do this since a large amount of historical data from the GHS was available (Bernal et al., 2017). The accuracy of estimates may be impacted by the sensitivity of ITSA to model specification and possible autocorrelation. In order to assure the validity of the findings, this limitation was overcome by closely examining the model's assumptions and applying strong statistical approaches (Sellers et al., 2010).

4.2.1 Statistical Assumptions

Although ITSA has many benefits, its use is predicated on a few crucial tenets. It is imperative to address these assumptions and carry out sensitivity studies in order to guarantee the validity and robustness of the findings. ITSA makes the assumption that the outcome variable's connection to time is accurately stated. This implies that the trend over time, both before and after the intervention, must be faithfully represented by the model. The intervention's effect is also assumed by the model to be additive and linear. This suggests that a change in the time series' level or slope can be used to illustrate the intervention's effects. The time series' observations are thought to be independent. This implies that the outcome variable's value at one point in time shouldn't be affected by its value at a later point in time.

Another assumption of the ITSA model is the assumption of stationarity. If the time series is stationary, it means that its statistical characteristics, including variance and mean, do not alter over time. Results from non-stationarity may be erroneous. The outcome variable is also assumed to be unaffected by any unmeasured confounders by the model. The estimates of the intervention effect may be skewed if unmeasured confounders exist. We investigated alternate model specifications in order to test the assumptions of additivity and linearity. To determine whether the impact of the intervention changed over time, interaction variables between time and intervention were included. To confirm that the linearity and additivity assumptions were met, the outcomes were then compared.

We used autoregressive integrated moving average (ARIMA) models to explain the time series data's association. In order to reduce the possible influence of unmeasured confounders, the analysis took into account a number of control variables, including economic indicators, demographic factors, and other health treatments that took place during the study period, which could affect the outcome variable.

Outliers are assumed to not exist in an ITSA model. If outliers exist, they can alter the results and interpretations of the model. To find and exclude data points that can unnecessarily affect the outcomes, outlier analysis was carried out. This made it easier to evaluate how resilient the results were to the presence of extreme values. Finally, the model assumes an absence of coincidence. Sensitivity studies examined if the outcomes were affected by the precise time of the CHPS intervention by changing the assumed date of the intervention. This aided in proving that the CHPS intervention, and not any other coincidental events, was the cause of the observed effects.

4.3 Evaluation Approach

In public health research, various methodological approaches, such as cohort, quasi-experimental and Randomised Controlled Trials (RCT) designs, are employed to investigate the efficacy of health interventions (Handley et al., 2018). This chapter used the quasi-experimental design, to evaluate the effectiveness of CHPS compound interventions in Ghana because of its competitive advantage of offering a more robust estimation of the intervention's influence on defined outcomes compared to observational designs given their increased tendency of accounting for potential confounders (Kontopantelis et al., 2015).

Apart from this competitive advantage, the choice of the quasi-experimental design was informed by the availability of comparable data to allow accounting for counterfactuals in determining the CHPS intervention's effectiveness. While RCTs also embody these advantages of the quasi-experimental design and could have been a more rigorous choice given their robustness per the evidence hierarchy order, they were not applicable in this chapter because of the impracticability of randomisation in the context of this evaluation (Kontopantelis et al., 2015). For example, it was not feasible for the researcher to consider the randomisation of communities into 'intervention' and 'control' given that the selection and implementation of the CHPS intervention were influenced by real-life indicators and not initially designed for evaluation research purposes. More importantly, it would have been unethical withholding potentially beneficial services from a control group.

Among the quasi-experimental designs, the Interrupted Time Series Analysis (ITSA) was adopted in this study, given its ability to assess the impact of interventions over time, accounting for changing trends (Hategeka et al., 2020). This ability was particularly important for this chapter as it aimed to use longitudinal data to compare pre-and-post CHPS intervention outcomes in selected communities. Using the longitudinal data allowed the researcher to explore whether and how changing trends over the years influenced defined outcome variables pre-and-post CHPS interventions and how the CHPS intervention behaved in the presence of those trends (Bryman, 2016). Empirically, this benefit could not have been achieved using one-time point data, e.g., cross-sectional data, given their rigidity to time-dependent changes (Bryman, 2016). While longitudinal data research is usually characterised by high financial and time costs and possible attrition, such limitation was not observed in this study as it accessed retrospective longitudinal data from the Ghana Health Service (GHS) database (Abbott et al., 2016; Ruspini, 2003).

The researcher adapted the conventional ITSA approach, which typically involves comparing intervention and control groups (Kontopantelis et al., 2015), to suit the dynamics of the CHPS intervention. This modification was necessary because the CHPS intervention was implemented nationwide simultaneously, eliminating the possibility of having a non-intervention group for a comparative analysis. Although this adaptation could be interpreted as a limitation, as it departs from the conventional ITSA approach, it offered a more robust option to understand the intervention's impact in a real-world, nationwide implementation scenario (Bernal et al., 2017). Again, the impact of the absence of a traditional control group was inconsequential in this study as it was limited by the analytical depth provided by the adopted longitudinal data approach (Liu, 2016). For example, the retrospective longitudinal data approach ensured sufficient data collection at successive intervals pre-intervention, which served as robust comparable comparators against the post-intervention data to estimate the intervention's contributions to the outcome variables. As already argued, this approach to defining 'control' groups in the context of ITSA is atypical; however, it enhanced this study's rigour, especially when compared to a cohort design, which is not amenable to comparative alternatives (Steventon et al., 2015).

4.4 Intervention and Outcomes

4.4.1 Intervention

The intervention in this chapter is the CHPS compound. It was defined in this study as the presence of an implemented community healthcare facility in a defined community in Ghana. CHPS compounds are healthcare facilities implemented in rural and underserved areas in Ghana to offer primary healthcare services such as health education/promotion, disease prevention including vaccinations/immunisation, specific maternal and infant health services, and provisions of first aids for referral cases (Agyepong et al., 2012). For succinctness, kindly refer to Chapter 1 for a detailed description of the objectives and operationalisation of the CHPS intervention in Ghana.

4.4.2 Outcomes

The outcomes in this study were the number of maternal deliveries, Outpatient Department (OPD) attendance, Family planning (FP) visits and Antenatal Care (ANC) visits (See Table 12 for their description). These outcomes were explored in this chapter because they are the key performance indicators and healthcare goals of the CHPS facilities in Ghana (Awoonor-Williams et al., 2013). Therefore, exploring other outcomes, like mortality, could possibly have yielded less significant outcomes, given their potential absence, insufficiency or incompleteness concerning data, as they are not the core outcomes of interest for the CHPS facilities. More importantly, estimating the CHPS effectiveness with such outcomes could have biased the generated findings as it would be an assessment of an intervention against an untargeted outcome (Bůžková, 2012). Nonetheless, where necessary and when comparable pre-and-post-intervention data on these outcomes are available, they were juxtaposed to assess whether the intervention influenced those outcomes to enhance this chapter's comprehensiveness and analytical depth.

Table 12: Description of the outcome variables

Outcome variables	Description	Variable Type
Maternal deliveries	Number of pregnancies delivered at the CHPS Compounds	Numeric Count
OPD	Outpatient Department (OPD) visits at the CHPS Compounds	Numeric Count
FP	Family planning (FP) visits at CHPS Compounds	Numeric Count
ANC	Antenatal Care (ANC) visits at CHPS Compounds	Numeric Count

4.5 Data source

The data for this evaluation was sourced from the Ghana Health Service (GHS) and the Ministry of Health (MoH), supplemented by the Geocoded Community-based Management of Severe Acute Malnutrition (CMAM) database. These databases, containing relevant pre-and-post CHPS intervention data from 2012 to 2019, provide a comprehensive overview of healthcare delivery metrics, including patient service numbers, health professional staffing levels, and the outcomes of interest. The data in these databases were accessed from the District Health Information Systems (DHIMS), a software implemented by GHS to collect real-time data on health service delivery and outcomes in CHPS facilities (Begum et al., 2020). The use of multiple databases for this evaluation exercise was to enhance the reliability and credibility of the accessed data. The accessed data included the number of maternal deliveries, OPD, family planning and antenatal visits, and the region in Ghana where the CHPS compound is located. Ethics approval for this study to access these secondary data from the GHS, MOH and CMAM databases was given by Brunel University's College of Health, Medicine, and Life Sciences (CHMLS) Research Ethics Committee and the Ethics Committee of the Ghana Health Service.

The Ghana Health Service (GHS) and the Ministry of Health (MoH) provided the data for this assessment, with additional data coming from the Geocoded Community-based Management of Severe Acute Malnutrition (CMAM) database. These datasets offer a thorough overview of healthcare delivery parameters, such as patient service numbers, health professional staffing levels, and the outcomes of interest. They cover pertinent pre- and post-CHPS intervention data from 2012 to 2019. Begum et al. (2020) reported that GHS adopted the District Health Information Systems (DHIMS) software to gather real-time data on health service delivery and outcomes in CHPS facilities, from which the data in these databases were retrieved.

To improve the accuracy and legitimacy of the data accessed, several databases were used for this assessment. The data that could be accessible comprised information on the quantity of births, visits to the outpatient department (OPD), family planning consultations, prenatal visits, and the geographic area of Ghana where the CHPS facility is situated. The research ethics committees of Brunel University's College of Health, Medicine, and Life Sciences (CHMLS) and the Ghana Health Service granted ethical approval for this study in order to access these secondary data from the GHS, MOH, and CMAM databases.

To guarantee consistency in data entry formats and codes across various datasets, the data were put through consistency checks. This involved confirming that numerical values fell within predicted ranges, dates were printed appropriately, and categorical variables were coded consistently. Multiple imputation techniques were employed to identify and rectify missing data in order to mitigate potential biases. Sensitivity analyses were performed for variables that had a large number of missing values in order to evaluate how these missing values affected the overall results.

Outliers in the data were found and dealt with using statistical techniques. We looked at extreme values to see if they were true observations or mistakes in data entry. False values were either removed or corrected, and true outliers were kept. To guarantee the accuracy of the data, cross-validation was done using additional publicly available health datasets. To find and fix inconsistencies, for instance, patient service numbers and health outcomes from the DHIMS were compared with information from the CMAM database.

Despite efforts to guarantee thorough data collection, incomplete values existed for a few variables, making full imputation impossible. The robustness of the results could be impacted by this incompleteness, especially for variables where there are large missing data sets. The proper reporting and recording procedures followed by healthcare professionals were critical to the data's accuracy. Bias in reporting may be introduced by inconsistent reporting procedures among various facilities and areas. Regional variations in healthcare infrastructure and resource accessibility may have an impact on the quality of the data.

4.6 Statistical Analysis

The ITSA linear regression model was used to analyse the data in this chapter, given its broader applicability to diverse data types and sensitivity to different data distributions compared to its alternative, i.e., the Autoregressive Integrated Moving Average (ARIMA) models (George & Gwilym, 2016; Box, 1975). Its ability to accommodate heteroscedasticity and autocorrelation, making it suitable for complex datasets where traditional assumptions may not hold, also informed its usage in this chapter (George & Gwilym, 2016). The model's residuals, or errors, ought to be independent.

More specifically, the linear model was used given the outcome variables are of numeric continuous distribution. However, the researcher checked to make sure there was a linear relationship between the time variable and the result, which is an assumption that must be satisfied. By fitting linear models to the data and visually examining scatterplots, this assumption was confirmed. A linear regression model could have also been fitted to analyse the data, given that it is also suitable for continuous variables.

The regression equation used in the analyses to estimate the impact of CHPS compounds on the outcome variables was:

$$Y_t = \beta_0 + \beta_1 T_t + \beta_2 X_t + \beta_3 X_t T_t + \varepsilon_t, \qquad (1)$$

Yt is the dependent variable, representing the outcome variable measured at each time point t. Tt represents the time the CHPS intervention was implemented (2012). Xt is a binary dummy variable representing pre- intervention (Xt = 0) and post-intervention (Xt = 1) periods. The coefficients β0, β1, β2, and β3 represent the intercept, the slope or trajectory of the outcome variable until the introduction of the intervention, the change in the level of the outcome variable immediately following the introduction of CHPS compounds, and the difference between the preintervention and postintervention slopes of the outcome variable, respectively. As mentioned earlier, the researcher used a before-and-after intervention approach; therefore, a control group was not included in the analyses.

The study navigated through three pivotal estimation challenges: seasonality, heteroscedasticity, and autocorrelation (Wang et al., 1994). The Newey-West variance estimator was used to counter the twin problems of autocorrelation and heteroscedasticity, ensuring consistent parameter estimates despite these complexities. Additionally, the Cumby-Huizinga test for autocorrelation was employed to accurately determine the autoregressive model’s order, leading to refined parameter adjustments (Proietti, T. 1998). Periodic functions were also used to account for the effect of possible influence of seasonality and long-term trends on the impact of the CHPS intervention on the defined outcomes, i.e., maternal deliveries, OPD, family planning, and antenatal visits (Shi et al., 2014). Stata version 17 SE was used to analyse the data.

A main assumption that needs to be satisfied for the model to be validated is that over time, the residuals' variance ought to remain constant. Any non-stationarity resulting from seasonality or long-term trends was evaluated and taken into consideration because they can distort the results significantly.

Both heteroscedasticity and autocorrelation were adjusted for in the error terms using this estimator. As a result, even in cases where the conventional ordinary least squares (OLS) assumptions like equal variance were broken, it produced consistent parameter estimates. This test was used to precisely ascertain the autocorrelation's order. In order to produce more accurate parameter estimates, the study was improved by determining and implementing the proper autoregressive model order. Sensitivity analyses were performed to assess how reliable the results were. These analyses involved adjusting the pre- and post-intervention periods' durations and testing the model under various assumptions on the intervention's time points. The findings appeared to be resilient to moderate modifications in model assumptions, as evidenced by the consistency of the results across these many scenarios.

4.7 Findings

4.7.1 Descriptive Findings

Six-hundred and thirty-seven (n = 637) CHPS compounds/facilities have been implemented in Ghana. Many of these are located in the Western region (n = 118; 18.5%), followed by the Upper East (n = 104; 16.3%), Eastern (n = 91; 14%), Central (n = 90; 14.1%) and the Northern (n = 81; 12.7%). The Greater Accra (n = 4; 0.6%) and Ashanti (n =14; 2.2%) regions had the fewest CHPS facilities in Ghana. Observably, the regions with fewer numbers of CHPS facilities have a more significant number of regional and district health facilities. The reverse was also observed for the regions with more CHPS facilities, confirming the CHPS program's objectives: to provide primary healthcare services to rural communities with little or no access to healthcare facilities. Figure 4 below illustrates the proportion of CHPS facilities per region in Ghana.

The delivery of medical supplies and staff can be difficult in remote places due to their typically rough terrain. This may make it more difficult to provide healthcare services consistently. The delivery of medical supplies and staff can be difficult in remote places due to their typically rough terrain. This may make it more difficult to provide healthcare services consistently. Ensuring community support and involvement is essential to CHPS's success.

However, cultural prejudices or a lack of knowledge about the advantages of the CHPS programme may cause opposition in some places.

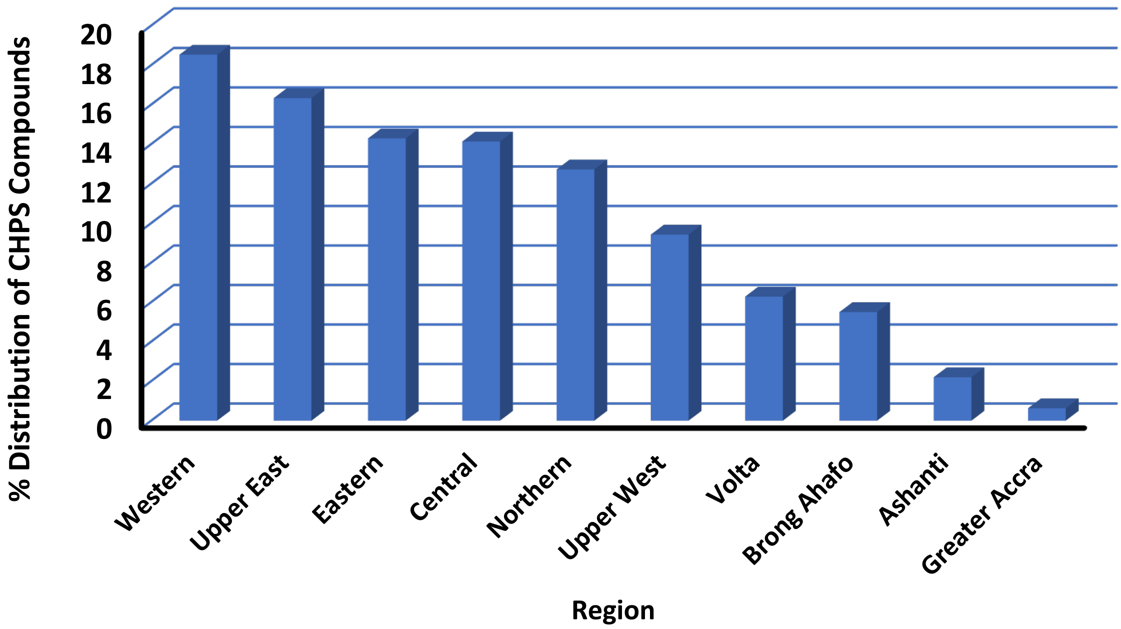


Figure 4: Percentage Distribution of CHPS Compounds

Source: Ghana Health Service Data (2020)

4.7.2 Descriptive Findings of the Outcome Variables

Table 13 provides the descriptive findings of the four outcome variables of interest: Maternal Deliveries, Family Planning, Antenatal, and Outpatient visits. Maternal deliveries ranged from 2,597 to 43,113 births across the CHPS facilities. Further, the mean number of maternal deliveries was 18,546.6, with a standard deviation of 12,231.97, indicating a wide variation in the number of deliveries across the CHPS compounds in Ghana. Similar dispersion was also observed for family planning, recording a mean of 325,929.6 and a standard deviation of 271,967.8. The number of visits in the CHPS facilities ranged from 21,382 to 819,623 for family planning visits, and 5,434 to 199,213 for antenatal visits.

Table 13: Descriptive Statistics of the Four Main Outcome Variables

Indicator	Mean	Standard Error	Median	Standard Deviation	Range	Minimum	Maximum
Deliveries	18546.69	3057.993068	16292	12231.97	40516	2597	43113
FP	325929.6	67991.95541	231453	271967.8	798241	21382	819623
ANC	71611.63	14260.88335	52234.5	57043.53	193779	5434	199213
OPD Visits	1519139	295076.9648	1138939	1180308	4268589	106780	4375369.4

Data Source: Ghana Health Service (2020)

The highest and lowest average number of OPD visits were recorded by CHPS facilities in the Ashanti (n= 4,375,369.4) and Oti (n = 106,780) regions, respectively. Maternal deliveries were comparatively low for all the regions, with CHPS facilities in the Ahafo region recording the lowest number of deliveries (n = 2,597), although their average number of antenatal visits (n = 49,756) was comparably higher than regions like Ashanti with relatively higher number of deliveries (number of deliveries: n = 24,512; number of antenatal visits: n = 38,072). Figure 5 and Table 14 below summarise these findings.

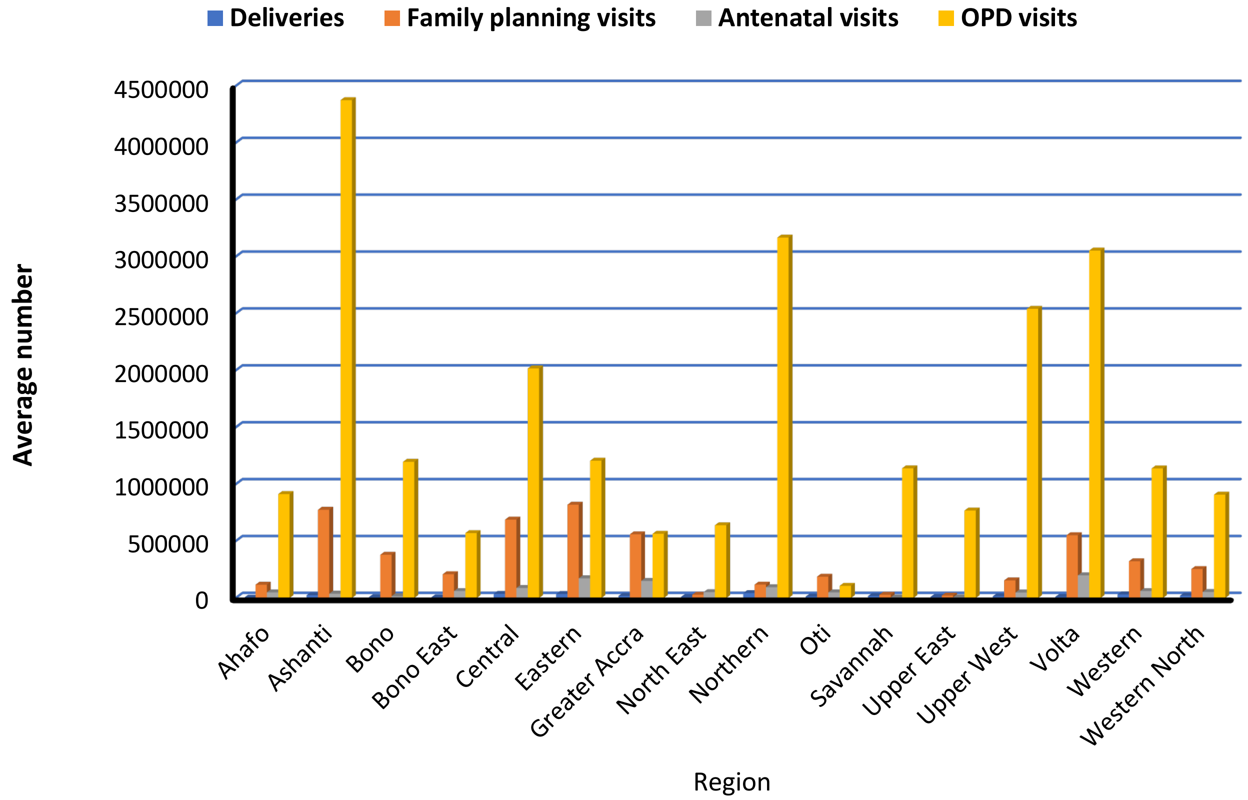


Figure 5: Regional Performance of the Four Variables

Data Source: Ghana Health Service (2020)

Table 14: Regional Performance of the Four variables

Region	Visits			
	Deliveries	FP	ANC	OPD
Ahafo	2597	116804	49756	913228
Ashanti	24512	775204	38072	4375369
Bono	7987	379877	16206	1196763
Bono East	6118	208733	61480	570181
Central	36161	688599	88081	2017314
Eastern	34798	819623	172738	1206679
Greater Accra	17952	559568	150037	564123
Northeast	8608	28935	51462	639286
Northern	43113	117634	94785	3167346
Oti	12391	186983	49743	106780
Savannah	17245	28618	5434	1139148
Upper East	8668	21382	5943	768647
Upper West	15339	154485	48311	2541016
Volta	9362	551380	199213	3053435
Western	31863	322876	61518	1138730
Western North	20033	254173	53007	908171

Source: Ghana Health Service Data (2020)

4.8 Findings of the Outcome Analysis

4.8.1 Maternal Deliveries

Table 15 shows a summary of the model statistics for maternal deliveries. Spanning a period of 9 years from 2012 to 2020, the model includes 9 observations and a maximum lag of 0. The F-statistic (F (3, 5)) is 1028.27, and the associated probability is 0, indicating that the model is highly significant. This statistical significance implies that there is a strong relationship between the variables Yt is the dependent variable, Tt represents the time the CHPS intervention was implemented (2012). Xt is a binary dummy variable representing pre-intervention (Xt = 0) and post-intervention (Xt = 1) periods. The coefficients β0, β1, β2, and β3 represent the intercept, the slope or trajectory of the outcome variable until the introduction of the intervention, ($Y_t = \beta_0 + \beta_1 T_t + \beta_2 X_t + \beta_3 X_t T_t + \varepsilon_t$,), and it provides a solid foundation for further investigation and analysis. It is essential to consider other factors and potential confounders that may affect the results and validate the model's robustness.

Aggressive malaria control programmes may be associated with improved health outcomes, which could distort the CHPS intervention analysis's findings. Independent of the CHPS programme, ongoing immunisation programmes in some areas may result in better mother and child health indicators. Some localities offer district hospitals and larger healthcare facilities as an option to CHPS compounds, which could distort the results of the comparison analysis. Maternal delivery rates, for instance, are consistently high in non-CHPS areas like Greater Accra, where district hospitals are more prevalent, suggesting improved access to trained birth attendants. Service delivery and health outcomes may also be impacted by an uneven distribution of medical professionals among geographic areas. These have to be taken into consideration when contextualising the findings of the study.

Additionally, exploring different time intervals and lags may also provide insights into the underlying trends and patterns in the number of deliveries.

Table 15: Model Summary for Number of Deliveries

Indicator	Result
Time variable	Year
Period	2012-2020
Time Interval	1
Number of Observations	9
Maximum lag	0
F (3, 5)	1028.27
Prob > F	0

Table 16 in the study delineates the Newey-West model coefficients, focusing specifically on the number of deliveries. The model initially estimates the starting level of deliveries at 14,089. A noteworthy trend emerges prior to the year 2016: there was a statistically significant yearly increase in the number of deliveries by 2,094 ($P < 0.05$, with a 95% confidence interval [CI] ranging from 853 to 3,335). This trend denotes a consistent rise in deliveries before any intervention was implemented. The year 2016, marked as the first year of the intervention, was pivotal because the data reveals a significant leap in the number of deliveries by 3,722 during this period ($P < 0.05$, 95% CI = [950, 6,494]). This increase not only signifies an immediate impact of the intervention but also sets a precedent for its effectiveness.

Furthermore, the intervention's influence extends beyond its immediate impact. There was a significant change in the annual delivery trend compared to the pre-intervention period. Post-intervention, the number of deliveries escalated by an average of 7,598 per year ($P < 0.05$, 95% CI = [6,183, 9,013]). This shift indicates that the intervention had a profound and lasting influence, not just causing a one-time spike but altering the overall yearly trend in deliveries.

The data from the Newey-West model underscores a critical finding: there was a significant increase in the number of deliveries both before and after the 2016 intervention. The intervention itself seems to have been a key driver in this rising trend, not only triggering an immediate surge in the number of deliveries but also contributing to a sustained increase in subsequent years.

Table 16: Newey–West Model Coefficients for Number of Deliveries

_Deliveries	Coefficient	std. err.	t	P>|t|	[95% conf. interval]
_t	2093.4	482.6868	4.34	0.007	852.6142, 3334.186
_x2016	3721.5	1078.212	3.45	0.018	949.867, 6493.133
_x_t2016	7597.7	550.3558	13.81	0	6182.965, 9012.435
_cons	14088.9	1260.43	11.18	0	10848.86, 17328.94

Yt is the dependent variable, representing the outcome variable measured at each time point t. Tt represents the time the CHPS intervention was implemented (2012). Xt is a binary dummy variable representing pre- intervention (Xt = 0) and post-intervention (Xt = 1) periods.

Table 17 shows the post-intervention linear trend for the number of deliveries. After the introduction of CHPS compounds, the number of deliveries increased significantly at a rate of 9,691 per year (95% CI = [9,011.45, 10,370.75]). This finding demonstrates that the intervention had a substantial impact on the annual growth of deliveries, with a consistently positive trend following its implementation. The significant increase in the annual trend suggests that the intervention played a crucial role in boosting the number of deliveries, and it would be beneficial to explore the specific factors contributing to this effect. The post-intervention linear trend analysis reveals a considerable annual increase in the number of deliveries following the introduction of CHPS compounds. This suggests that the intervention has had a positive and lasting impact on delivery trends, emphasizing the importance of understanding the underlying factors and mechanisms responsible for this change.

Table 17: Post-intervention Linear Trend for Number of Deliveries

Linear Trend	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
Treated	9691.1	264.3955	36.65	0	9011.45 10370.75

Figure 5, above, evidently illustrates a significant increase in the number of deliveries at the various CHPS Compounds after the introduction of CHPS compounds compared to the pre-intervention period from 2012 to 2015. This visual representation supports the findings reported in Tables 16 and 17, emphasising the positive impact of the intervention on the number of deliveries. The substantial jump in the number of deliveries after the introduction of CHPS compounds indicates the effectiveness of the intervention in improving healthcare access and delivery, particularly in the context of maternal and child health services. This further highlights the importance of understanding the specific factors and mechanisms that contributed to this positive change, as well as evaluating the long-term sustainability and effectiveness of the CHPS compounds intervention. Figure 6 provides a clear visual representation of the significant increase in the number of deliveries after the introduction of CHPS compounds. This supports the previous findings from the Newey-West model coefficients and postintervention linear trend analysis, suggesting that the intervention has had a considerable and lasting impact on delivery trends in the various CHPS Compounds.

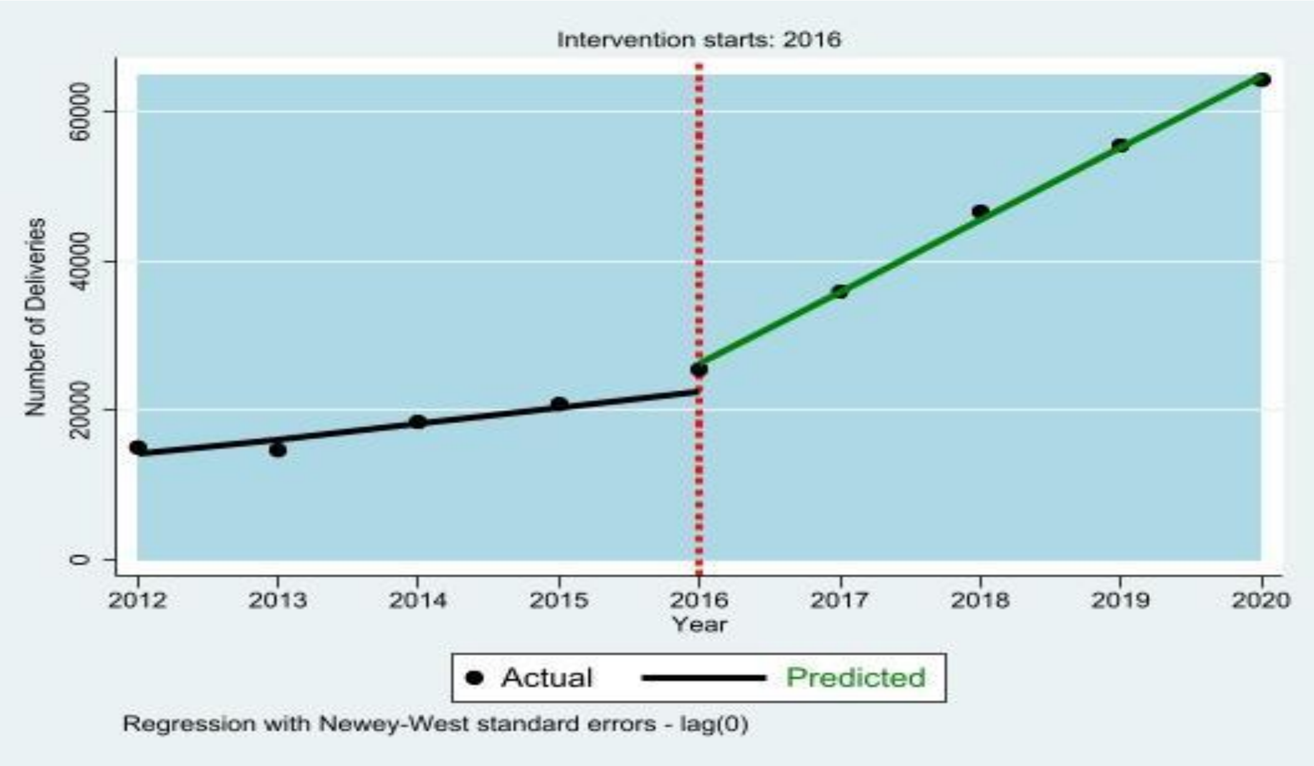


Figure 6: Single-group ITSA with Newey–West standard errors and 0 Lag for Number of Deliveries.

4.8.2 Test of Model Adequacy in Accounting for the Right Autocorrelation

Table 18 shows the Cumby-Huizinga test for Autocorrelation for the number of deliveries. This test is essential for determining the model's effectiveness in addressing right autocorrelation within the data. The table is structured around testing two hypotheses: the null hypothesis (H0) which posits the absence of serial correlation (q=0) and the alternative hypothesis (HA) suggesting the presence of serial correlation at specified ranges or lags. The results are laid out across two main columns, each examining different lag intervals. These intervals are analysed in terms of their chi-square (chi2) statistics, degrees of freedom (df), and p-values. The first set of results examines a range of lags from 1-1 to 1-6, while the second set scrutinizes individual lags from 1 to 6.

In the initial lag 1-1, the chi2 value is 1.225 with a corresponding p-value of 0.2684, indicating a lack of significant serial correlation at this particular lag. This trend shifts in the 1-2 and 1-3 lag ranges where the chi2 values are 7.287 and 8.662 respectively, with p-values falling below the 0.05 threshold, signifying the presence of serial correlation in these ranges. However, the lag range is observed to widen from 1-4 to 1-6. Here, the p-values ascend above the 0.05 mark, implying an absence of significant serial correlation at these extended intervals.

Similarly, when each lag is inspected individually, the p-values consistently remain above 0.05, suggesting no significant serial correlation at these specific lag levels. These findings imply that while there is some degree of serial correlation at shorter lag ranges, it appears to diminish as the lag interval expands. The absence of significant serial correlation at individual lag levels reinforces the robustness of the model, indicating that it effectively captures the essential dynamics of the number of deliveries without being excessively influenced by autocorrelation. This aspect is vital for the reliability of the model in analysing the trends and effects of interventions on the number of deliveries, offering confidence in the study's findings and conclusions.

Table 18: Cumby-Huizinga test for Autocorrelation (Breusch-Godfrey) for Number of Deliveries

H0: q=0 (serially uncorrelated) HA: s.c. present at range specified				H0: q=specified lag 1 HA: s.c. present at lag specified			
lags	chi2	df	p-val	lag	chi2	df	p-val
1-1	1.225	1	0.2684	1	1.225	1	0.2684
1-2	7.287	2	0.0262	2	1.287	1	0.2566
1-3	8.662	3	0.0341	3	1.208	1	0.2717
1-4	8.84	4	0.0652	4	0	1	0.9995
1-5	9	5	0.1091	5	1.017	1	0.3133
1-6	9	6	0.1736	6	0.106	1	0.7449

The null hypothesis (H0) which posits the absence of serial correlation (q=0) and the alternative hypothesis (HA) suggesting the presence of serial correlation at specified ranges or lags. chi-square (chi2) statistics, degrees of freedom (df), and p-values.

4.9 Antenatal Visits

Table 19 presents the ITSA model summary for antenatal visits. With 9 observations spanning a period of 9 years from 2012 to 2020, the model shows a significant result ($F(3, 5) = 1254.69$) and a maximum lag of 5. This statistical significance indicates a strong relationship between the variables, providing a solid foundation for further investigation and analysis. The significant relationship suggests that factors influencing the number of antenatal visits might be worth examining more closely. It is essential to consider other factors and potential confounders that may affect the results and validate the model's robustness. Additionally, exploring different time intervals and lags may provide insights into the underlying trends and patterns in the number of antenatal visits.

Table 19: Model Summary for Antenatal Visits

Indicator	Result
Time variable	Year
Period	2012-2020
Time Interval	1
Number of Observations	9
Maximum lag	5
F (3, 5)	1254.69
Prob > F	0.000

Table 20 presents the Newey-West model coefficients for antenatal visits. The starting level of the number of antenatal visits is estimated at 85,923. Before 2016, there was a significant increase in the number of antenatal visits by 5,856 per year (P < 0.05, 95% CI = [4,689, 7,024]). In 2016, the first year of the intervention, the number of antenatal visits experienced a significant increase of 18,056 (P < 0.05, 95% CI = [13,526, 22,585]). Moreover, there was a significant change in the annual trend of antenatal visits relative to the pre-intervention trend, with an increase of 7,140 visits per year (P < 0.05, 95% CI = [4,403, 9,877]). This indicates that the intervention in 2016 had a substantial impact on the number of antenatal visits. The increase in the annual trend suggests that the intervention not only had an immediate effect but also influenced the subsequent years. The Newey-West model coefficients show that the number of antenatal visits significantly increased both before and after the intervention in 2016. The intervention appears to have played a significant role in the increasing trend of antenatal visits, with substantial growth observed in the first year and a continued increase in the annual trend thereafter.

Table 20: Newey–West Model Coefficients for Antenatal Visits

ANC	Coefficient	std. Err.	t	P>|t|	[95% conf. interval]
_t	5855.8	454.0832	12.9	0	4688.542, 7023.058
_x2016	18055.2	1762.066	10.25	0	13525.66, 22584.74
_x_t2016	7139.6	1064.662	6.71	0.001	4402.799, 9876.401
_cons	85922.8	827.3815	103.85	0	83795.95, 88049.65

Yt is the dependent variable, representing the outcome variable measured at each time point t. Tt represents the time the CHPS intervention was implemented (2012). Xt is a binary dummy variable representing pre- intervention (Xt = 0) and post-intervention (Xt = 1) periods.

Table 21 presents the post-intervention linear trend for the number of antenatal visits. After the introduction of CHPS compounds, the number of antenatal visits increased significantly at a rate of 12,996 per year (95% CI = [10,869, 15,123], P < 0.001). This finding demonstrates that the intervention had a substantial impact on the annual growth of antenatal visits, with a consistently positive trend following its implementation. Figure 7, which is shown below, further illustrates the rate of growth in the number of antenatal visits after the introduction of CHPS compounds.

Table 21: Postintervention Linear Trend for Antenatal Visits

Linear Trend	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
Treated	12995.4	827.4516	15.71	0	10868.37 15122.43

Figure 7 below further validates the findings presented in Tables 20 and 21 by illustrating a significant upward trajectory in the number of antenatal visits post CHPS intervention. This visual representation supports the previous findings from the Newey-West model coefficients and post intervention linear trend analysis, emphasising the positive impact of the intervention on the number of antenatal visits. The substantial upward trend (Pre-intervention depicted by black line and post-intervention depicted by green line in figure 7 below) in the number of antenatal visits after the introduction of the intervention indicates its potential effectiveness in improving healthcare access and delivery, particularly in the context of maternal and child health services.

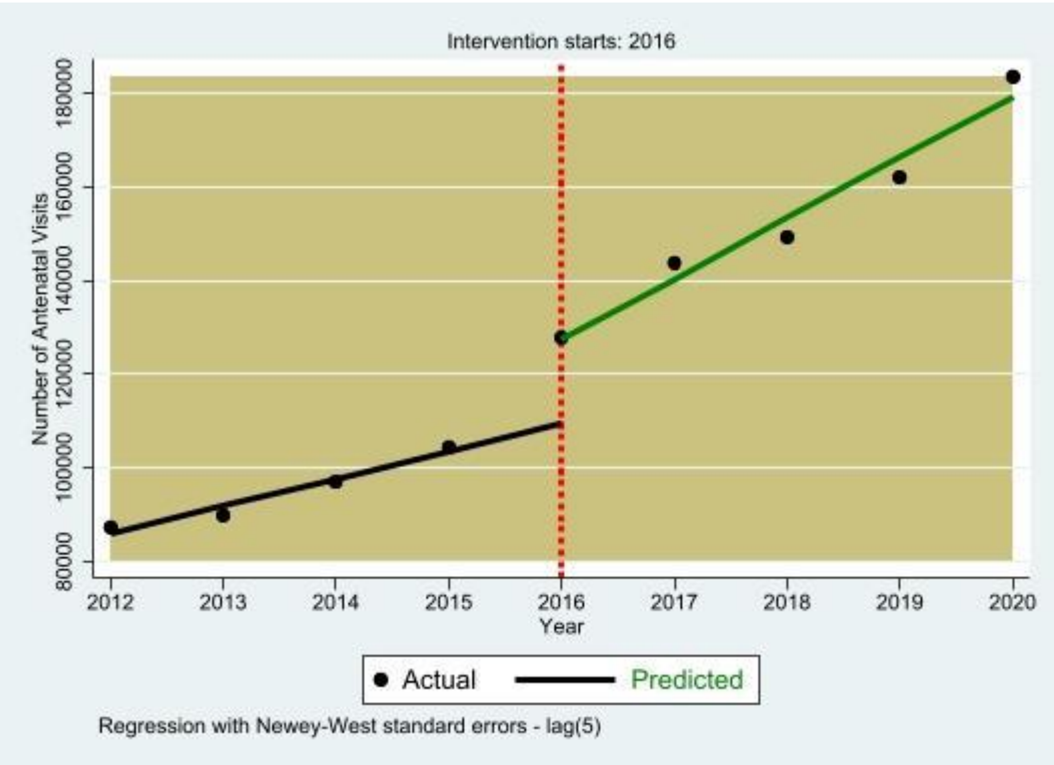


Figure 7: Single-group ITSA with Newey–West standard errors and 5 Lags for Antenatal Visits.

4.9.1 Test of Model Adequacy in Accounting for the Right Autocorrelation

Table 22 presents the Cumby-Huizinga test for autocorrelation (Breusch-Godfrey) for antenatal visits. Consistent with the outcomes in Table 20 and Table 21 where we see, from the post-intervention linear trend, that after the introduction of "CHPS +", the number of antenatal visits increased significantly (p=0.000) annually at a rate of 12996 (95% CI = [10869 15123]). The null hypothesis (H0) assumes that there is no serial correlation present at the specified lag, while the alternative hypothesis (HA) suggests that serial correlation is present.

As seen in Table 22, the p-values for lags 1 to 6 on the right side of the table are all greater than or equal to 0.05. This indicates an acceptance of the null hypothesis for all lags, suggesting that there is no evidence of serial correlation in the residuals of the model at these lags. Given these results, the choice of an autoregressive model AR (0) at lag 0 appears to be appropriate for the data, as none of the lags from 1 to 6 show significant serial correlation.

This implies that the model has adequately captured the relationships in the data and that there is no need to incorporate additional autoregressive terms to account for potential serial correlation. Thus, the choice of the AR (0) for the regression model is validated by the absence of autocorrelation in the residuals. By taking autocorrelation into account, this method guarantees that the significance levels of the coefficients are appropriately assessed.

Practical factors pertaining to the data's periodicity are reflected in the lag intervals that were selected. Since healthcare data is collected on a monthly or quarterly basis, looking at up to six lags guarantees that any quarterly trends or seasonal patterns are noted. The point at which autocorrelation decreases can be found by testing up to six lags, which provides a clear image of the dependency structure in the data. This makes it easier to divorce real trends from noise.

If serial correlation is absent, then additional autoregressive elements are not necessary for the linear regression model to appropriately reflect the underlying data patterns. Confirming the robustness of the results can be done through sensitivity analyses that compare the AR (0) model's output with models that include higher-order lags (like AR (1) or AR (2)). By incorporating lagged dependent variables or differencing the data, among other robustness tests, it is ensured that the model's conclusions hold true over a range of assumptions.

Table 22: Cumby-Huizinga test for Autocorrelation (Breusch-Godfrey) for Antenatal Visits

H0: q=0 (serially uncorrelated) HA: s.c. present at range specified				H0: q=specified lag-1 HA: s.c. present at lag specified			
lags	chi2	df	p-val	lag	chi2	df	p-val
1-1	1.102	1	0.2938	1	1.102	1	0.2938
1-2	6.194	2	0.0452	2	3.702	1	0.0543
1-3	7.721	3	0.0522	3	1.685	1	0.1943
1-4	9	4	0.0611	4	0.412	1	0.5208
1-5	9	5	0.1091	5	4.357	1	0.0369
1-6	9	6	0.1736	6	0.002	1	0.9648

4.10 Family Planning

Table 23 presents ITSA model summary for family planning visits for 9 observations over a period of 9 years from 2012 to 2020. The model is significant with an F (3, 5) value of 104.42

and a probability greater than F (Prob > F) of 0.0001. The maximum lag for the model is 1. The model summary indicates that the ITSA for family planning visits is a significant and relevant approach to analyse the data. The significant result provides a strong foundation for further analysis to better understand the relationship between interventions and family planning visit trends over time.

Table 23: Model Summary for Family Planning Visits

Indicator	Result
Time variable	Year
Period	2012-2020
Time Interval	1
Number of Observations	9
Maximum lag	5
F (3, 5)	104.42
Prob > F	0.0001

Table 24 presents the Newey-West Model Coefficients for family planning visits. The starting level of the number of family planning visits was estimated at 285,353 (p<0.05, 95% CI [233,152, 337,556]). Before the intervention in 2016, there was a significant increase of 79,260 visits per year (p<0.05, 95% CI [44,373, 114,146]). In 2016, the first year of the intervention, there was a non-significant decrease in the number of visits by 1,228 (p>0.05, 95% CI [-98,664, 96,209]). Following this, there was a significant decrease in the annual trend of visits (relative to the pre-intervention trend) by 20,050 visits per year (p<0.05, 95% CI

[4,403, 9,877]). This suggests that the intervention had a significant impact on reducing the annual trend of family planning visits.

Table 24: Newey–West Model Coefficients for Family Planning Visits

FP	Coefficient	std. err.	t	P>|t|	[95% conf. interval]
_t	79259.1	13571.46	5.84	0.002	44372.56 114145.6
_x2016	-1227.9	37904.31	-0.03	0.975	-98664.04 96208.24
_x_t2016	-20049.2	20365.4	-0.98	0.37	-72400.12 32301.72
_cons	285353.1	20307.46	14.05	0	233151.1 337555.1

Table 25 presents the post-intervention linear trend for Family Planning Visits. Despite the inconsistent growth in the number of family planning visits demonstrated in Table 24, there is a significant rise in the rate of growth (59,210, p=0.005, 95% CI [27,753, 90,667]). This suggests a relative upward growth post-intervention, as evident in Figure 7. However, this rate of growth appears lower than what might have been expected without the intervention.

Table 25: Postintervention Linear Trend for Family Planning Visits

Linear Trend	Coef.	Std. Err.	t	P>|t|	[95% Conf. Interval]
Treated	59209.9	12237.26	4.84	0.005	27753.01 90666.79

Figure 8 visually illustrates the trends in the yearly number of family planning visits to the CHPS compounds. It confirms the general upward growth in the visits over the years. However, after the introduction of the intervention, there appears to be a slight downward movement in the number of visits. This suggests that the intervention might have influenced the trend, causing a temporary reduction in family planning visits before the overall upward growth trend resumed.

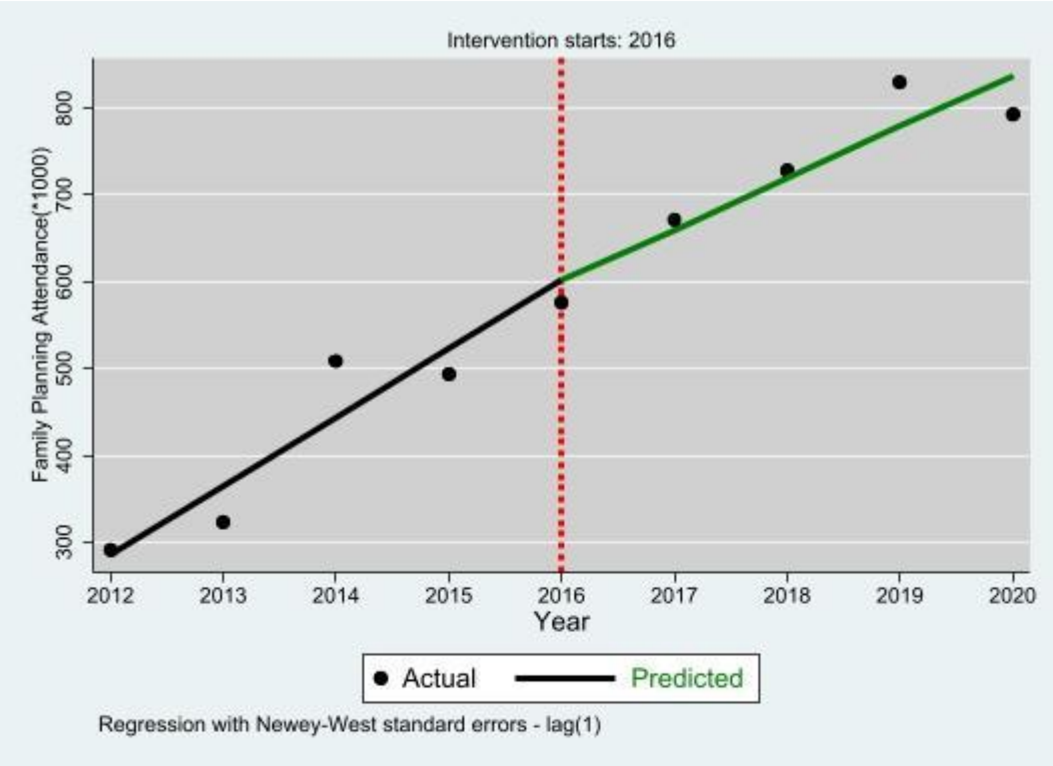


Figure 8: Single-group ITSA with Newey–West standard errors and 1 Lag for Family Planning Visits.

4.10.1 Test of Model Adequacy in Accounting for the Right Autocorrelation

Table 26 presents the Cumby-Huizinga test for autocorrelation (Breusch-Godfrey) for Family Planning Visits. The table tests for the presence of serial correlation in the residuals at different lag levels. From the right side of the table, we can observe the presence of autocorrelation in the residuals at lag 1 (chi2 = 5.43, df = 1, p-val = 0.0198). Since the p-value is less than 0.05, we reject the null hypothesis (H0) of no serial correlation and conclude that there is autocorrelation present at lag 1. This validates the choice of an Autoregressive (AR) model of order 1 (AR (1)) for the regression model, as it accounts for the autocorrelation observed in the data.

The null hypothesis that there is no serial correlation is rejected based on the results of the Cumby-Huizinga test for Family Planning Visits, which show a strong serial correlation at lag 1. This result supports the application of an AR (1) model, which takes autocorrelation into account by including the lagged dependent variable. Regression analysis is made more accurate and reliable by the AR (1) model, which also makes sure that the relationships in the data are sufficiently recorded. The study strengthens the credibility of the results by addressing serial correlation, which guarantees the validity and robustness of its conclusions regarding the effect of the CHPS intervention on Family Planning Visits.

Greater rates of family planning visits in non-CHPS areas may be a result of the more extensive family planning services and larger healthcare infrastructure that are offered there.

Table 26: Cumby-Huizinga test for autocorrelation (Breusch-Godfrey) for Family Planning Visits

H0: q=0 (serially uncorrelated) HA: s.c. present at range specified				H0: q=specified lag 1 HA: s.c. present at lag specified			
lags	chi2	df	p-val	lag	chi2	df	p-val
1-1	5.43	1	0.0198	1	5.43	1	0.0198
1-2	6.003	2	0.0497	2	0.015	1	0.9041
1-3	6.973	3	0.0728	3	0.013	1	0.9105
1-4	8.126	4	0.0871	4	0.012	1	0.9112
1-5	9	5	0.1091	5	1.208	1	0.2718
1-6	9	6	0.1736	6	2.5	1	0.1138

4.11 Outpatient Department (OPD) Visits

Table 27 presents the model summary for OPD visits, focusing on the number of deliveries. The data consists of 9 observations covering a period of 9 years from 2012 to 2020. The maximum lag considered in the analysis is 5. The overall model fit is found to be non-significant (F (3, 5) = 0.41, Prob > F = 0.7540). This non-significant result indicates that the model is not a good fit for the data, and it is not able to explain the variability in the number of deliveries adequately.

Table 27: Model Summary for OPD Visits

Indicator	Result
Time variable	Year
Period	2012-2020
Time Interval	1
Number of Observations	9
Maximum lag	5
F (3, 5)	0.41
Prob > F	0.7540

Table 28 presents the Newey-West Model Coefficients for OPD visits. The non-significance of the model is further demonstrated in this table, where only the constant term shows statistical significance (p=0.001, 95% CI [1,556,330, 3,309,585]). The other coefficients (_t, _x2016, which represents the effect of an intervention, change, or event that occurred in the year 2016 and _x_t2016 which represents an interaction term between time (represented by '_t') and the intervention or change in 2016) have p-values greater than 0.05, indicating that they are not statistically significant. This means that the model is unable to capture the relationship between the variables and OPD attendance effectively, even after transformation. As a result, it is not recommended to rely on this model for drawing conclusions about the impact of the intervention on OPD attendance.

Table 28: Newey–West Model Coefficients for OPD Attendance

OPD	Coefficient	Std. Err.	t	P>|t|	[95% conf. interval]
_t	34699.4	122040.4	0.28	0.788	-279015.4 348414.2
_x2016	346728.3	501758.6	0.69	0.52	-943083.2 1636540
_x_t2016	-57322	180784.9	-0.32	0.764	-522044.4 407400.4
_cons	2432957	341022.9	7.13	0.001	1556330 3309585

Figure 9 displays the trends for OPD visits over time. The lack of a discernible pattern in the figure supports the non-significance of the ITSA model for OPD attendance, as already seen on Tables 27 and 28. The absence of a clear pattern in the data means that the model is unable to adequately capture the relationship between the variables and OPD visits, making it difficult to draw any reliable conclusions about the impact of the intervention on OPD visits.

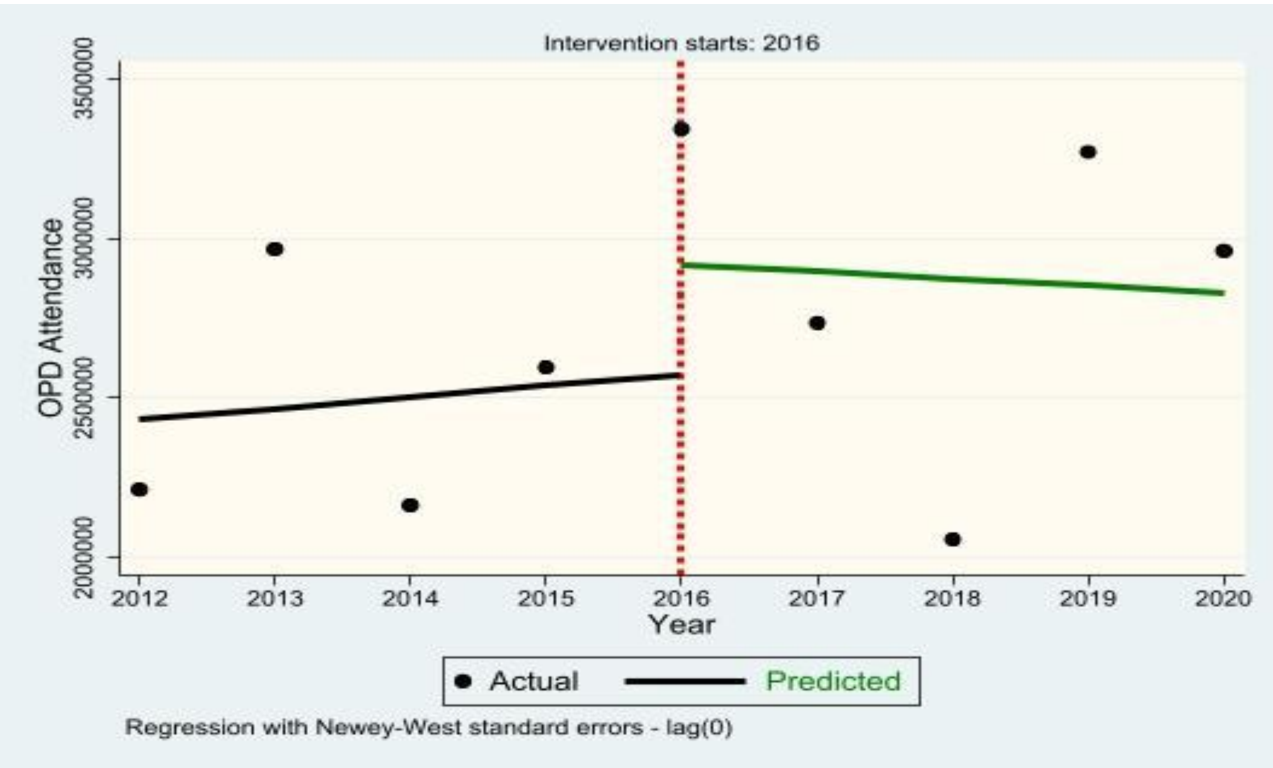


Figure 9: Single-group ITSA with Newey–West standard errors and 1 Lag for OPD Attendance

4.12 Discussions

This chapter evaluated the effectiveness of the CHPS compound intervention in Ghana using the ITSA model. It compared the number of maternal deliveries, antenatal, family planning and OPD visits before and after the CHPS intervention to estimate the intervention's effectiveness. The compared outcomes were informed by the core objectives and performance indicators of the CHPS intervention (Agyepong et al., 2012; Agyepong & Kodua, 2012). The chapter used retrospective longitudinal data from 2012 to 2020, with 2016 as the interruption time/intervention start date. The data was accessed from the GHS, MOH and CMAM databases. The findings of the analysis are discussed below per the assessed outcomes.

4.12.1 Maternal deliveries

The analysis showed that the CHPS intervention significantly increased the immediate number of maternal deliveries/births in the studied areas. While this increase could be attributed to the inherent characteristics of the CHPS interventions, such as its increased community engagement and regular health education (Awoonor-Williams et al., 2016), it could also be a function of a potentially increasing number of populations within reproductive ages in the defined communities over the years (Ventura et al., 2003).

The observed increase in the annual trend of deliveries after the intervention however shows that the intervention had not only immediate effects but also long-term impacts. This observation confirms the evidence in the literature that effective healthcare interventions can lead to long-lasting improvements in health outcomes and continued growth in the utilisation of healthcare services (Awoonor-Williams et al., 2016; Ganle et al., 2016; Sakeah et al., 2023). Like the immediate impacts, the observed long-term impacts of the CHPS intervention on maternal deliveries could also be attributed to the multiple factors enshrined in the CHPS intervention. These factors include increased availability and accessibility of healthcare services, community mobilization and awareness campaigns, and targeted efforts to address barriers to healthcare access, such as cultural, financial, and geographic factors (Adongo et al., 2014; Assan et al., 2018; Nyonator et al., 2005).

Nonetheless, when juxtaposed with existing literature, health literacy and community engagement in healthcare delivery are more likely to enhance health service uptake and utilisation, such as delivering at a healthcare facility, compared to the number of persons within reproductive ages, especially as reproductive ages do not necessarily connote pregnancies and deliveries (Kozlova & Sekitski-Pavlenko, 2020; Viktorsson et al., 2019). Assuming they indicate pregnancies, they do not determine whether they will be delivered at a healthcare facility.

Studies have shown that improving access to healthcare services in rural communities, particularly maternal healthcare, can lead to better health outcomes and increased utilisation of healthcare facilities for deliveries (Sakeah et al., 2014; Sharma et al., 2016). Reflectivity, complementing the improved access to healthcare with enhanced quality skills of health service deliverers, such as traditional birth attendants, within these rural communities, could reduce undesired health outcomes, like maternal and neonatal mortality rates (Awoonor-Williams et al., 2016; Sakeah et al., 2014). This assertion is particularly important as evidence shows that the services of these rural health service deliverers are still patronised and often preferred to healthcare facilities (Tabong et al., 2021).

4.12.2 Antenatal visits at CHPS Compounds (ANC)

The findings showed that the CHPS intervention significantly increased the immediate and long-term utilisation of antennal services in the implemented communities. (Afulani et al., 2021). Consistent with the existing body of research, this finding confirms that healthcare initiatives, like the CHPS program in Ghana, can significantly influence the number of women who access prenatal/antenatal care. Access to antenatal care is essential for ensuring the early identification and management of potential complications during pregnancy, which contributes to reducing maternal and neonatal mortality rates (Pervin et al., 2012). Therefore, the increased antenatal visits post-CHPS interventions suggest that sustaining and improving the CHPS intervention could significantly avert pregnancy-related dire consequences, which could have detrimental impacts on the mother and child (Kpienbaareh et al., 2022). Like the maternal delivery outcome, the significant increase in the antenatal visits per year post-CHPS intervention could be attributed to various the inherent characteristics of the CHPS interventions, i.e., increased access to healthcare services, increased community engagement, and health education efforts (Awoonor-Williams et al., 2013; Adongo et al., 2014; Nyonator et al., 2005).

The significant increase in the annual trend suggests that the intervention played a crucial role in boosting the number of antenatal visits, and it would be beneficial to explore the specific factors contributing to this effect. The post intervention linear trend analysis reveals a considerable annual increase in the number of antenatal visits following the introduction of CHPS compounds. This suggests that the intervention has had a positive and lasting impact on antenatal visit trends, emphasising the importance of understanding the underlying factors and mechanisms responsible for this change.

4.12.3 Outpatient visits at the CHPS Compounds (ODP)

The non-significant findings in Table 28 concerning the relationship between the CHPS intervention and OPD attendance suggest that the model may not be appropriate for understanding the impact of the CHPS program on OPD attendance. However, this may be unlikely as the same was not observed for other outcomes, such as maternal deliveries and antenatal visits. Therefore, the lack of a significant relationship could be attributed to other factors, such as confounding variables that could affect OPD attendance but were not accounted for in the model. These factors could include variations in disease prevalence, health-seeking behaviour, accessibility of healthcare services, or the quality of care provided at CHPS compounds (Oduro-Mensah et al., 2013; Sakeah et al., 2014). It is also possible that the intervention did not have a significant impact on OPD attendance because it focuses primarily on providing maternal and child health services in rural communities, and the emphasis on these specific services may not directly translate to a significant increase in overall OPD attendance (Nyonator et al., 2005; Awoonor-Williams et al., 2013).

The non-significant findings could also be attributed to methodological limitations in the study design or data collection process, such as a small sample size or measurement error in the variables. It could also be due to the lack of an actual control group for further comparison. Further research is, therefore, warranted to explore the relationship between the intervention and OPD attendance and whether other factors influence the relationship. A more comprehensive study design, including a well-defined control group and a larger sample size, may be more appropriate for understanding the impact of the CHPS program on OPD attendance.

Visits for maternity and child health services may be influenced differently from OPD attendance by variations in the health-seeking behaviour of community members. Cultural views, the availability of alternative healthcare alternatives, and opinions about the severity of the sickness could all be relevant factors in this situation (Oduro-Mensah et al., 2013). OPD attendance patterns may be impacted by variations in disease frequency over time or between geographical areas, even in the absence of a CHPS intervention.

Variations in the burden of disease may result in changes in the need for general outpatient treatment (Sakeah et al., 2014). Services related to mother and child health in rural areas are the main emphasis of the CHPS programme. It's possible that placing more focus on these particular services won't result in more people visiting the OPD generally, which covers a wider spectrum of medical conditions (Nyonator et al., 2005; Awoonor-Williams et al., 2013).

4.12.4 Family planning visits at CHPS Compounds

The results presented in Table 24 indicate that the intervention influenced family planning visits. Before the intervention, there was a significant annual increase in the number of family planning visits. However, the first year of the intervention saw a non-significant decrease in the number of visits. Most importantly, the post-intervention visits saw a significant decline in the annual trend of visits relative to the pre intervention trend. These findings suggest that the intervention may have affected the number of family planning visits in a way that deviates from the pre intervention trend. One possible explanation for this observation could be that the intervention improved the quality and accessibility of family planning services, resulting in more effective contraceptive use and a reduced need for frequent family planning visits (Campbell et al., 2014; Adongo et al., 2013).

Alternatively, the intervention may have promoted increased awareness and knowledge about family planning methods, leading to more efficient use of services and fewer visits (Haberlen et al., 2017; Krenn et al., 2014). The decreased annual trend of family planning visits could be due to changes in healthcare policies, socioeconomic conditions, or cultural factors that could influence family planning practices and utilization rates (Doubeni et al., 2012; Oversveen et al., 2017). Family planning practices may have been impacted by the policy changes that accompanied the intervention. For example, service delivery or accessibility may have been impacted by new regulations or funding adjustments, which could have contributed to the reported drop in visits (Doubeni et al., 2012)

Further research is needed to determine the specific mechanisms responsible for the observed changes in family planning visits and assess the sustainability and effectiveness of the intervention over time. Qualitative research methods, such as interviews and focus group discussions, could provide valuable insights into the factors influencing family planning visits and help identify potential areas for improvement (Johnson et al., 2020; Kriel et al., 2019).

Additionally, comparative studies relating the findings of this study with similar research conducted in other settings could help contextualize the impact of the intervention on family planning visits and inform the development of targeted interventions to improve family planning services in rural communities (Andoh-Adjei et al., 2018; GHS, 2020).

4.13 Considerations For Future Research

Compile and combine information on the study population's income bracket, work situation, and degree of education. With the aid of these data, socioeconomic disparities may be taken into account and a clearer picture of how these elements affect healthcare utilisation can be obtained. Incorporate measures on patient satisfaction, staffing levels, and the availability of necessary medications while discussing the calibre of care given at CHPS compounds.

The level of education can have an impact on health-seeking behaviour and healthcare service awareness, which can have an impact on outcomes like family planning visits and maternal births (Doubeni et al., 2012). Changes in the standard of care offered at CHPS compounds and other medical facilities can have an impact on utilisation rates and patient satisfaction.

According to Oduro-Mensah et al. (2013), variations in staffing numbers, the accessibility of medical supplies, and general facility conditions can affect such results. Determining these elements' impact on healthcare outcomes might be aided by their evaluation. Surveys should be used to learn about the study populations' cultural beliefs and health-seeking practices. By incorporating these insights, the observed patterns of healthcare utilisation can be given context.

4.14 Implication of Study for Theory, Policy, and Practice

The findings discussed above have implications for theory and practice, particularly those targeted at improving maternal and child health outcomes in rural areas. From a theoretical perspective, the results of this study provide insights into the complex relationship between healthcare interventions and health outcomes. The findings suggest that interventions can have both immediate and sustained impacts on health outcomes and that the nature and magnitude of these effects may vary depending on the intervention type, target population, and contextual factors. This highlights the need for a nuanced understanding of the mechanisms through which interventions operate and the factors that influence their effectiveness. This understanding is crucial for policymakers and healthcare planners as it underscores the complexity of healthcare interventions and the necessity of avoiding oversimplified assumptions about their efficacy. The study also underscores the importance of using rigorous research methods, such as ITSA, to evaluate the impact of interventions and avoid making unsupported claims about their effectiveness (Bernal et al., 2017).

In a practical context, the findings inform several key areas of healthcare policy, especially concerning the design and execution of interventions targeting maternal and child health in rural environments. Firstly, the results advocate for interventions similar to the CHPS program, which aim to enhance healthcare accessibility and utilisation, demonstrating their potential effectiveness in improving health outcomes. This finding is pivotal for policymakers in prioritizing and allocating resources towards programs that facilitate healthcare access.

Additionally, the study emphasizes the critical role of continuous monitoring and assessment in maintaining the efficacy and longevity of healthcare interventions. This aspect is particularly important, as it highlights the need for sustainable and capacity-building focused interventions, rather than those seeking only immediate results. For healthcare interventions to be truly effective in the long term, they must evolve and adapt, aligning with the changing needs and circumstances of the target population.

Given that CHPS significantly improves maternal births and prenatal visits, extending the program's reach to additional rural regions may improve maternal and child health outcomes even more. More financing and resources should be considered by policymakers to encourage the construction of additional CHPS compounds, especially in underprivileged areas. The results emphasise how important it is for CHPS facilities to continuously enhance their quality. By maintaining and improving the quality of care given, sufficient staffing, training, and access to necessary medical supplies can assist increase the use of these services.

The post-intervention drop in family planning visits should be addressed with focused community engagement and education initiatives. Utilisation may rise if communities are made aware of the value and advantages of family planning. Tracking the effectiveness of CHPS facilities and identifying areas for improvement can be facilitated by putting in place strong monitoring and evaluation mechanisms. Frequent evaluations can guarantee that the programme adjusts to evolving community requirements and healthcare obstacles.

4.15 Limitation of the Study

This study acknowledges several limitations, particularly regarding the statistical methods used and the data sources. One of the key limitations lies in the choice of statistical analyses, particularly the use of linear regression models. This is because the linear regression model, while versatile and widely used, may not always be the best fit for count data, which typically characterises healthcare-related outcomes such as the number of deliveries or patient visits. Count data often follows a Poisson or a negative binomial distribution, differing fundamentally from the continuous data assumptions underlying linear regression. As such, using linear regression models can potentially lead to biased or inaccurate estimates, especially in terms of variance. This limitation suggests the need for future research to consider employing count models like Poisson or negative binomial regression, which are specifically designed for count data and may provide more accurate results in this context.

Another limitation is the reliance on routine health data, which, while valuable, may not capture the full spectrum of relevant information. This data may miss certain nuances or fail to include variables that could influence the study's outcomes. Additionally, the absence of a control group limits the ability to make causal inferences from the study's findings. Without a comparison group, it is challenging to ascertain whether the observed effects can be attributed solely to the CHPS program or if they are the result of other extraneous factors.
The GHS, MoH, and CMAM databases provided secondary data for the study, which may have limits in terms of quality and completeness. It's possible that certain relevant variables weren't included in full or weren't available in the datasets. Biases may be introduced by the lack of a control group and the dependence on pre- and post-intervention comparisons. The results could have been impacted by unobserved confounding variables, such as concurrent health interventions and socioeconomic shifts. Despite the fact that the results offer insightful information, regional differences in healthcare infrastructure and community characteristics may prevent the findings from being applicable to all Ghanaian rural areas.

4.16 Conclusion

Using ITSA, the chapter assessed the impact of the CHPS intervention across four health outcomes – maternal deliveries, antenatal, family planning and outpatient visits at CHPS compounds. The findings showed that the intervention has significantly improved maternal and child health outcomes, particularly in the number of maternal deliveries and antenatal visits since 2016. These results reinforce the CHPS program’s role as a vital intervention for bolstering maternal and child health in rural areas, often challenged by limited healthcare access. The study” outcomes not only attest to the effectiveness of the CHPS program but also highlight the necessity for continuous evaluation and monitoring. Such ongoing assessments are crucial for measuring the program's sustained impact, pinpointing areas necessitating enhancements, and ensuring the program's adaptability to evolving healthcare needs. The absence of significant findings on the OPD visits demonstrates that effectiveness CHPS compounds needs further strengthening to encompass all desired outcomes. A potential exploration is examining the positioning of CHPS compounds as the literature has suggested that CHPS compounds effectiveness are driven by the positioning of the facilities relative to population concentration points (Addi et al., 2021). Understanding these factors is essential for formulating targeted interventions to improve healthcare accessibility and utilisation in outpatient settings.

The next chapter examines another critical aspect of healthcare service provision: the strategic positioning of CHPS facilities. The chapter aims to explore factors that could influence where these facilities are established, ensuring they align with recommended guidelines and effectively serve the intended populations. By exploring these determinants, the chapter sheds light on how the placement of CHPS compounds can optimise healthcare delivery, particularly in rural settings where such facilities play a pivotal role in enhancing community health outcomes. The insights gained here will not only contribute to a better understanding of healthcare infrastructure development in Ghana but also inform policy decisions and strategic planning for the effective deployment of health services in rural areas.

Chapter 5: Determinants Of Positioning of CHPS Facilities to Meet Recommended Guidelines.

5.1 INTRODUCTION

This chapter takes its cue from the literature review findings in chapter 2, which indicated that to date there is limited information on the factors that determine the location or positioning of a CHPS compound. This chapter provides data on the determinants/drivers of CHPS compound location within Ghanaian districts to understand whether they are within the Ghana Health Service recommended guidelines of 8km (Ghana Health Service, 2014). The data sources and the method for analysing the data are presented below. Also, the findings from this chapter could inform policies around future positioning of CHPS compound to achieve its overarching aim.

Understanding these factors is essential for multiple reasons. First, the strategic location of CHPS compounds guarantees prompt access to critical healthcare services for marginalised and rural communities, which is key for enhancing health outcomes and minimising health inequities. Secondly, it facilitates more efficient resource allocation, guaranteeing that capital expenditures on healthcare infrastructure provide optimal returns. Last but not least, adhering to the suggested principles when choosing CHPS compound locations can improve the efficacy and efficiency of healthcare delivery, eventually advancing Ghana's overall objective of attaining universal health coverage.

The association between the independent factors and the CHPS compound placement was examined using logistic regression models. This analysis makes use of logistic regression, which enables the investigation of the simultaneous effects of several independent variables on a binary dependent variable, in this case, the presence or absence of CHPS compounds within the advised 8 km radius.

The study is predicated on the assumption that the selected independent variables adequately represent the variables impacting the CHPS compound placement. There are a few possible restrictions, though: The computed associations may be distorted by strong correlations between the independent variables. To evaluate this problem, multicollinearity diagnostics like Variance Inflation Factors (VIF) should be used. Certain variables may be endogenous, which means that other factors outside of the model could affect them and skew the results. Robustness tests or instrumental variable approaches could be used to address any endogeneity.

5.2 METHODOLOGY

5.2.1 Data Source

The data set used in this chapter was obtained from the Ghana Health Service as part of a larger dataset for future analysis. The dataset was accessed after the appropriate ethical considerations and approval had been met (ethics approval from Brunel Research Ethics Committee). The GIS data collection was a core part of this chapter's assessment; the goal was to highlight each community's assets and health needs. The GIS data was ideal for this study given the increased availability of remotely sensed datasets and other digital databases, combined with declining hardware and software prices and improvements in Global Positioning Systems (GPS) accuracy (Tanser, 2006).

The dataset comprised the GPS coordinates (latitudes and longitudes) of all the healthcare facilities in Ghana, their categorisation of the region, and districts in which they were located. The town and ownerships of the facilities were also indicated in the dataset.

A google earth satellite imagery, which was georeferenced in ArcGIS, was used for the network analysis of Ghana. Further point locations of Health facilities and community locations were obtained from a dataset held by the Ghana Health Service and Ghana Statistical Service (see Appendix 1 for further information on GIS data generation and processing).

In evaluating whether CHPS compounds in Ghana fulfil their core mandate of reducing disease flashpoints, it is essential to consider how hindsight data on disease flashpoints can be utilized without deviating from the study's objectives. One primary factor to consider in using hindsight data is the potential for disease flashpoints to demonstrate consistency over time, especially concerning maternal health and outpatient department (OPD) visits (Campbell & Graham, 2006; Tatem et al., 2012). Research suggests that areas identified as disease hotspots often remain so due to persistent underlying factors, such as inadequate healthcare infrastructure, socioeconomic challenges, and specific environmental conditions (Noor et al., 2006). In the context of maternal health, for instance, evidence shows that areas with poor access to skilled birth attendants and high poverty rates are likely to experience recurrent maternal health issues (Cambell & Graham, 2006). Such findings suggest that maternal health-related disease flashpoints may not be transient but instead may continue to pose health risks over time, making historical data an equally informative tool for evaluating CHPS effectiveness.

Additionally, certain diseases related to maternal health and OPD visits, such as malaria and respiratory infections, are known to exhibit geographic clustering due to favourable environmental conditions for disease vectors (Tatem et al., 2012). Given that these environmental factors do not fluctuate significantly, retrospective data on malaria flashpoints can reliably indicate areas where preventive measures, such as CHPS interventions, should be focused. Socioeconomic challenges, including poverty and limited educational resources, also play a central role in sustaining disease flashpoints. Studies (such as Adeyeye et al., 2021) have shown that poverty is associated with an increased burden of disease due to factors like malnutrition. In districts with high poverty levels, maternal health issues and OPD-related conditions such as infectious diseases and malnutrition are often more prevalent and persistent. Hindsight data, in this case, becomes highly relevant, as socioeconomic conditions typically change gradually, if at all meaning that disease flashpoints related to poverty will likely continue to pose risks for years.

5.2.2 Dependent variables

Based on the WHO and GHS recommendations on CHPS compound's locations, the following three categorical dependent variables were explored in this chapter. These variables were selected to cater for the various contextual features per district and ensure outliers were catered for and findings reflect those scenarios.

1. At least one CHPS facility located below 8km from the associated district.

This variable described whether a district had at least one CHPS compound situated below 8km. It was examined as a binary outcome with a 'yes' or 'no' response. As such, districts with at least one CHPS compound below 8km distance were coded as 0 and those who did not have at least one CHPS compound below 8km were coded as 1.

2. Average distance of total CHPS facility in the district below 8km

This variable described the total number of CHPS compounds situated in a district, whether the average distance of all the facilities was below 8km. It was examined as a binary outcome with a 'yes' or 'no' response. Consequently, districts with the average of their total CHPS compounds below 8 km distance were coded as 0 and those who did not have the average of their total CHPS compounds below 8km were coded as 1.

3. All CHPS facilities in the district below 8km from the associated district

This variable described whether a district had its total CHPS compounds situated below 8km. it was examined as a binary outcome with a 'yes' or 'no' responses. As such, districts with all their CHPS compounds below 8km distance were coded as 0 and those who did not have all their CHPS compounds below 8km were coded as 1. Please see a summary of the dependent variables in table 29.

Table 29: List of Dependent Variables

Dependent Variables	**Specification**
At least 1 CHPS facility below 8km	This was defined as a "YES" OR "NO" variable, with 1 representing "YES".
Average distance of total CHPS compounds below 8km	This variable was defined as the average of the total distance of all the CHPS compounds to their associated district, per district
All CHPS facilities below 8km	This was defined as a "YES" OR "NO" variable, with 1 representing "YES".

5.3 Independent Variables

The selection of the independent variables was informed by the findings of chapter 2 (literature review), these findings were further asserted with the study conducted by (Field & Briggs, 2001). The independent variable included total surface area, total number of CHPS compounds, average number of children (ages 0 to 15 years), average number of Adults (ages 16 to 60 years), average number of senior citizens (60 years and above), Sum of total population in the district, Sum of total births in the district, mean of total pregnancies in the district, sum of total built settlement extent, gross domestic product per square kilometre of the district and total population density count in the district. These variables were informed by the arguments in the study by (Fiscella et al. 2000). The population's ages were described as the number of years lived and were categorised into three groups, 0-15 years, 16-60 years and ≥60 years. The sum of population was defined based on the registered home address of individuals in the district. Also, the sum of total births in the district described the total number of births entered in the birth's registry in the district. The variable "mean of total pregnancies" described the total number of pregnancies that were registered with the various health facilities across the district. The built settlement extent sum described the total number of physical features (Nieves, et al., 2020). The gross domestic product per square kilometre describes the value of the gross domestic product per square kilometre. The final variable, population density count, was defined as the population density value for each district. All the independent variables were assessed as continuous variables. Table 30 below captures all the independent variables assessed in this study.

Table 30: List of Independent Variables

Independent Variables	Specification
Average Number of Children	The number of registered residents in the district within the ages of 0-15 years
Average Number of adults	The number of registered residents in the district within the ages of 16-60 years
Average Number of senior citizens	The number of registered residents in the district 60 years and above
Sum of total population	The total number of registered residents in a given district.
Sum of total birth	The total number of births registered in a district
Mean of pregnancies	The average number of pregnancies registered in per district
Sum of built settlement	The total number of physical structures within the district
Gross domestic product / square km	This is the total monetary value of all finished goods and services in per district.
Population density count	This is the total number of registered individuals living in a square mile per district
Total surface area	This is the total two-dimensional space occupied by the district
Number of CHPS facilities	This is the total number of CHPS facilities situated within the boundaries of each district.

5.4 Data Analysis

The analyses were conducted in two main stages. First, descriptive analysis (162) of the data was conducted to explore the accuracy of the generated GIS dataset and describe the characteristics of the variables. Second, regression models were fitted to investigate associations between the dependent variables and the independent variables. STAT SE/17.0 was used for the data analysis, and the significance level set at $p<0.05$.

5.4.1 Descriptive Analysis

As indicated above, descriptive analysis was conducted to check the accuracy of the GIS dataset generated and show the sample characteristics. The accuracy was done to ascertain the dataset's consistency, check for outliers and, most importantly ensure that the values were well specified and correctly inputted (Kleppner, 2010). With regards to the sample characteristics, means, standard deviations, minimum were used to summarise the continuous variables, while proportions were used for the categorical variables. The researcher also presented results from a Pearson correlation analysis to show the degree of relationships between the study's independent variables.

5.4.2 Regression Analysis

Three logistic regression models were fitted to examine factors that determine the positioning of CHPS facilities (Enuameh et al., 2016). First a binary logit model was used to explore the key drivers and determinants of at least 1 CHPS facility below 8km. The binary logit model was used because the dependent variable in this model was binary. As indicated, the rationale for this analysis was to explore the basis for the positioning of CHPS facilities whether they were in line with the GHS policy guidelines on CHPS positioning to increase end user consumerization. In the logit model, districts that had at least one CHPS compounds below 8km were coded as “0” and those that did not have any CHPS facility below 8km were coded as “1”.

Secondly, another logit model was fitted to explore the determinants of average distance of total CHPS compounds below 8km. Just like the first dependent model, this dependent variable also had a binary outcome, as such districts with CHPS facilities whose average distance was below 8km were coded as “0” and those whose average distance were above 8km were coded as “1”. This dependent variable was also informed by the GHS guideline.

Finally, a last logit model was used to examine the determinants of all CHPS facilities below 8km. Also, for this analysis, the dependent variable had a binary outcome, as such districts with all their CHPS facilities within 8km were coded as “0” and those who did not have all their CHPS facilities within 8km were coded as “1”.

Before fitting the model, the dataset was checked to ensure they met the logistic regression assumptions (Stoltzfus, 2011). Thus, the Variance Inflation Factor (VIF) was used to examine any multicollinearity that could influence the model output (Senaviratna et al., 2019). Also, checks for random patterns among the observations in the dataset to guarantee their independence were conducted. Following the assumptions checks, the Hosmer–Lemeshow test was used to check the model fit (Paul et al., 2013). This was to ensure that the model accurately predicted the probability of the outcomes. Subsequently, based on the Hosmer–Lemeshow test output, a p-value <0.05 was indicative of a poor model fit, whereas a $p > 0.05$ indicated a good model fit (Nattino et al., 2020). In the event of a poor fit ($p<0.05$), the Hosmer–Lemeshow test was limited in highlighting where the model fits poorly (Nattino et al., 2020.

5.5 Results

The research examined 117 districts, with the majority (n=68, 58.12%) having at least one CHPS facility within 8 kilometres. However, many of them (n= 83, 70.94%) did not have all of their total CHPS facilities within the GHS mandated threshold of 8km. In addition, a higher proportion of the districts (n=97, 82.91%) did not have all their CHPS facilities within an 8-kilometer radius.

The average number of CHPS facilities in the 117 districts was 5.44 (3.86), with a high of 17 per district. Furthermore, the mean number of adults (defined as those aged 16 to 50) was 73,612 (38,324), with a maximum value of 250,089, making this the biggest age grouping. In addition, the average number of children was second in line, with a mean of 41,184 (18,105.69) and a high of 112,119. Furthermore, the average number of senior persons was 8,061 (4131.48), with a high of 25499. Finally, the mean value of the total constructed settlement extent was 3393.74 (3210.45), with a minimum value of 257 and a maximum value of 18421.

5.5.2 At Least One CHPS Location Less Than 8 kilometres

It was more likely that a district would have at least one CHPS facility within 8 kilometres if its population density was higher and its GDP per square kilometre was higher. According to GHS recommendations, this implies that regions with higher population densities and levels of economic activity give priority to healthcare accessibility. To maximise the benefit of CHPS facilities, these findings support targeted investments in healthcare infrastructure in heavily populated areas.

All CHPS facilities were more likely to be located within the advised 8 km radius in districts with bigger built settlement expenses and higher total population counts. This suggests that population density and physical infrastructure are important factors in determining where healthcare facilities are located. In order to improve healthcare accessibility, strategies for the placement of CHPS facilities should take population distribution and physical infrastructure development into account.

The results of this investigation are in line with earlier studies (Fiscella et al., 2000; Enuameh et al., 2016) that emphasise the significance of demographic and economic factors in affecting healthcare accessibility. According to the model, districts with larger proportions of senior adults (60+) and children (ages 0–15) were also more likely to have CHPS facilities within an 8 km radius on average. This is a reflection of these demographic groups' increased healthcare needs. When determining the optimal location for CHPS facilities, policymakers must take demographic factors into account in order to guarantee that marginalised groups receive sufficient access to medical care.
However, by offering a more detailed analysis of particular characteristics like the number of children and senior persons, which were not thoroughly covered in previous research, this study offers fresh insights.

The results are presented in tables 31 and 32 below.

Table 31: Descriptive summary of dependent the variables (n=116)

Dependent Variables	**YES** **Number (%)**	**NO** **Number (%)**
At least 1 CHPS facility below 8km	68 (58.12)	49 (41.88)
Average distance of total CHPS compounds below 8km	34 (29.06)	83 (70.94)
All CHPS facilities below 8km	20 (17.09)	97 (82.91)

Table 32: Descriptive summary of independent variables (n=116)

Independent Variables	Mean (Std. dev)	Min	Max
Number of CHPS facilities	5.44 (3.86)	1	17
Average Number of Children (0-15 years)	41184 (18105.69)	13290	112119
Average Number of Adults (16-60 years)	73612 (38324)	20242	250089
Average Number of Senior Citizens (60 years and above)	8061 (4131.48)	1734	25499
Total Surface Area	1.31e+09 (1.41e+09)	8.58e+07	8.35e+09
Total Population	123177.8 (60467.8)	36241.85	359642.9
Total sum of births	3885.75 (1817.63)	1156.55	11117.7
Sum of pregnancies	7.41 (10.1388)	.56	66.67
Total built settlement extent	3393.74 (3210.45)	257	18421
Gross domestic product per square km	1311.44 (1405.72)	86	8351
Population density	1512.79 (1630.95)	99	9522

Table 33: Pearson Correlation Coefficients

	AREA_M2	*mber of Child*	*umber of Adul*	*r of Senior Ci*	*lPopulation_*	*Births_sum*	*Pregsmean*	*ttlementexte*	*gdppersqkm*	*pdensitycour*	*umberofCHP*
AREA_M2	1										
Number of C	0.03293516	1									
Number of A	-0.0642881	0.93467645	1								
Number of S	-0.1005371	0.90983574	0.91552168	1							
TotalPopulat	-0.0288713	0.95433882	0.98246005	0.91491355	1						
Births_sum	0.08796519	0.89475425	0.82205831	0.7690853	0.87150516	1					
Pregsmean	-0.3686929	0.42320356	0.52103057	0.44530686	0.52633088	0.49811015	1				
Builtsettlem	-0.2135643	0.31501465	0.44550382	0.3314444	0.39955829	0.25155481	0.29672791	1			
gdppersqkm	0.99999998	0.03293813	-0.0642908	-0.1005488	-0.0288655	0.08797737	-0.3686874	-0.2135765	1		
Popdensitycc	0.99738223	0.03331619	-0.0661662	-0.1058413	-0.0266398	0.09035234	-0.3661371	-0.2133706	0.99738194	1	
NumberofCH	-0.0894921	-0.1384328	-0.1040347	-0.1165519	-0.1000164	-0.1681384	-0.026662	-0.0800438	-0.0894687	-0.0922995	1

Table 33 is the correlation result using the Pearson correlation coefficient. The analysis of the data revealed a negative relationship between a list of the variables. This includes the relationship between the following variables: surface area and number of adults; surface area and number of senior citizens; surface area and total population; surface area and built settlement; as well as surface area and number of CHPS.

Also, there is a negative relationship between these variables- number of adults and Gross domestic product per square km; number of adults and number of CHPS compound. Also, the data revealed in Table 34 shows that the number of CHPS compound variable has a negative relationship with all the variables in the correlation matrix.

The findings of the regression analysis showed that the number of CHPS facility in a district determines the odds of having at least one CHPS facility located below 8km and all CHPS facilities below 8km. Thus, the higher the number of CHPS facilities in a district, the higher the chance of one finding at least one of the CHPS below 8Km (OR= 1.17, p-value=0.01) (Model 1). Similarly, the number of CHPS in a district was associated with nearly 2 times the odds of having all its CHPS facilities below 8km (OR=1.57, p-value = 0.00). This finding suggests that the probability of finding a district with all its CHPS compound below 8km is 57%. See the regression findings in Table 34 below.

Table 34: Findings of Regression Analysis

	Model 1		Model 2		Model 3	
Variable	**At least 1 CHPS facility below 8km**		**Average distance of total CHPS compounds below 8km**		**All CHPS facilities below 8km**	
	OR	**95% CI**	**OR**	**95% CI**	**OR**	**95% CI**
Number of CHPS	1.17*	1.03 - 1.33	1.06	0.94 - 1.19	1.57**	1.18 - 2.08
Total Surface Area	0.99	0.99 – 1.00	0.99	0.99 - 1.00	0.99	0.99 - 1.00
Average Number of Children	0.99	0.99 - 1.00	0.99	0.99 - 1.00	0.99	0.99 - 1.00
Average Number of Adults	1.00	0.99 - 1.00	1.00	0.99 - 1.00	0.99	0.99 - 1.00
Average Number of Senior Citizens	1.00	0.99 - 1.00	0.99	0.99 - 1.00	1.00	0.99 - 1.00
Total Population sum	0.99	0.99 - 1.00	1.00	0.99 - 1.00	0.99	0.99 - 1.00
Births sum	1.00	0.99 - 1.00	1.00	0.99 - 1.00	1.00	0.99 - 1.00
Pregnancy's mean	0.99	0.94 - 1.05	1.02	0.93 - 1.11	1.05	0.90 - 1.22
Built settlement extents sum	1.00	1.00 - 1.00	1.00	0.99 - 1.00	1.00	0.99 - 1.00

GDP/sqkm	2.77	0.67 - 11.56	1.90	0.44 - 8.24	1.61	0.24 - 10.89
Pop density count	0.99	0.99 - 1.00	0.99	0.99 - 1.00	0.99	0.99 - 1.00

OR=Odds ratio, CI= Confidence interval, * - p-value<0.05, ** p-value<

5.6 DISCUSSION

In this chapter, we sought to unravel the determinants and key factors driving the positioning of CHPS (Community-based Health Planning and Services) facilities in Ghana. Utilising Geospatial Information Systems techniques, data from 216 districts, as sourced from the Ghana Health Service, was analysed. Notably, 117 of these districts had at least one CHPS facility, while the remaining 99 districts had none. Within the districts that had CHPS facilities, a majority (82.9%) had their cumulative distance from these facilities under 8 kilometres, aligning with the GHS guidelines for CHPS positioning (GHS, 2020). The range of CHPS facilities per district was quite broad, from one to seventeen, averaging around 5.44.

An analysis of the position of CHPS compound data indicated there was the negative correlation between the surface area of a district and the number of CHPS facilities it contained. This finding implies that larger districts tend to have fewer CHPS facilities. Furthermore, this correlation extended to the number of adults, senior citizens, total population, and built settlements, suggesting a potential influence of population density on the availability of CHPS facilities. This phenomenon mirrored the disparity between rural and urban healthcare provision (Gupta et al., 2021). But this could be explained by the fact that there are often fewer CHPS facilities in larger districts. Moreover, the negative correlation between built settlements and CHPS facilities raises questions about how infrastructure in rural areas might limit healthcare availability.

The study also unearthed a negative correlation between the number of adults and GDP per square kilometre, and the number of CHPS compounds and GDP per square kilometre. This pattern indicates that economic factors play a role in the distribution of CHPS facilities, aligning with the notion that economic development correlates with better healthcare access (Chen et al., 2021).

Interestingly, the negative correlations across various variables in the matrix hint at a multifaceted influence on CHPS facility availability. While these insights are primarily descriptive, they hint at an intriguing possibility: districts with more CHPS facilities might correspond to areas with a higher prevalence of underserved communities. This hypothesis, while grounded in observational data, calls for more empirical research to fully understand the dynamics at play, echoing the sentiments of Noor (2004).

In the regression analysis, the number of CHPS facilities in a district was a significant determinant of their positioning within the 8km guideline set by GHS (2020). This finding suggests that increasing the number of CHPS facilities in a district could enhance adherence to this policy and, ostensibly, increase geographic accessibility for the intended populations (Pu et al., 2020). A district's placement inside the 8km criterion is significantly influenced by the quantity of CHPS facilities in that district. This shows that expanding the CHPS network can improve regional accessibility to healthcare services and adherence to GHS policies.

However, geographic accessibility doesn't necessarily equate to effective utilization, as other socioeconomic factors also come into play (Zakar, 2019). Cultural and financial barriers, as noted by Higgins-Steele et al. (2018) and Harefield et al. (2018), remain significant obstacles to primary healthcare uptake. Therefore, it's crucial that CHPS policy implementation is approached holistically, acknowledging the interplay of various factors and striving for equity in healthcare coverage.

This regression outcome aligns with findings from similar studies (Cheng et al., 2020; Pan et al., 2018), suggesting that an incremental increase in CHPS facilities per district could be a strategic move for policymakers in Ghana to ensure better geographic accessibility. To our knowledge, this is the first study delving into the determinants of CHPS positioning in Ghana, potentially laying the groundwork for further research aimed at enhancing CHPS facility performance. However, the cross-sectional nature of this study limits the ability to draw causal inferences between variables. Additionally, the study's scope was constrained by the availability and validation of spatial data for GIS analysis.

5.7 Strengths and Limitations

A notable strength of this study lies in its utilization of Geospatial Information Systems techniques to generate data across 216 districts in Ghana. This approach has allowed for a comprehensive mapping and analysis of the distribution of CHPS (Community-based Health Planning and Services) facilities, lending a broad perspective that enhances the generalizability of our findings. Such an extensive dataset is invaluable for policymakers and other stakeholders looking to understand and improve healthcare facility distribution across the country.

However, the study is not without its limitations. A primary constraint is its cross-sectional design, which inherently limits the ability to draw causal relationships between the variables. To truly understand the dynamics between the CHPS facilities, socioeconomic factors, and health outcomes, there is a need for longitudinal studies that can trace these relationships over time. Another limitation stems from the challenges associated with the availability and quality of spatial data used in GIS data generation. The study's scope and depth might have been affected by potential gaps or inaccuracies in the spatial data. Future research in this area would benefit from the collection of more precise and up-to-date spatial data, which would contribute to the robustness and validity of the research outcomes.

In studying the placement of CHPS compounds, it is essential to recognize that a variety of factors can influence where these facilities are situated (Peters et al. 2008; Guagliardo, 2004). While the independent variables selected—such as population demographics, economic activity, and spatial attributes—provide a robust framework for analysing facility placement, other significant factors, including political considerations, geographic accessibility and community demands also play a role in determining the location of these primary healthcare centres (Penchansky & Thomas, 198; Marmot, 2005).

Decisions about CHPS compound placement may be influenced by local or national government priorities, which could result in facilities being sited without consideration to the outlined independent variables (Kruk & Freedman, 2008). Similarly, in remote or mountainous areas, even high-need locations may lack facilities due to logistical challenges related to terrain, road and transportation networks (Guagliardo, 2004). Despite the influence of these factors, the selected variables for this study are appropriate and robust for analysing CHPS compound placement because they capture the fundamental demographic, economic, and spatial characteristics that most directly correlate with the demand and feasibility of healthcare services (peters et al., 2008). Additionally, these factors are quantifiable and as such, where they do not provide sufficient explainers for the determinants for siting the facility, further qualitative reasoning such as geography or politics can be further investigated (Marmot, 2005).

5.8 Policy and Research Implications

The insights gained from this study carry substantial weight for health policy formulation in Ghana. A key recommendation for policymakers is the advocacy for a gradual increase in the number of CHPS facilities across districts. Such an increment is pivotal for enhancing geographic accessibility to healthcare. By making improvements to the infrastructure in rural areas, established settlements can lessen the detrimental effects of inability to access healthcare, allowing for equitable access in all places. In parallel, there's a need for a holistic approach that considers the synergy between various policy initiatives in the health sector to coordinate flow of resources. This comprehensive strategy is essential to address and potentially overcome the barriers to equitable healthcare coverage.

Moreover, the study underscores the urgency for additional research aimed at elevating the functionality of CHPS facilities in Ghana. Future research endeavours could pivot towards examining the relationship between disease occurrence and factors related to CHPS facilities. This examination should include a broad spectrum of variables, such as socioeconomic factors, cultural impediments, and financial constraints, to gain a deeper understanding of their impact on the utilization and effectiveness of CHPS facilities.

Furthermore, the findings highlight the necessity for more longitudinal and qualitative studies. These studies are crucial in establishing causal links and providing a richer, more nuanced understanding of the factors influencing the use of CHPS facilities. Such in-depth research would be instrumental in shaping targeted interventions and policies designed to enhance healthcare access and outcomes across Ghana.

Community health officers should be stationed in nearby compounds as part of implementation techniques, and health services are integrated with community resources. Prior studies have demonstrated that CHPS can considerably enhance healthcare results in these specific domains (Nyonator et al., 2005; Awoonor-Williams et al., 2013). By offering actual data on the factors influencing CHPS facility placement, this study adds to the body of knowledge and may help shape future developments in the program's execution.

The GHS recommendation that CHPS facilities be located within 8 kilometres was met by most districts (82.9%), demonstrating general compliance but variation within districts. Enforcing guidelines and keeping an eye on them on a regular basis are essential to upholding accessibility requirements and filling in regional gaps as a practical step to equitable health provision. Involve local communities in the selection of the site of CHPS facilities and the order of importance of service delivery. Involving the community ensures that services are tailored to the needs and preferences of the local population, builds trust, and promotes the use of healthcare services.

5.9 Conclusion

In this chapter, we embarked on an insightful exploration to uncover the factors influencing the strategic placement of Community-based Health Planning and Services (CHPS) facilities across Ghana. Our analysis, which employed Geospatial Information Systems techniques and encompassed data from 216 districts, unveiled a stark contrast: while 117 districts were equipped with at least one CHPS facility, an alarming 99 districts lacked such essential healthcare infrastructure. This significant disparity underscores an urgent need for policy intervention, particularly in underserved areas.

A key observation from our study is the adherence to Ghana Health Service guidelines by the majority of districts with CHPS facilities, positioning these units within an 8-kilometer radius of the communities they serve. However, a notable negative correlation emerged between the surface area of districts and the number of CHPS facilities, suggesting that larger districts are often underserved in terms of healthcare facilities. This finding not only mirrors the challenges faced in rural healthcare delivery but also emphasizes the impact of population density and settlement patterns on the accessibility of healthcare services.

Furthermore, our analysis revealed that economic factors, notably the inverse relationship between a district's GDP per square kilometre and the number of CHPS facilities, are pivotal in shaping the distribution of these healthcare services. The regression analysis underlined the importance of the number of CHPS facilities in a district as a determinant of their compliance with the GHS guideline. Yet, it is crucial to acknowledge that geographic accessibility alone does not guarantee effective healthcare utilization. As highlighted in prior research, socioeconomic constraints, including cultural and financial barriers, pose significant hurdles to accessing healthcare. It lays the groundwork for subsequent research aimed at enhancing the distribution and effectiveness of CHPS facilities.

This upcoming chapter aims to deepen our understanding of the relationship between the location of CHPS facilities and the incidence of diseases. Through examining how the positioning of these facilities correlates with disease outbreak points, we aim to provide further insights into the strategic placement of healthcare services, thus contributing to the development of more effective healthcare policies and practices in Ghana. This analysis is crucial for ensuring that CHPS facilities are not only strategically positioned but also effectively contribute to mitigating health risks and improving overall community health outcomes.

The findings regarding the positioning of CHPS compounds in Ghana are integral to understanding the broader goal of the study, which is to evaluate the effectiveness of CHPS facilities (Ghana Health Service, 2014). These insights highlight the structural and environmental factors shaping CHPS services, allowing for a more comprehensive assessment of their effectiveness in meeting healthcare needs (Peters et al., 2008). This standard reflects a deliberate attempt to reduce travel time and physical distance between healthcare services and the population, especially in underserved rural areas (Guagliardo, 2004). Our study observes that most districts with CHPS facilities conform to this guideline, highlighting heightened adherence in terms of policy compliance. This compliance is essential in evaluating the effectiveness of CHPS, as it reinforces the principle that primary healthcare should be available within a reasonable distance, a foundational aspect of CHPS' mission to make healthcare accessible at the community level (Kurk & Freedman, 2008).

However, the study also identifies a significant negative correlation between district surface area and the number of CHPS facilities, suggesting that larger districts tend to have fewer

CHPS units relative to their size. This discrepancy highlights the existing shortfall in achieving universal health care access, as it suggests that residents in more expansive rural districts may experience limited access to primary healthcare services (Penchansky & Thomas, 1981). The finding brings attention to the spatial inequalities inherent in healthcare distribution, which can hinder CHPS' mission to provide equitable healthcare access (Marmot, 2005). Addressing these spatial gaps could enhance the effectiveness of CHPS facilities, ensuring that even the most isolated communities are not left underserved.

Economic factors also play a crucial role in shaping CHPS facility placement and, consequently, healthcare access. The inverse relationship between a district's GDP per square kilometre and the number of CHPS facilities suggests that economically disadvantaged areas, often characterized by lower GDP densities, may still be underserved, even if slightly improved (Adeyeye et al., 2021). This economic constraint implies that communities in poorer districts may lack adequate healthcare infrastructure, thereby limiting the reach and impact of CHPS facilities. Such disparities emphasize that healthcare effectiveness cannot be measured solely through geographic accessibility but must also consider the economic context in which healthcare facilities operate (Peters et al., 2008). Moreover, the regression analysis that identifies the number of CHPS facilities in a district as a determinant of compliance with GHS guidelines suggests that when districts have more CHPS facilities, they are better positioned to adhere to guidelines concerning healthcare accessibility. It reinforces the understanding that facility density directly impacts how well CHPS can meet its mandate of universal access to healthcare (Ghana Health Service, 2014).

Importantly, the study recognizes that geographic proximity alone is insufficient to ensure effective healthcare use, as socioeconomic barriers such as cultural norms and financial limitations also affect access (Marmot, 2005; Kruk & Freedman, 2008). This underlines the need for additional interventions that address the financial and cultural constraints faced by rural populations.

Finally, the forthcoming chapter aims to examine the relationship between CHPS facility positioning and disease incidence, further linking placement to healthcare outcomes. This analysis will assess how the spatial arrangement of CHPS facilities correlates with patterns of disease outbreaks, offering insights into whether current CHPS placement strategies effectively mitigate health risks. This analysis is pivotal for informing evidence-based policy recommendations, as it will help determine whether CHPS facilities are strategically positioned not only for access but also for maximising their impact on health outcomes (Guagliardo, 2004).

Chapter 6: An Analysis of Disease Occurrence Points Relative to CHPS Facilities Related Factors.

6.1 Introduction

Chapter 4 analysed the determinants of the positioning of CHPS facilities. It was however indicated in the literature review (chapter 2), the complexity of the positioning of CHPS facilities, which requires a holistic approach to critically understand the arguments associated to the positioning of CHPS facilities. The aim of this chapter is to assess the core mandate of CHPS compounds to reduce disease flash points and whether the facilities are meeting it, as well as the related CHPS facilities factors that relate to meeting this core mandate. The findings of this chapter will then further inform the positioning of CHPS compounds and facilitate creation of policy to address these characteristics and ensure the core mandates are fully met. The next subsection presents the methodology employed to analyse the data.

6.2 Methodology

6.2.1 Data Source

The data used for the analysis in this chapter was obtained from the Ghana Health Service, as discussed in chapter 4. The GIS data results were further mined and categorised for use as dependent variables. This was done by gathering the GPS coordinates of all the CHPS facilities located in the various districts of Ghana through spatial analysis and GIS techniques. The waypoints for all CHPS compounds in Ghana were gathered as well as the disease flashpoints. The data was compiled by the Ghana Health Service as part of its monitoring and evaluation of all health facilities in Ghana, the data was verified through GIS cross-referencing. While historical disease data have limitations, consistent clustering patterns suggest reliability in identifying disease-prone areas.

The use of GIS as a method for data sourcing has many challenges, the most significant is the acquisition of detailed data sources with accurate locational and attributional information on the study areas. To an extent this limitation was reduced by sourcing data from both the Ghana Health Service and conducting spatial checks to ascertain the quality of data. The primary approach is often through two methods:

6.2.2 Dependent Variables

Distance from disease outbreaks/occurrence point to districts was the dependent variable in this chapter. It described the straight-line distance from the disease flash point to the district, as such, it was assessed as a continuous variable.

Table 35: Descriptive summary of dependent variables (n=216)

Dependent Variables	Mean (Std. dev)	Min	Max
Distance from Disease outbreak points to Districts	13.48 (13.51)	0.54	84.17

Operational Definition: The straight-line distance measured from the geographic site where a disease epidemic originates (the flash point) to the centroid of each district is referred to as the "distance from the disease outbreak/occurrence point to districts."

Unit of Measurement: Kilometres (km) are used to express distance.

Type: Because it is evaluated as a continuous variable, the geographical relationship may be precisely measured and analysed.

Method of Calculation: The straight-line (Euclidean) distance between each district centroid and the outbreak point is determined using Geographic Information Systems (GIS) techniques.

Data Sources: Official health and geographic data repositories are the source of the geographic coordinates of district centroids and disease outbreak locations.

Goal and Significance: Understanding this distance is essential for evaluating the geographical dissemination of illnesses and the availability of medical care during epidemics. It sheds light on the possible delays in medical response times and the necessity of carefully placing CHPS facilities in order to effectively control and reduce the spread of disease.

6.3 Independent Variables

The independent variables included CHPS-related variables; notably, the distance from CHPS facilities to districts, the existence of CHPS facilities or not for every given district and the total number of CHPS facilities per district. Also, other socioeconomic variables, like GDP per square kilometre (Km), number of children, adults, and senior citizens, built settlement and population density were examined in this chapter. In all, the characteristics of 216 districts were explored as independent variables and these variables were informed by the reviewed literature. The description and specification of the socioeconomic variables were similar to those in table 30 of chapter 5.

1. **Variable: The distance between districts and CHPS facilities.**

Definition: The distance in a straight line between the centroid of each district and the closest CHPS facility is measured by this variable.

Unit of measurement: kilometres (km).

Type: Continuous variable.

Calculation Method: The Euclidean distance between each CHPS facility and the district centroid is determined using Geographic Information Systems (GIS) tools.

2. **Variable: If CHPS Facilities Are Available**

Definition: The presence or absence of a CHPS facility in a district is indicated by this binary variable.

Operationalization: The CHPS facility is present and is coded as 1 and if there is no facility available, it is coded as 0

Type: Binary

3. **Variable: Total CHPS Facilities in Each District**

Definition: The total number of CHPS facilities in each district is indicated by this variable

Type: Continuous variable.

4. **Variable: GDP per Square Kilometre**

Definition: The economic output per unit area in each district is represented by this variable.

Unit of measurement: GDP per square km

Type: Continuous variable

Source: Local government documents and economic data repositories.

5. **Variable: Number of kids (between the ages of 0 and 15)**

Definition: The total number of people living in each district between the ages of 0 and 15.

Type: Continuous variable

Source: Data from population censuses.

6. **Variable: Adult population (ages 16 to 60)**

Definition: The total number of people in each district who are between the ages of 16 and 60.

Type: Continuous variable

Source: Data from population censuses.

7. **Variable: The count of elderly individuals (60 years of age and older)**

Definition: The total number of people sixty years of age or older who live in each district.

Type: Continuous variable.

Source: Data from population censuses.

8. **Variable: Built Settlement Area**

Definition: The total area of land that has been developed within each district is measured by this variable.

Unit of measurement: Square kilometres (km2).

Type: Continuous variable.

Calculation Method: GIS analysis of data on land use and satellite photography.

9. **Variable: Population Density**

Definition: The population density in each district per square kilometre.

Unit of measurement: Persons per square km.

Type: Continuous variable.

Calculation Method: District total population divided by district land area.

6.4 Data Analysis

The Poisson family of the Generalized Linear model (GLM) was fitted to investigate the key determinants of distance of disease outbreaks from a district among 216 districts. The rationale for this analysis was because the dependent variable was a count variable with a skewed distribution (Sellers et al. 2010). The assumptions for GLM, such as correct distribution of residuals and correct specification of variance structure were checked before fitting the Poisson model (Sellers et al. 2010). Finally, all the independent variables were included in the model to unmask actual determinants of disease outbreak distance from a district. STATA SE/17.0 was used for the data analysis, and the significance level set at $p<0.05$.

6.5 Results

The distance from a district to disease outbreaks was found to be significantly associated with the existence of CHPS facilities and the number of CHPS facilities in a district. For instance, districts with no CHPS facilities were 12% more likely to be closer to disease outbreaks compared to those with CHPS facilities (P-value = 0.02). Also, districts with six to eleven CHPS facilities were far from disease outbreaks than those with less than 6 CHPS facilities (Correlation coefficient = 0.22; P-value =0.00). However, those with over eleven CHPS facilities were 31% closer to disease outbreaks than those with less than 6 CHPS facilities.

Additionally, districts with CHPS facilities located 50 – 74km away from the district were 28% farther from disease outbreaks. Conversely, none of the other independent variables determined the distance from a district to disease outbreaks.

Please see table 36 for a summary of this regression findings.

Table 36: Determinants of distance from a district to disease outbreaks (N= 216 districts).

Variables	Distance from districts to disease outbreaks		
	Correlation Coefficient	95% CI	P-value
Existence of a CHPS facility Yes No	 -0.12*	 -0.20 – -0.20	 0.02
Number of CHPS > 6 6 – 11 ≥12	 0.22** -0.31*	 0.11 – -0.33 -0.53 – -0.097	 0.00 0.01
Total Surface Area	-7.31×10^{-08}	-2.01×10^{-08} – 5.43×10^{-08}	0.26
Total Population sum	6.56×10^{-06}	3.83×10^{-06} – 9.28×10^{-06}	0.00
Births sum	3.13×10^{-06}	-0.00 – 0.00	0.83
Mean Pregnancies	0.00	-0.00 – 0.00	0.13
Built settlement extents sum	0.00	0.00 – 0.00	0.00
GDP per square km	0.06	-0.06 – 0.19	0.31
Population Density Count	-0.00	-0.00 – -0.00	0.00
Number of Children	2.06×10^{-06}	-5.77×10^{-07} – 4.69×10^{-06}	0.13
Number of Adults	-4.81×10^{-06}	-7.92×10^{-06} – -1.71×10^{-06}	0.00
Number of Senior Citizens	-0.00	-0.00 – -0.00	0.00
Distance of CHPS from Communities >25km 25km – 49km 50km – 74km ≥75km	 -0.07 0.28** 0.06	 -0.18 – 0.04 0.18 – 0.39 -0.05 – 0.17	 0.22 0.00 0.26

6.6 Discussion

In this chapter, we go into the nuances of CHPS-related characteristics and their impact on the proximity to disease outbreaks in districts, as uncovered in Chapter 4. Employing a generalized linear regression model with the Poisson family, we explored the intriguing dynamics between the presence of CHPS facilities and the geographical spread of diseases.

Interestingly, districts equipped with CHPS facilities were found to be more distanced from disease hotspots compared to those without such facilities. This was quantified as a 12% increased likelihood of being nearer to disease outbreaks in districts lacking CHPS facilities (P-value= 0.02). This finding not only aligns with the established importance of primary healthcare in disease control (Kruk et al., 2010; Langlois et al., 2016) but also hints at a potentially proactive role of CHPS facilities in disease prevention and surveillance (Kebede et al., 2010; Fall et al., 2019). Significant economic differences may exist in districts with a high concentration of CHPS facilities, which may have an impact on healthcare access and the transmission of illness.

In more economically active regions, higher rates of mobility and migration may contribute to the spread of diseases by attracting diseased individuals to the area.

Furthermore, the study reveals that the sheer number of CHPS facilities in a district has a significant bearing on disease proximity. Districts with a higher concentration of CHPS facilities (6 – 11) demonstrated a more pronounced distancing from disease flashpoints. This supports the notion that enhanced primary healthcare availability is pivotal in reducing disease burdens (Bitton et al., 2019). Greater numbers of CHPS facilities may correspond with regions where access to healthcare is improved, which could result in increased rates of illness outbreak reporting and identification.

However, a curious reversal in this trend was observed in districts with more than eleven CHPS facilities, which were found to be 31% closer to disease outbreaks compared to those with fewer facilities. This counterintuitive finding, potentially influenced by unique demographic or community attributes in these districts, underscores the complexity of the relationship between healthcare infrastructure and disease dynamics (Cowling et al., 2020; Sajadi et al., 2020).

There may be a larger risk of disease transmission in districts with more than eleven CHPS facilities due to their higher population densities. Infectious diseases can spread quickly in densely populated areas, which can increase the frequency of outbreaks. These neighbourhoods may support greater populations due to their denser built surroundings, but they also run the risk of fostering the spread of infectious diseases.

The correlation may indicate that healthcare infrastructure development is being done more reactively than proactively, with facilities being built in reaction to recurring illness outbreaks rather than proactively preventing them.

6.7 Avenues for Future Research

To determine particular traits of populations in districts with different numbers of CHPS facilities, future research must focus on a thorough demographic analysis. Age distribution, household size, patterns of movement, and socioeconomic position are a few examples of the factors to explore in future research.

The research can additionally investigate the impact of environmental and socioeconomic factors in further detail. Further research should analyse the effects of variables of frequency and control of disease outbreaks, including income levels, employment rates, water quality, and sanitary facilities. To gain a deeper understanding of the influence of these factors on disease dynamics, it could also consider integrating variables including transportation networks, sanitation facilities, and water quality.

To monitor changes in illness patterns and healthcare infrastructure over time, longitudinal studies should be conducted. This would make it easier to identify causes and understand how CHPS facilities affect public health over the long run. That will provide a better picture than the stationary picture provided by the current study.

The focus was primarily on the presence and quantity of CHPS facilities, overlooking other pertinent aspects like staff expertise and resource availability. Future research should incorporate these dimensions for a more holistic understanding of how CHPS facilities influence disease outbreak dynamics.

6.8 Strengths and Limitations

Because the analysis was mainly focused on characteristics connected to CHPS, it is possible that other healthcare facilities, such as district hospitals and private clinics, were not taken into consideration. These facilities may also play a major role in managing and preventing disease. The study may have overlooked other significant elements impacting disease outbreak dynamics, such as local healthcare policies, public health campaigns, and community health programmes, by concentrating on CHPS facilities. If other supportive healthcare systems are heavily involved, the actual impact of CHPS facilities may be overstated.

The study's scope was also limited to certain socioeconomic variables. it did not take into account other important aspects such as transportation networks, water and sanitation infrastructure, or environmental conditions. The dynamics of disease and the accessibility of healthcare can be greatly impacted by these variables.

Because the study was cross-sectional, it was difficult to determine a cause-and-effect link between the existence of CHPS facilities and the proximity of disease over longer periods of time. A more thorough knowledge of how changes in healthcare infrastructure over time affect illness patterns might be possible with longitudinal data. Thus, the conclusions drawn from the study have to be put in context.

The dependability of the results may also be impacted by the spatial data's resolution and correctness when used for GIS analysis. Conclusions concerning the closeness of diseases may be impacted by potential mistakes in geocoding and distance measurements. This should be considered when broadening the applicability of the study's findings. Finally, the absence of additional healthcare determinants and the narrow regional emphasis may limit the findings' generalizability. This is because, the various regions may have distinctive attributes throughout districts may impact the efficacy and influence of CHPS facilities and consequently overall generalizability.

6.9 Policy and Research Implications

The insights garnered from this study carry significant weight for health policy formulation in Ghana. They underscore the need for a strategic expansion of CHPS (Community-based Health Planning and Services) facilities across all districts. This expansion is not just about reducing the geographical distance to disease outbreaks but also about tackling the broader issue of health inequities. The study's findings suggest that merely having CHPS facilities is not enough; there needs to be a focused and gradual increase in these facilities to truly enhance healthcare accessibility and coverage.

Moreover, this research highlights an area that requires further exploration. It points out the necessity for additional studies to understand the dynamics affecting disease outbreak proximity in districts with a dense network of primary healthcare facilities. This is particularly pertinent in light of the observation that districts with a higher number of CHPS facilities tend to be closer to disease hotspots. Showing the factors behind this phenomenon could provide invaluable insights for health policymakers and practitioners, enabling them to tailor their strategies more effectively.

To guarantee that underprivileged and remote districts are adequately covered, policymakers should give top priority to the equitable deployment of CHPS facilities. This entails identifying locations with restricted access and gradually adding more facilities. Rather than random expansion, the findings recommend a deliberate, steady rise in the number of CHPS facilities. This strategy increases the efficacy of the facilities by assisting in ensuring that they are suitably staffed, furnished, and integrated into the community's healthcare system.

It's important to keep a close eye on districts with more than eleven CHPS facilities because these locations have been shown to be closer to disease outbreaks. The fundamental causes of this tendency, such as population density, patterns of movement, and regional healthcare-seeking behaviours, should be looked into by policymakers. In such areas designated as disease hotspots, carry out focused health interventions. To slow the spread of diseases, this could entail putting mobile health clinics into service, improving disease surveillance systems, and stepping up public health education initiatives.

Policymakers should also encourage the merging of CHPS locations with other healthcare services, such as specialty clinics and district hospitals, in order to establish a unified healthcare system that can react quickly to medical emergencies.

6.10 Conclusion

The findings from this chapter provide a comprehensive understanding of the role and impact of Community-based Health Planning and Services (CHPS) facilities in disease management and healthcare delivery across Ghana. Using a generalized linear regression model with the Poisson family, the study has effectively highlighted the relationship between the presence of CHPS facilities and the geographic distribution of disease outbreaks within districts.

A significant takeaway from the study is the evident positive influence of CHPS facilities in reducing the proximity of districts to disease hotspots. The data indicates that districts with CHPS facilities have a 12% lower risk of being near disease outbreaks compared to those without such facilities. This finding is consistent with existing literature, emphasizing the vital role primary healthcare plays in disease prevention and surveillance (Kruk et al., 2010; Langlois et al., 2016; Kebede et al., 2010; Fall et al., 2019). Furthermore, the study reveals that the number of CHPS facilities within a district is a crucial factor; districts with a moderate number of facilities demonstrate a greater distance from disease flashpoints. This underscores the importance of primary healthcare accessibility in mitigating disease incidence (Bitton et al., 2019).

However, an intriguing trend reversal is observed in districts with more than eleven CHPS facilities, which paradoxically are found to be closer to disease outbreaks. This unexpected finding points to the complex interplay of healthcare infrastructure and disease dynamics, potentially influenced by unique demographic or local community characteristics, warranting further in-depth research (Cowling et al., 2020; Sajadi et al., 2020).

While the chapter employs an innovative analytical approach and provides valuable insights into CHPS facilities' role in disease management, it also acknowledges certain limitations. Specifically, the analysis focuses primarily on the presence and quantity of CHPS facilities, without addressing other critical aspects like staff expertise or resource availability within these facilities. Addressing these limitations presents a promising avenue for future research, which could adopt a more holistic view by examining a wider array of factors that contribute to the effectiveness of CHPS facilities in managing diseases.

These results have important ramifications for Ghanaian healthcare policy and practice. According to the study, improved disease prevention and control can be achieved by strategically and moderately expanding the number of CHPS facilities, which will ultimately improve public health outcomes. To guarantee that CHPS facilities efficiently fulfil their intended function, policymakers should prioritise fair distribution and sufficient support for these facilities. Furthermore, in order to establish targeted interventions, it is imperative to comprehend the mechanisms underlying the closeness of disease outbreaks in districts with a high density of CHPS facilities.

In the next chapter, the focus will shift to explore another crucial aspect of healthcare delivery. This chapter will delve into the operational efficiency of CHPS facilities, specifically analysing patient waiting times and the routing system within these healthcare centres. The aim is to uncover insights into the operational challenges and opportunities within CHPS facilities, contributing further to the understanding of how these centres can optimize their services for better healthcare delivery and patient satisfaction. This exploration is not only significant for enhancing healthcare service quality but also for informing policies and strategies aimed at improving patient experiences in Ghana’s healthcare system.

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Chapter 7: An Analysis of Patient Waiting Times and Routing in CHPS Compounds.

7.1 INTRODUCTION

The previous chapters highlighted the critical knowledge gaps in examining the influence of patients waiting times on the uptake of community healthcare facilities (Chapter 2) and argued the robust methodological approaches to address the highlighted gaps (Chapter 3).

A healthcare system is a pure service network distinguished by a strong degree of human participation both at the asset (paediatricians, caregivers, and so on) and institution levels (patients) (Paparella, 2016). If faced with the unpredictability caused by individual input, this system might be difficult to create, manage, or enhance (Yip and Hsiao, 2020). Moreover, the outcome of a patient's prognosis is dependent on various personal variables, which usually results in variations in the number of resources, the procedure, and the path assigned to clients. This variation results in increased wait times and lower productivity. A way to properly deal with the challenge is to rely on computer models.

According to some research, primary healthcare facilities can effectively decrease wait times and enhance patient satisfaction (Kruk et al., 2010; Bitton et al., 2019). Nonetheless, further studies highlight important obstacles that may impair these facilities' efficacy, including a lack of resources and variations in service quality (Yip and Hsiao, 2020; Paparella, 2016). These disparities imply that although primary healthcare can be an effective instrument for enhancing health outcomes, its application and functioning are intricate and necessitate thorough assessment of numerous contextual elements.

Furthermore, a number of studies have provided support for the use of computer models to address operational difficulties in healthcare settings (Harefield et al., 2018; Cowling et al., 2020). These models have the ability to forecast patient flow, optimise resource allocation, and shorten wait times. However, there are several obstacles to the actual use of such models, such as problems with data quality and the requirement for ongoing model validation and modification to account for the intricacies of the real world (Sajadi et al., 2020).

This Chapter, therefore, aims to contribute empirical data that could guide the ongoing conversations on the operation of the CHPS program and further have implications for the policy's sustenance and improvements in Ghana to align with the Sustainable Development Goal (SDG) 3.8's universal health coverage goal (WHO, 2016).

7.2 Methodology

The purpose of this study was to assess the patient waiting times and suggest alternatives to enhance the care procedure by reducing long waits to their benchmark levels or lower as required. Despite significant resources allocated to supporting hospital supplies in Ghana, long waiting times remain a prominent challenge in health care systems (Laar, et al., 2019). The technique took doctors, caregivers, and examination areas into account as control factors. This method is comparable to the valuable research presented by (Corsini et al., 2022) and (Bloechle & Laughery, 2019).

Simulation has been used in virtually all segments of the healthcare delivery analysis field. Simulation applications in healthcare include modelling for staffing decisions, facility design and location, patient flow, appointment scheduling, capacity allocation, and logistics.

Comprehensive literature surveys on simulation applications in healthcare have been published by studies such as (Schweizer, 1973), (Jun et al., 1999), (Fone et al., 2003), (Brailsford et al., 2009) and (Mielczarek & Uziałko-Mydlikowska, 2010).

7.3 Design

7.3.1 Simulation methods

There are a number of simulation methods that can be used for building health facility models. Three of the closest fit models will be evaluated and the best choice model highlighted. The models to be considered are Discrete Event Simulation (DES), System Dynamics (SD) and Agent-Based Simulation (ABS).

7.3.2 System Dynamics (SD)

Systems Dynamics (SD) is a popular method for modelling continuous systems and was founded by Forrester (1958). It works based on a set of differential equations that tracks instantaneous changes in a dynamic system. A typical dynamic system can be characterised by interdependence, mutual interaction, information feedback, non- linearity, and circular causality concepts. SD is known to be a method for strategic-level thinking since it looks at systems from higher levels to capture the whole system. It is for this reason that in SD we examine cohorts but not individuals. Aggregating individuals, as discussed in an earlier section, helps a model to be simpler and less detailed.

An SD model has two basic elements: stocks to keep track of levels of 'things' and flows for the rate of change of 'things. 'Things' are the entities in a system that change their states based on the feedback loops from other stocks. The entity concept in SD is different from that in Discrete Event Simulation (DES) since entities represent cohorts but not individuals. Feedback-loop concept resides at the heart of SD and is represented by casual relationships. A casual loop diagram is used to visualise feedback loops that exist in a system. There are two types of feedback: positive reinforcement, which represents behaviour of growth, and negative reinforcement, which represents behaviour of balancing (Sterman, 2000). It is worth noting that SD not only looks at events but also patterns of behaviour since it evaluates the cause-and-effect relationship in a system. Levels are static and they only change when flows are in action.

Most of the SD models in the healthcare domain are either used for persuasion purposes or for providing a framework for evaluation of tactical studies, as reported by Dangerfield's (1999) survey on SD applications in a European healthcare context. Dangerfield comments that SD models are more appropriate for studying the interrelationship between elements of healthcare systems. An influential paper by Lane et al (2000) supports this idea; their SD hospital model showed that the link between the ED and other units of a hospital is significant for the whole hospital performance. The model results were not terribly detailed but generated insights for decision makers. Brailsford et al (2010) also agree that SD models tend to look at strategic-level problems, whereas DES is used for operational-level problems.

7.3.3 Agent-Based Simulation (ABS)

ABS is a simulation method for modelling dynamic, adaptive, and autonomous systems. It is employed to discover systems by using 'deductive' and 'inductive' reasoning. At the core of an ABS model, there are 'autonomous' and 'interacting' objects called agents. Agents are like entities in a DES model; however, agents are social and interact with others and they live in an environment and their next actions are based on the current state of the environment. In addition, an agent senses its environment and behaves accordingly based on simple rules defined. Agents may have explicit goals to maximise or minimise, may learn, and adapt themselves based on experience (which needs memory, e.g., using dynamic attributes). The definition of agent behaviours ranges from simple 'if-then' statements to complex models, for example cognitive science or artificial intelligence.

Macal & North (2010) is a classical tutorial for ABS modelling in which the virtue of ABS is best described by a flock simulation model (Boids-Sim by Reynolds 2012). In this model, each agent, for example a bird, has three rules governing its movement: cohesion: move to the average position of its nearby 'flockmates', separation: avoid crowding local 'flockmates', and alignment: move towards average heading of local 'flockmates'. By applying these rules to each agent, one might observe group behaviour of a flock. The generalisation of this observation is twofold: first, simple rules might explain complex behaviours and, second, local information is significant in a group's behaviour.

Is a hospital, or a part of it, a system of this kind? If yes, then we can think about ABS for modelling hospitals. The answer to this question is not yet entirely clear, but ABS surely has great potential and is an emerging method for hospital simulation modelling. So far, it has been used for epidemic modelling, for example by Laskowski et al (2011), who model the spread of influenza virus infection within an ED. Their model includes a collection of agents (patients and healthcare workers) and their individual characteristics, behaviours, and interactions on the ED layout. The results suggest that patient-oriented infection control policies tend to have a larger effect than policies that target healthcare workers. In addition, note that, as Siebers et al (2010) suggest, ABS is not yet well adopted by industry and is used primarily by academics.

An ABS model has three elements: agents, which have attributes (static or dynamic levels, e.g., variables) and behaviours (conditional or unconditional actions, e.g., methods); interactions, which define relationships between agents; and environment that are external factors that affect agents and interactions. On the representation of behaviour of an agent, state charts using Unified Modelling Language is one of the methods (Borshchev & Filippov, 2004; Sobolev et al, 2008).

7.3.4 Discrete Event Simulation (DES)

DES is the father of all simulation methods and has a long history. DES is used to model systems that change states dynamically, stochastically, in discrete intervals. DES is particularly a powerful method in systems that have a strong queuing structure since it is based on tracking entities that change state in a system. Queues are formed naturally by entities that compete for resources.

The DES is attractive for modelling health facilities for the following reasons:

- Flexibility in responding to scale changes and the level of detail: Most DES software offers great flexibility in supporting the level of detail needed by the modeller. A DES model can be either extremely detailed or less detailed, based on the needs of the modeller. Programming languages, embedded in simulation software, add to this flexibility.

- Individual patient focus: Movements of individual patients in treatment processes through time can be tracked in a DES model. That is, instead of cohort behaviour of patients, individual patient behaviour can be modelled.
- Stochastic factors affecting hospital systems: There are variations and stochastic elements in most parts of hospitals, such as random emergency arrivals, length of stay of patients, and clinic appointments. These factors can be easily modelled in DES.
- Ease of use in reusable components: To cope with the complexity in hospital processes, DES also offers modularity in model building, by reusable components ranging from function code or a whole component to represent, for example, a hospital ward.
- Visual representation of patient flows: DES is also used as a communication tool for the users. DES offers visual features, such as animation, which ease understanding of the system.

Table 37: Comparison of Discrete Event Simulation (DES), System Dynamics (SD), and Agent-Based Simulation (ABS)

DES	SD	ABS
Individual focus (Entity)	Group focus (Cohort)	Individual focus (Agent)
Processors defined	Rates are defined	No processors defined
Rules are defined in processors	Rules are defined in differential equations	Rules are defined in Agents (autonomy)
Queues exist explicitly	Queues exist explicitly but as levels	Queues exist implicitly
Events derive the simulation	Rates derive the simulation	Local Environment and agents drive the simulation

Mostly stochastic Discrete time intervals	Mostly deterministic Stepped time intervals	Mostly deterministic Stepped time intervals

This study however used the Discrete Event Simulation (DES) method. In the model, there are patients or clients who visit a Primary Health Care facility (PHC) and are routed to various zones in the PHC facility.

The type and amount of data collected are crucial for model construction and testing. The statistics are time estimates gathered at several process phases via on-site inspections and assessments. This is discussed in the subsection that follows.

DES was chosen for the study because it was a strong fit for the particular context and goals, which included evaluating patient waiting times and offering solutions to improve treatment procedures in CHPS (Community-based Health Planning and Services) facilities. Understanding and reducing patient wait times in CHPS facilities is the main goal of this portion of the study. DES is highly proficient in simulating intricate patient flows and queuing systems, offering valuable insights into the causes of delays and strategies for reducing them.

For operational decision-making, which is essential for overseeing day-to-day healthcare delivery, DES is especially well-suited. In order to optimise resource allocation and shorten wait times, it enables the simulation of various situations and actions. The modelling of several levels of detail, from individual patient interactions to overall system performance, is made flexible by DES. This adaptability is crucial for capturing the subtleties of multistage healthcare delivery and a wide range of patient needs in CHPS facilities.

Healthcare professionals, legislators, and other stakeholders can better understand the findings thanks to the visual depiction of patient flows and system dynamics in DES. This may help people easily understand and support suggested interventions.

7.4 Model Development

In this section of the study, we describe the development of DES (Discrete Event Simulation) models of CHPS compounds via the generic modelling approach. The DES models simulate provision of care to the following patient types: a. Outpatients and b. Inpatients and/or emergency cases.

The resources in each CHPS compound consist of doctors, nurses, and community health workers. Each resource is accessed by one or more of the above patient types. The number of doctors varies between one and five depending on CHPS configuration. Nurses were also categorised as resources. The staff nurses are divided into two categories: a. Attending nurses, who work closely with the doctors and b. Staff Nurses, who attend to inpatients and assists minor injury cases.

7.4.1 Generic Modelling Approach and CHPS Operational Data Collection

The generic modelling approach is a natural choice for developing simulation models of CHPS compounds. This is because the diverse health landscape of Ghana implies that developing a broadly representative model of CHPS operations would require surveying multiple instances of the facility of interest, identifying operational commonalities (and differences), and then conceptualising and developing this archetypal model based on the information synthesised from the survey – essentially the generic modelling approach. The study provides a brief overview of the generic modelling approach and the concept of model reuse below and places the CHPS compound modelling effort within this context.

In their paper regarding generic modelling in the healthcare facility simulation context, (Fletcher & Worthington, 2009), propose a classification scheme for a simulation model based on the extent to which a simulation model is generic (referred to in the paper as a model's 'genericity'). The authors suggest that the evaluation of a simulation model in terms of 'genericity' must be done in terms of two key attributes: model abstraction and transportability, and model reuse. A simulation model may possess one of four level of 'genericity' in terms of model abstraction and transportability. These are, in descending order of genericity: level 1 – generic principal models not specific to an industry or a particular setting, such as general queueing models; level 2 – generic modelling frameworks or toolkits with models of units common to a specific industry (e.g., Patient arrival station at hospitals, operating theatres), which can be leveraged to generate models of facilities of multiple types; level 3 – a generic model of a specific facility or process type (such as a generic model of accident and emergency (A&E) departments in the UK public health system, or outpatient clinics); and level 4 – models of a specific facility or process in a specific setting. In the case of this study, the CHPS compounds models developed are clearly of level 3, which also is the most common seen type in the literature (GHS, 2018).

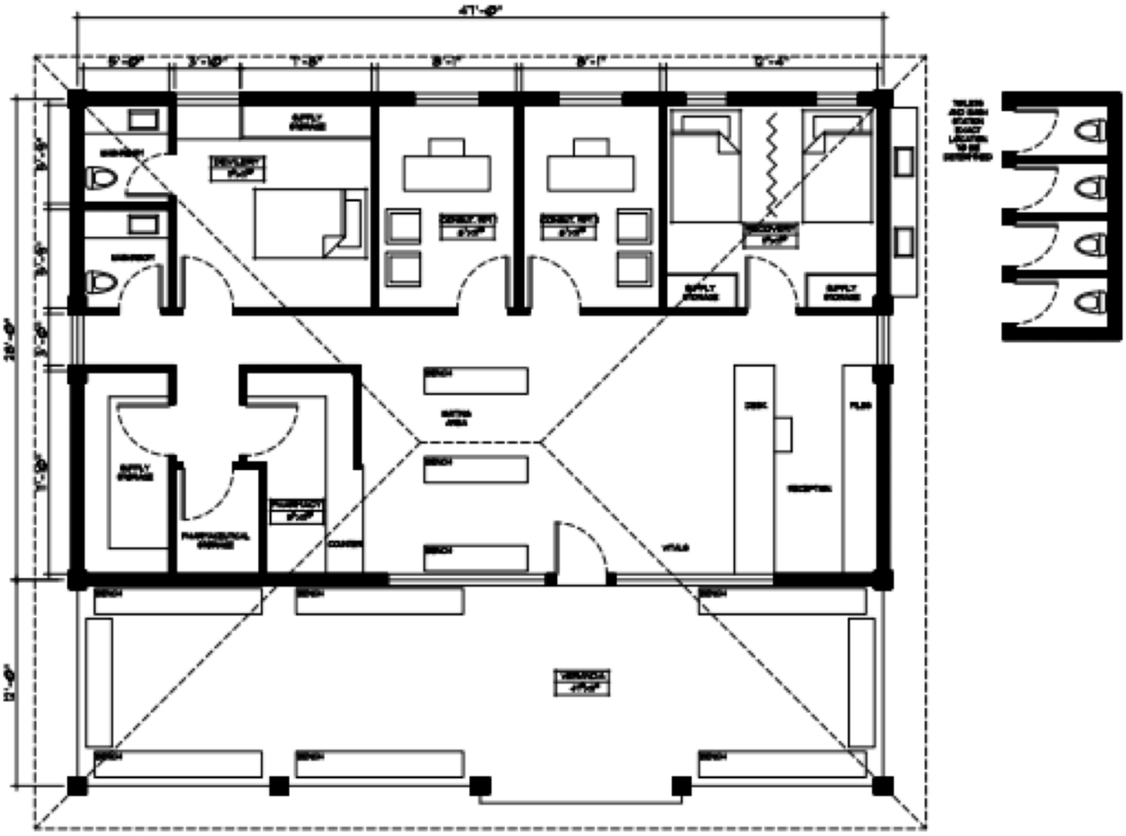

Figure10: Modelling CHPS Compound Systems

7.5 Data Collection and Input Analysis

The data used for the analysis in this chapter, stemmed from the larger dataset obtained from Ghana Health Service. The dataset was accessed after the appropriate ethical considerations and approval had been met (ethics approval from Brunel Research Ethics Committee).

The dataset comprised the clock in times of all the health personnel allocated to a CHPS facility, their rank and job titles, as well as the duration of their shifts.

The model prepared in this project considers the resources present at CHPS compounds like Patient Arrival, Attending Station, Patient Registration, Waiting Room, and Physician Assessment Rooms.

There were two sorts of timeframes gathered: waiting durations and activity lengths. The waiting duration is the amount of time a person spends between the completion of one process or event and the beginning of the following action in the procedure. The time needed to accomplish an action in the procedure is referred to as its duration. Table 38 displays the various durations gathered.

The following activity times may be calculated using the given times: attendance time (T2 - T1) and enrolment duration (T3 – T2). T3 duration is determined by the codes issued by the attending nurse. Patient arrival times also were recorded for various weeks. A sample size of 640 was gathered for every data point during a period of 90 days, from 0800 to 2000 hours. The researcher discovered fitted probabilities (all P-values > 0.1) for every data set utilizing Arena software's input analyser (Table 39).

According to the findings, 77% of patients were cared for in a single visit (no laboratory tests were necessary) and 23% underwent lab tests, necessitating a repeat examination from the same physician who ordered the examinations. Triangular, Poisson, and Exponential distributions are abbreviated as TRIA, POIS, and EXPO, respectively. All timing values are given in minutes.

To guarantee correctness and consistency in data recording, inter-rater reliability tests were carried out. There were several data collectors involved, and any differences were found and corrected by comparing their recordings. This procedure assisted in guaranteeing that the information gathered was trustworthy and uniform among various raters.

The information gathered from various sources was cross verified through the technique of data triangulation. This required comparing pertinent medical records and logs with data points from the CHPS facilities. Triangulation aided in confirming the dataset's completeness and accuracy.

Initial Testing Prior to the full-scale data gathering, a pilot testing phase was carried out to find any possible problems with the data collection procedure. This stage ensured that the final dataset was solid and dependable by improving the methods and tools for gathering data. Standardised tools and procedures were used. This included minimising subjectivity and potential inaccuracies in data recording by using pre-set codes and categories for various timeframes and activities.

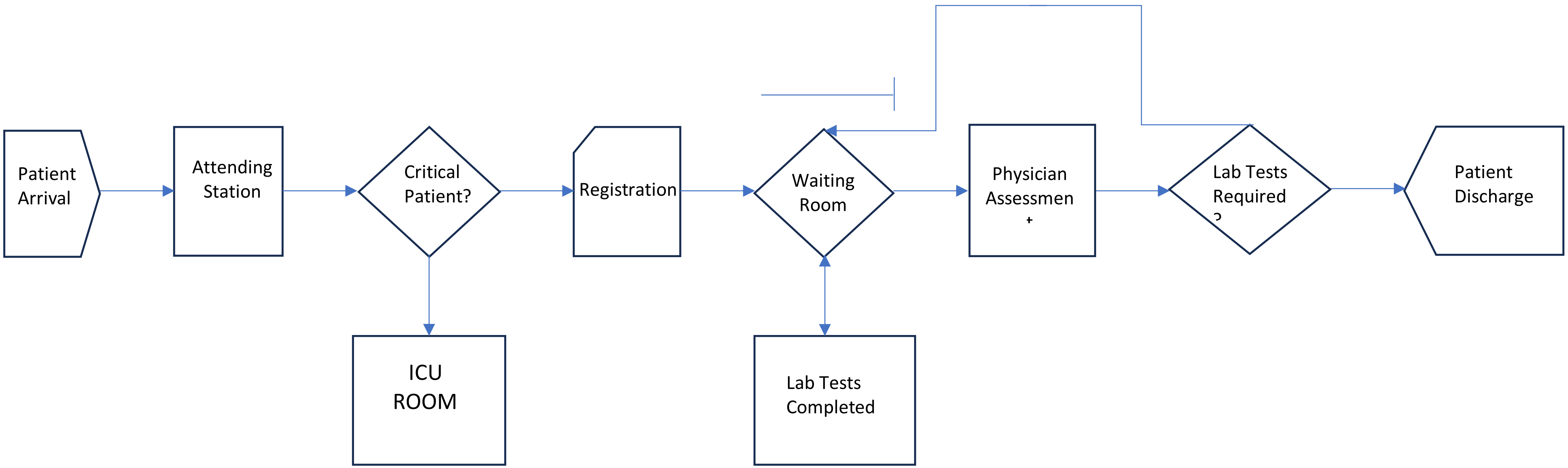

Figure 11: Model of Care Process in the CHPS compound.

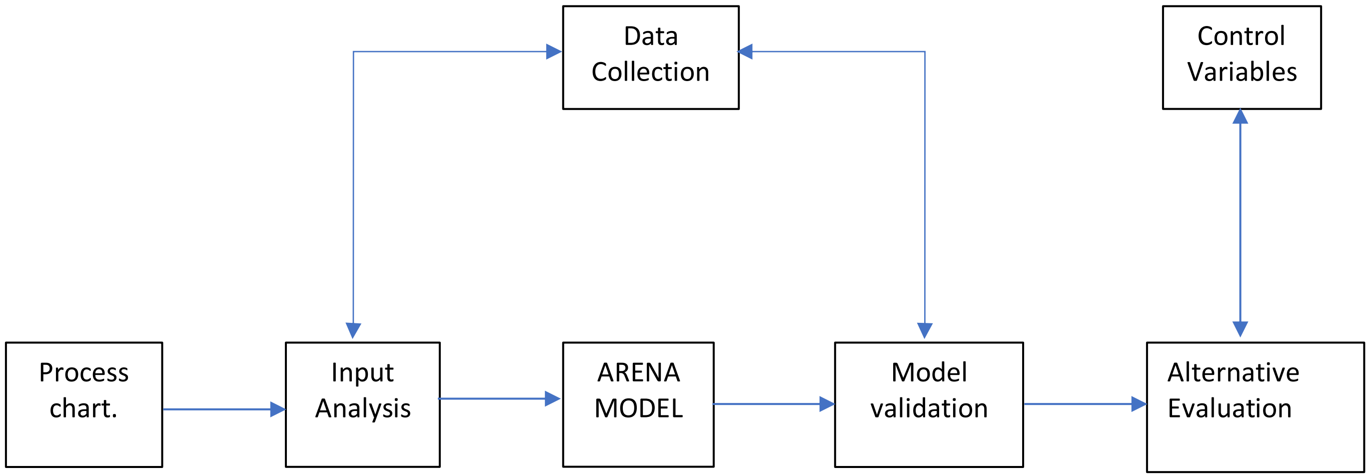

Figure 12: Model Simulation / Methodology main steps

Table 38: Collected waiting and activity durations.

Waiting times		Activity times	
T1	Time between arrival and attending	T6	Time required for tests completion
T2	Time between attending and registration	T7	Time required for physician assessment
T3	Time from registration to available exam room	T8	Exam room ready time
T4	Time from first assessment to discharge		

Table 39: Fitting statistical distributions (time unit in minutes)

Patient arrival time			Physician Assessment time		Process activities time	
			First Visit	Second Visit		
Mon	EXPO (7.0)	Code3	TRIA (25,30,40)	TRIA (10,12,15)	Attending	POIS (6)
Tue	EXPO (9.5)	Code4	TRIA (25,30,40)	TRIA (8,10,12)	Regist.	ATTEND (3,5,7)
Wed, Thurs, Fri	EXPO (10)	Code5	TRIA (25,30,40)	TRIA (6,7,5,9)	Lab tests	ATTEND (30,45,60)

7.6 Model Validation

Based on the given data, a variety of parameters have been developed to identify model bounds. These are detailed below.

i. Only weekdays (Monday through Friday) were taken into account.

ii. The procedure was only replicated from 0800 to 2000 hours on any particular day.

iii. Durations were assumed to be caused only by caregivers, doctors, or rooms. Other sources were not taken into account.

iv. The patient's waiting period from entering the room to the arrival of the physician was not taken into account.

v. Nurses and doctors collaborate, when a doctor is given or discharged, a nurse is likewise allocated or published. When a new physician is hired, a new nurse is also hired.

vi. Only five of the eight examination halls have been evaluated because the remaining rooms are allocated for special circumstances.

The model's constraints were caused by the underlying factors.

i. The flow of patients allocated to attending codes 1 or 2 was not taken into account. This flow accounts for much less than 7% of the entire flow.

ii. In the CHPS structure, all transition times (journey times) were ignored.

iii. Arrivals were quite slow on Saturday and Sunday relative to other days during the week. These were left out of the model since the CHPS complex rarely achieved stable conditions during these days. This will prevent type I and type II errors: small time values on weekends will average out larger values on weekdays.

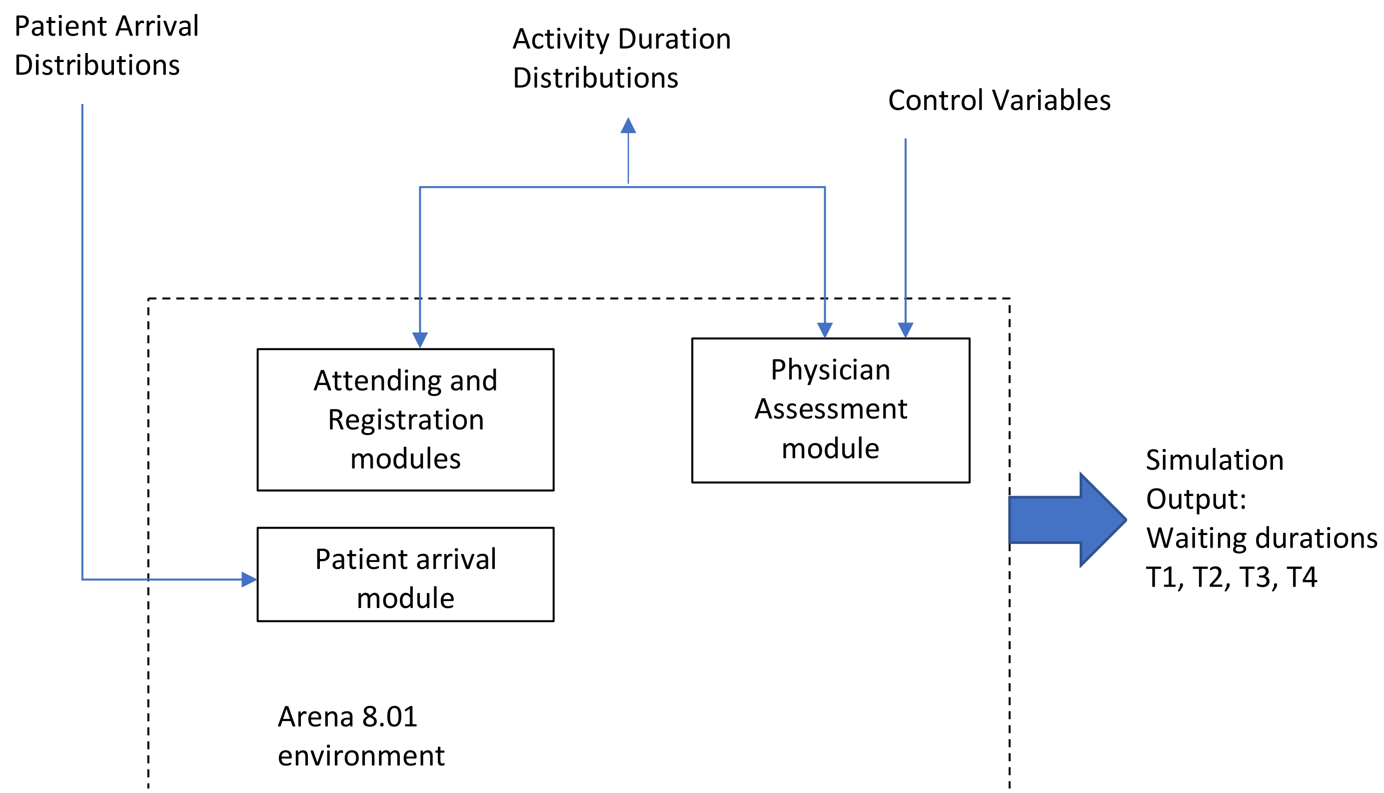

Figure 13: CHPS Compound Arena model.

Table 40: Simulation output vs. real collected data (time in minutes)

Days	**Duration T1**			**Duration T2**			**Duration T3**			**Duration T4**		
	M3	S3	R3	M3	S3	R3	M3	S3	R3	M4	S4	R4
Mon	13.6	5.7	12.7	1.4	0.5	1.7	200.9	15.4	235.0	58.2	6.8	36.0
Tue	4.7	1.2	6.6	0.8	0.2	0.6	139.8	18.4	144.0	49.9	4.7	36.0
Wed	4.2	1.3	10.0	0.7	0.2	1.8	115.5	32.6	121.0	56.7	5.8	40.0
Thurs	4.2	1.3	10.0	0.7	0.2	1.8	115.5	32.6	121.0	56.7	5.8	40.0
Fri	4.2	1.3	17.9	0.5	0.2	2.2	111.2	34.9	101.0	56.7	10.3	40.0

Throughout model development, a modular approach was used. The final system consists of three components: patient arrival, attendance and registering, as well as physician evaluation. The latter includes sub-modules for lab tests and client release. T1, T2, T3, and T4 are the waiting times produced by the model (Figure 14).

Each workday was modelled using the model. Each day, ten 12-hour replications were done. In Arena Simulation and other discrete-event simulation platforms, the choice of 10 replications of 12-hour shifts is a practical standard to ensure statistical reliability while balancing computational efficiency (Law, 2015). The number of replications ensures that the results are statistically valid and can be used to make confident decisions. Each simulation is subject to variability due to random inputs. By performing multiple replications, Arena generates a range of results, which reduces the impact of outliers and randomness. Ten replications provide a good balance, ensuring enough data points for meaningful analysis while avoiding excessive computational overhead (Law, 2015). Ten replications also allow analysts to detect whether key performance measures are converging. If results from 10 replications show consistent trends, it suggests the model outputs are reliable. If convergence is not achieved, analysts can increase the number of replications (Law,2015).

However, studies in healthcare simulation often suggest replication periods that align with typical working hours, which can range from 8 to 12 hours depending on the healthcare facility's operational structure (Sharif, Aziz, Ahmad and Nawawi, 2016; Härmä et al., 2022). These durations are used because they capture patient flow variations that occur throughout the workday, offering insights into peak times, resource constraints and patient wait times.

Such studies recommend that replication periods should reflect the actual shift durations in healthcare facilities to produce realistic and applicable findings for facility management.

Among reconstructions, the service was constantly initialised. The simulation result was matched to the gathered data for model evaluation at a 95% level of confidence. Table 40 summarises the contrast. Mi and Si represent the average values and standard deviation of simulated Ti (i= 1, 2, 3, 4). Ri denotes the real gathered mean value.

T3 had the greatest deviation from actual data. For example, R3 - M3 = 35 minutes on Monday amounts to a 15% relative inaccuracy. Raising the frequency of replications has no discernible impact on this inaccuracy. As a result, it is much more likely to be triggered by model off-sets (systematic errors). This can be addressed by rethinking patient transfer times and other preceding assumptions and restrictions. The concept is still useful for making choices. It generates a variety of outputs, including queue timings, queue sizes, as well as asset use. These results, along with the animation, also were shown to hospital staff for verification reasons. The primary emphasis was on waiting duration T3, which accounts for the majority of the total waiting time in the procedure. The simulation model is used to identify five solutions for improving T3 in the next subsection.

7.7 Model Assumptions

The model assumes the patterns of only weekdays. Due to the low and erratic patient attendance rates on weekends, the model only incorporates data from weekdays (Monday through Friday). This presumption guarantees that the model concentrates on periods of peak activity, yet it might miss possible fluctuations in patient flow and resource usage that might transpire on weekends.

The simulation operates daily from 8:00 to 2:00, matching the hours when CHPS facilities are open for business. Any potential variances in patient arrival and service provision outside of these hours are not included in this assumption, which could have an impact on overall waiting times and resource allocation.

It is assumed that the only factors influencing durations are carers, doctors, and examination rooms; other potential factors, like administrative delays or outside interruptions, are not taken into account. While this makes the model simpler, it can leave out other important factors that affect wait times. The waiting period between a patient's entrance into the examination room and the arrival of the physician is also not taken into consideration by the model. The overall amount of time patients must wait could be underestimated as a result of this assumption. It's possible that real-world staffing variances and their effects on service delivery are not reflected in the assumption that nurses and doctors are always hired and fired simultaneously. This is because the model assumes a constant in staff linkages.

If only some of the examination halls are evaluated, significant differences in room usage may be overlooked, particularly during busy periods or in exceptional cases. Certain patterns of patient flows are also assumed out of the model/ If patient flows with attending codes 1 or 2 are excluded, certain cases that may have an impact on system performance as a whole may go unnoticed, which could result in conclusions that are not fully formed.

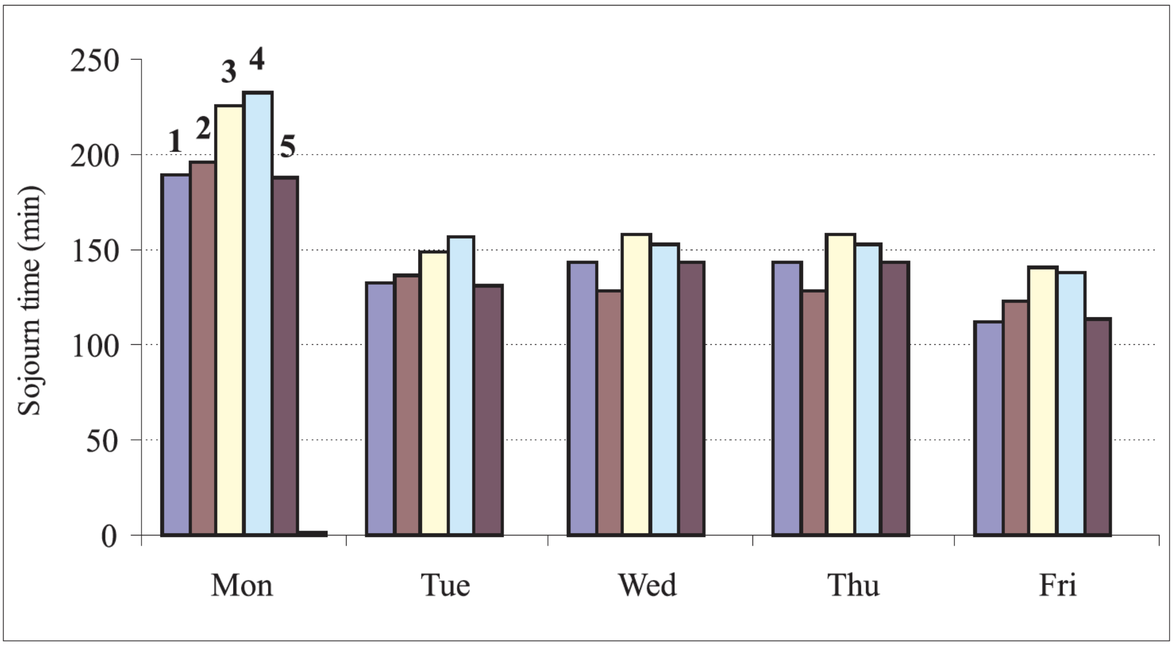

Figure 14: Visit throughout the week for choices 1, 2, 3, 4, and 5.

7.8 Design Alternatives

The variants are designed with doctors, caregivers, and examination chambers as control factors in mind. The CHPS complex initially engages 5 doctors, five nurses, three attending nurses, including three community health workers, all of whom begin their separate hours. It also has 8 examination rooms and yet only uses five of them. The health facility's quality assurance team was looking for a cost-effective approach to minimise waiting period by expanding personnel and/or room occupancy within financial limits. As a result, the researcher created the five possibilities shown below (Table 41).

For every day, 10 repetitions of 12 hours were used to replicate each alternative. The simulation tallies were used to gather patient sojourn time in the CHPS facility (time spent in the system from admission to discharge). This duration equalled the total of Ti (i=1, 2, 3, 4).

The number of people served in a day and the number of rooms used also was recorded. The findings are collected and analysed in the succeeding section.

7.9 CHPS compound Overview

The CHPS compound is the main component of the primary healthcare service system of the Ghana Health Service. CHPS compounds are primary health care facilities which employ at least 7 Community Health Officers and at least 2 Community Health Volunteers. One of the core mandates of the CHPS compounds is to bridge the equity gaps in access to health care and nutrition services and ensure sustainable financing arrangements that protect the less privileged citizenry.

7.9.1 Physical Layout

Figure 10 depicts the physical configuration. The CHPS complex building is divided into five unique zones: patient arrivals and waiting area (zone 1), assessment rooms (zone 2), inpatient facility rooms (zone 3), midwifery and delivery rooms (zone 4), as well as medical dispensary (Zone 5). Individuals coming from zone 1 are first brought to assessment rooms, which are then used to treat patients, whereas acute inpatient rooms are for unwell patients whose symptoms must be observed.

7.9.2 Healthcare Staff and Shifts

The CHPS needs one nurse at reception and a second in the inpatient care units to operate 24 hours a day, seven days a week (Ministry of Health, 2005). Their shift is eight hours long, beginning at 12:00 and ending at 1600 hrs. There are 5 doctors: three with an 8-hour shift beginning at 00:00, 0800, and 1600, and 2 with 7 and 6-hour periods beginning at 1000 and

1700, respectively. Intersecting shifts allow for the presence of more than a doctor at specified periods. Examining room caregivers collaborate with physicians and perform comparable hours.

7.9.3 Patient Flow

There are three basic aspects of the random flow of patients. For starters, it is caused by a periodic disease or event. During the dry (Harmattan) period, most clients are treated for colds, lung infections, and viral diseases, while admissions during the warm are frequently connected to recreational occurrences and allergies. Secondly, the flow varies significantly depending on the day of the week; Mondays and Fridays see more arrivals than the rest of each week. Third, client admissions rise between the hours of 0800 and 2000 on any particular day. This conclusion is supported by Figure 15, which depicts the client arrival trend based on information obtained from several CHPs units.

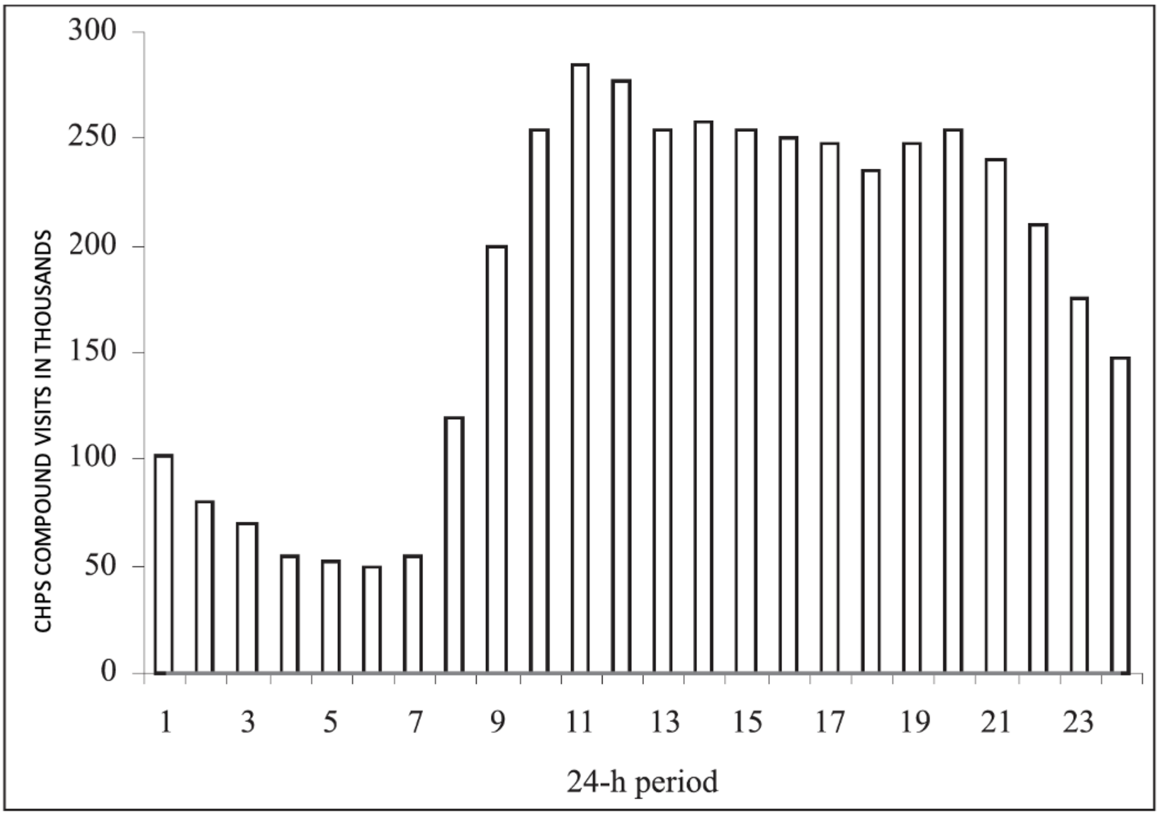

Figure 15: Patient arrival pattern over a 24-hour period

7.9.4 Process Stages

Figure 13 depicts the steps of the procedure. An ordinary patient goes into the system at zone 1, selects a ticket, and then waits. When his/her ticket is called, the patient is evaluated by an examining nurse who looks for any obvious serious signs. If a patient's health is determined to be serious, he is transported to an inpatient care room for emergency care. If the patient is found to show no signs for need of emergency care, an attending code is assigned by the attending nurse based on the clinical history.

After receiving an attending code, the patient awaits physician evaluation. The length of the wait is determined by the availability of doctors as well as examination rooms. The physician may order lab testing after his initial evaluation. If this is not the case, the patient is either sent home or moved to some other health institution for admission. A patient with laboratory results must wait for a further evaluation by the doctor who ordered the testing. Following the second examination, the person may be permitted to go home with medication or hospitalised.

7.9.5 Attending Codes

Attending codes are essential for accurate patient discharge. Waiting periods for each code are regulated in Ghana. Patients with code 1 have no waiting time (critical condition); those with codes 2, 3, 4, and 5 have a maximum wait period of 15, 30, 60, and 120 minutes, respectively. Waiting times were gathered by code during a period of 90 days, between the hours of 0800 and 2000. The data were gathered by in-person visits to the CHPS facilities and reconciled with data from the Ministry of Health. Table 41 shows the mean values (in minutes).

Table 41: Average waiting times by code

	Waiting times by weekdays					MOH Standards
	Mon	Tue	Wed	Thurs	Fri	
Code 1	0	0	0	0	0	0
Code 2	0	0	4	0	0	15
Code 3	74	47	52	30	71	30
Code 4	213	128	157	100	119	60
Code 5	283	160	184	117	136	120

The attending dispatches patient flow based on the following rates (collected over the same timeframe): 18% code 3, 54% code 4, 20% code 5, and fewer than 7% for codes 1 and 2. Table 41 demonstrates that waiting time norms for codes 3, 4, and 5 were not satisfied. Approximately 93% of patients who visit the CHPS complex are affected by these inconveniences.

7.10 Simulation Results

Figures 16 and 17 depict patient sojourn times and T3 waiting periods, respectively. As previously stated, period T3 accounts for the majority of the overall waiting period in the CHPS facility. Larger T3 levels lead to a longer stay duration and worse service quality.

Alternatives 1, 2, and 5 resulted in a considerable improvement in sojourn time as well as waiting length (Figure 16). When contrasted to the real scenario at the CHPS site, these solutions saved up to 2 hours. Alternative 1 is more cost-effective as it needs only 2 medical personnel (one doctor and one caregiver) but no exam room. Alternative 5 was the least appealing fiscally since it required four more employees.

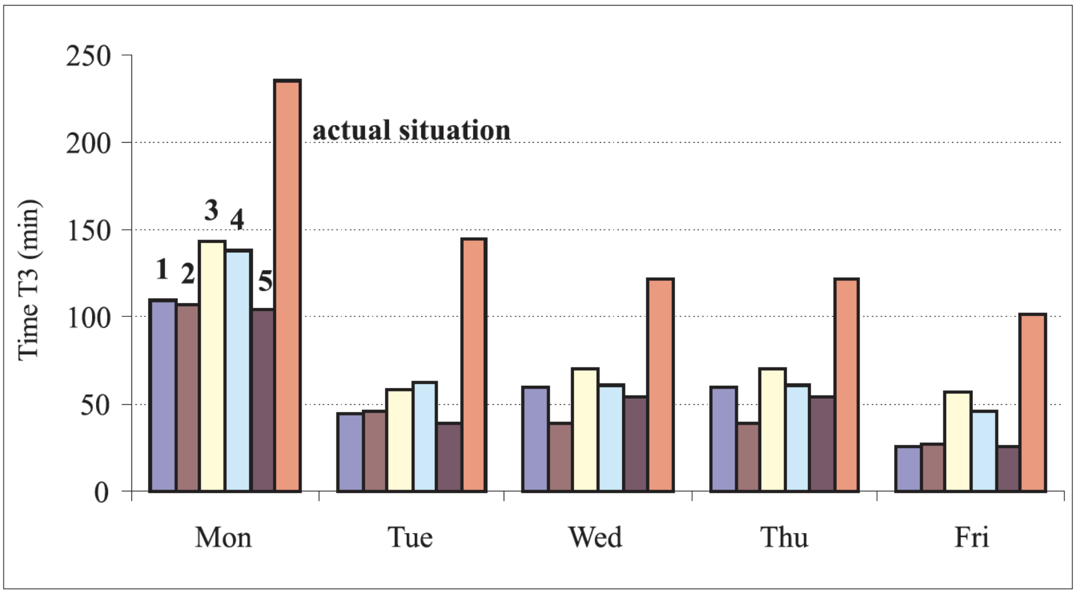

Figure 16: T3 waiting time per option compared. real value

Shorter wait times results in an increase in service level (number of patients handled) (Figure 17). Alternatives 1 and 2 provide comparable service levels. Introducing an exam room without a proportional boost in medical staff will have minimal impact on improving service levels. Actually, option 5 demonstrates that more cases can be handled with much more workers. Although alternative 5 outperforms alternative 1 in terms of service capacity, it is still a minor gain (five to eight more patients) as contrasted to alternative 1. The change in service level is minimal enough to support alternative 5 financially.

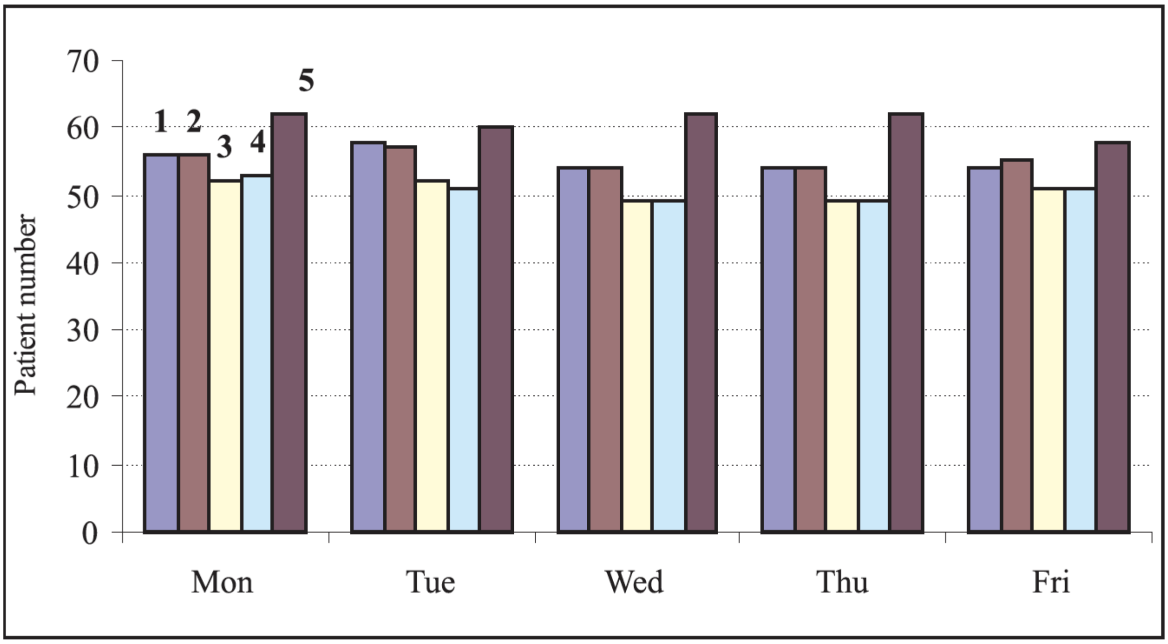

Figure 17: For each choice, the patient number treated during the weekdays.

Figure 18 depicts the rates of exam room utilisation. Alternatives 1 and 2 provide equivalent wait times and levels of service. Extending a room doesn't quite result in a substantial increase in these two metrics. As per Figure 18, adding a room reduces room utilisation from alternatives 1 to 2. Identical observations apply to choices 3 and 4. Increasing exam rooms without increasing personnel does not result in a marked improvement in the waiting period. This conclusion is consistent with the results of (Doudareva & Carter, 2021), (Saunders et al., 2019), and (Corsini et al., 2022). An additional room also entails housekeeping and maintenance charges, making options 2 and 4 less appealing when contrasted to alternatives 1 and 3.

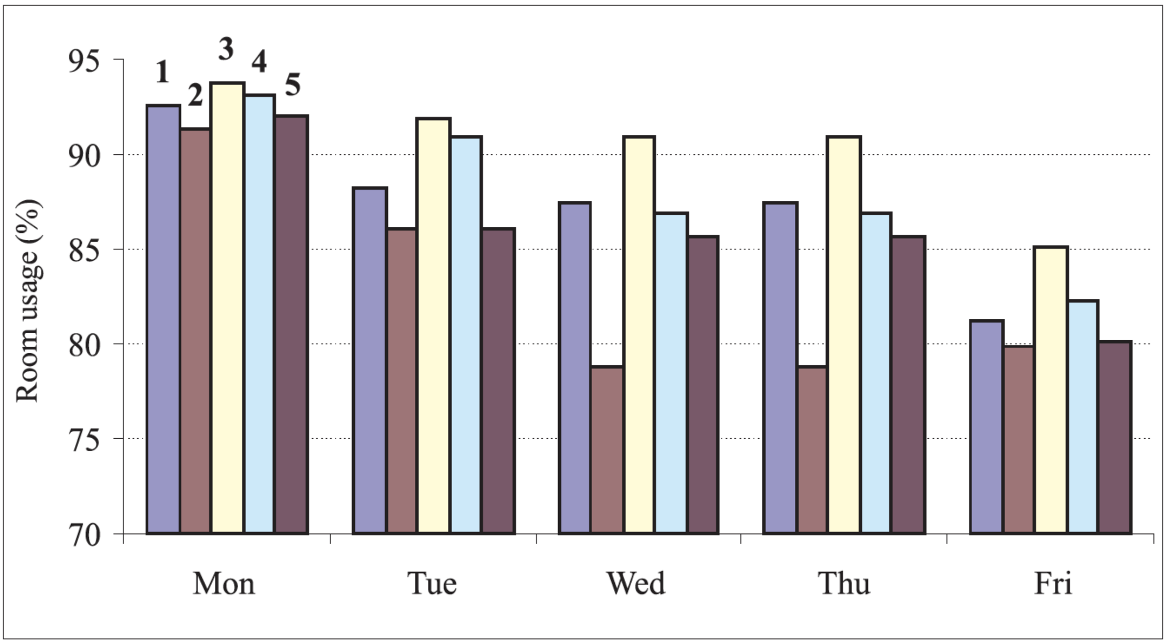

Figure 18: Each alternative's use of inpatient care rooms during the week

7.11 Discussion & Conclusion

In this study, the operations of a CHPS compound are simulated via the method of discrete event simulation. The simulation model was developed by assessing operational data from the Ghana Health Service for CHPS facilities. Lengthy average wait time is among the prevalent challenges affecting most healthcare organizations (British Columbia Medical Association, 2006). Another study by Eilers (2004) further asserted this finding with their study indicating long waiting time as a grave concern for most patients. The direct effect of waiting time on demand for health care is the impact of waiting time itself in the CHPS facility on demand for health care. The indirect effect of waiting time will be the effect of waiting time on the usage of insurance in seeking treatment against cash payment.

Consequently, quality of service delivery is a pivotal element in any healthcare system and thus is a crucial component to the achievement of health-related sustainable development goal three, which aims to ensure healthy lives and promote the well-being of all individuals at all stages (World Health Organization, 2014). The swift delivery of the healthcare process is one of the factors that contribute to the attainment of comprehensive healthcare coverage.

With careful forecasting and planning, it is possible to address seasonal fluctuations (such as an increase in respiratory illnesses during dry seasons) by modifying resource allocation and preparedness. Implementing the findings from this chapter in this way may require reallocating resources like equipment and medication, proactive planning, and trend monitoring. However, it has the added benefit of smoothening the healthcare process.

With staff training and a clear process map, streamlining patient flow from registration to doctor assessment by fine-tuning processes and perhaps rearranging physical arrangements (e.g., waiting rooms, examination rooms) is doable. It can entail rearranging workflow patterns or making small facility modifications, but it has immense benefits in delivering quality healthcare outcomes.

Also, for healthcare providers to have enough downtime and seamless shift changes, scheduling shifts for physicians and nurses to achieve maximum efficiency by implementing shifts that coincide with peak patient arrival times (0800–2000 hours) calls for close collaboration. This works best by adapting shift schedules to operational requirements and patient flow patterns. It will also require negotiating the work hours of healthcare personnel and implementing strategies to mitigate possible effects on workload and exhaustion.

Staff training and procedure standardisation can help ensure that attending codes are assigned on time and that patient expectations are managed in accordance with established norms. Adherence to protocol and direct, transparent communication are necessary for its implementation as well. Updating IT systems to improve code tracking and management will be necessary to maintain a seamless flow.

In order to maximise resource utilisation, the study emphasises how critical it is to match personnel schedules with patient arrival patterns. Effective management of human resources necessitates meticulous planning, particularly in settings with restricted workforce capacity. Financial Implications: Making workforce modifications and initial investments in infrastructure (such as bettering waiting spaces and streamlining patient flow) may be necessary when implementing improvements based on simulation results. It's critical to weigh the financial effects against possible increases in operational effectiveness and patient outcomes.

Stakeholder Opinions: Involving Healthcare Providers: During the implementation of operational improvements, healthcare providers are essential. Implementation can go more smoothly if you involve them in the process and take the time to understand their worries about task management and workflow adjustments. Patient Expectations: It's important to address patients' expectations about wait times. Waiting experiences can have a big impact on how satisfied and compliant patients are with their care. Enhancing patient satisfaction and the overall experience should be the goal of any improvements found through simulation.

7.12 Policy Recommendations

When it comes to healthcare planning and management, policymakers ought to think about providing incentives for the use of simulation techniques. This covers the cost of training healthcare workers, purchasing simulation software, and providing assistance with data gathering and analysis. They must examine current laws pertaining to the provision of healthcare services and contemplate amending them to allow for more effective patient flow and shorter wait times. They must also consider incorporating the use and understanding of simulation software in training healthcare professionals so they can continually improve their operations.

Health administrators must consider creating flexible schedules for staffing that take into account patterns of patient arrivals found through simulation. This may aid in cutting down on idle time and maximising resources during busy times. By putting in place standardised procedures for attending codes, maximising room utilisation, and reducing needless delays, these health administrators can streamline patient routes from registration to discharge.

Policymakers must establish systems for ongoing patient and healthcare provider input to track the effects of improvements that are put into place. These can be incentive or punishment systems that will create adherence to clocking in to provide the needed data for insights. This guarantees that changes can be made quickly to handle new issues.

7.12.1 Continuous Quality improvement

The simulation experiment conducted on the CHPS facilities in Ghana enabled the researcher to collect and obtain further information into the procedure. DES entails not just data gathering and output evaluation but also understanding the system's intricacy and building a viable model that can be used for education and performance assessment. This study assists the researcher in suggesting subsequent qualitative enhancements.

1. Because it publishes the arrival time on drawn-out cards, the usage of a ticket dispenser with such a built-in time clock allows for a precise prediction of T1. When issuing codes, the attending nurse might take that time into account.
2. A second community health worker or nurse could be engaged to help people fill out fact sheets about their medical problems and medication histories. To expedite the procedure, the sheet could be submitted at the attendance or registration.
3. Digitize patient files to enable faster processing and interaction among the CHPS facility's many operations.
4. Whenever patient flow is critical, an extra standby attending the nursing station might allow for improved prioritized dispatch.

Discrete event modelling was used to simulate, evaluate, and develop a generalised CHPS facility in this study. An examination of waiting periods by patient code revealed that they were long in relation to Ghanaian and worldwide health standards. Thus, the study's purpose was to minimise long waits through what-if assessment utilising simulation. For 2 iterations, only codes 3–5 was examined. For starters, this represents 93% of patients visiting the CHPS facility. Next, codes 1 and 2 adhere to norms. Numerous data points were gathered between 0800 and 2000 hours, Monday through Friday. The weekend was not included because of its sluggish dynamic to prevent type I and II errors. The collection time was chosen based on historical data and staff knowledge. Arena software was used for modelling and simulation. The simulation results suggest that the wait time from enrolment to the available exam room

(T3) was among the most bothersome (3 to 4 hours at times). 5 options for increasing personnel and exam facilities within the budget constraints were developed. The option with one additional physician and nurse from 0800 to 1600 h resulted in the greatest improvement rate for waiting time T3. It enables an extra 16 patients to be treated from 0800 to 2000 h.

Simulation results demonstrate that increasing the number of examination rooms rather than increasing the personnel has no impact on waiting time. Based on the observations with the procedure, a number of evaluative suggestions have been presented. Even though these recommendations are specific to the investigated sample CHPS facilities, they may be applicable to numerous other health services dealing with comparable issues.

Chapter 8: Discussions And Conclusions

8.1 Introduction

This chapter provides a synopsis of the study, highlighting how exactly the research attempted objectives and discussing the wider ramifications of the findings. It starts by summarising the primary objectives of the study (as laid out in Chapter 1) and describes the principal approaches used to achieve these goals. The chapter subsequently discusses the study's wider implications and how the results add to the body of knowledge already available on the factors influencing the effectiveness of CHPS compounds and the CHPS initiative as a whole. The chapter also touches on discussions of the limitations of the study and outlining potential directions for additional or future research.

This study provides the first empirical analysis of CHPS effectiveness using a multi-method approach, contributing to health policy optimization. The study incorporates interrupted times series analysis, GIS based facility mapping, and simulation modelling to assess healthcare service delivery. The integration of these methodologies enhances understanding of CHPS implementation, offering a comprehensive framework for evaluating decentralized healthcare systems. The findings contribute to the optimization of health policy by providing evidence-based insights into the effectiveness, distribution and operational challenges of CHPS, guiding future healthcare resource allocation and policy formation.

8.2 Overview of the Study’s Objectives

The primary aim of this study was to evaluate the effectiveness and implementation of primary health service centres in Ghana, specifically focusing on the Community-based Health Planning and Services (CHPS) compounds. This research intended to inform policymaking and enhance health service delivery through optimized location, positioning, and operational efficiency of CHPS zones. To achieve this aim, the study set forth four specific objectives: identifying the determinants and key drivers associated with CHPS facilities' location and positioning by the Ghana Health Service to achieve maximal outcomes; analysing the effectiveness of the implementation strategies of the CHPS initiative on health service delivery in the Ghanaian context; determining the level of operational effectiveness of CHPS compounds using the core mandates of CHPS facilities in Ghana as a measurement variable; and determining how to improve the operational efficiency of CHPS compounds in line with their core mandates.

A comprehensive review of the literature formed the foundation of the study, focusing on interventions in primary and community health service. The review included six studies discussing innovative programs in primary and community health service delivery across various countries, eighteen studies examining research methodologies used in community primary health care services, and 15 studies evaluating different primary health care innovations and interventions in various communities.

Innovative programs that incorporate technology into primary and community health services were a key focus of the reviewed studies. For example, the use of telemedicine and mobile health (mHealth) apps were found to significantly enhance healthcare delivery and accessibility. The review highlighted the critical role of Community Health Workers (CHWs) and presented programs that train CHWs to provide basic healthcare services, lead health education sessions, and promote preventive care practices. Culturally sensitive approaches to healthcare delivery were also identified as crucial for the success of the CHPS effort, as indicated by the evaluated research. Overall, it was identified that CHWs can improve health outcomes by fostering better community acceptance and engagement in health programs by tailoring health interventions to align with local cultural practices and beliefs.

In conducting this study, a systematic review was performed to identify gaps in the existing literature, particularly within the African context. This effort contributed to a general understanding of the topic and highlighted areas requiring further research. Following the systematic review, the study evaluated conceptual frameworks, leading to the selection of appropriate models to guide the research. The study mainly employed a number of quantitative methodologies to arrive at a thorough analysis. The quantitative efforts used logistic and generalized linear model (GLM) regression analyses as well as simulation analysis to explore the determinants and key drivers of CHPS facilities' location and positioning and to assess the effectiveness of implementation strategies on health service delivery.

Overall, this research aimed to provide actionable insights for policymakers and healthcare practitioners to enhance the operational efficiency of CHPS compounds. By addressing the identified gaps and applying the findings from the literature review, the study sought to contribute to the achievement of comprehensive healthcare coverage and the sustainable development goal of ensuring healthy lives and promoting well-being for all individuals at all economic strata. The practical implications of this study offer recommendations for optimizing resource allocation, improving stakeholder engagement, and implementing cost-effective strategies to enhance the overall effectiveness of primary health service centres in Ghana.

8.3 Contributions to the literature

The primary goal of this study was to evaluate the effectiveness and implementation of the Community-based Health Planning and Services (CHPS) compounds in Ghana, focusing on their role in primary health service delivery. Despite the significant role CHPS compounds play in providing healthcare to underserved and rural communities, there is still limited literature assessing their effectiveness, with most studies focusing on secondary and tertiary facilities (Alhassan et al., 2015; Jehu-Appiah et al., 2014; Nonvignon, 2017). This study aimed to fill this gap, providing insights that can inform policies to enhance healthcare access and quality in line with the United Nation's Sustainable Development Goal (SDG) 3.

Chapter 4 of this thesis evaluated the effectiveness of the CHPS intervention using Interrupted Time Series Analysis (ITSA) to compare maternal deliveries, antenatal visits, family planning visits, and outpatient department (OPD) visits before and after the intervention. The findings indicated that the CHPS intervention significantly increased maternal deliveries and antenatal visits immediately and in the long term. This aligns with previous studies suggesting that community engagement and increased accessibility lead to sustained improvements in health outcomes (Awoonor-Williams et al., 2016; Ganle et al., 2016; Sakeah et al., 2023).

The observed increase in maternal deliveries were attributed to the enhanced community engagement and health education inherent in the CHPS model. These efforts likely improved health literacy and encouraged more women to deliver in healthcare facilities, reducing maternal and neonatal mortality rates (Awoonor-Williams et al., 2016; Kpienbaareh et al., 2022). Similarly, the significant rise in antenatal visits post-CHPS intervention underscores the critical role of increased healthcare access and community mobilization in improving maternal health services (Afulani et al., 2021; Pervin et al., 2012).

However, the study found no significant impact of the CHPS intervention on OPD attendance. This lack of impact was thought to be due to methodological limitations or the specific focus of the CHPS program on maternal and child health services, which might not translate into increased general OPD visits (Nyonator et al., 2005; Awoonor-Williams et al., 2013). Further research with a comprehensive study design and control groups was recommended to better understand the relationship between CHPS interventions and OPD attendance to contribute to existing literature.

There was a significant annual increase in family planning visits before the intervention, but a non-significant decrease in the first year of the intervention, followed by a significant decline in the post-intervention trend. This was seen to be in line with findings from Campbell et al. (2014) and Adongo et al. (2013) that indicate that improved quality and accessibility of family planning services leads to more effective contraceptive use and reduced need for frequent visits. Further qualitative research is however needed to explore the specific mechanisms behind these changes and to assess the sustainability of the intervention's impact on family planning services (Johnson et al., 2020; Kriel et al., 2019). This chapter's findings addressed key gaps in the literature on the effectiveness of primary healthcare facilities in Ghana. They emphasized the need for strengthened CHPS facilities through infrastructure upgrades, adequate medical supplies, and continuous training for community health workers.

Chapter 5 of this thesis explored the determinants and key factors influencing the positioning of Community-based Health Planning and Services (CHPS) facilities in Ghana, addressing a significant gap in the literature regarding the equitable distribution of primary healthcare resources. Utilizing Geospatial Information Systems (GIS) techniques, data from 216 districts were analysed, revealing that 117 districts had at least one CHPS facility while 99 had none.

The findings highlight a critical issue: larger districts tend to have fewer CHPS facilities. This negative correlation between district surface area and the number of CHPS facilities indicates that larger, possibly more rural districts are underserved compared to smaller, possibly more urbanized districts (Gupta et al., 2021). This disparity suggests that population density and district size are influential factors in the distribution of CHPS facilities, mirroring broader rural-urban healthcare provision inequities.

This study contributed to the literature by providing the first empirical analysis of the factors determining the placement of CHPS facilities in Ghana, highlighting the need for a holistic approach to healthcare policy implementation. Economic factors were also found to play a significant role. The study found a negative correlation between the number of CHPS facilities and GDP per square kilometre, indicating that economically disadvantaged areas have fewer CHPS facilities (Chen et al., 2021). This aligns with existing literature suggesting that economic development is intricately linked to better healthcare access, since CHPS zones are mostly set up in underserved areas.

The regression analysis confirmed that increasing the number of CHPS facilities in a district significantly improves adherence to the Ghana Health Service (GHS) guideline of having facilities within an 8-kilometer radius of the population. This finding underscored the importance of expanding the CHPS network to enhance geographic accessibility and ensure that underserved communities receive adequate healthcare services (Pu et al., 2020). This study contributed to the literature by providing the first empirical analysis of the factors determining the placement of CHPS facilities in Ghana, highlighting the need for a holistic approach to healthcare policy implementation.

Chapter 6 explored the relationship between the presence of CHPS facilities and the proximity to disease outbreaks in Ghana, addressing the literature gap concerning the role of primary healthcare in disease prevention and control. Using a generalized linear regression model, the study revealed that districts with CHPS facilities were generally more distanced from disease hotspots than those without such facilities. The study also uncovered that districts with a higher concentration of CHPS facilities (6-11) were significantly more distanced from disease flashpoints. This reinforces the notion that enhanced primary healthcare availability is crucial in reducing disease burdens (Bitton et al., 2019). However, it was observed that districts with more than eleven CHPS facilities were found to be 31% closer to disease outbreaks compared to those with fewer facilities.

This analysis suggested that while CHPS facilities generally contribute to better disease control, their distribution and the local demographic and economic contexts must be considered to optimize their impact. The presence of more than eleven CHPS facilities in a district may indicate a reactive rather than proactive healthcare infrastructure development, where facilities are built in response to recurring outbreaks rather than to prevent them. The findings emphasized the importance of strategic placement and the consideration of local demographic and economic factors to optimize the role of primary healthcare in preventing and controlling disease outbreaks.

Chapter 7 went into the operational dynamics of CHPS compounds in Ghana through discrete event simulation, highlighting the implications for service delivery efficiency and healthcare outcomes. By analysing operational data from the Ghana Health Service, the study identified lengthy average wait times as a significant challenge, echoing previous findings on the impact of waiting times on healthcare demand and service quality (British Columbia Medical Association, 2006; Eilers, 2004).

The study contributed to the importance of efficient healthcare delivery for addressing seasonal fluctuations in disease incidence, such as respiratory illnesses during dry seasons, healthcare facilities can optimize resource allocation and preparedness, thus improving the overall healthcare process.

The study also contributed to standardizing procedures and updating IT systems for better code tracking and management are also critical for ensuring smooth operations and managing patient expectations. The study underscored the financial implications of these improvements, suggesting that initial investments in infrastructure and workforce adjustments can lead to significant gains in operational efficiency and patient outcomes.

8.4 Revisitation of the Methodological Approach

The systematic review followed PRISMA guidelines, with a search strategy informed by a prior pilot review to identify relevant databases and keywords. The pilot review identified Scopus, Web of Science, and PubMed as key databases. The literature search, conducted from June to July 2020, used Boolean operators to help develop comprehensive search terms. Identified papers were managed using RefWorks to handle duplicates and references. The review used the SPICE framework (Setting, Population/Perspective, Intervention, Comparison, and Evaluation) to select eligible studies, enhancing relevance and comparability (Riesenberg & Justice, 2014). Despite its limitations in diverse CHPS settings, broader definitions were used to avoid excluding pertinent studies. This approach, along with a comprehensive literature search and the use of the Scopus database, aimed to ensure the inclusion of all relevant studies.

The quality of selected studies was assessed using the AHRQ checklist for observational studies and the MINORS checklist for non-randomized control trials. The AHRQ's eleven-item checklist rated studies as high, moderate, or low quality based on the number of 'yes' responses. The MINORS checklist rated studies similarly on a 24-item scale. To ensure reliability, a second reviewer independently assessed approximately half of the studies. This dual-review process aimed to reduce potential bias and increase data extraction reliability (Haywood et al., 2004). Early evaluations of the CHPS program in Ghana utilized cross-sectional and observational studies, which provided initial insights into its impact on health outcomes. Nyonator et al. (2005) and Phillips et al. (2006) documented improvements in child health services and reproductive health in CHPS areas, with higher immunization rates and antenatal care attendance. Awoonor-Williams et al. (2013) and Agyepong et al. (2012) reported reduced maternal and child mortality rates, attributing these improvements to enhanced healthcare access.

However, these designs had limitations in establishing causality. Interrupted Time Series (ITS) analysis, as used by Addi et al. (2022) and Assan et al. (2018), offers a more robust approach, showing significant declines in under-five mortality and increases in skilled birth attendance post-CHPS, thus providing stronger causal evidence of the program's effectiveness. This approach was chosen for its ability to provide robust estimates of intervention effects while accounting for potential confounders, which was a significant advantage over other observational designs (Kontopantelis et al., 2015). Randomized controlled trials (RCTs) were deemed impractical and unethical for this study due to the inability to randomly assign communities to intervention and control groups and the moral issue of denying beneficial services to a control group.

Longitudinal data from the Ghana Health Service (GHS) database was used to avoid issues typically associated with cross-sectional data, such as the inability to account for time-dependent changes (Bryman, 2016). The chapter also acknowledged that other quasi-experimental methods, like controlled before-and-after studies, were unsuitable due to the nationwide and simultaneous implementation of CHPS, which made it impossible to define clear intervention and control groups. ITSA was additionally preferred because it could control for confounding variables over time within the same population, thereby addressing biases that might arise from comparing diverse groups (Kontopantelis et al., 2015).

Autoregressive Integrated Moving Average (ARIMA) models were used to account for time series data relationships, and control variables like economic indicators and demographic factors were included to minimize the impact of unmeasured confounders. Outlier analysis was conducted to ensure that extreme values did not skew results, and sensitivity analyses were performed to confirm the robustness of findings, ensuring that the observed effects were indeed due to the CHPS intervention and not coincidental events. This comprehensive methodological approach allowed for a thorough evaluation of the CHPS intervention's impact on health outcomes in Ghana, ensuring the validity and reliability of the results (Sellers et al., 2010).

In chapter 5 Interrupted Time Series Analysis was again used to assess the efficacy of the Community-based Health Planning and Services (CHPS) compound interventions in Ghana. The data was sourced from the Ghana Health Service (GHS) The dataset included GPS coordinates of healthcare facilities, categorized by region and district. The dependent variables explored were based on World Health Organization (WHO) and GHS recommendations and included three categorical measures: the presence of at least one CHPS facility below 8 km from the district centre, the average distance of CHPS facilities below 8 km within a district, and all CHPS facilities being below 8 km from the district centre. Each variable was examined as a binary outcome with "yes" or "no" responses. The study also defined several independent variables, informed by a literature review and previous studies, including district surface area, number of CHPS compounds, demographic data (ages 0-15, 16-60, and 60+), total population, number of births, mean pregnancies, built settlement extent, GDP per square kilometre, and population density.

Data analysis proceeded in two main stages: descriptive analysis and regression modelling. Descriptive analysis was used to check the accuracy of the GIS dataset and describe the characteristics of the variables. Means, standard deviations, and proportions were calculated to summarize the continuous and categorical variables, respectively. Pearson correlation analysis was also performed to assess the relationships between the independent variables.

Three logistic regression models were employed to investigate the factors influencing the placement of CHPS facilities. The first model examined the determinants of having at least one CHPS facility within 8 km, coding districts with such facilities as "0" and others as "1". The second model focused on the average distance of CHPS facilities within a district, using the same coding scheme. The final model assessed whether all CHPS facilities in a district were within 8 km, again using binary coding. Prior to fitting the models, the dataset was checked for logistic regression assumptions, including multicollinearity using the Variance Inflation Factor (VIF) and the independence of observations.

The data for this chapter 6 analysis was also sourced from the Ghana Health Service database. This spatial analysis conducted enabled the creation of dependent and independent variables for the study. The primary challenge of using GIS for data sourcing was acquiring detailed data with accurate locational information, mitigated by using official data and conducting spatial checks.

The dependent variable, "distance from disease outbreaks/occurrence point to districts," was measured as a continuous variable in kilometres, representing the straight-line distance from disease flashpoints to district centroids. This metric was crucial for understanding disease spread and the placement of CHPS facilities to manage epidemics effectively. Independent variables included the distance from CHPS facilities to districts, the presence of CHPS facilities, and the total number of CHPS facilities per district. Additionally, socioeconomic variables such as GDP per square kilometre, population demographics (children, adults, and senior citizens), built settlement area, and population density were examined. These variables were informed by literature reviewed in Chapter 2. The data analysis employed Generalized Linear Models (GLM) to investigate the determinants of the distance of disease outbreaks from districts across 216 districts. This approach was chosen due to the count nature and skewed distribution of the dependent variable.

Chapter 7 aimed to assess patient waiting times and propose alternatives to reduce these times in Ghanaian healthcare facilities. Despite substantial resources allocated to healthcare in Ghana, long waiting times remain a significant issue (Laar et al., 2019). The study used simulation methods, specifically Discrete Event Simulation (DES), to model patient flows and improve treatment procedures. This method considers doctors, caregivers, and examination areas as control factors, like the approaches used by Corsini et al. (2022) and Bloechle & Laughery (2019).

Simulation methods, including System Dynamics (SD), Agent-Based Simulation (ABS), and DES, have been widely used in healthcare for various applications such as staffing decisions, patient flow, and facility design (Schweizer, 1973; Jun et al., 1999; Fone et al., 2003; Brailsford et al., 2009; Mielczarek & UziaÅko-Mydlikowska, 2010). DES was however selected for its ability to handle detailed patient interactions and queuing systems, which is essential for operational decision-making in healthcare settings. It allows for flexible modelling of individual patient behaviour and stochastic factors, making it suitable for CHPS (Community-based Health Planning and Services) facilities.

The DES model simulated patient care in CHPS compounds, including outpatient and inpatient/emergency cases, with resources such as doctors, nurses, and community health workers. The generic modelling approach was used, allowing for the creation of a broadly representative model based on multiple facility surveys. Data for the study were obtained from the Ghana Health Service, following ethical approval. The dataset included health personnel's clock-in times, job titles, shift durations, and patient arrival times. Two types of timeframes were collected: waiting durations and activity lengths, with a sample size of 640 data points over 90 days. The data were analysed using Arena software.

8.5 Summary of the Study’s Findings

This subsection details all the findings from the study in relevant highlights and shows how they fit in the broader narrative of the overall study.

8.5.1 Effectiveness of the CHPS intervention

8.5.1.1 Maternal Deliveries

The analysis demonstrated that the CHPS intervention significantly increased the immediate and long-term number of maternal deliveries in Ghana, attributed to the intervention's enhanced community engagement and health education efforts (Awoonor-Williams et al., 2016). This finding aligned with the literature that effective healthcare interventions led to sustained improvements in health outcomes and service utilization (Ganle et al., 2016; Sakeah et al., 2023). The increase in deliveries highlights the impact of CHPS on healthcare access, community mobilization, and efforts to overcome cultural, financial, and geographic barriers (Adongo et al., 2014; Nyonator et al., 2005).

Furthermore, the study supports the notion that health literacy and community engagement significantly enhance health service uptake, suggesting that these factors are more influential than the mere increase in reproductive-age populations (Kozlova & Sekitski-Pavlenko, 2020; Viktorsson et al., 2019). The research also emphasized the importance of improving access and quality of healthcare services in rural areas, which can lead to better maternal health outcomes and increased facility-based deliveries (Sharma et al., 2016). The study contributes to the understanding that enhancing the skills of traditional birth attendants can further reduce maternal and neonatal mortality, as these practitioners remain a preferred choice in rural communities (Tabong et al., 2021).

8.5.1.2 Antenatal Visits

The findings showed that the CHPS intervention significantly increased the immediate and long-term utilization of antenatal services in the implemented communities (Afulani et al., 2021). This confirms that healthcare initiatives like CHPS can significantly influence the number of women accessing prenatal care, essential for reducing maternal and neonatal mortality (Pervin et al., 2012). The increased antenatal visits suggest that sustaining and improving the CHPS intervention could avert pregnancy-related complications (Kpienbaareh et al., 2022). Like the maternal delivery outcome, the rise in antenatal visits post-CHPS is attributed to increased healthcare access, community engagement, and health education (Awoonor-Williams et al., 2013; Adongo et al., 2014; Nyonator et al., 2005).

The significant annual increase in antenatal visits underscores the intervention's positive and lasting impact. Exploring the specific factors contributing to this trend is crucial for understanding the mechanisms responsible for this change.

8.5.1.3 OPD Attendance

The non-significant findings as shown in Table 28 regarding the relationship between the CHPS intervention and OPD attendance suggest that the model may not fully capture the impact of the CHPS program on OPD attendance. This contrasts with significant findings for maternal deliveries and antenatal visits. The lack of significance might be due to unaccounted confounding variables such as disease prevalence, health-seeking behaviour, accessibility, or quality of care at CHPS compounds (Oduro-Mensah et al., 2013; Sakeah et al., 2014). The findings suggest the CHPS program's focus on maternal and child health services may not directly impact overall OPD attendance (Nyonator et al., 2005; Awoonor-Williams et al., 2013).

Methodological limitations, such as small sample size or measurement errors, could also explain the non-significant findings. The absence of a control group for comparison further complicated the analysis. Variations in health-seeking behaviour, cultural views, alternative healthcare options, and perceptions of illness severity potentially added further levels of complexity to OPD attendance trending differently from maternity and child health services (Oduro-Mensah et al., 2013). Additionally, fluctuations in disease prevalence could alter the need for general outpatient care, independent of the CHPS intervention (Sakeah et al., 2014).

8.5.1.4 Family Planning Visits

The results as shown in Table 24 indicated that the CHPS intervention impacted family planning visits, showing a significant annual increase before the intervention and a non-significant decrease in the first year of the intervention. Post-intervention, there was a significant decline in the annual trend of visits compared to the pre-intervention trend. This suggests that the intervention may have altered family planning visit patterns. One explanation could be that improved quality and accessibility of services led to more effective contraceptive use, reducing the need for frequent visits (Campbell et al., 2014; Adongo et al., 2013). Increased awareness and efficient use of family planning methods may have also contributed to fewer visits (Haberlen et al., 2017; Krenn et al., 2014). Changes in healthcare policies, socioeconomic conditions, or cultural factors might have influenced family planning practices and utilization rates (Doubeni et al., 2012; Oversveen et al., 2017).

Policy changes accompanying the intervention, such as new regulations or funding adjustments, could have impacted service delivery or accessibility, contributing to the decrease in visits (Doubeni et al., 2012). Further research is however needed to understand the mechanisms behind these changes and assess the intervention's sustainability and effectiveness over time. Qualitative methods, such as interviews and focus groups, could provide further insights into the factors affecting family planning visits and identify areas for improvement (Johnson et al., 2020; Kriel et al., 2019).

8.5.2 Determinants of positioning of CHPS facilities to meet recommended guidelines.

Chapter 5 conducted a comprehensive analysis using Geospatial Information Systems (GIS) techniques to investigate the factors influencing the placement of CHPS (Community-based Health Planning and Services) facilities across 216 districts in Ghana. The findings revealed several key insights that contribute significantly to understanding healthcare access and distribution in rural and urban contexts.

Firstly, it was observed that most districts with CHPS facilities were within 8 kilometres of at least one facility, aligning closely with Ghana Health Service (GHS) guidelines. This underscores the initial success of CHPS in spatially distributing healthcare resources as per policy recommendations, thereby potentially enhancing geographic accessibility for communities in need.

A notable discovery was the negative correlation between district size and the number of CHPS facilities, suggesting that larger districts tend to have fewer healthcare facilities. This finding highlights a potential disparity in healthcare access between rural and urban areas, where rural districts with larger land areas may face challenges in healthcare provision despite potentially greater healthcare needs.

Furthermore, the analysis revealed negative correlations between various demographic and economic factors (such as adult population, senior citizens, total population, built settlements, and GDP per square kilometre) and the number of CHPS facilities. This indicates that economic development and population density play crucial roles in determining the availability of healthcare resources. Areas with higher economic activity and population densities tended to have more CHPS facilities, reflecting a trend seen in broader healthcare access patterns.

The regression analysis further supported these observations, showing that the number of CHPS facilities significantly influences adherence to the 8-kilometer guideline set by the GHS. Increasing the number of CHPS facilities within a district can potentially improve adherence to policy guidelines and enhance regional accessibility to healthcare services, addressing spatial disparities in healthcare access.

Importantly, the study suggested that while geographic accessibility is crucial, effective utilization of healthcare services depends on addressing broader socioeconomic and cultural barriers. These include factors such as health literacy, financial constraints, and cultural beliefs, which influence healthcare-seeking behaviour and service uptake.

These findings contribute new insights into the spatial distribution and determinants of CHPS facility positioning in Ghana, offering a foundational understanding for policymakers and stakeholders. By identifying key factors influencing facility placement, such as district size, economic development, and population density, this study informs strategies to optimize healthcare resource allocation and enhance equitable healthcare access across diverse geographical and demographic contexts.

However, the study's cross-sectional nature and reliance on spatial data availability for GIS analysis present limitations. Future research could build upon these findings with longitudinal data and qualitative investigations to deepen understanding of how healthcare policies and local contexts interact to shape healthcare access and utilisation in Ghanaian communities.

8.5.3 Disease occurrence points relative to CHPS facilities related factors.

In this chapter 6, the study investigated the relationship between CHPS facilities and their impact on the proximity to disease outbreaks across districts, as earlier investigated in Chapter 4. Using a Poisson regression model, the study uncovered compelling dynamics that shed light on the role of primary healthcare infrastructure in disease mitigation and surveillance.

The findings highlight a significant association: districts with CHPS facilities tend to be farther from disease hotspots compared to those without such facilities. Specifically, districts lacking CHPS facilities exhibited a 12% higher likelihood of being closer to disease outbreaks, emphasizing the protective role of CHPS in disease containment and prevention. This aligns with existing literature that writes on the pivotal role of primary healthcare in disease control efforts and public health (Kruk et al., 2010; Langlois et al., 2016).

Interestingly, the concentration of CHPS facilities within districts also emerged as a critical factor. Districts with a moderate number of CHPS facilities (6 - 11) demonstrated significantly greater distancing from disease outbreaks, indicating that optimal distribution and availability of healthcare services contribute to reduced disease burdens. This underscores the importance of strategic healthcare infrastructure planning in mitigating local disease transmission rates (Bitton et al., 2019).

However, a nuanced finding emerged for districts with more than eleven CHPS facilities, where the proximity to disease outbreaks unexpectedly increased by 31%. This result suggests complex interactions between healthcare infrastructure, population dynamics, and disease epidemiology. It may indicate that densely populated areas with numerous CHPS facilities face heightened risks of disease transmission due to increased population density and mobility, factors that can facilitate disease spread despite healthcare access improvements (Cowling et al., 2020; Sajadi et al., 2020).

This study contributes to quantifying the spatial relationship between CHPS facilities and disease outbreaks, highlighting both the protective benefits and potential challenges associated with healthcare infrastructure development. The findings underscore the importance of not only expanding healthcare access but also strategically aligning healthcare resources with local disease dynamics to optimize public health outcomes.

8.5.4 Patient waiting times and routing in CHPS compounds.

In chapter 7, the operations of CHPS compounds were simulated using discrete event simulation, drawing data from CHPS facilities data from the Ghana Health Service in Ghana. A key challenge identified was lengthy average wait times, reflecting broader concerns in healthcare settings globally (British Columbia Medical Association, 2006; Eilers, 2004). Long waiting times not only impact patient satisfaction but also influence healthcare demand patterns, potentially affecting the choice between using insurance or paying out-of-pocket for services.

Addressing seasonal fluctuations in healthcare demand, such as those related to respiratory illnesses during dry seasons, requires proactive resource allocation and readiness, informed by simulation-based forecasting and trend monitoring. Streamlining patient flow through process optimization and physical layout adjustments were found to be able to significantly enhance operational efficiency and patient outcomes. This includes aligning staffing schedules with peak patient arrival times, ensuring adequate downtime between shifts, and standardizing procedures to improve service delivery and patient satisfaction.

However, the study suggested that the financial implications of such adjustments must be carefully considered, balancing the costs of workforce changes and infrastructural improvements against potential gains in operational efficiency and patient care outcomes. Involving healthcare providers and patients in the implementation process is crucial for successful operational improvements, ensuring that changes address real-world concerns and enhance overall healthcare experiences.

8.6 Comparative of the Empirical Findings

The findings of the study are contrasted with more established bodies of knowledge in this subsection of the chapter.

8.6.1 Effectiveness of the CHPS intervention

8.6.1.1 Maternal Deliveries

Based on the empirical findings from the analysis of CHPS (Community-based Health Planning and Services) intervention effectiveness, several key themes emerge regarding its impact on maternal deliveries in Ghana. The CHPS intervention significantly increased immediate maternal deliveries in the studied areas, attributed to enhanced community engagement and health education efforts (Awoonor-Williams et al., 2016). Furthermore, the observed long-term impacts of CHPS on maternal deliveries suggest sustained improvements stemming from increased healthcare accessibility, community mobilization, and targeted efforts to address healthcare access barriers (Adongo et al., 2014; Assan et al., 2018; Nyonator et al., 2005). This is consistent with findings that enhancing access to healthcare services in rural areas can notably enhance maternal health outcomes and increase facility-based deliveries (Sakeah et al., 2014; Sharma et al., 2016).

Comparatively, studies from other countries reinforce the notion that community-based healthcare interventions can enhance maternal health outcomes. For instance, research in similar settings has shown that improving healthcare access through community engagement and educational initiatives can increase facility-based deliveries and reduce maternal mortality (Das et al., 2015; Koblinsky et al., 2016). Additionally, studies from contexts outside Ghana emphasize the critical role of traditional birth attendants (TBAs) and local healthcare providers in improving maternal health outcomes, like findings on the continued utilization of such rural health service deliverers despite the presence of healthcare facilities (Ganle et al., 2015; Montagu et al., 2017).

These comparative insights highlight the universal relevance of community-based approaches in improving maternal health outcomes. They highlight the effectiveness of strategies focused on healthcare access, community mobilization and leveraging local healthcare providers to improve maternal health outcomes, which are key elements mirrored in the CHPS intervention in Ghana.

8.6.1.2 Antenatal Visits

Based on the findings regarding the CHPS intervention's impact on antenatal services utilization in Ghana, significant increases were observed immediately and over the long term (Afulani et al., 2021). This aligns with global research indicating that healthcare initiatives, such as CHPS, can effectively enhance access to antenatal care, crucial for early detection and management of pregnancy complications, thereby reducing maternal and neonatal mortality rates (Pervin et al., 2012).

Comparatively, studies in other countries mirror the positive impact of community-based healthcare initiatives on antenatal care patronage. For instance, research in sub-Saharan Africa and Southeast Asia demonstrates that similar programs enhance antenatal care access and utilization, contributing to improved maternal health outcomes (Titaley et al., 2010; Wilunda et al., 2013). These findings reinforce the global relevance of community-based approaches in promoting maternal health through increased antenatal care utilization.

Moreover, the sustained increase in annual antenatal visits following CHPS implementation highlights the program's enduring impact on healthcare-seeking behaviour among pregnant women (Afulani et al., 2021). This sustained effect mirrors findings from studies in many other settings, suggesting that continuous community engagement and improved healthcare accessibility are critical in sustaining positive health outcomes (Magoma et al., 2014; Shiferaw et al., 2016).

8.6.1.3 OPD Attendance

The non-significant findings regarding the relationship between the CHPS intervention and outpatient department (OPD) attendance, as presented in Table 28, suggest complexities in understanding the program's impact on broader healthcare utilization beyond maternal and child health services. Unlike outcomes such as maternal deliveries and antenatal visits, which showed significant improvements post-intervention (Afulani et al., 2021), OPD attendance did not exhibit a similar pattern. This discrepancy may stem from numerous factors not adequately addressed in the study.

Comparatively, studies from other countries suggest similar challenges and considerations regarding healthcare use beyond specific intentions of use designed by the program. For instance, research in low-resource settings like LMICs highlights how healthcare utilisation patterns can be influenced by cultural beliefs, availability of alternative healthcare options, and perceptions of illness severity (Goudge et al., 2009; Sturmberg et al., 2017). These factors show the complexity of healthcare-seeking behaviours and the varied impacts of community-based health interventions on diverse types of healthcare services.

Moreover, variations in disease burden and epidemiological trends can significantly affect OPD attendance patterns over time and across different geographic areas, regardless of specific intervention programs (Sakeah et al., 2014). Thus, understanding these contextual factors is crucial for interpreting and enhancing the effectiveness of community-based healthcare initiatives like CHPS in promoting comprehensive healthcare access.

8.6.1.4 Family Planning Visits

Initially, there was a significant annual increase in family planning visits before the intervention. However, following the implementation of the CHPS program, the first year showed a non-significant decrease in visits, and subsequent years saw a significant decline in the annual trend relative to pre-intervention levels. This suggests that while the intervention initially influenced family planning visits positively, there was a notable shift in utilization patterns over time.

While further research is essential to pinpoint the specific mechanisms driving these changes in family planning visits, similar studies from different backgrounds enhance our understanding by pointing out that family planning uptake declines with increased education in the long term (Sharma et al., 2018), contextualizing these findings within the broader healthcare landscape strategies to enhance family planning services in rural communities (Andoh-Adjei et al., 2018; GHS, 2020).

8.6.1.5 Determinants of positioning of CHPS facilities to meet recommended guidelines.

Key findings in this subsection revealed that 117 districts had at least one CHPS facility, while 99 districts had none. Among districts with CHPS facilities, a majority (82.9%) were positioned within 8 kilometres of cumulative distance, adhering to Ghana Health Service (GHS) guidelines for accessibility. The distribution of CHPS facilities varied widely, with districts hosting between one to seventeen facilities on average.

A notable discovery was the negative correlation between district surface area and the number of CHPS facilities, indicating larger districts tended to have fewer CHPS facilities. This trend extended to variables like adult population, senior citizens, total population, and built settlements, suggesting population density influenced facility availability, akin to rural-urban healthcare disparities observed elsewhere (Gupta et al., 2021). Economic factors, reflected in GDP per square kilometre, also correlated negatively with the number of CHPS facilities, underscoring the influence of economic development on healthcare access (Chen et al., 2021).

Comparatively, international studies highlight similar findings in healthcare facility distribution. For instance, research in rural India found that population density and economic factors significantly influenced the distribution of primary healthcare centres, akin to the findings in Ghana (Patel et al., 2015). Moreover, studies in Sub-Saharan Africa underscore economic development's critical role in shaping healthcare access, echoing the correlation observed between GDP per square kilometre and CHPS facility density in Ghana (McPake et al., 2013). These comparative studies emphasize the universality of economic and demographic factors influencing healthcare infrastructure planning and policy formulation globally.

8.6.1.6 Disease occurrence points relative to CHPS facilities related factors.

In this subsection, a generalized linear regression model with the Poisson family was used to explore how the presence and concentration of CHPS facilities influence the geographical spread of diseases.

Interestingly, the number of CHPS facilities within a district significantly influenced disease proximity. Districts with moderate concentrations of CHPS facilities showed greater distancing from disease flashpoints, indicating that increased availability of primary healthcare resources correlates with reduced disease burdens (Bitton et al., 2019) Comparatively, international studies on healthcare infrastructure and disease dynamics reveal similar complexities. Research in other regions has shown that healthcare facility density and population density influence disease transmission patterns, with densely populated areas often experiencing higher disease burdens despite better healthcare access (Chowell et al., 2021; Tatem et al., 2012). Moreover, studies in urban settings highlight the challenges of balancing healthcare infrastructure expansion with effective disease control measures in rapidly growing and densely populated areas (Bollyky et al., 2019; Reiner et al., 2020).

These comparative insights prove the global relevance of understanding how healthcare infrastructure interacts with disease dynamics, emphasising the need for context-specific strategies to optimise healthcare access and disease control efforts.

8.6.1.7 Patient waiting times and routing in CHPS compounds.

In this study, the operations of CHPS compounds were simulated using discrete event simulation (DES), providing insights into operational efficiencies crucial for healthcare delivery. The simulation model developed based on data from in this study, the operations of a CHPS compounds are simulated via the method of discrete event simulation. The simulation model was developed by assessing operational data from the Ghana Health Service for CHPS facilities. Lengthy average wait time is among the prevalent challenges affecting most healthcare organizations (British Columbia Medical Association, 2006). CHPS compounds in Ghana, highlighted lengthy average wait times as a significant challenge, echoing broader concerns in healthcare organizations from other parts of the world (British Columbia Medical Association, 2006; Eilers, 2004). This issue directly impacts healthcare demand within CHPS facilities and indirectly influences healthcare seeking behaviour, particularly in terms of insurance usage versus cash payments.

Comparatively, international studies underscore similar challenges and strategies in healthcare management, emphasizing the universal need for efficient resource allocation, workforce planning, and operational streamlining to meet healthcare demands effectively (Tran et al., 2017; Viberg et al., 2013). Standardizing procedures, enhancing IT systems for improved code tracking, and transparent communication were similarly found to be essential for optimizing patient care and operational efficiency when it comes to patient wait times. The study suggested personnel schedules be aligned with patient arrival patterns to maximize resource utilization, particularly critical in settings with limited workforce capacity like the areas community health centres operate as indicated in the study by Ganguly and Nandi (2016).

8.7 Research Findings to the Literature

The comprehensive findings presented across various facets of the CHPS program in Ghana contribute significantly to the existing literature on healthcare interventions and health system dynamics. Firstly, the empirical studies highlighted several key outcomes of CHPS interventions. Notably, there was a significant increase in maternal deliveries and antenatal visits following CHPS implementation. This finding aligns with broader global health research emphasizing the critical role of accessible primary healthcare in improving maternal and child health outcomes (Awoonor-Williams et al., 2016; Ganle et al., 2016; Pervin et al., 2012). These studies highlight how community engagement, health education, and improved healthcare access contribute to enhanced service utilization and health outcomes.

Secondly, geospatial analyses revealed patterns in the distribution of CHPS facilities. The negative correlation between district size and the number of CHPS facilities suggests that population density influences healthcare resource allocation. This finding resonates with global studies on healthcare access disparities between rural and urban areas (Gupta et al., 2021; Noor, 2004). It underscores the importance of geographic accessibility in healthcare planning and policy formulation, particularly in resource-constrained settings.

Moreover, studies on disease proximity and CHPS facilities demonstrated varying impacts on disease outbreak dynamics. While districts with CHPS facilities showed greater distancing from disease hotspots, the complex relationship between healthcare infrastructure and disease transmission highlighted in these findings calls for nuanced policy considerations (Bitton et al., 2019; Cowling et al., 2020). This adds valuable insights to global discussions on the role of primary healthcare in disease prevention and control strategies (Kruk et al., 2010; Langlois et al., 2016).

Additionally, operational simulations exposed critical challenges within CHPS compounds, such as lengthy wait times and operational inefficiencies. These findings underscore the need for continuous quality improvement initiatives in healthcare delivery, resonating with global efforts to enhance healthcare service delivery through process optimization and resource management (British Columbia Medical Association, 2006; Eilers, 2004).

Overall, the synthesized findings contribute to the existing literature by providing empirical evidence and operational perspectives on CHPS effectiveness and challenges. They highlight the nuanced impacts of CHPS interventions on health service utilization, disease dynamics, and operational efficiency within the Ghanaian context. Importantly, these contributions reveal the importance of context-specific healthcare interventions and the need for evidence-based policy formulation to achieve sustainable improvements in healthcare delivery and outcomes.

At the core of this study lies the understanding that the effectiveness of CHPS compounds is fundamentally tied to their distribution, resource allocation and the operational factors within these healthcare units (Ghana Health Service, 2020; Peters et al., 2008). The analysis of facility distribution revealed stark disparities, with some of the districts lacking a CHPS facility altogether. This unequal distribution aligns with existing theories on healthcare access, which emphasize the influence of socioeconomic and geographic factors on health outcomes (Guagliardo, 2004; Marmot, 2005). The findings underscore the need for a more deliberate and equitable approach to healthcare resource allocation by demonstrating that districts with a higher GDP per square kilometre tend to have fewer CHPS facilities (Chen et al., 2021). This emphasizes the need for CHPS compounds to be strategically placed to maximize their reach and effectiveness, particularly in impoverished and remote districts. In doing so, this study echoes the theories of resource-dependence theories (Pfeffer & Salancik, 1978), where the availability of critical resources directly influences organizational and, in this case, healthcare efficacy.

In addition to geographical distribution, the study identifies several operational factors that profoundly affect the utilization of CHPS facilities. The analysis of patient waiting times confirms the critical role of operational efficiency in enhancing healthcare outcomes (Kruk & Freedman, 2008). Long wait times, in particular, may emerge as a deterrent to the use of healthcare services, a finding consistent with established research that links patient satisfaction and service utilization (Campbell & Graham, 2006). Discrete event simulation (DES) as used in this study demonstrated that optimizing patient flow, from registration to medical assessment, could significantly reduce waiting times and improve patient experience (Law, 2015). This operational insight is essential for informing policy changes that would streamline healthcare delivery in CHPS facilities, aligning with Lean and Six Sigma principles, which emphasise the importance of reducing delays to increase service efficiency (Womack & Jones, 1996).

The examination of CHPS compounds' role in disease prevention and control further reveals the critical impact of these facilities on community health. Through geospatial analysis, the study found that districts with CHPS facilities had a lower incidence of disease hotspots, reinforcing the crucial role of accessible primary healthcare in reducing health risks. This finding aligns with the ecological model of health, which posits that the physical and organizational environments surrounding individuals, including access to healthcare, are key determinants of health outcomes (McLeroy et al., 1988). Notably, this study found an interesting trend: districts with an optimal number of CHPS facilities (up to ten) were farther from disease outbreak centres, while those with more than eleven facilities appeared to be closer to disease hotspots. This result suggests a potential saturation effect, indicating that merely increasing the number of facilities does not necessarily improve health outcomes unless accompanied by an efficient distribution and operational model. This pattern invites further investigation into detailed reasons for the phenomena.

Through a comprehensive Geospatial Information Systems (GIS) analysis of 216 districts, the study uncovered that facility distribution is influenced by multiple demographic and economic factors. While 117 districts hosted at least one CHPS facility, a substantial number, 99 districts, lacked such facilities altogether, highlighting significant gaps in healthcare accessibility. Within the districts that hosted CHPS facilities, most (82.9%) had cumulative distances to these facilities within 8 kilometres, aligning with Ghana Health Service (GHS) guidelines (Ghana Health Service, 2020).

The analysis revealed a negative correlation between district surface area and the number of CHPS facilities, suggesting that larger districts may face accessibility challenges due to fewer facilities. This negative relationship extended to population variables, including the number of adults, seniors, and total population size, indicating a possible connection between population density and facility placement (Penchansky & Thomas, 1981). The disparity aligns with similar rural-urban healthcare inequities (Gupta et al., 2021) and emphasizes that lower-density, larger districts may require strategic resource allocations to enhance healthcare access. Economic indicators, particularly GDP per square kilometre, were also negatively correlated with facility numbers, suggesting that economic factors significantly impact healthcare availability, echoing the idea that economic development correlates with enhanced healthcare access (Chen et al., 2021).

These findings point to the potential for policy-driven expansions of CHPS facilities to enhance geographic accessibility, reinforcing the value of targeted infrastructure growth for underserved regions. However, while geographic access is a critical consideration, the influence of cultural, socioeconomic, and infrastructural barriers remains substantial, as highlighted by studies on healthcare utilization barriers. As such, an integrated approach to policy that considers economic, social, and demographic factors is essential for equitable healthcare access.

Further, the study delves into the importance of continuous monitoring and adaptation within CHPS compounds. The findings from the interrupted time series analysis (ITSA) on maternal and child health outcomes revealed significant improvements in maternal deliveries and antenatal visits following the implementation of CHPS interventions, particularly since 2016 (Bernal et al., 2017). These positive outcomes underscore the importance of CHPS compounds as critical providers of maternal and child health services in areas with limited healthcare access. However, the absence of significant findings related to outpatient visits suggests that these facilities are not fully meeting all primary healthcare needs, highlighting a critical gap in service provision that could be bridged by strategic planning and targeted interventions (Campbell & Graham, 2006; World Health Organization, 2013). This insight aligns with the primary healthcare theory that emphasises the holistic role of community-based services in achieving comprehensive health outcomes (Starfield, 1998).

The findings from the synthesis and analysis on the effectiveness of CHPS compounds clearly reflect and reinforce the primary objective of this paper: to rigorously measure the effectiveness of community healthcare facilities within the Ghanaian context, specifically the CHPS intervention.

The first major finding was that CHPS compounds significantly increased maternal deliveries, and that aligns directly with CHPS's mandate to improve maternal health outcomes in rural Ghana (Campbell & Graham, 2006). This positive shift is crucial, as it demonstrates that CHPS compounds fulfil their purpose of extending maternal healthcare to underserved populations. The observed trend in maternal deliveries not only highlights an immediate impact but also suggests a long-term improvement in maternal health outcomes due to sustained accessibility and awareness of healthcare services. This aligns with global health literature that underscores how community-level interventions can lead to lasting improvements in maternal and child health outcomes. The evidence that CHPS compounds contribute significantly to maternal deliveries supports the CHPS mandate to bolster rural maternal healthcare access, meeting one of the main objectives of this paper.

Similarly, the findings on antenatal visits reinforce the effectiveness of CHPS compounds in achieving their community health goals. The significant increase in antenatal care uptake both immediately and in the long term aligns according to the analysed data with CHPS's role in expanding prenatal care accessibility, emphasising the facility's capacity to fulfil its objective of enhancing maternal and child healthcare. This finding supports broader healthcare literature that links antenatal visits with improved maternal and neonatal health outcomes.

However, the non-significant findings concerning OPD attendance indicate that while CHPS compounds effectively target specific maternal and child health services, they may not influence general outpatient services as directly. This observation points to the focused scope of CHPS compounds, which prioritize maternal and child health rather than a full range of outpatient services. This limited scope provides essential insight into CHPS's operational effectiveness; it suggests that while CHPS compounds are highly effective in their target areas, their design may not directly boost general outpatient visits. Thus, this study offers a nuanced view of CHPS effectiveness, demonstrating that the intervention achieves its main goals while highlighting areas for potential expansion.

The findings on family planning visits also reveal the complex factors influencing CHPS effectiveness. The initial decline in family planning visits post-intervention may reflect the program's initial focus on maternal health services, while the decrease in the long-term trend could efficacy due to heightened awareness requiring fewer visits. Furthermore, the observed decrease suggests that community education around family planning could be influential in the indirect role the CHPS initiative plays in promoting healthcare knowledge (Adeyeye et al., 2021). Taken together, these findings demonstrate that CHPS compounds are indeed meeting their primary effectiveness goals in maternal and child healthcare while also offering insights into areas where the intervention can enhance or expand its impact.

Districts with CHPS facilities were shown to have greater distances from disease outbreaks than those without, indicating a possible protective effect of CHPS services in disease prevention (Tatem et al., 2012). This correlation suggests that CHPS facilities may play a role in preventing or controlling the spread of diseases through localized healthcare access and proactive interventions. Interestingly, districts with 6-11 CHPS facilities showed significant distancing from disease flashpoints, emphasizing the protective role of primary healthcare infrastructure in reducing disease burdens. The trend suggests that current healthcare infrastructure expansion may be more reactive than proactive, with facilities being established in response to recurrent outbreaks rather than to pre-emptively prevent them. By strategically expanding CHPS facilities, there could be improved healthcare access but also reduced frequency and impact of disease outbreaks, particularly in densely populated or economically active regions where healthcare needs may be heightened by higher disease transmission risks.

Finally, the study uses discrete event simulation techniques to analyse operational efficiency challenges within CHPS compounds. High wait times emerged as a critical barrier to healthcare access, consistent with previous findings on healthcare service delays (Law, 2015).

The simulation revealed that extended wait times negatively influence demand for healthcare, underscoring the need for operational improvements.

To enhance service delivery, the study suggests realigning resource allocation and shift schedules to optimise staff efficiency. Improving patient flow, through layout modifications or better resource planning, could reduce wait times and enhance healthcare delivery quality.

8.8 Limitations of thesis

This study investigated various aspects of Community-based Health Planning and Services (CHPS) facilities in Ghana, drawing from multiple chapters and methodological approaches. While the research contributes valuable insights into healthcare infrastructure and service delivery in rural settings, it is essential to critically examine its limitations across different chapters to contextualize the findings effectively.

The literature review explored the effectiveness of community healthcare facilities globally but encountered methodological challenges. Many included studies relied on dated data before 2010, potentially limiting their relevance to current healthcare contexts shaped by evolving socioeconomic and health developmental landscapes. Moreover, the review primarily synthesized evidence from observational studies without rigorous adjustment for confounders or consideration of interactions among factors. This limitation hinders the establishment of causal relationships crucial for assessing the effectiveness of CHPS facilities. The study utilized Geospatial Information Systems (GIS) to analyse the distribution of CHPS facilities across 216 districts in Ghana. While this approach enhances the study's generalizability by providing spatial insights, it is constrained by its cross-sectional design. This design limitation prevents the establishment of causal relationships between CHPS facility distribution, socioeconomic factors, and health outcomes over time. Longitudinal data would provide more robust insights into the dynamic interactions between healthcare infrastructure and disease patterns.

Moreover, the quality and completeness of spatial data used in GIS analyses may affect the study's accuracy and depth, potentially introducing biases or limitations in spatial analyses. The reliability of spatial data used in GIS analyses is another critical limitation discussed in Chapters 5 and 6. Potential errors in geocoding and distance measurements may influence conclusions regarding disease proximity and healthcare facility accessibility.

Chapter 5 for instance focused on disease proximity in relation to CHPS facilities but overlooked crucial variables such as transportation networks, water and sanitation infrastructure, and environmental conditions. These factors significantly influence disease dynamics and healthcare accessibility, potentially impacting the study's conclusions. Moreover, the study's narrow regional focus and exclusion of other healthcare determinants, such as district hospitals and private clinics, may limit the generalizability of findings across different healthcare settings in Ghana.

8.9 Implications of the Thesis

8.9.1 Policy Implications

i. Strategic Expansion of CHPS Facilities:

Policymakers should prioritize the equitable distribution of CHPS facilities, particularly in underserved and remote districts. This strategic approach involves identifying locations with limited healthcare access and gradually increasing the number of facilities to enhance healthcare coverage. Rather than a haphazard expansion, a deliberate and gradual increase in CHPS facilities is recommended. This ensures that facilities are adequately staffed and integrated into the community's healthcare system. Special attention should be given to districts with more than eleven CHPS facilities, as these areas have shown proximity to disease outbreaks. Policymakers should investigate the underlying causes, such as population density and mobility patterns, and implement targeted health interventions to mitigate disease spread.

ii. Enhancing Healthcare Accessibility and Utilization:

Policymakers should consider allocating more funding and resources towards the construction of additional CHPS compounds, especially in underprivileged areas. This investment is crucial for improving maternal and child health outcomes. Involving local communities in the site selection and service delivery priorities of CHPS facilities ensures that services are tailored to the needs and preferences of the local population, thereby building trust, and promoting healthcare patronage.

iii. Simulation Techniques in Healthcare Management:

Health policymakers should consider providing incentives for the use of simulation techniques in healthcare planning and management. This includes training healthcare workers, purchasing simulation software, and supporting data collection and analysis. Existing regulations related to healthcare service delivery should be reviewed and potentially revised to allow for more efficient patient flow and reduced wait times. Lastly, establishing systems for patient and healthcare provider feedback is crucial for tracking the impact of these implemented improvements. This can include incentive or penalty systems to ensure adherence to clocking in to provide necessary data for insights.

8.9.2 Research Implications

i. Understanding Disease Dynamics:

Future research should focus on longitudinal studies to establish causal links and provide a deeper understanding of the factors influencing CHPS facility utilization and health outcomes. This approach can trace the dynamics between healthcare interventions and health outcomes over time. Additional studies are needed to understand the dynamics affecting disease outbreak proximity in districts with a dense network of CHPS facilities. Investigating the factors behind this, such as socioeconomic factors, specific cultural barriers and financial constraints can provide valuable insights for customizing healthcare strategies.

ii. Improving CHPS Facility Functionality:

Future research should consider a broad spectrum of variables, including socioeconomic factors, cultural impediments, and financial constraints, to understand their impact on the utilization and effectiveness of CHPS facilities. Research should focus on identifying areas for continuous improvement in CHPS facilities. This includes maintaining and enhancing the quality of care provided, ensuring sufficient staffing, training, and access to necessary medical supplies.

iii. Simulation in Healthcare:

Encouraging the use of simulation techniques can help healthcare administrators create flexible staffing schedules based on patient arrival patterns. This data-driven approach can optimize resource allocation and improve patient flow. Implementing standardized procedures for patient flow, room utilization, and minimizing delays can significantly enhance healthcare delivery outcomes. Future research should explore the best practices for integrating these procedures into existing healthcare systems.

8.10 Concluding Comments

This study has provided a comprehensive examination of the role and impact of Community-based Health Planning and Services (CHPS) facilities in rural Ghana, shedding light on their effectiveness in improving healthcare outcomes, particularly maternal and child health. Through a robust framework, involving both geospatial analysis and discrete event simulation, the research has uncovered critical insights into the distribution, utilization, and operational challenges of CHPS facilities.

The study revealed that districts with CHPS facilities were more distanced from disease hotspots compared to those without such facilities, underscoring the pivotal role of primary healthcare in disease prevention and control. Additionally, the simulation of CHPS operations highlighted significant issues related to lengthy wait times, which can adversely affect healthcare demand and utilization. The findings advocate for interventions to streamline patient flow and improve service delivery efficiency, emphasizing the importance of staff training and flexible staffing schedules.

The implications for policy are many-fold. Firstly, there is a clear need for a strategic and equitable expansion of CHPS facilities across Ghana, prioritizing underserved, and remote districts. Policymakers should consider a strategic increase in the number of CHPS facilities to ensure they are adequately staffed, equipped, and integrated into the community’s already existing healthcare system. Moreover, continuous monitoring and assessment of these facilities are essential to maintain their effectiveness and adapt to evolving healthcare needs.

From a research perspective, the study highlights the need for more longitudinal and qualitative studies to establish causal links and provide a deeper understanding of the factors influencing CHPS facility utilization and health outcomes. It was suggested that future research should explore the dynamics affecting disease outbreak proximity in districts with dense networks of CHPS facilities, considering a broad spectrum of variables, including socioeconomic factors, cultural impediments, and financial constraints.

Additionally, the study advocates for the use of rigorous research methods, such as Interrupted Time Series Analysis (ITSA), to evaluate the impact of healthcare interventions accurately. This approach can help avoid unsupported claims and provide robust evidence to inform policymaking.

In conclusion, this study has made significant contributions to the understanding of primary healthcare provision in rural Ghana, particularly through the lens of CHPS facilities. The findings offer valuable insights for policymakers and healthcare planners, emphasizing the importance of strategic expansion, continuous monitoring, and integration of healthcare services to enhance health outcomes. By addressing the identified challenges and leveraging the recommendations provided, stakeholders can work towards a more effective and equitable healthcare system in Ghana. The study also sets a foundation for future research, highlighting the need for continued exploration and evaluation of healthcare interventions to ensure they meet the evolving needs of rural populations.

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Appendix 1 Pilot Review

9.1 INTRODUCTION

This pilot review was conducted to inform the methods of the main literature review and identify datasets and search terms frequently used by systematic reviews that examine effectiveness of Community health centres in rural areas.

9.2 METHODS

9.2.1 Search Strategy

Scopus, the largest database with over 37,000 titles from medicine, technology, and social sciences, was searched between 4th May and 28th May for relevant systematic reviews. Scopus was chosen as the search engine due to its larger coverage of citation and consistency of results (Jeroen Bosman, 2006).

This pilot review used the following search terms: (“Community Health Centre”) AND (“Effectiveness OR Effective OR Evaluation) AND (Review) AND PUBYEAR > 2009.

Demonstrated in table: 42 is the search result from Scopus database.

Table 43: Pilot review Search Return

Database	Initial Hits	Filters Used	Final Results
Scopus	4,995	Limit to systematic reviews – 183	183
Total			183

9.3 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 revised policy period and the initial policy. (Ghana Health Service, 2016) The table (43) below shows the eligibility criteria that was used in this study.

Table 44: Pilot review Eligibility Criteria

INCLUSION CRITERIA	EXCLUSION CRITERIA
Systematic reviews examining effectiveness of Community Health Centres	Reviews examining the effectiveness of health Clinics
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.

9.4 Data Extraction

A developed data extraction question was used to extract data from the selected systematic reviews. Three 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?

9.5 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).

9.6 Results

Overall, one hundred and thirty (183) systematic 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, one hundred and seventy-seven (177) reviews were removed because they were not related to the topic under study.

The abstracts of the nine remaining reviews were screened to ensure they met the eligibility criteria. This second screening resulted in the elimination of 3 more systematic reviews that did not meet the inclusion criteria. Consequently, only six systematic reviews met the eligibility criteria for the pilot review. The Prisma diagram below has been used to demonstrate the selection process.

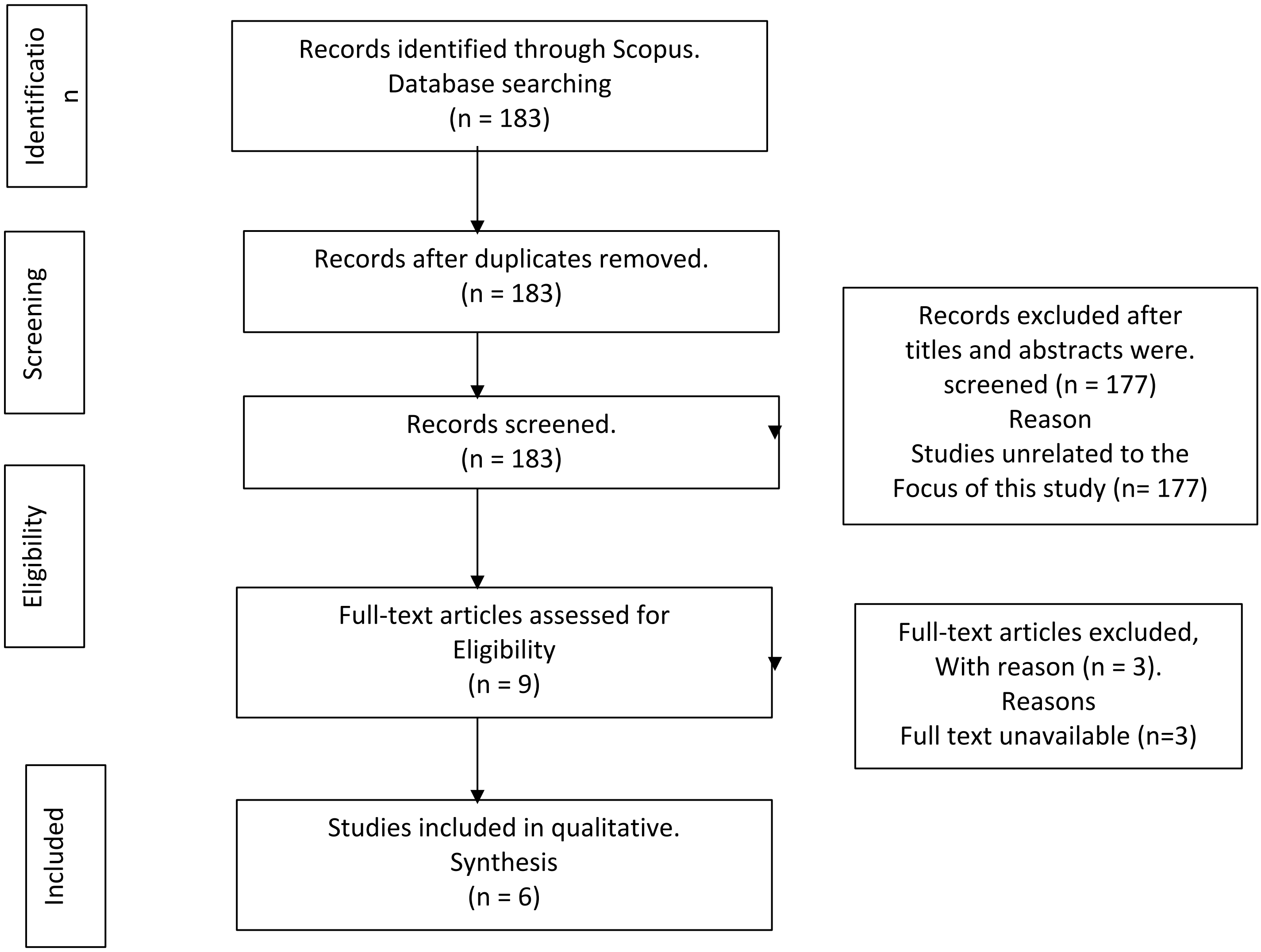

Table 54: Pilot Review Data Extraction

REVIEWS	AUTHOUR/YEAR	DATABASE	SEARCH TERMS
A systematic review of Community health centre-based interventions for people with Diabetes	Hae-Ra Han et al., (2019)	PubMed, EMBASE, CINAHL and Scopus	'Community Health Centres' OR community health centre or satellite centre' or satellite centres' 'neighbourhood health centres'
Models of care involving district hospitals: a rapid review to inform the Australian rural and remote context	Susan A. Nancarrow et al., (2015)	CINAHL, Medline, PsycINFO, APAIS-Health, ATSI health, Health Collection, Health & Society, Meditext, RURAL, PubMed and Google Scholar.	'rural', 'small general and district hospitals', 'rural health services organisation & administration', 'medically underserved area', 'specific conditions, interventions, monitoring and evaluation', 'regional, rural, and

			remote communities’, ‘NSW’, ‘Australia’ and ‘other OECD countries’
Effectiveness of community health workers delivering preventive interventions for maternal and child health in low- and middle-income countries: a systematic review	Brynne Gilmore et al., (2013)	CINAHL, Embase, Ovid Nursing Database, PubMed, Scopus, Web of Science and POPLINE. Google, Google Scholar and WHO search engines	“Community health Care”, “volunteer” “aide” “support” “extension” “assistant” “surveyor” “distributor” “auxiliary” Etc.
Impact of community-based nurse-led clinics on patient outcomes, patient satisfaction, patient access, and cost effectiveness: A systematic review	Sue Randall et al., (2017)	Medline, CINAHL and Embase	‘nurse-managed centres’ ‘Practice’ ‘nurse’ ‘Ambulatory Care’ ‘nurse-led clinic’ ‘nurse led clinic’ ‘community’ ‘primary health care’ and ‘primary care’

Community health extension program of Ethiopia, 2003–2018: successes and challenges toward universal coverage for primary healthcare services	Yibeltal Assefa et al., (2019)	PubMed, Embase and Google scholar.	Health extension worker OR Health extension program OR community health OR community health workers OR health development army OR health extension package) AND (performance OR success OR efficiency OR cost effectiveness OR challenge OR limitation OR gaps OR weakness OR attitude OR Failure OR cost OR strength OR monitoring OR evaluation
Nurse-led primary healthcare walk-in	Jane Desborough et al., (2011)	Medline, CINAHL and EBSCO, The	walk-in, minor injury unit, nurse-led,

centres: an integrative literature review		Cochrane Database of Systematic Reviews, Google Scholar, and the World Health Organisation (WHO)	nurse practitioner, nurse manag*, primary health care, primary care, ambulatory care facilities, health service accessibilities, accessibility, convenient care, nurse's role, and nurse administrators

9.7 Databases

The common databases used by the selected reviews were PubMed, Embase, CINAHL, Scopus, Medline, WHO, PsycINFO, The Cochrane Database of Systematic Reviews and Google Scholar. Table: 45 below has been used to show the databases and the frequency of use across the selected reviews.

Table 46: Pilot Review Data Extraction

DATABASE	NUMBER OF REVIEWS THAT USED IT
PubMed	4 / 6
Embase	4 / 6
CINAHL	4 / 6
Scopus	2 / 6
Medline	3 / 6
Google Scholar	4 / 6
COCHRANE	1 / 6
WHO	2 / 6
PsycINFO	1 / 6

9.8 Search Terms

The following keywords ‘community health centre’, ‘primary health centre’, ‘effective’ were the most frequent search terms used by the selected systematic reviews. The search terms and frequency of use has been demonstrated in table: 46 below.

Table 47: Identified search terms and frequency of use (Pilot Review)

SEARCH TERMS	NUMBER OF REVIEWS THAT USED IT
Community Health Centre	2 / 6
Primary Health Centre	2 / 6
Primary Care	1 / 6
Rural Health Centre	1 / 6
Nurse-managed centres	1 / 6
Effective	1 / 6
Successful	1 / 6

9.9 Quality Appraisal

All the selected systematic review papers 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 four 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 47 below.

Table 48: Identified search terms and frequency of use (Pilot Review)

Studies/Reviews	Q1	Q2	Q3	Q4	Q5	Q6	Q7	Q8	Q9	Q10
Hae-Ra Han et al., (2019)	YES	YES	YES	YES	YES			YES	YES	YES
Susan A. Nancarrow et al., (2015)	YES	YES	YES	YES	YES			YES	YES	YES

Brynne Gilmore et al., (2013)	YES	YES	YES	YES	YES			YES	YES	YES
Sue Randall et al., (2017)	YES	YES	YES	YES	YES			YES	YES	YES

9.10 CONCLUSION

In conclusion, CINAHL, PubMed, Embase, Scopus, Medline, Google Scholar, WHO were the most common databases used by the selected systematic reviews examining the effectiveness of community health centres. In addition, 'Community health Centre' 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: Selected Studies Data Extraction

Data Extracted from 39 Studies

Elements	Findings
Title of the study	Enhancing Community-Based Participatory Research Through Human-Centred Design Strategies
Name of authors	Elizabeth Chen, Cristina Leos, Sarah D. Kowitt, Kathryn E. Moracco,
Year of publication	2020
Aims/objectives of study	The aim of the study was to compare and contrast the research approaches in public health-oriented studies which are the Human centred Design, and the community based Participatory research aiming at their processes, their purpose, values, and outcomes. The study also aimed at providing recommendations as to how both approaches can be integrated in research
Study design	Cross-sectional Design
Setting of the study	Durham, North Carolina,
Country of study	USA

What were the characteristics of the study population?	researchers, practitioners, and community members
How many arms did the study have?	1
What was the description of the comparator(s)?	CBPR & HCD
What are the outcomes used in the study	The differences in values are reflected in the differences in purpose and outcomes for the two approaches. HCD's primary purpose is to actively test and build solutions intended to scale across a larger user base, far beyond participants in the original project. HCD aims to create a product or service a tangible solution that can be widely and successfully implemented immediately on conclusion of the project, with a specified business model to support its implementation and dissemination. As a result, research and data collection comprise a smaller proportion of the

	process, with most effort directed toward building and testing solution prototypes. In contrast, CBPR emphasizes generating research findings and uncovering highly localized, contextual insights for and with the participating community. While CBPR may contribute to a solution, it is essentially a research process and, as such, its primary goal is to generate new knowledge that can inform future action. Significant effort is spent on collecting, analysing, and interpreting data (Israel et al., 1998) and instead of developing a product to address a problem faced by community members,

	CBPR aims to build capacity within the community to address existing and future challenges.
Findings of the study	1. It was found that the two approaches i.e. the HCD and CBPR are distinct, but they also overlap at a point. 2. HCD and CBPR are similar in that they both value a bidirectional exchange of knowledge and cocreation 3. Both approaches have distinct values that affect the nature of their work and goals. HCD centres its work on cultivating deep empathy, thinking creatively, and instilling delight in their users.
The authors limitations	1. While we reviewed dozens of articles and source materials on HCD and CBPR, we did not employ the methods of a systematic review or formal meta-analysis

	2. We also recognize that our five recommended instrumental HCD strategies cover the inspiration (form transdisciplinary teams, cultivate greater empathy, recruit, and work with “extreme users”) and implementation (rapidly prototype, create tangible products or services) phases of design thinking but not the ideation phase.

Elements	Extracted findings
title of the study	Synthesizing Evidence-Based Strategies and Community-Engaged Research: A Model to Address Social Determinants of Health
Author (s)	Lisa Jane Hardy, Kyle David Bohan, Robert Talbot Trotter
Year of publication	2013
Aims/objectives of the study	The aim of the study is to produce knowledge on the use of Evidence based Strategies in studying health issues particularly obesity in communities
Study design	Non-randomised intervention, Rapid Assessment, Response, and Evaluation (RARE)

What is the study setting	This study implemented this approach within a community in northern Arizona. The study area is historically known as the most ethnically diverse neighbourhood housing the highest number of low-income residents in Flagstaff.
What is the country of study	USA
Place of study (Health Facility/not)	Health facilities, community, and educational institutions
Was the study in a rural or urban area?	Rural
Type of health professionals at the centres	public health professionals,

characteristics of the study population	45% of residents identify themselves as Hispanic or Latino. Among non-Hispanic and Latino residents 39.2% report that they are American Indian or Alaska Native
How many arms did the study have?	1
What are the outcomes used in the study	Hermosa Vida research and planning resulted in the selection of multiple strategies for enhancing the safety net and addressing the SDH in one U.S. city.
How were the outcomes of the study measured	Multileveled intervention designs

What was the sample size	6,700
Finding made in the study	1. The best approaches to modern public health concerns often involve looking beyond standardized or evidence-based behavioural change intervention models and targeting the social determinants of health (SDH) at the root of the problem. 2. The concept of SDH is derived from the principle that substantial health inequalities are caused by the unequal distribution of power, income, goods, and services within social, political, and economic structural frameworks

Limitations of the study	1. Most of the limitations concern the issue of quality-control mechanisms for data collection and analysis. 2. The primary methodological limitations for RARE have been thoroughly identified and answered in the rapid ethnographic assessment methodological literature

Elements	Findings
Title of study	Population-Based Research: The Foundation for Development, Management and Evaluation of Community Nursing Centre
Name of Author(s)	Doris F. Glick, Karen Macdonald Thompson, Richard A. Bridge
Year of publication	1999
Aims/objectives of study	The aim of the study is to study the development, management, and evaluation of Community Nursing centres by the use of the population-based research approach
What is the study design	Cross-sectional

What is the country of study	USA
What was the place of study (Health Facility/not)	University of Virginia Primary Care Community Nursing Centre
Was the study in a rural or urban area?	Urban & Rural
What were the types of health care professionals working at centre?	Community health workers
What were the characteristics of the study population?	1. Elderly and disabled people with the average age of 66 2. Low-income women and children with the average age of 19

	3. Rural area school pupil from grade K to Grade 12
How were the outcomes of the study measured	Program outcomes are evaluated based on the use of population level data
What were the findings of the study	1. The use of population level data is important for the development of public health needs 2. Aggregate data that portray the features of the entire population studied usually serves as the base line of the planning and development of health programs that promote and protect the health needs of the communities.

	3. Knowing the populations in the study has helped in the choice of programs and health services to plan and deliver to each distinct population.
Limitations of the study	1. The study was limited only to the clinics of University of Virginia primary care nursing centre; a larger scope would have provided the researchers with more features to consider in the development of more appropriate health programs

Data extraction questions	Findings made
What is the title of the study	Tailoring Community-Based Wellness Initiatives with Latent Class Analysis — Massachusetts Community Transformation Grant Projects
What are the names of the authors	Mariana Arcaya, Timothy Reardon, Joshua Vogel, Bonnie K. Andrews, Wenjun Li, Thomas Land,

What is the year of publication	2014
What are the aims/objectives of the study	The objectives of the study are to produce knowledge on the public health initiatives that work best for effective ways of delivery and evaluation of the interventions that best prevent chronic diseases at the community level.
What is the study design	Non-randomised intervention
What is the country of study	USA
What was the place of study (Health Facility/not)	Health Facility
Was the study in a rural or urban area?	Urban

What were the types of health care professionals working at centre?	Community health workers
What were the characteristics of the study population?	1. Lower income communities 2. Majority of the populations studies were below the poverty rate. 3. The population also have poor health outcomes resulting from chronic smoking and obesity

What was the description of the intervention?	1. LCA methodology to address programmatic and evaluation challenges associated with implementing a municipal-based wellness intervention program across a large number of heterogeneous communities. The approach considered intervention inputs (e.g., retail environment), effect modifiers (e.g., age), and outcome measures of the prospective interventions (e.g., obesity prevalence).
What were the findings of the study	1. The prevention and wellness community typology derived from the analysis serves as a basis for 1) establishing proper evaluation benchmarks, 2) establishing efficient-yet-tailored communications campaigns, 3) facilitating knowledge exchange across peer communities, and 4) using cost-effective, context-specific intervention selections and staff training

What were the author stated limitations	1. The model was constrained to produce 10 classes for pragmatic reasons despite model fit statistics indicating that 2 or more of these classes could be combined 2. Although our input variables were selected based on 6 domains that were considered directly relevant to Mass in Motion and CTG programs, it is possible that some inputs are redundant while other relevant indicators were overlooked

Data Extraction questions	Findings

What is the title of the study	Health service engagement with consumers and community in Australia for issue Engagement and accountability with your community
What are the names of the authors	Shane Rendalls, Allan D. Spigelman, Catherine Goodwin and Nataliya Danie
What is the year of publication	2019
What are the aims/objectives of the study	To provide an overview of consumer and community engagement in health service planning, quality improvement and programme evaluation in Australia, and key components and importance of a strong suite of tools for achieving effective outcomes.
What is the study design	Cross-sectional
What is the country of study	Australia
What are the outcomes used in the study	As an outcome of the first-year evaluation, the PHN is engaging in a co-design process with the contracted service provider, staff, consumers, and other key stakeholders including local hospital services and other community service providers. Based on the programme logic, the assessment and triage criteria, SMART activity output and outcome measures will be defined. The inclusion of external stakeholders in the co-design process will facilitate the development of

	measures to assess the cross-agency collective impact of the programme on the demand for other services.
What were the findings of the study	1. Consumer engagement is a recognised component of the Australian health system. It is reflected in the national and state health policy and is a mandatory requirement of hospital accreditation. 2. The application of co-design principles is gaining increasing popularity in health service planning and programme evaluation. Co-design is an important enabler of patient/community-centred service planning and evaluation; however, on its own it may lead to poorer outcomes. Co-design must occur within a broader systemic framework.
What were the author stated limitations	The research identifies a conceptual framework, approaches, and tools of value to health service management and planners.

Data Extraction Questions	Findings
What is the title of the study	A Primary Care–Public Health Partnership Addressing Homelessness, Serious Mental Illness, and Health Disparities

What are the names of the authors	Lara Carson Weinstein, Marianna D. LaNoue, James D. Plumb, Hannah King, Brianna, Stein and Sam Tsemberis, PhD
What is the year of publication	2013
What are the aims/objectives of the study	To produce information on the public health interventions for vulnerable groups like the homeless and mentally ill patients
What is the study design	Non-randomised intervention Design
What is the country of study	USA
What was the place of study (Health Facility/not)	Not in health facilities
Was the study in a rural or urban area?	Urban area

What were the types of health care professionals working at centre?	Personal physicians, psychiatrists, nurses etc.
What were the characteristics of the study population?	Mentally ill and homeless people
How many arms did the study have?	1
What was the description of the intervention?	1. Firstly, formal partnership was formed between the DFCM and PTH-PA, and a primary care physician was embedded into the PTH-PA Assertive Community Treatment team to provide on-site primary care and population-based health monitoring and services

	2. Secondly, Additional clinical, evaluation, and educational partnerships have been formed with the Jefferson's Center for Urban Health, Department of Emergency Medicine, School of Nursing, and School of Public Health 3. Thirdly, an analysis was done using the Local Public Health System Performance Assessment Instrument16 (version 2.0) to characterize the manner in and degree to which the program is meeting the performance standards set forth for the project.
What was the description of the comparator(s)?	No access to onsite primary health care and mental health for homeless individuals
What are the outcomes used in the study	1. The outcome was that the success of this model program relies largely on the extension of the existing academic PCMH.
What were the findings of the study	Supportive housing models such as Housing First are working to end homelessness and promote recovery in this population. Combining on-site primary care and population health management with Housing First offers significant opportunities

	for improving the health of this severely marginalized group. The PTH-PA/Jefferson DFCM Partnership represents a community of solution, and multiple measures provide preliminary evidence that this model is feasible.
What were the author stated limitations	The greatest of these is sustainability. The services of the embedded primary care physician are not able to be reimbursed under cur- rent insurance mechanisms. Services currently are provided through a DFCM contract with PTH-PA combined with in-kind departmental support. New models of reimbursement through the PCMH structure and accountable care organizations may improve this situation. Another significant challenge is that of work- force development and enhancement, both in family medicine and community psychiatry. We believe that our educational programs for residents and medical students will begin to increase the comfort level of medical providers when working with individuals with SMI and collaborating with behavioural health providers in community settings. Both the issues of sustainability and workforce training limit the potential for scaling up and disseminating our current model.

Data extraction Question	Findings

What is the title of the study	Implementing a chronic disease strategy in two remote Indigenous Australian settings: A multi-method pilot evaluation
What are the names of the authors	Peter d'Abbs, Barbara Schmidt, Kathryn Dougherty, and Kate Senior
What is the year of publication	2008
What are the aims/objectives of the study	The objective of this study is to test an evaluation framework designed to evaluate implementation of the North Queensland Indigenous communities between August and December 2005.
What is the study design	Non-randomised intervention
What is the study setting	Both communities are located in Cape York, North Queensland. Community A has an estimated population of around 600 people; Community B has an enumerated population of 750, although health centre records indicate a higher number.
What is the country of study	Australia

What was the place of study (Health Facility/not)	Community health centres
Was the study in a rural or urban area?	The study focused on rural areas
What were the types of health care professionals working at centre?	Community health professionals
What were the characteristics of the study population?	Remote rural community members

What was the description of the intervention?	
What was the sample size	The study used two communities the first community had the population of 600 and the second community was of the population of 720 people
What was the description of the intervention?	Process evaluation involved health centre staff in both communities; clinical audits used random samples from the adult population (each sample n = 30); ethnographic fieldwork was conducted with resident population.
What are the outcomes used in the study	On almost all indicators, implementation of NQICDS had progressed further in Community A than in Community B; however, some common issues emerged, especially lack of linkages between health centres and other groups, and lack of support for client self-management.

What was the sample size	
What were the findings of the study	It was found that, the evaluation framework is an effective and acceptable framework for monitoring implementation of the NQICDS at the primary health centre level

Data extraction questions	Findings
What is the title of the study	Involving Local Health Departments in Community Health Partnerships: Evaluation Results from the Partnership for the Public's Health Initiative
What are the names of the authors	Allen Cheadle, Clarissa Hsu, Pamela M. Schwartz, David Pearson, Howard P. Greenwald, William L. Beery, George Flores, and Maria Campbell Case
What is the year of publication	2008

What are the aims/objectives of the study	1) strengthen the capacity of communities to engage residents to act on their own and in partnership with health departments and other institutions to protect and improve the community's health and well-being; (2) enhance the capacity of health departments to respond to community-based and community-driven priorities; (3) create sustainable partner- ships between communities and health departments that promote and define mutual responsibility for improving community health; and (4) develop state and local policies that support and sustain local capacity to improve community health.

What is the study design?	Non-randomised intervention
What is the country of study	USA
Was the study in a rural or urban area?	Urban
What was the place of study	

(Health Facility/not)	Health facility
What were the types of health care professionals working at centre?	1. PPH staff, an external Initiative-level evaluator the Centre for Community Health and Evaluation (CCHE) and local evaluators
What was the sample size	37
What were the findings of the study	1. Out of the 37 partnerships funded continuously throughout the 5 years of the initiative, between 25% and 40% were able to make a high level of progress in each of the Initiative’s five goal areas.

	2. health departments able to work effectively with community groups had strong, committed leaders who used creative financing mechanisms, inclusive planning processes, organizational changes, and open communication to promote collaboration with the communities they served.

Data Extraction Questions	Findings
What is the title of the study	Integrating Community Health Workers Within Patient Protection and Affordable Care Act Implementation
What are the names of the authors	Nadia Islam, Smiti Kapadia Nadkarni, Deborah Zahn, Megan Skillman, Simona C. Kwon and Chau Trinh-Shevrin,
What is the year of publication	2015

What are the aims/objectives of the study	1. To discuss the varied strategies for integrating Community health workers models within the Public Protection and Affordable Care Acts (PPACA) implementation and expansion of Health Information Technology efforts 2. To discuss the payment option of this integration.
What is the design of the study	Cross sectional study
What is the country of study	USA
What was the place of study (Health Facility/not)	Yes, in health facilities (Patient-Centred Medical Home, Health homes and Center for Medicare and Medicaid)
What are the findings of the study	1. The Integration of Community health workers in the program has proven that community health workers play a vital role in administering health care that is cultural appropriate as patient and family centred as well

	2. That the Community health workers can also health in the coordination of access to health services and programs such as disease prevention programs in the communities 3. The study also found that the community health workers also function very much in the management of support care and health promotion in their various communities.

Data extraction questions	Findings
What is the title of the study	Innovative Perspective on Health Services for Vulnerable Populations
What are the names of the authors	Susan J Henley, Elizabeth A. Tyree, Deborah L. Lindsey, Sharon O. Lambeth, Christine M. Burd

What is the year of publication	1998
What are the aims/objectives of the study	The aim of the study is to assess primary health care (PHC) as conceptualized by WHO and adopted by Nursing Centre of North Dakota and the potential to address the unique configuration of health needs in rural communities (North Dakota)
What is the study design?	Non-randomised intervention design
What is the study setting	The researchers studied the participants in their natural setting: mainly their home in their communities and are mostly studied in the family setting.
Was the study in a rural or urban area?	Rural
What is the Country of study	USA

What was the place of study (Health Facility/not)	Health Facility The place of study was a “centre without wall facility”. Patients were cared for individually in their communities and home.
What were the characteristics of the study population?	1. Native Americans 2. Migrant farm workers

	3. Rural families
What were the types of health care professionals working at centre?	Nurses (student nurses) were the main health care professionals working at the centre.
What was the description of the intervention?	Primary health care perspective as designed by WHO is to inform and shape health care delivery to meet the needs of rural populations appropriately.
What are the outcomes used in the study	1. Health care professionals who are educated with this vision of practice will become extremely useful as 21st century leaders in planning for and meeting the unique health needs of rural populations.

	In a climate of ongoing change, health professionals can seize these challenges and recast them as opportunities to operationalize theory and health sciences into the foundation for innovative and effective service provision for vulnerable rural population.
What was the sample size	Data regarding individual client outcomes including health status and satisfaction are collected and analysed along with aggregate program data. Nearly 440 individuals in family received nursing case management services from the UND Nursing centre from 1994-1998. Another 1500-2000 people participated in health education session and almost 500-1000 health screenings were conducted annually since 1994 through the nursing centre.
What were the findings of the study	The following findings were made in the study 1. The nursing centre gives more attention to empowering the community and the families in it more than bureaucracy 2. The nursing centre does not operate in competitive nature to other health care service

	providers but rather see themselves an invited and needed participant in helping communities to fulfil their health needs. 3. The Nursing centre also collaborates with community-based organisations in delivering services
What were the author stated limitations	1. Scarcity of resources in rural areas 2. Reimbursement is varied and not dependent on fee-for-service. An evolving dynamic among economic, demographically remote, sparsely populated arears will increasingly pose challenges to the promotion of health, prevention of disease and management of chronic illness in rural communities.
What were the author stated strengths	2. Health care professionals who are educated with this vision of practice will become extremely useful as 21st century leaders in planning for and meeting the unique health needs of rural populations. In a climate of ongoing change, health professionals can seize these challenges and recast them as opportunities to operationalize theory and health sciences into the foundation for innovative

	and effective service provision for vulnerable rural population.

Data extraction Questions	Findings
What is the title of the study	An Integrative Behavioural Health Care Model Using Automated SBIRT and Care Coordination in Community Health Care
What are the names of the authors	Ronald Dwinnells and Lauren Misik
What is the year of publication	2017
What are the aims/objectives of the study	To discuss the use of Automated SBIRT as well as the coordination of service delivery in community health centres when it comes to issues of Behavioural health.
What is the study design?	Non-randomised intervention (3-period, Interrupted time series)

What is the country of Study	USA
What was the place of study (Health Facility/not)	Yes (community health facilities in Ohio)
Was the study in a rural or urban area?	Urban areas
What were the types of health care professionals working at centre?	BH counsellors, BH care coordinators, Full-time licensed independent behavioural health counsellors, Licensed Professional Clinical Counsellor [LPCC] and a Licensed Independent Social Worker
What were the characteristics of the study population?	A target population where more than 90% are at or lower than 200% of the federal poverty level and 93% are uninsured, on Medicaid and/or Medicare.

What was the description of the comparator(s)?	Process A (Electronic Tablets Used for Both BH Screening and Demographic/Insurance Intake with No BH Care Coordination Support) Process B (Paper Screenings Only)

	Process C (Electronic Tablets Were Used for Behavioural Screening Only. A BH Care Coordinator Was Added in This Process)
What was the sample size	1821
What was the description of the intervention?	1. The first step was to do a behavioural health screening with Mobile tablets without the presence of a professional behavioural health coordinators 2. Then a paper base screen was done 3. Lastly another screen was done with Mobile tablets with the Behavioural health coordinator present to administer professional diagnosis and service delivery

What were the findings of the study	1. It was found that, A fully integrated, efficient, and effective BH program promotes the success of the chronic care or disease management model of primary health care delivery. This brought about early direction and treatment for the patients

Data extraction questions	Findings
What is the title of the study	Changes in chronic disease management among community health centres (CHCs) in China: Has health reform improved CHC ability?
What are the names of the authors	Zhaoxin Wang, Jianwei Shi, ZhiguiWu Huiling Xie, YifanYu, Ping Li, Rui Liu, and Limei Jing
What is the year of publication	2017
What are the aims/objectives of the study	To discuss the new approaches to disease management in community health centres in China

What is the study design?	Non-randomised intervention
What is the country of study	China
What is the study setting?	Both Rural and Urban
What was the place of study (Health Facility/not)	Health Facility (Community Health Centre)
What were the types of health care professionals working at centre?	General Practitioners & Public Health physicians

What was the description of the intervention?	Introduction of CHCs staff to manage CDs
What was the description of the comparator(s)?	No CHC staff to manage Chronic Diseases
What are the outcomes used in the study	Evaluating the longitudinal changes of CHCs' ability for chronic disease prevention and treatment at both the macrolevel and microlevel

How were the outcomes of the study measured	Financial investment, the capacities regarding health facilities and talent and the chronic disease prevention activities in CHCs. One! Way analysis of variance was also used to examine significant increases or decreases in the number of these capacities across different groups between 2010 and 2015.
What was the sample size	44 CHCs
What type of statistical analysis was conducted	SAS 9.30 was used to conduct basic descriptive financial investment analysis and capacities regarding health facilities. One-way analysis of variance was also used to examine significant increases or decreases in the number of these capacities across different groups between 2010 and 2015.
Findings of the study	1. The study found that the new approaches to disease management in community health have resulted in an improvement in detection and management of chronic diseases

Limitations of the study	1. The study analysed the longitudinal data in Pudong New Area in Shanghai to reflect the changing abilities of CHCs for CDM 2. It was difficult obtain data involving the incidence of chronic diseases in the given area each centre serviced.

Data Extraction Questions	Findings
What is the title of the study	Community-Oriented Medical Education in Glasgow, Developing a community Diagnosis Exercise
What are the names of the authors	Hilary Davison, Simon Capewell, Jane Macnaughton, Scott Murray, Phil Hanlon, and James McEwen
What is the year of publication	1999
What are the aims/objectives of the study	To describe a community diagnostic teaching and learning exercise that has been introduced into Glasgow's new undergraduate medical curriculum.

What is the study design?	Non-randomised intervention
What is the study setting?	University of Glasgow
What is the country of study	UK
What were the characteristics of the study population?	Medical Students
How many arms did the study have	The study was done in three faces (the first was an exploration of the strengths and weaknesses of routine statistical methods and realised in results in lack of detailed information, the second face is a community based participatory appraisal, and the final face was campus-based activities where students present their findings in groups
Was the study in a rural or urban area?	Urban

What were the characteristics of the study population?	1st year medical undergraduate students
What was the description of the intervention?	Vocational Studies programme.
What was the description of the comparator(s)?	No Vocational Studies programme.
What are the outcomes used in the study	This innovative community-oriented teaching programme gave students some insight into how health, morbidity and mortality are measured, why these might vary between different communities, and how different

	community members' perspectives might differ regarding perceived health and social needs.
What was the sample size	43
What are the findings of the study	1. It helps students to gain more insight into the ways to measure health morbidity and mortality. 2. The new innovation helps students to understand why these morbidity and mortality varies from community to community 3. It also helped the students to gain more insights into why different community members have different perceptions of health and social needs

Data Extraction Questions	Findings
What is the title of the study	The Jerusalem Experience: Three Decades of Service, Research, and Training in Community-Oriented Primary Care
What are the names of the authors	Leon Epstein, Jaime Gofin, Rosa Gofin and Yehuda Neumark
What is the year of publication	2002
What are the aims/objectives of the study	To discuss the areas of study in community health care education.
What is the study design?	Cross-Sectional Design
What are the findings made in the study	1. The community health service education has been categorised into areas such as community diagnosis, Reassessments, evaluation, and Intervention planning

Data extraction questions	Findings
What is the title of the study	Developing health service delivery in a poor and marginalised community in Northwest Pakistan
What are the names of the authors	Heather Ohly, Helen Bingley, Nicola Lowe, Rashid Mehdi, Zia Ul Haq, Mukhtiar Zaman.
What is the year of publication	2018
What are the aims/objectives of the study	To improve maternal health and reduce child mortality through developing health service delivery in a poor and marginalised community in Northwest Pakistan
What is the study design?	Non-randomised intervention
Was the study in a rural or urban area?	Rural

What is the study setting	A rural community in Peshawar District, Khyber Pakhtunkhwa Province
What was the place of study (Health Facility/not)	In health facilities
What were the types of health care professionals working at centre?	Community health workers
What were the characteristics of the study population?	poor and marginalised community

What was the description of the intervention?	The intervention was multifaceted, with four main components which are; 1. Service development including reproductive health, immunisations, gynaecological, safe delivery, and nutrition services 2. Staff capacity development including professional staff and volunteers 3. Community engagement including the formation of village health committees (locally known as Jirga) to promote awareness and assist with health campaigns and referrals to the health centre

	4. Introduction of a micro-credit scheme to women who were pregnant (equivalent to 12 GBP) to cover the cost of ultrasound, transport expenses, medicine, and delivery charges
What was the description of the comparator(s)?	No service development, staff capacity development, community engagement and the introduction of a micro-credit scheme.
What are the outcomes used in the study	The evaluation assessed the efficiency and effectiveness of project implementation, including a survey of maternal and child health indicators.

Data Extraction Questions	Findings
What is the title of the study	Transdisciplinary Approaches to Understanding and Eliminating Ethnic Health Disparities: Are We on the Right Track?
What are the names of the authors	Sarah Knerr, and Stephanie M. Fullerton
What is the year of publication	2012
What are the aims/objectives of the study	To present how ethnic discriminations can be eliminated from the provision of primary community health care
What is the country of study	USA
Was the study in a rural or urban area?	Rural

What is the design of the study	Cross-Sectional Design
What are the findings of the study	1. Intervention and community engagement outcomes have received less attention than more process-oriented research outcomes 2. A renewed focus on the ultimate products of transdisciplinary approaches, namely effective multilevel interventions, specific health outcome improvements, and greater community involvement, will aid this promising research paradigm in carrying out its philosophical commitment to ending population health disparities

Data extraction questions	Findings
What is the title of the study	Evaluating the Legacy of Community Health Initiatives, A Conceptual Framework and Example

	from the California Wellness Foundation's Health Improvement Initiative
What are the names of the authors	William L. Beery, Sandra Senter, Allen Cheadle, Howard P. Greenwald, David Pearson, Ruth Brousseau and Gary D. Nelson
What is the year of publication	2005
What are the aims/objectives of the study	To provide a framework for evaluating the legacy of the California wellness Foundation's health improvement Initiatives
What is the study design	Non-randomised intervention
What was the place of study (Health Facility/not)	health facilities such as clinics
What is the country of study	USA
Was the study in a rural or urban area?	Urban

What were the types of health care professionals working at centre?	Community health workers
What were the characteristics of the study population?	1. Staff members and workers of the health facilities 2. Community members
What was the description of the intervention?	The Health Improvement Initiative of the California Wellness Foundation is a partnership based non-governmental initiative that concentrates on activities such as the provision of direct health services, improving the environment and

	institutions into more healthy ones as well as advocate for policy changes in the health sector
What are the outcomes used in the study	The immediate outcomes of the interventions found in the study were that; 1. That the elements of the initiative such as partnerships, their main activities and other capacity building initiatives can be sustained effectively 2. That the scope of activities can be broadened or become less depending on the findings

	After the evaluations were done it was found that,
What were the findings of the study	The HII left a significant legacy in the nine communities. Nearly all of the coalition-building, systems change, direct services, and population health measurement accomplishments of the partnerships during the HII were still evident 1 year after funding had ceased, and two thirds were comparable in scope or had experienced progress or expansion after the HII. As shown in Table 6, only 5 of the 58 (9%) significant accomplishments across the four areas were discontinued altogether. More than one third of the accomplishments (22 of 58, or 38%) experienced expansion after the initiative ended.

What were the author stated limitations	The difficulties of conducting randomized trials with community-based initiatives have led to the widespread use of a case-study, logic-model approach to evaluation, with a focus on inter-mediate rather than long-term outcomes.

Data extraction questions	Findings
What is the title of the study	Simulation Experience in Community Health Nursing: Postpartum Evaluation of the Mother and the Infant at Home Environment
What are the names of the authors	Elif Ates, Bahire Ulus, and Azize Karahan
What is the year of publication	2020
What are the aims/objectives of the study	The aim of this study was to improve the skills of undergraduate nursing students in data collection methods and techniques used for postpartum evaluation of the mother and the infant at home environment by using simulation experience.
What is the study design	Quasi-experimental design
What is the country of study	Turkey

What was the place of study (Health Facility/not)	Yes (Family health centres)
Was the study in a rural or urban area?	Urban
How many arms did the study have?	Three arms or stages (the participatory stage, first implementation face and second implementation face
What was the sample size	63 nursing students
What type of statistical analysis was conducted	data was analysed by using the SPSS 21.0 statistical software. Statistical significance was set at $p < 0.05$ and 95% confidence interval

What were the characteristics of the study population?	1. Mothers and infants from one months old to eight months old 2. Third year undergraduate nursing student
What are the outcomes used in the study	1. a statistically significant difference between the self-confidence subscale of the SCLS after the simulation activity and the actual home visits (p < 0.05). 2. Comparison of the scores obtained from the satisfaction subscale of the SCLS after the simulation activity and the actual home visits reveals no statistically significant difference (p > 0.05

	3. we found a statistically significant difference between FDPC scores obtained from the simulation-based home visit scenario and the actual home visits ($p < 0.001$).
What were the findings of the study	It was found that; t simulation-based learning in community health nursing improves self-confidence of nursing students and contributes to their skills on data collection and diagnosis during home visits.

Data extraction Questions	Findings
What is the title of the study	Evaluating a community-based public health intervention using a complex systems approach
What are the names of the authors	Anna Matheson, Mat Walton, Rebecca Gray, Kirstin Lindberg, Mathu Shanthakumar, Caroline Fyfe, Nan Wehipeihana, Barry Borman
What is the year of publication	2020

What are the aims/objectives of the study	To describe the methods used in evaluating community based public health interventions
What is the study design	Non-randomised intervention
What is the country of study	UK
What was the place of study (Health Facility/not)	In health facilities
What were the findings of the study	1. the study found that framing social systems as complex helps in coming out with the right methods to evaluate issues liked public health initiatives 2. While using existing methods, the combination of approaches within a frame of social complexity offers an innovative approach to public health evaluation.

What were the author stated limitations	1. One limitation is that treating each community as a case study makes it difficult to get quantitative data with sufficient numbers for statistical significance
What were the author stated strengths	1. The strengths of the approach are the ability to explicitly layer complex systems theories with intervention theory; the emphasis on the participation and perspectives of stakeholders; and the gathering of in-depth, context-rich information about each case. 2. The systematic comparison used in all the cases also allowed for some level of generalizability

Data Extraction Questions	Findings
What is the Title of the study	Three evaluation methods of a community health advocate program

What are the names of the Authors	Marilyn Rodney, Carla Clasen Gloria Goldman, Ronald Markert and Donna Deane,
What is the year of publication	1998
What is the study design	Case studies
What is the country of study	USA
What was the place of study (Health Facility/not)	Community health facilities
Was the study in a rural or urban area?	Urban
What were the characteristics of the study population?	Health workers and community members adults above the age of 18.

How many arms did the study have?	The study has three arms: 1. Advocates Evaluation Program 2. Advocates’ Community Service Site Evaluation 3. Advocate client Evaluation

What was the sample size	2,777 respondents
What were the findings of the study	1. The study found that; from the indications of the results, the CHA program can be considered a success. 2. The CHAs generally decided that the training program adequately prepared them for their roles and functions. 3. It studies also showed that there were t systematic frustrations and barriers that made it more difficult for health service professionals to do their jobs well.

Data extraction questions	Findings
What is the title of the study	Evaluation of residency training in the delivery of culturally effective car
What are the names of the authors	Marıa Luisa Zuniga, Dean E Sidelinger, Gregory S Blaschke, Frank A Silva, Shelia L Broyles, Philip R Nader & Vivian Reznik
What is the year of publication	2006
What are the aims/objectives of the study	To evaluate the course of resident training in the delivery of culturally effective care in order to improve clinician capacity to effectively care for patients from diverse backgrounds.
What is the study design	Non-randomised intervention Design
What is the country of study	USA
What is the study setting	The 2 paediatric residency programmes in California at the University of California San Diego (UCSD) and the Naval Medical Centre San Diego (NMCSD)

What was the place of study (Health Facility/not)	Not in health facility
What were the characteristics of the study population?	Health care trainees
What are the outcomes used in the study	A significant pre/post rotation increase was noted in residents' self-perceived ability to identify culture-related issues that may impact on the patient's view of illness (P < 0.001) and ability to address a culture-related issue (P < 0.001). Community evaluations rated residents positively on behaviours that reflected communication skills and professionalism, but less positively on knowledge about communities.

How were the outcomes of the study measured	Data for evaluation of the residency programme was drawn from 4 locally developed measures. Measures were based on an existing survey and findings from the original block rotation in community paediatric
What were the findings of the study	1. The delivery of culturally effective care includes effective cross-cultural communication 2. residents started the block rotation with a reasonable level of knowledge about identifying community needs and resources.
What were the author stated limitations	1. Recruitment of a comparison group was not feasible in this study, as the rotation included all paediatric residents in the immediate area

	2. The study was also limited because resident self-report may be influenced by a desire to show improvement, and only 4 weeks transpired between the pre- and post-rotation measurements 3. Another limitation concerns our lack of information on residents' later practice of community paediatrics following graduation

Data Extraction questions	Findings
What is the title of the study	A review of CARE's Community Score Card experience and evidence
What are the names of the authors	Sara Gullo, Christine Galavotti1 and Lara Altman
What is the year of publication	2016

What are the aims/objectives of the study	To review CARE international's Score card as a social-accountability approach in health care
What is the study design?	Non-randomised intervention
How many arms did the study have?	The review was done in four faces
What were the findings of the study	1. After the review of the CSC, it was found that there were a lot of important impacts of the framework for instance the range of outcomes, suggests that the CSC is contributing to significant changes 2. There is also evidence that the CSC may contribute to improvements in service availability, access, utilization, and quality 3. The CSC seems particularly suited to building trust and strengthening relationships between the community and service providers and to improving the user-centred dimension of quality.

	4. Several projects reported CSC related benefits to providers ranging from increased capacity to advocate for shifts in resources to increased support from community members
What were the author stated limitations	1. Most part of the evaluations that were included in this review had limitations and were qualitative which demanded the interpretations be done with a lot of caution to avoid bias

Data Extraction Questions	Findings
What is the title of the study	Developing a good practice model to evaluate the effectiveness of comprehensive primary health care in local communities
What are the names of the authors	Angela Lawless Toby Freeman, Michael Bentley, Fran Baum, and Gwyn Jolley

What is the year of publication	2014
What are the aims/objectives of the study	1.What are the characteristics of Australian CPHC that need to be captured in a model? 2. What processes are required to develop such a model? 3. Does use of a theory driven program logic model provide a means of describing CPHC as a whole that can be used as a basis of evaluation?
What is the design of the study	Non-randomised intervention

What is the study setting	Comprehensive Primary Health Care (CPHC)
What is the country of study	Australian
What was the place of study (Health Facility/not)	Health facility
Was the study in a rural or urban area?	Urban

What was the description of the intervention?	Comprehensive Primary Health Care
What was the description of the comparator(s)?	No Comprehensive Primary Health Care
What are the outcomes used in the study	Using the logically causal pathway progress toward these ‘big picture’ outcomes can be tracked through achievement of more proximal outcomes such as increased individual knowledge and skills; increased health enhancing behaviour; improved quality of life for individuals; slowed progression of conditions; decreased rates of preventable conditions and issues; increased supportive environments for health; increased social capital; increased planned, managed care; and decreased acute, episodic care.
What are the findings of the study	

What are the author’s stated limitations of the Study	1. The study took place in sites that had implemented CPHC in the Alma Ata tradition over several decades. The high degree of consensus gained in this study may not be replicated in other sites. The

Data Extraction Questions	Findings
What is the title of the study	Qualitative Process Evaluation of Urban Community work: A preliminary view
What are the names of the authors	Noel Chrisma, Kristen Santuria, Gary Tang and Bookda Gheisar
What is the year of publication	2002
What are the objectives of the study	To Describe the evaluation of health practitioners service provision to communities

What is the Design of the study	The process evaluation model
What is the study setting	Urban and underserved communities in the greater Seattle area
What is the country of study	USA
What was the place of study (Health Facility/not)	At a health facility
Was the study in a rural or urban area?	Urban
What are the findings made in the study	1. Designs for community-oriented projects vary from grassroots endeavours in which local activists organize to solve local problems to programs led by public health specialists to promote population health

	2. Leadership structure similarly varies but often includes an advisory committee, a coalition, or other organizational means to seek broad participation

Appendix 3: Description of study area

10.1 Description of Study Area

Ghana is located just a few degrees north of the equator with a tropical climate. It sits atop an ancient Precambrian craton – a stable part of Earth's continental crust that is estimated to have formed about 2 billion to 300 million years ago.

Its topography is dominated by low-lying plains, and its south-central and southwestern regions contain a forested plateau region, home to the Ashanti uplands and Kwahu plateau. Ghana occupies an area of about 238,535 square kilometres, with 16 administrative regions. It comprises Ashanti, Bono, Bono East, Ahafo, Central, Eastern, Greater Accra, Northern, Savannah, Northeast, Upper East, Upper West, Volta, Oti, Western and Western North Regions with a total population of about 30.8 million (GSS, 2021). It shares boundaries with Togo to the east, and Côte d'Ivoire to the west. The landscape consists mainly of plains and low plateaus covered by rain forests in the west and Lake Volta in the east.

The region's climate is relatively dry, with a single rainy season in May and ends in October. The amount of rainfall recorded annually varies between 750 millimetres and 1,050 millimetres. The dry season starts in November and ends in March/April, with maximum temperatures occurring towards the end of the dry season (March-April) and minimum temperatures in December and January. The harmattan winds, which occur from December to early February, have a considerable effect on temperatures in the region, making them vary between 14^{o}C at night and 40^{o}C during the day. Humidity is very low, aggravating the effect of the daytime heat. The rather harsh climatic conditions adversely affect economic activity in the region, and the health sector enables cerebrospinal meningitis to thrive, almost to endemic proportions (Codjoe & Nabie, 2014).

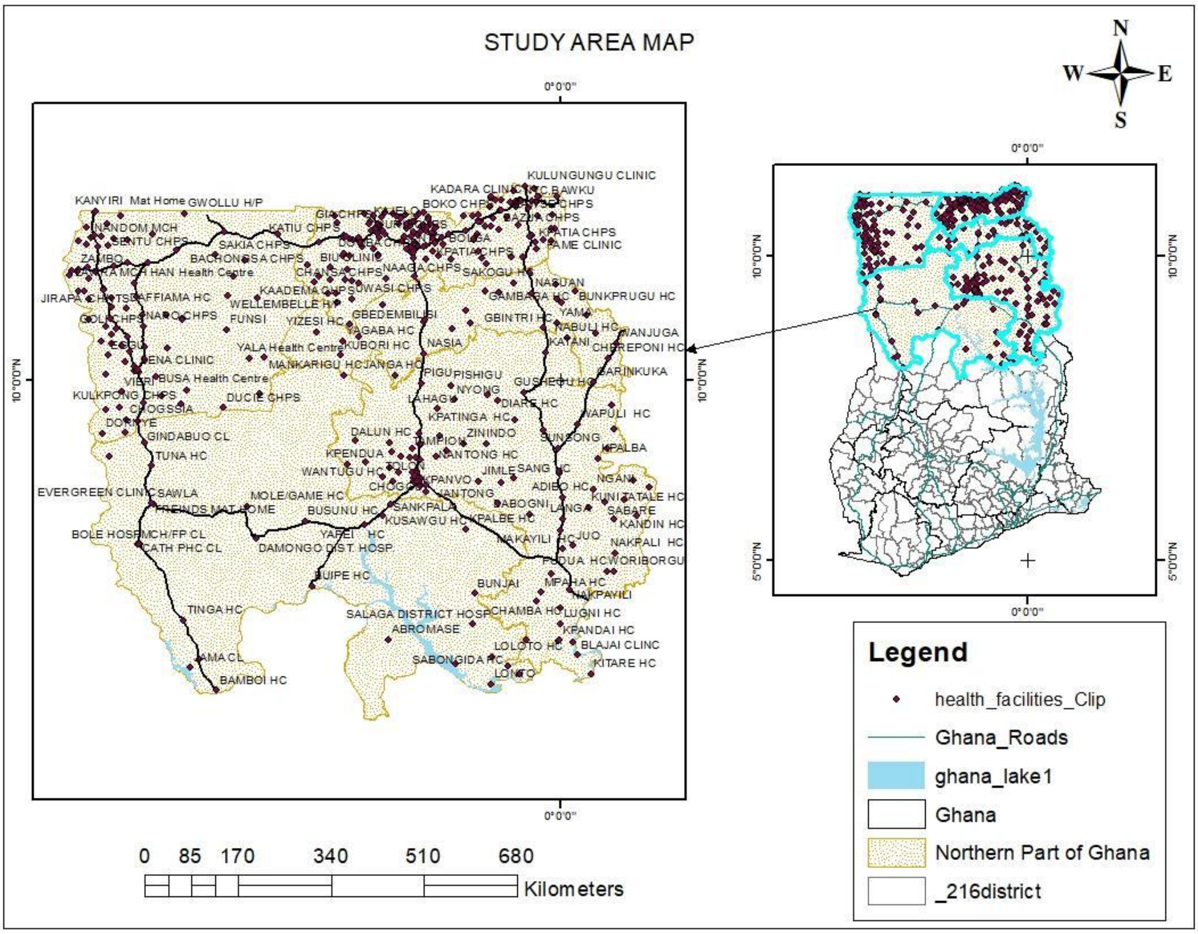

Figure 19: Map of Section of Study Area (Northern Part of Ghana)

Appendix 4: GIS data generation and processing

11.1 Data Pre-processing

Although there are multiple systems for getting data into GIS, perhaps geocoding, a tool for translating location information into corresponding latitudes and longitudes in health databases, is increasingly popular.

11.2 Coordinates alignment (Using Geocoding)

Geocoding refers to the process of converting addresses into longitude and latitude coordinates based on the selected reference data (e.g., road network and area boundary) (Chang, 2006). An address without spatial information is just equivalent to a piece of text message. Geocoding aims to place these non-spatial messages into a spatial reference system. The quality of geocoding depends on the completeness and positional accuracy of located addresses. Completeness is the proportion of addresses that can be geocoded and depends on the quality of the collected data on addresses. The positional accuracy reflects the level of proximity of geocoded objects to their true location (Ribeiro, et al., 2014; Zandbergen, 2007).

The geocoding process is prone to several errors, such as biased estimates of the associations between the built environment and health (Boone et al., 2008; Hay et al., 2009; Kravets and Hadden, 2007). The completeness and proximity of objects to their associated true locations are possible sources of bias. First, a lower match rate may be achieved with incomplete address information. Secondly, when high match rates are achieved but low positional accuracy, addresses may be geocoded to incorrect locations, forming biased estimates and results.

The data curated by the Ghana Health Service were geocoded based on the coordinate data provided in the dataset. This form of geocoding increased the probability of high match rates by ensuring the coordinates was geocoded with minimum approximations. The dataset utilised was also a current version, which reduced the likelihood of variations from time of collection to geocoding.

For example, in England, the spatial location of 16,956 children from the National Child Measurement Program was identified (Williams, et al., 2015); in the USA, Duncan, et al. (2014) used GIS to successfully geocode the residential addresses of nearly 50,000 children and adolescents in the electronic health record from 14 paediatric practices of Harvard Vanguard Medical Associates.

11.3 Centroid (geometric) Processing

GIS enables the identification of geometric centroids (the geographical centre) or population-weighted centroids (the point that minimises the total distance to all the communities in a district. A *centroid* is a single point representing the "centre" of a spatial unit. Centroids may be used as points from which exposure measures are undertaken, such as proximity estimates or the density of features in a buffer.

11.4 Geo-data base Creation

For generating a geodatabase, the following data has been used.

1. Ghana country base map using Google imagery

2. Ghana highways and road network shapefile

3. Shapefile of health service facilities and community location points.

11.5 Data processing and analysis

For the data processing following steps were taken:

• Geo-referencing of Ghana country image file.

• Generation of shapefile of CHPS compounds, clinics, regional hospitals, and district hospitals.

• Digitisation of the road network

• Generation of a topological map

• Generating Network Ge0-dataset

• Analysis by using a network analysis tool

GPS coordinates of all the CHPS facilities located in Ghana were extracted from the Ghana Health Service dataset. The waypoints for all CHPS compounds in the country were gathered, and features of the environment such as a key social or geographic landmark, for example, the chief's palace or a market square, were used as benchmarks. The existing secondary dataset obtained from the Ghana health service was processed and cleaned before being implemented in this study. The GPS coordinates were then catalogued and paired with the accurate facility categorisation and name. The dataset was then processed and recorded in a processable standardised GIS format (Soler & Marshall, 2002).

To measure physical access to CHPS facilities in Ghana, the researcher used GIS to estimate travel times to the nearest CHPS facility and derive the CHPS catchment boundaries.

The Environmental Systems Research Institute (ESRI), ArcView GIS software, was then used to aggregate the data, create a topographic map, and highlight the CHPS facilities in line with GIS industry-standard operationalisation (Dolinskiy, et al., 2020). To highlight the CHPS facilities, they were digitised, and a road network was also digitised. A street base map was added in ArcGIS software from the Google Earth satellite imagery and georeferenced to get the coordinates. Geo-referencing involved image alignment in a coordinate system (Kumar & Kumar, 2016).

Layers are the mechanisms used to display geographic datasets in ArcGIS. For the analysis, the layers will be categorised as major roads (mainly the Highways) and minor roads (city roads connecting the highways and other urban localities), lanes and by-lanes. (Das et al., 2019). The table of contents lists all the layers present on the map and shows what the features in each layer represent (Laixing et al., 2008). After successful creation, the base map digitisation for each layer was done to form a skeleton of the prevailing road network. *Digitisation* is the process of making an electronic version of a real-world object or event, enabling the object to be stored, displayed, and manipulated on a computer, and disseminated over networks (Manjula et al., 2010).

The Generate Service Areas tool chooses whether to use the network cost attribute specified in the Time Attribute or Distance Attribute parameter depending on whether the units you specify here are time or distance based.

Makes a service area network analysis layer and sets its analysis properties. A service area analysis layer is useful in determining the area of accessibility within a given cut-off cost from a facility location.

The Generate Service Areas and Make Service Area Layer tools are similar but designed for different purposes. Generate Service Areas was used for setting up a geoprocessing service; it simplified the setup process; in conjunction with the Make Service Area Layer. Also, a Make Service Area Layer was needed to generate service area lines; Generate Service Areas does not provide the option to generate lines (McLafferty S, 2005).

The ArcGIS software was used to create a service-area geoprocessing service, using Generate Service Areas. In contrast, the researcher created a model with the Make Service Area Layer, properly connected it to various other tools, and published the model to create a service-area geoprocessing service (see figure 6).

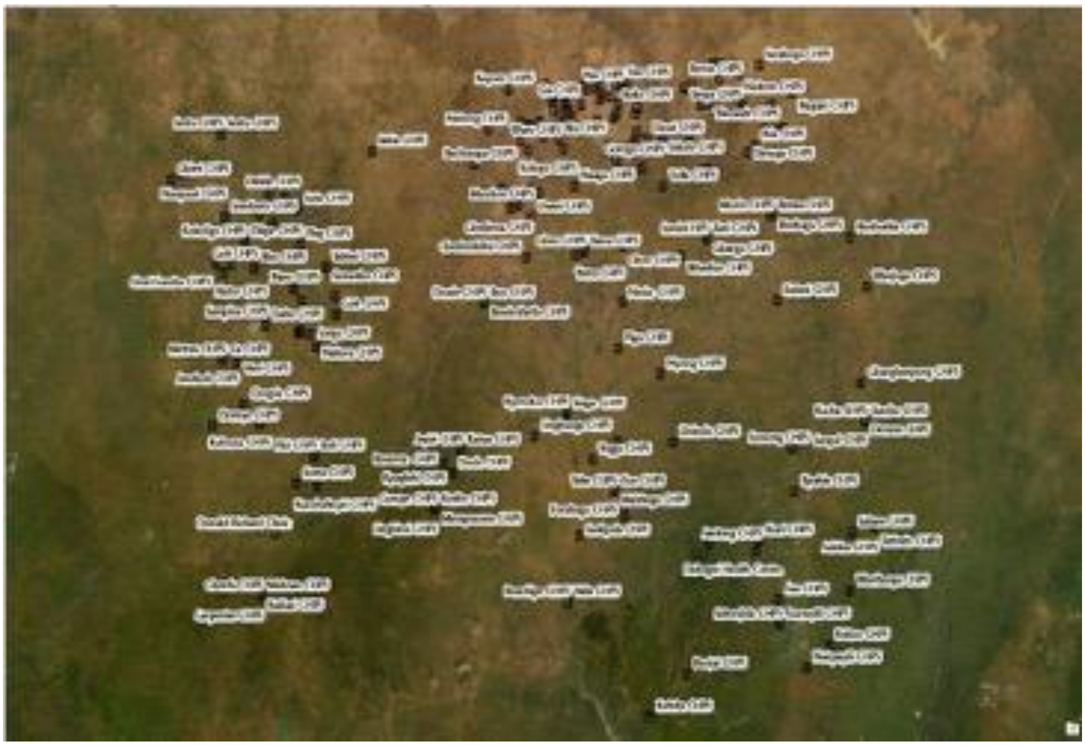

Figure 20: Image showing the base map of a section (northern region) overlayed with the locations of the CHPS.

11.6 Multiple Overlay Buffer Analysis

Buffer analysis is used to create a regular (e.g., circular) zone with a certain radius (using a predefined scale, with either Euclidean or network distance) on a given address/location to demarcate a catchment or influential area. Buffers help capture all features of the built environment that surround a specific originating location. For example, the number of CHPS compounds within a buffer might be used to estimate a community's accessibility of the CHPS compound, among other factors. However, limitations include the binary representation of features (e.g., it is either considered in or out of the buffer), which can be overcome with the utilisation of a fuzzy (using a decreasing weight function for distances further away) rather than sharp boundary (Chaix et al., 2009). Buffers are readily created within a GIS once the user has defined the scale, type (Euclidean and network distance), and point of origin (e.g., around a community or centroid). However, these decisions should be informed by the hypothesised relationship between the exposure and outcome (Diez, 2001). For example, the Ghana Health Service policy framework defines access as being within 8 km from the point of interest (GHS, 2001; Mba & Aboh, 2010). This study, therefore, accessed the locational appropriateness of the CHPS facilities based on the stipulated policy framework of GHS (2001) & the findings of Mba & Aboh (2010).

11.7 Network Distance Analysis

Network analysis enables the measurement of the distance between an origin and destination along with a network of lines which can include road, public transportation, pedestrian and cycling network paths. Because distance is measured along with the transportation network rather than as Euclidean (straight-line) distance, network distance can provide a more precise measure of accessibility. Within built environments, the network travel distance required to reach a destination may be more significant than the straight-line distance due to features related to the built environment (e.g., the presence of buildings), natural barriers (e.g., rivers or steep hills), and characteristics of the network itself (e.g., cul-de-sacs, one-way streets). Network distance measures can be readily calculated within GIS, provided that accurate network data are available. Measures of travel time can also be derived (e.g., the number of minutes required to travel from a participant's house to the closest CHPS facility in a GIS using the information on network distance and the average speed of travel along each segment of the network. It is also feasible to develop more sophisticated measures of travel time that incorporate factors such as traffic density, traffic signals, road surface, and topography, each of which would improve estimates of accessibility.

11.8 Proximity Analysis

Proximity, or closest facility analysis, is an essential indicator of accessibility and is used to determine which feature (e.g., CHPS) is closest to a particular point (e.g., community) and the actual distance to the nearest feature. Proximity is vital because accessibility is increased when features are closer, thus potentially influencing their contribution to health behaviours. Proximity can be measured using Euclidean distance, network distance, or the estimated travel time along with a network. Proximity measures derived from network analysis are based on a least-cost analysis: the shortest distance or time from an origin to a destination. As the actual travel routes for study subjects are not usually known, least-cost analysis is considered the best approximation as it assumes the subject would use the shortest travel route (or quickest if travel time estimations are used).

11.9 Analysis

After collecting the data points, the GPS coordinates were triangulated and overlayed on the road map layer to ensure data points mapped were accurate. The Environmental Systems Research Institute ArcView 10.5 software was then used to aggregate the data, create maps, and highlight findings (Graham et al., 2011).

ArcGIS can digitise or trace features without a mouse or puck-clicking using several options: streaming, tracing, or freehand drawing. The mouse pointer is used to trace the desired feature with these methods. There are three procedures where digitising can be done;

- Tracing
- Streaming
- Freehand drawing

For this research, the CHPS were digitised by tracing intensively with a mouse.

Tracing is used to create a new feature that follows the shape of an existing feature. Tracing can be done directly over an existing feature or at an offset value.

[1]

[1] Note: To specify, the Trace Options tool in ArcGIS was utilised. The default value is set to zero; this is to trace directly on top of an existing feature.

Figure 21: Image showing digitised CHPS on base map to vector CHPS (polygon)

Network analysis in GIS rests firmly on the theoretical foundation of graph theory and topology (Das et al., 2019). The most common and familiar implementations of network models are those used to represent the networks with which much of the population interacts every day: transportation and communications networks. Routing is the act of selecting a course of travel, and it is arguably the most fundamental logistical operation in network analysis. Although network analysis in GIS has mainly been limited to the most specific routing functions, the recent past has seen the development of object-oriented data structures, the introduction of dynamic networks, the ability to generate multi-modal networks, and simulation methods to generate solutions to network problems.

There are, of course, many significant networks design problems that are very difficult to solve optimally due to their combinatorial complexity. To allocate and provide urban facilities in an area with a complex road network, determining the shortest route and travel demand (trips generated and attracted) from the facility to the concerned area is necessary.

Generating the shortest path between two locations in a road network is a problem that can be solved by various map services and commercial navigation products. There are several highly efficient algorithms for determining the optimal route. A buffer geoprocessing function is a deterministic tool in defining the cluster of CHPS compounds located close to the highly populated and developed towns (capital towns).

Dijkstra's algorithm is an algorithm for finding the shortest paths between nodes in a graph, which may represent, for example, road networks.

The algorithm for the network analysis is represented in brief as below:

G= (V, E) G= (V, E)

where V is a set of vertices and E is a set of edges.

Dijkstra's algorithm keeps two sets of vertices:

• S the set of vertices whose shortest paths from the source have already been determined.

• V-S the remaining vertices.

• The other data structures needed are:

• D array of best estimates of the shortest path to each vertex

• Pi an array of predecessors for each vertex

The basic model of operation is:

1. 1.

Initial is d and pi.

2. 2.

Set S to empty.

3. 3.

While there are still vertices in V-S.

1. a.

Sort the vertices in V-S according to the current best estimate of their distance from the source.

2. b.

Add u, the closest vertex in V-S, to S.

3. c.

Relax all the vertices still in V-S connected to u.

Pseudo code for Dijkstra's Algorithm:

• Distance [s] ← 0 (distance to source vertex is zero)

• for all v ∈ V–{s}

• do distance [v] ← ∞ (set all other distances to infinity)

• S ← ∅ (S, the set of visited vertices is initially empty) Q ← V (Q, the queue initially contains all vertices) while Q ≠ ∅ (while the queue is not empty)

• do u ← min distance (Q, distance) (select the element of Q with the min. distance)

• S ← S ∪ {u} (add u to list of visited vertices) for all v ∈ neighbours[u]

• do if distance [v] > distance [u] + w (u, v) (if new shortest path found)

• then d[v] ← d[u] + w (u, v) (set new value of shortest path)

• (if desired, add traceback code)

• return dist.

For the analysis to run over the digitised road network, a network geo dataset was created, resulting in a layer consisting of the junctions and edges connected topologically. Ward analysis was done using the Intersection tool to get the statistics of all the categorised roads created as layers. The origin and destination points were selected to solve the network to determine the shortest route and serve this study's purpose.

Appendix 5: Ethics Approval Letter

College of Health, Medicine and Life Sciences Research Ethics Committee (DHS)
Brunel University London
Kingston Lane
Uxbridge
UB8 3PH
United Kingdom

www.brunel.ac.uk

17 March 2021

LETTER OF CONFIRMATION

Applicant: Mr Prince Edward Okine

Project Title: An analysis of the effectiveness and spatial distribution of health service centres in rural Ghana: The case of the CHPS zones in Ghana.

Reference: 30178-NER-Mar/2021- 31817-1

Dear Mr Prince Edward Okine,

The Research Ethics Committee has considered the above application recently submitted by you.

The Chair, acting under delegated authority has confirmed that, according to the information provided in your application, your project does not require ethical review.

Please note that:

- Approval to proceed with the study is granted providing that you do not carry out any research which concerns human participants, their tissue and/or their data.
- The Research Ethics Committee reserves the right to sample and review documentation relevant to the study.
- If during the course of the study, you would like to carry out research activities that concern a human participant, their tissue and/or their data, you must inform the Committee by submitting an appropriate Research Ethics Application. Research activity includes the recruitment of participants, undertaking consent procedures and collection of data. Breach of this requirement constitutes research misconduct and is a disciplinary offence.

Good luck with your research!

Kind regards,

Professor Christina Victor

Chair of the College of Health, Medicine and Life Sciences Research Ethics Committee (DHS)

Brunel University London

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