KWAME NKRUMAH UNIVERSITY OF SCIENCE & TECHNOLOGY,

KUMASI, GHANA

COLLEGE OF HEALTH SCIENCES

SCHOOL OF PUBLIC HEALTH

DEPARTMENT OF HEALTH POLICY, MANAGEMENT AND ECONOMICS

COST-EFFECTIVENESS ANALYSIS OF TELEMEDICINE FOR PRIMARY HEALTHCARE IN AMANSIE-WEST DISTRICT, GHANA

BY

BENJAMIN OTSEN

JUNE, 2016

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BY

BENJAMIN OTSEN (B.A. ECONOMICS & SOCIOLOGY)

A THESIS SUBMITTED TO THE DEPARTMENT OF HEALTH POLICY, MANAGEMENT AND ECONOMICS, COLLEGE OF HEALTH SCIENCES, SCHOOL OF PUBLIC HEALTH, IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE DEGREE OF MASTER OF PUBLIC HEALTH IN HEALTH SERVICES PLANNING AND MANAGEMENT

JUNE, 2016

DECLARATION

I declare herewith that this thesis write up is entirely my own output. To the best of my knowledge it does not contain any previously published material except those for which acknowledgement has been given in the text.

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HEAD OF DEPARTMENT

DEDICATION

I dedicate this write up to my father, John Oteng, David Larbi, my guardian, for their invaluable encouragement and support throughout the time spent on this work and to Kate Pobee, my best friend whose comfort was denied to enable me devote time to further my education.

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ACRONYMS

WHO	The World Health Organization
CEA	Cost Effectiveness Analysis
CHNs	Community Health Nurses
CHPS	Community-Based Health Planning and Services
CHWs	Community Health Workers
CPHC	Conventional Primary Healthcare

DALYs	Disability-Adjusted Life Years
GHS	The Ghana Health Service
KNUST	The Kwame Nkrumah University of Science and Technology
MDGs	Millennium Development Goals
MOH	The Ministry of Health
MVP	Millennium Villages Project
NFSD	Norvatis Foundation for Sustainable Development
OECD	Organization of Economic Coorperation and Development
PHC	Primary Healthcare
QALYs	Quality-Adjusted Life Years
TCC	Teleconsultation Center
TM	Telemedicine
US	United States of America

DEFINITION OF TERMS

Term	**Meaning**
Conventional Healthcare	Primary Conventional Primary Healthcare (CPHc) refers to primary healthcare through the Community-based Health Planning and Services (CHPS) compound, health post and health center

Telemedicine — Telemedicine involves the use of mobile phones, trained personnel and communication lines which allow for transfer of information from the local sites to a central Teleconsultation centre

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ABSTRACT

Access to healthcare remains a major issue facing people living in remote parts of Ghana; hence making interventions to improve healthcare provision necessary. However, the limited supply of resources calls for the need to ensure efficiency in the allocation of resources towards healthcare interventions. With its introduction in the Amansie-West District, telemedicine has improved provision of healthcare. There is, nonetheless, no evidence of economic evaluation of this project.

The study sought to investigate the cost-effectiveness of telemedicine for primary health care in the Amansie-West District.

A Cost-Effectiveness Analysis (CEA) was conducted using a study population of four primary healthcare sites; namely Keniago, Tontotkrom, Manso Ankam and Manso Abore. Costing was done from the perspective of the healthcare provider and capital assets were annuitized at a 3% discount rate. Data on the costs of telemedicine and the conventional primary healthcare were quantified manually. The annuitization of capital outlays and Incremental Cost Effectiveness Ratio (ICER) and Marginal Cost Effectiveness Ratio (MCER) were computed manually.. Sensitivity analysis was conducted with Microsoft Excel 2007 to assess robustness of the ICER.

Annualized total cost of $305,042.93 and $227,007.9 were associated with the conventional Prmary Healthcare (CPHc) and Telemedicine (TM) respectively. The ICER for TM was -$453.7 and MCER with an assumption of 50% utilization of TM services was $255.65.. ; indicating a 80.63% reduction in cost per effectiveness.

The pilot telemedicine project in the Amansie-West District was both cost-effective and cost saving.

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CHAPTER ONE-INTRODUCTION

1.0 Background

The World Health Organization (WHO) in various forums has expressed the need to uphold the rights of individuals to have access to healthcare. The attainment of the highest standard of health is essential for the enjoyment of life and also inevitable for economic and social development, further emphasizing the key role of government (Organization, 1989). Thus, prior to the recent global financial and economic crisis, healthcare expenditures in the Organization for Economic Cooperation and Development (OECD) countries averaged 4% per annum (Organization, 2010). However, following the crisis, average health spending across the OECD grew at only 0.2% between 2009 and 2011 (Organization, 2010). This coupled with the ever-growing health needs of the populations and the rising costs of health services is making it difficult for governments to meet their obligations.

The United Nations Millennium Development Goals (MDGs) which was set in 2000 targeted improving the health and welfare conditions of the world's poorest people by 2015. This aim however, remains a mirage as many people particularly in developing countries like Ghana continue to suffer under poor healthcare conditions (Takeda Pharmaceutical Company Limited, 2013). Many people are still unable to access healthcare because of factors such as geographical barriers, inadequate health professionals and socio-economic conditions; sharp contrast to healthcare expenditures which averaged 4% of Gross Domestic Product (GDP) per annum in OECD countries (The World Bank, 2014).

The Conventional Primary Healthcare (CPHc) in Ghana refers to primary healthcare through the Community-based Health Planning and Services (CHPS) compound, health post and health center. This usual mode of delivery is fraught with a number of challenges. These health

facilities are less resourced to engage enough trained health professionals to manage the number of people needing care. Sub-Saharan Africa averages 1.15 health workers per every 1,000 of its citizens (Our Africa, n.d.). According to the Ghana Statistical Service, over 45% of the country's population is rural dwellers. Unfortunately, this section of the population is the worst affected in terms of the inequitable distribution of healthcare resources. The Ghana Shared Growth and Development (201-213) revealed that the doctor and nurse population ratio is one doctor to 10,425 and one nurse to 1.251 (Peacefmonline.com, 2014); a situation which impacts most severely on rural healthcare delivery.

It against some of these challenges that the WHO estimates that 243 million cases of malaria caused 863,000 deaths; mostly of children under 5 years old in the year 2008 (Gollogly, 2009). One other contributing factor to this was the issue of access to treatment (Gollogly, 2009). It is estimated that about half of Africans do not have access to essential drugs (Our Africa, n.d.).

As part of efforts to bridge the gap between rural and urban in terms of access to healthcare, the Government of Ghana in 2010 in collaboration with the Millennium Villages Project (MVP), Norvatis Foundation for Sustainable Development (NFSD) began preparations to pilot Telemedicine programme in the Bonsaaso Cluster in Amansie West District. The Telemedicine service involves the use of mobile phones, trained personnel and communication lines which allows for transfer of information from the local sites to a central Teleconsultation centre. The telemedicine project is to augment the Community-based Health Planning Services (CHPS) which is the conventional mode of primary healthcare in rural Ghana.

1.1 Problem Statement

Health systems in developing countries have not adequately responded to the health needs of people, according to World Health Report 2008 (Organization, 2014). The worst affected in these countries are rural communities such as Amansie West District in Ghana where geographical access to healthcare especially is far from satisfactory. Telemedicine has the potential for improving both the accessibility and quality of health care while lowering health indicators such maternal and neonatal and under-five mortality. Following its introduction in the Amansie District in 2006, under-five mortality has improve do by 38% against national target of 50% and also a 50% reduction in maternal mortality (Appiah, 2014). Additionally, referrals from the periphery health facilities to the district hospital have been significantly reduced (Personal Communication, 2014).

The limited nature of resources demands that allocation must be done to maximize the health benefit for the population served. This makes economic assessment necessary to identify, measure, value and compare costs of alternative healthcare delivery modes being considered to inform decisions about such a programme. However, there is generally lack of economic evaluation research for telemedicine programmes. The research base for telehealth evaluation is limited for several reasons (Garshnek et al.). Improved technology is viewed as a superior approach so the need for evaluation is dismissed. Innovation creates excitement, and therefore moves the attention from evaluation to implementation. This might be the case because of the healthcare needs of the underserved communities. New methods of healthcare delivery render traditional evaluation models obsolete (Garshnek et al.).

This study thus sought to determine the cost effectiveness of the telemedicine which was piloted in the Amansie West District, Ashanti Region compared to the conventional mode of primary health care.

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1.2 Rationale for the Study

This study sought to gather data on cost and effectiveness of providing primary health through telemedicine and the conventional mode. As part of gathering this data, this study attempted demonstrate the cost-effectiveness of telemedicine and how well it improves health outcomes relative to the traditional mode of primary healthcare in the Amansie West District. Healthcare managers stand the risk of investing scarce in interventions that are not cost-effective. This study therefore provides well researched documented information on the costs and effectiveness of telemedicine services. The study revealed important differences in costs and output (services); differences between the two types of health strategies in the rural areas and will also enable decision makers to select a more cost-effective method of providing healthcare services. The findings will therefore enable planners and budgeting managers of relevant health organizations to allocate resources effectively. The study will help the healthcare providers to improve the provision of healthcare services and to efficiently use the resources. Furthermore, the results of this study could serve as baseline information for future researchers.

The findings of this work shall provide additional basis for the expansion of the telemedicine project to the entire Amansie-West District and beyond.

1.3 Conceptual Framework

The PHC system in the Amansie-West District is graphically described by Figure 1.0. The system is such that a person in need of healthcare first of all might either meet a Community Health Worker (CHW) or visit Community-Based Health Planning and Services (CHPS) facility for treatment. In cases

where a CHW is unable to provide care, the patient is referred to the District Hospital. However, with the introduction of TM, the CHW/CHPS facility calls the Tele-Consultation Centre (TCC) for assistance as and when necessary in the provision of care.

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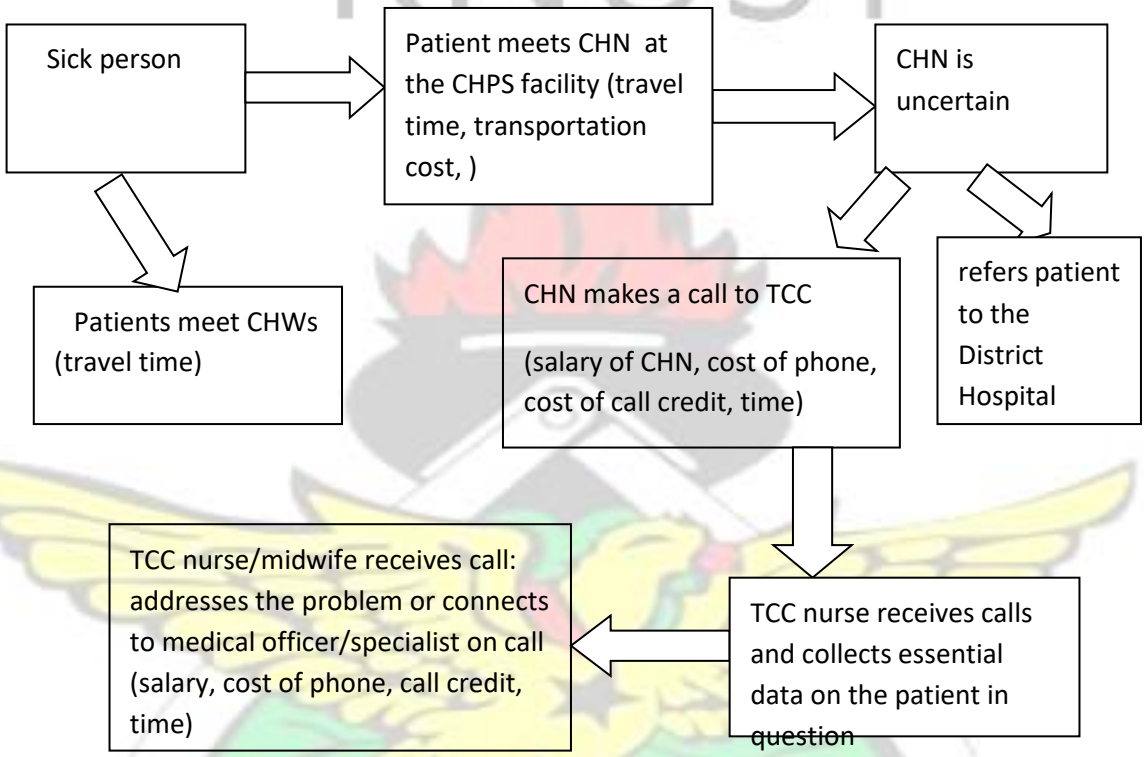

Figure 1.0 Framework for Assessing Cost

There are three categories of cost represented in Figure 1.0. These are:

i. Cost associated with the operations of conventional CPHc

ii. Cost associated with the operations of TM iii. Cost incurred by patients

The costs associated with conventional CHPc include the salaries of care providers, cost of facilities, cost of equipment, among others. The costs related to the operations of the teleconsultation centre include salaries of the health staff who manned the TCC, salaries of technicians, cost of equipment, cost of telephone, cost of phone credits and cost of installation.

The framework proposed by Lobley (1997) in his paper entitled 'The economics of Telemedicine' was utilized to analyze the costs associated with the conventional PHC versus TM. Lobley noted that there are two broad divisions of cost associated with telemedicine; capital and variable. The capital costs are the cost of equipment for telemedicine and which do not vary with the number of patients served, while the variable costs vary in proportion to number of patients.

The capital cost includes the cost of equipment for tele-health which he recommends should be annuitized over a period of five years.

The variable cost on the other hand refers to those cost which vary in proportion to the number of patients. This type of cost is sensitive to the volume of workload. This include drugs and non-drug expenditures, airtime and internet data bundle.

He further indicated that the savings provided by telemedicine should be compared to the cost of the alternative health intervention. Lobley argued for the inclusion of the benefits of telemedicine which are not easy to quantify such as access to faster treatment and referrals and reduced stress related to less travel time (Lobley, 1997). These categories of cost include of all the resources to all parties relevant to the telemedicine project (Field, 1996). Lobley noted that the increasing cost of healthcare makes it necessary for economic evaluation to be conducted

on interventions intended to improve healthcare. This was to ensure economic value for the resources allocated to that specific intervention. He opined that telemedicine has the potential to reduce the cost of healthcare service delivery. The initial capital outlay for telemedicine was a major cause for his push for economic evaluation. Capital costs include the outlay for telehealth video equipment which the author recommends should be annuitized over a five year period (Lobley, 1997). The savings provided by telemedicine need to be compared to the costs associated with the next best health intervention (Lobley, 1997).

Lobley's proposal for a standardized economic evaluation of telemedicine and subsequent discussion of cost inclusions lends itself to the cost-effectiveness analysis of the of telemedicine programme in Amansie-West District. First, he proposes that public health preventive programs are appropriate for economic evaluation. Second, Lobley provides a time frame of five years for the depreciation of tele-health equipment.

However, the time frame of five years for the depreciation of tele-health equipment was modified for the purposes of this study. The annualization method of adjusting for depreciation was employed. Additionally, the perspective of costing in this study limited the inclusion of all cost to only the operations of telemedicine and the conventional primary healthcare.

1.4 Research Questions

1. What is the cost of providing primary healthcare for people in a community through the conventional mode?
2. What is the cost of providing primary healthcare for people in a community through telemedicine?

3. Is it cost-effective to provide primary healthcare in communities through the conventional mode as compared to the use of telemedicine?

1.5 Study Objectives

1.5.1 General Objective

The broad objective of the research was to assess the cost-effectiveness of Telemedicine for primary healthcare delivery in the Amansie-West District.

1.5.2 Specific Objectives

In order to achieve the broad objective, the specific objectives were to estimate the:

i. cost of the conventional mode of healthcare delivery ii.

effects of the conventional mode of healthcare delivery

iii. cost of telemedicine as mode of healthcare delivery iv.

effects of telemedicine as mode of healthcare delivery

v. the cost-effectiveness of telemedicine versus conventional mode of healthcare delivery.

1.6 Scope of study

The study focused on the cost and effects of primary healthcare using telemedicine relative the conventional mode of the CHPS and health centres. The areas involved were Tontokrom and Keniago where telemedicine was piloted and Manso Ankam and Manso Abore for the traditional mode of primary healthcare. The cost of primary healthcare was limited to the perspective of the care provider.

1.7 Organization of the Thesis

The outline of this thesis is in the order of appearance of the title page, dedication, acknowledgement, the table of content, list of tables and figures, acronyms, definition of terms, and abstract. Chapter one begins with an introduction, a brief background to access to healthcare, a statement of the problem, the study rationale, research questions and objectives. It ends by describing the conceptual framework and the scope of the study. Chapter two gives an account of review of works done on cost analysis of telemedicine. The current situation in Ghana is also described. Chapter three begins with the description of the study type and design; it gives an account of how the study was conducted. It ends with a description of the statistical processes used to arrive at the results presented. In Chapter four, the findings of the study were presented beginning with the finding on the first objective and ending with the sensitivity analysis. Chapter five is a discussion of the findings in comparison with the findings of other works presented in the literature review. The last chapter (six) details the conclusions from the study and recommendations necessary for scaling the implementation of telemedicine across the entire District. The references used in this study are outlined in detail for easy follow up after this chapter.

CHAPTER TWO -LITERATURE REVIEW

2.0 Introduction

This chapter presents a review of some literature relevant to the study. The main topics include: brief history of telemedicine in Ghana, studies on cost of conventional primary healthcare delivery, effect of conventional primary healthcare, effect of telemedicine on care and peered reviewed articles that discuss the cost analysis of telemedicine.

2.1 History

The feasibility study to begin telemedicine operations in Ghana was undertaken in September 2008. Following this, a participatory design workshop was organized in January 2009. This workshop was attended by stakeholders comprising officials from Ministry of Health, Ghana Health Service, Norvatis Foundation for Sustainable Development and Millennium Villages Project. In July 2010, Ghana launched its E-health strategy. This policy envisioned that Ehealth will assist the provision of quality affordable and the most current health services in an equitable and timely manner by improving communication and the utilization of information for planning, managing and delivering health services. This policy legally paved way for actual telemedicine activities to officially start in September 2010. As part of these activities, five doctors attended the first "Medgate Training Workshop" was organized in Bassel, Switzerland in October, 2010. The second and third in the series of these workshops were organized in Kumasi in November 2012 and June 2013 respectively. The teleconsultation equipment was installed in July, 2011; thus, making it possible for actual pilot implementation of telemedicine to start in May, 2012. An Open Medical Record System was also installed in August 2012.

2.2 Cost of Conventional Primary Healthcare

Primary Healthcare means essential health care based on practical, scientifically sound, culturally appropriate and socially acceptable methods that is universally accessible to people in communities, involves in community participation and the first level of contact with our health system (King, 2001). This definition implies that primary healthcare provides the first point of call for all new health needs and problems. In Ghana, healthcare delivery has been organized into primary, secondary and tertiary levels. The primary level structure allows for the provision of primary healthcare. The primary level is represented by the health care

delivery system at the District level. In Ghana, the full cost of running a district hospital in 2002 and 2003 were estimated as were US$496,240 and US$487,537 using standard costfinding and cost analysis tools recommended by WHO. It was noted that recurrent cost items such as salaries and overhead are major components of the total cost (Aboagye et al., 2010). Younis (2013) conducted a retrospective study using data from government hospitals and primary healthcare centers to determine the unit cost of health services provided by hospitals and PHCs during the year 2008. The study revealed that in the PHCs the unit cost per visit was highest for psychiatry programs ($26.00); followed by other programs ($21.50), chronic diseases ($21.00), maternal and child health ($11.50), preventive programs ($9.00) and general medicine ($6.50) (Younis et al., 2013). Hussain (1983) in a study of cost analysis of primary health care centre in Bangladesh through the examination of records and papers and by interviewing staff it was observed that capital and recurrent costs were US$ 36382 and US$ 59556 respectively in 1979 (Hussain, 1983). Another study estimated the cost of running a primary health care center in Northern India to be a total of Rs 777,015 (US $24,282) with 80% being recurrent costs using cost items such as capital costs for land, building, furniture, vehicles and equipment and also other recurrent cost including salaries, drugs and vaccines. . However, for land, the opportunity cost was calculated using current market rates. A 10% discount rate was assumed for the study. (Anand et al., 1993). Khurshid (2010) noted in study that sought to estimate the cost recovery of a primary health facility in Banglesdesh that total cost of PHC was US $57548.44 from the perspective of the provider. Of this amount, 75% was variable costs (Alam and Ahmed, 2010).

2.3 Effect of Conventional Primary Healthcare

There is an association between PHC and better health. It has been observed that infant and child health in middle level and developing countries has significantly improved since the introduction of PHC (Macinko et al., 2003). For instance, in a study in Niger, it was observed that children who lived in villages adjacent to health dispensaries were approximately 32% less likely to have died during the study period than children who lacked access to modern health services (Magnani et al., 1996). Even in developed countries primary health care has proven to be linked to improved access to healthcare services, positive health outcomes, and a decline in hospitalization and use of emergency department visits(Starfield et al., 2005) . A study in Australia revealed that stronger primary health care is negatively related to low birth weight, that is, high levels of primary care are related to to reduced rates of low birth weight; lower overall national healthcare costs; lowered mortality of infants from 1 to 12 months of age(Griew et al., 2008). In Brazil, PHC through the Family Health Programme (FHP) demonstrated to be inversely associated with mortality rates from cerebrovascular and heart disease. FHP coverage on cerebrovascular disease mortality and on heart disease mortality was 0.82 (95% confidence interval 0.79 to 0.86) and 0.79 (0.75 to 0.80) respectively, reaching the value of 0.69 (0.66 to 0.73) and 0.64 (0.59 to 0.68) when the coverage was consolidated during all the previous eight years (Rasella et al., 2014). PHC has the potential to also avert the negative effect of poor economic conditions on health (Shi, 2012). The positive effect of primary care was also found in the significant relationship between reduced mortality and illness, regardless of whether the care is characterized by supply of primary care physicians, a relationship with the source of care, or the receipt of important features of primary care. The evidence shows that primary care is associated with a more equitable distribution of health in populations, a finding which holds in cross-national and also

within national studies(Starfield et al., 2005). One study found that people receiving good PHC (as characterized by accessibility, comprehensiveness, coordination, continuity and accountability) are 10-15% more likely to report being in good health in comparison to those receiving poorer PHC (Planning, 2011). Another study looked at the contribution of PHC to mortality in OECD countries. 6 The study differentiated between three different measures of mortality: all-cause, all- cause premature and case-specific premature death from asthma and bronchitis, emphysema and pneumonia, cardiovascular disease and heart disease. For all three levels, there is strong evidence that better PHC care is associated with lower mortality. Even when controlling for important macro-economic influences (GDP per capita, number of physicians per 1,000 population, percent of elderly in the population) and for micro-level effects (average number of ambulatory care visits, per capita income, alcohol and tobacco consumption), the relationship between PHC and health is positive and significant (Macinko et al., 2003). Additionally, another study showed that the effect of adding one PHC physician per population of 10,000 people in the US is associated with an average improvement of 5.3% across a number of population based measures of health such as allcause mortality, heart disease mortality, stroke mortality, infant mortality, low birth weight, life expectancy, and self-reported health (Starfield et al., 2005). In Ghana, PHC strategies have led to improvement in the health of children and pregnant women of some communities. These activities in their totality have positively impacted on morbidity and mortality in children under-five and on maternal mortality in children under five over the study period 1987 to 1990. Although malaria, acute respiratory infections and diarrhoea diseases continue to be the lead causes of childhood morbidity, deaths as a result of these diseases have sharply declined. Measles and other vaccine preventable diseases no longer contribute greatly to childhood morbidity and

mortality. Infant and under five mortality have declined from 114.6/1000 and 155.6/1000 live births to 40.8/1000 and 61.2/1000 live births respectively (Afari et al., 1995).

2.4 Effects of Telemedicine

Telemedicine has shown to achieve lower medical and pharmacy cost; more efficient ways of delivery, for example lower hospital admissions and readmissions and less use of hospital emergency departments; and a 160 percent return on investment when compared to nonparticipating areas (Rosenberg et al., 2012). The substitution of telemedicine for person-toperson encounters should minimize the need for travel and the related opportunity costs and other inconveniences encountered in the process of obtaining care. Telemedicine offers residents of rural areas, correctional instutions and nursing homes could receive many services instead of travelling to distant tertiary facilities for both specialized and rountne health care services..

Telemedicine helps patients and care providers to bridge the distance and time barriers that separate them. Obviously, these savings inure to the benefit of clients(Bashshur, 1995). According to a survey, patients who received care through the Hospital at Home Model created by the Johns Hopkins University Schools of Medicine and Public Health telemedicine showed comparable or better clinical outcomes as well as higher satisfaction level (Cryer et al., 2012). Additionally, patients achieved savings of 19 percent over cost for similar in-patients. These savings largely accrued from lower average length-of-stay and use of fewer laboratory and diagnostic tests compared with similar patients in hospital acute care (Cryer et al., 2012). In a study which examined the impact of care which integrates a telehealth tool, significant savings was observed among patients who received care through the tele-health tool; which was associated with spending reductions of approximately 7.7-13.3 percent ($312-542) per person

per quarter (Baker, 2011). A study in India revealed that the application of information technology and telemedicine has led to a reduction the life expectancy gap between American Indian and Alaska Native people and whites (from eight years to five years) and improved measures of diabetes control (including 20 percent and 10 percent reductions in the levels of low-density lipoprotein cholesterol and hemoglobin A1c, respectively) (Sequist et al., 2011). An application of telemedicine to patients with heart failure to observer vital signs and manage their health at home revealed a 46% reduction in emergency department use and a 53% reduction in hospitalizations post-enrollment compared to pre-enrollment (Mierdel and Owen, 2015). In addition, six months after Telehomecare discharge, inpatient admissions and emergency department visits continued to decline, by 65% and 57% respectively, compared to pre-enrollment (Mierdel and Owen, 2015)

In Africa the usefulness of telemedicine cannot be over emphasized given the fact that the continent is resource limited and still enduring the effects of scarce human resource especially in health (Wamala and Augustine, 2013). Inspite of this the uptake of telemedicine in Afirca remains low. Telemedicine calls for information and communication infrastructure, the ability to use that infrastructure, a fairly stable supply of electricity and people to maintain and support the infrastructure (Mars, 2013). Currently only 6.7% of households in Africa have access to internet at home, 16.3% of people use the Internet, and fixed broadband penetration is 0.3%. Internet coverage in Africa is half that of Asia and the Pacific and is the lowest of any developing world region (Mars, 2013).

2.5 Cost effectiveness of Telemedicine

Economic evaluations in telemedicine are significantly different in terms of both the study context and the methods applied (Bergmo, 2009). Thus, researchers are divided on the cost

effectiveness of telemedicine. Some studies have found telemedicine to be cost effective; whereas others have found it not to be. For other researchers, there seem not be conclusive information that telemedicine and telecare interventions are cost-effective relative to conventional health care (Mistry, 2012).

Some studies have found e-health/telemedicine to be cost-effective. In a study which sought to establish the cost effectiveness of outpatient pulmonary subspecialty consultations through telemedicine, telemedicine was identified to be cost-effective ($335 per patient/year) compared to routine care ($ 585 per patient/year) (Agha et al., 2002). The rising cost of healthcare for prisoners in the U.S. motivated a study to determine the clinical and economic impact of tele-ophthalmology in evaluating diabetic retinopathy in prison inmates with type 2 diabetes. The study found tele-ophthalmology to be superior in the cost effectiveness analysis: $16, 514/18.73 QALYs for tele-ophthalmology and $17,590/18.58 QALYs for non-tele-ophthalmology (Aoki et al., 2004). In another study which sought to estimate the cost, effectiveness and the return on investment of telemedicine consultations provided to health care providers of acutely ill and injured children in rural Emergency Departments (EDs),, telemedicine was observed to be cost effective with average cost of $3641 per child/ED/year in 2013 US dollars for a telemedicine consultation(Yang et al., 2015). The cost effectiveness of telemedicine was demonstrated in a research which examined the telemedicine delivery of cognitive behavioural therapy for bulimia nervosa. The total cost per recovered subject was $9324.68 for face-to-face and $7300.40 for telemedicine (Crow et al., 2009). In a study which considered the application of Mobile Stroke Unit to provide prehospital stroke treatment, it was observed that the benefits were more than its cost with a benefit-cost ratio of 1.96 in the baseline experimental setting. Researchers concluded that the model is highly cost-effective across a wide range of possible situations . Telemedicine was found to be

cost-effective in another study which sought to assess the clinical outcomes and cost-effectiveness of a fourth-generation synchronous telehealth program for patients with chronic cardiovascular diseases after retrospectively examining patients who joined the telemedicine programme (Ho et al., 2014).

Some other studies have revealed that telemedicine has a low tendency of cost effectiveness relative to standard care of patients. A randomized controlled trial involving patients with chronic obstructive pulmonary disease, heart failure who received telehealth support and usual care or usual care only was conducted in England. a involving patients with heart failure, chronic obstructive pulmonary disease, or diabetes. Telehealth proved to have a low probability of cost-effectiveness with incremental cost per quality-adjusted life year of £79,000 when added to usual care (Hailey and Yu, 2013). In a systematic review of 55 out of 612 articles, it was observed that there is not sufficient information to conclude that telemedicine is a cost effective means of delivering health care (Whitten et al., 2002). In another randomized controlled trial which sought to compare real time tele-dermatology with outpatient dermatology in terms of clinical outcomes, cost benefits and patient re-attendance, no significant difference was observed in the reported clinical outcome of the two interventions. The study found the conventional outpatient care to be cost –effective relative to teledermatology (Wootton et al., 2000). Another study investigated the cost effectiveness of On-Site Practice-Based Collaborative Care (PBCC) against Off-Site Telemedicine-Based Collaborative Care (TBCC) for depression in Federally Qualified Health Centre (FQHCs) revealed that TBCC intervention was more cost effective than the PBCC. The TBCC intervention resulted in more depression-free days and QALYs but at a greater cost than the PBCC intervention (Pyne et al., 2015).

In a study of people with chronic health conditions of heart failure, chronic obstructive pulmonary disease, it was observed that the Quality of Life Years (QUALY) gained by patients using telehealth in addition to usual care was similar to that by patients receiving usual care only (Henderson et al., 2013), however, total cost associated with telehealth intervention was even higher; thus teleahealth does not seem to be cost effective addition to conventional support and treatment Henderson et al., 2013).

2.6 Theoretical Underpinnings

Robbins (1935) defined economics as "the science which studies human behaviour as a relationship between ends and scarce means which have alternative uses" (Robbins, 2007). The main goal of economics is maximize human welfare in the light of the unlimited human needs and wants and the limited resources which have alternative uses. It therefore makes it imperative to ensure efficiency in the allocation of these limited resources to satisfy human needs and wants. Efficiency in this context is a key word. The appropriation of resources can be done in a number of ways, however, to ensure this, allocation is done in a manner such that the amount of outcome for a given amount of cost is maximized, or cost is minimized for a given outcome. . Economic Efficiency, in effect assesses whether health care resources are being utilized to achieve the best value for money and is, therefore, concerned with the relation between resource inputs and intermediate output or final health outcomes (Slothuus, 2000). Efficient allocation of resources refers to the combination of inputs, outputs and distribution of inputs, output such that any change in the economy could make someone better off only by making someone worse off. In terms of production, efficiency is producing the highest value of goods and services with given resources. In the case of consumption, efficiency is attained

with the exhibition of willingness-to-pay (cite). Hence any intervention, investment which seeks to increase the welfare of society will cause the re-allocation of society's resources. Economists postulate that in determining whether an intervention represents an efficient use of resources, rational management decisions must be informed by an evaluation of the costs and benefits of an intervention or alternative interventions on public health. This calls for placing "economic" values on these interventions and their consequences. Economic value is used in the context welfare economics to measure impact of a proposed intervention from the point of view of society's welfare. A major concern in economic evaluation has to do with assigning monetary value to the impact of a proposed intervention on the society's welfare which is sometimes difficult to quantify (Organization, 2004).

2.6.1 Types of Economic Evaluation

There are four different methods of economic evaluation which can be applied in the field of healthcare (Slothuus, 2000). These are Cost-Utility Analysis (CUA), Cost-Effectiveness Analysis (CEA), Cost-Benefit Analysis (CBA) and Cost-Minimization Analysis (CMA).

Cost-Minimization Analysis (CMA)

This method is applied when the two or more interventions that are being compared have the same outcome (Briggs and O'Brien, 2001). In this regard, it becomes only necessary to determine the cost of each intervention or strategy and then compare. The decision rule is to select the intervention which incurs the least cost since the general rule is to minimize cost.

Cost-Benefit Analysis (CBA)

This method deals with measuring cost and benefits in commensurate terms, usually money (Palmer et al., 1999). In CBA, both the cost side and the benefit side are determined in monetary units; which has the advantage of being able to compare projects across sectors. CBA makes it possible to determine whether an intervention offers an overall net welfare gain and also how that welfare gain from that intervention compares with that of alternative intervention. CBA enables comparison to be made across different interventions or strategies (Layard et al., 1994).

Nonetheless, a major setback of CBA is the difficulty of assigning monetary values to all pertinent outcomes, including changes in the length or quality of life.

Cost-Utility Analysis (CUA)

This method measure an interventions effect in both quantitative and qualitative aspects of health (morbidity and mortality) using a utility based measure such Quality-Adjusted Life Years (QALYs) (Palmer et al., 1999). In CUA, estimates of utility are assigned to health outcomes, enabling comparisons of disparate technologies.

Cost-Effectiveness Analysis (CEA)

Cost effectiveness analysis attempts to answer the question of reaching regarding how to achieve a specific goal given the minimum resources. In CEA, cost are quantified monetarily just like the other methods, however the health benefits are measure in natural units such as

life years saved or number of patients seen (Edejer, 2003).CEA avoids this limitation by using more natural units of outcomes such as lives saved or strokes averted. As such, CEA can only compare interventions whose outcomes are measured in the same units.

Since geographical barriers exist for a substantial portion of the remote and confined populations, telemedicine as an intervention sought to decrease unnecessary referrals to the District hospital.

Considering the health benefit to be measured, we deemed it appropriate to perform costeffectiveness analysis to determine the economic value of allocating resources to telemedicine for the achievement of the specific objective relative the conventional primary healthcare.

CHAPTER THREE-METHODOLOGY

3.0 Introduction

This chapter deals with how the study was conducted.

3.1 Study type and Design

A retrospective economic evaluation was conducted on the telemedicine project which was piloted in two sub-districts in the Amansie-West District. The specific type of economic evaluation was Cost-Effectiveness Analysis (CEA). This method compares the costs of two or more interventions or policies with the measures of health outcomes (Robinson, 1993). With CEA health improvement is measured in natural units (e.g. cases of disease prevented) (Robinson, 1993). A CEA involves assessing the gains (effectiveness) and resource input requirements (costs) of alternative ways of achieving a specified objective. The effectiveness can be measured using intermediate outcomes or final outcomes. The summary measure for

CEA is the cost-effectiveness (CE) ratio, which measures the net cost of the intervention or program relative to its health effects. The CE ratio is the cost per unit of health gain. A crosssectional community-based survey was employed to obtain quantitative data on the cost and effects of both telemedicine and the conventional mode of primary health care delivery.

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3.2 Interventions

3.2.1 Telemedicine (TM)

The Telemedicine (TM) activities were based on telephones, telecommunications network, mobile phones and a Tele-Consultation Center (TCC). Tontokrom and Keniago health centers served as pilot facilities while the St. Martins Hospital at Agroyesum hosted the TCC.

The health facilities which involved in the pilot project were given mobile phones to call the TCC for assistance whenever a patient visited a care could not be given at that level.

3.2.2 Conventional Primary Healthcare (CPHc)

The Conventional Primary Healthcare (CPHc) refers to the first level of healthcare provided through Community-Based Health Planning and Services (CHPS) compound, Health Centers, and Health Posts. These health facilities are usually manned by Community Health Nurses, Staff Nurses and Physician Assistants. The Manso Ankam Community-Based Health Planning and Services (CHPS) compound and Manso Abore Health Center served as the Conventional Primary Healthcare (CPHc).

3.3 Profile of study area

Amansie-West district is one among the thirty others in the Ashanti Region. It was carved out of the then Amansie District in 1978 and has Manso Nkwanta as the district capital. This district covers an area of 1,364 sq km with major rivers such as Offin, Oda and Nwine. The major towns in the district are Manso Nkwnta, Manso Abore, Manso Atwere and Manso Edubia. The

projected population for the year 2014 was 149, 437 and annual growth rate of 2.7% . The ratio of male to female ratio in percentage is 48:52. The predominant ethnic group is Akan and the main language is Asante Twi. The household size averages 10. Majority of the people are into small scale and illegal mining, 30% of the people are into cocoa, citronella and food crop farming and the remaining are into petty trading. The district has seven (7) sub-districts; namely Agroyesum, Antoakrom, Edubia, Essuowin, Keniago, Manso Nkwanta and Tontokrom, 21 health facilities, 54 but 12 functional CHPS compounds, and 160 communities. The district has a total of 295 health worker including 3 Medical Officers, 6 Physician Assistants, 22 Midwives, 32 General Nurses, 22 Enrolled Nurses, 84 Community Health Nurses (CHNs), and 181 Community Health Worker (CHWs). The health services offered by the health system include immunization, health promotion, medical, surgical, obstetrics/gynaecological services, ophthalmologic and rehabilitative services for buruli ulcer patients.

The Amansie-West District was chosen for the pilot implementation of the Telemedicine because at the time the District recorded the highest maternal mortality among other negative health indicators.

3.4 Study Population

The estimated study population included four primary healthcare sites in the Amansie West District namely Keniago,Tontokrom, Manso Ankam and Manso Abore.

3.4.1 Inclusion Criteria

Primay healathcare facilities which were under the jurisdiction of the Amansie West District Health Directorate and were either involved or not in the TM pilot implementation project qualified to participate in the study.

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3.5 Sampling

3.5.1 Method of sampling

This study focused on Manaso Ankam and Abore which served as the CPHc and Keniago and Tontokrom which also served as TM. The healthcare facilities were purposively sampled based on the advice of the District health Directorate and the E-health specialist with the Millennium Villages Project. It was assumed that these facilities truly represented the two alternative interventions bearing in mind the different healthcare facilities in the District, budgetary and time constraints for the research study.

Purposive sampling is historically connected to most study on telemedicine (Dossetor et.al 2002). This technique for selecting respondents may not allow for generalization. This notwithstanding, it does not mean that a non-probability approach should never be used in evaluating the impact of a programme (Rossi et al, 1993).

3.6 Data collection techniques and tools

3.6.1 Quantitative study

A set of data collection instruments was used to collect data on all cost associated with the conventional mode of primary healthcare (salaries of health staff, rent, utilities, furniture, operational tools, etc), cost of telemedicine, effect of telemedicine and the conventional primary healthcare on health outcomes.

The data on cost of telemedicine were collected from the office of Millennium Villages Project (MVP) whereas that of the conventional primary healthcare will be obtained from the District Health Directorate.

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3.7 Procedure

3.7.1 Costing

Costing was done through the three steps, namely: identification, quantification and valuation. The identification stage refers to the process by which all inputs into the provision of a service are identified and classified. The stage of quantification is where the indentified inputs are physically counted non-monetary quantities are assigned to measure the contribution of identified inputs into the service and or programme to be costed. The stage of valuation refers to assigning monetary value to the inputs identified and classified (White et al., 2006) . All these stages were successfully completed with the assistance of facility incharges, accounts officers and store keepers.

3.7.2 Perspective

In this CEA, we used a healthcare provider's perspective, focusing on the direct and indirect costs of providing primary healthcare through the two approaches.

3.7.3 Intervention time frame

The time frame for the cost-effectiveness analysis was two years. That is, from May 2012 when implementation started to May, 2014.

3.7.4 Analytic time frame

This is also referred to as analytic horizon. It refers to the entire period during which cost and benefits associated with the intervention are measured. For the purpose of this study, the period chosen was January to December 2013.

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3.7.5 Discounting

The concept of discounting is an important element in cost-effectiveness analysis which considers the fact that money available for spending today is worth more than the same amount of money available for spending in future. A discount rate of 3% was utilized as recommended by the U.S. Panel on Cost-Effectiveness in Health and Medicine (Gold, 1996).

3.7.6 Health Outcome

An intermediate health outcome was used as a measure of effectiveness for both the telemedicine and the conventional primary healthcare. The number of unnecessary referrals averted from the study facilities to the St. Martins Catholic Hospital (SMCH), Agroyesum.

Patients who received healthcare with the support of tele-consultation were considered for the health outcome in the telemedicine programme for the period January to December, 2013. For the conventional primary healthcare the health outcome was the number of unnecessary referrals avoided from the health facilities concerned during the same time frame. There were other secondary measures which were also collected and these included the number of patients seen at Out-Patient Department (OPD) and the number of baby deliveries recorded from the operational areas of both interventions.

3.8 Study Variables

The study gathered data on all cost associated with telemedicine (equipment, maintenance, salaries of technicians, salaries of health professionals, time spent, opportunity cost etc), all

cost associated with the conventional mode of primary healthcare (salaries of health staff, rent, utilities, furniture, operational tools, etc), effect of telemedicine on access to care, effect of telemedicine on health outcomes, effect of conventional healthcare, and effect of the conventional mode on health outcomes.

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Table 1: Table of Study Variables

Variable	**Measure**
Cost of telemedicine	Building
	Furniture
	Vehicles
	Land
	Computer & Accessories
	Fixtures & fittings
	Water tank
	Mobile phones
	Fan
	Telemedicine equipment (General)
	Installation
	Power back up
	Data transmission lines
	Documentation
	Rent
	Salaries
	Allowances
	Repairs & maintenance
	Light bill
	Water bill
	Fuel
	Painting

Cost of conventional primary healthcare	Building
	Furniture
	Vehicle
	Land
	Computer & accessories
	Fixtures & fittings
	Water tank
	Phones
	Air condition
	Fan
	Rent
	Salaries
	Allowance
	Repairs & maintenance
	Light bill
	Water bill
	Fuel
	Painting
Effects on health outcomes	Number of unnecessary referrals averted
	Number of babies delivered

3.9 Pre-testing

A pilot study was conducted from 25th May to 15th June, 2015 to pre-test data collection instrument. The reason for the pre-testing was to ensure the validity and reliability of the data collection instrument. Following this, all the necessary corrections were effected.

3.10 Data Handling

In order to ensure that concerns bothering on confidentiality, security, preservation of research data are not compromised, study was conducted in accordance to the stipulated guidelines by the Committee on Human Research Publication and Ethics of the School of Medical Sciences, Kwame Nkrumah University of Science & Technology, Kumasi.

Measures were also be put in place to ensure that electronic data are not altered, not erased, not lost and not accessed by unauthorized persons.

3.11 Data Analysis

The data were analyzed using several approaches. Data on the costs of telemedicine and the conventional primary healthcare were quantified manually. The annuitization of capital outlays and ICER and MCER calculations was done with the assistance of MS Excel 2007.Sensitivity analysis were be performed with MS Excel 2007 to confirm the model assumptions and minimize the possibility of bias resulting from the investigator assigning values (Jain et al., 2011).

3.12 Ethical consideration

A letter of approval dated 29th May, 2015 and referenced CHRPE/AP/232/15 was issued by the Committee on Human Research Publication and Ethics of the School of Medical Sciences, Kwame Nkrumah University of Science & Technology, Kumasi after all requisite documents were submitted. This enabled the study to be conducted while ensuring high ethical standards.

3.13 Limitations of the study

Since the study was retrospective, costs were identified after the 2012 start of the telemedicine programmed and so the data collected may not be as precise as it would be if the researcher were involved at the start of the process. The purposive sampling technique used in selecting respondents could potentially limit the generalizability of our findings on other settings. The societal perspective could not be used because of budgetary and time constraint. Telemedicine cost data on feasibility studies and all other pre-implementation cost such as training workshops could not be captured in the analysis because that was not readily available.

3.14 Assumptions

The following assumptions were made:

1. study population have characteristics that are shared by the target population and so was representative of the larger population,
2. unit prices of inputs were truly reflective of the prevailing prices relative to the period under study,
3. cost of technology for the telemedicine equipment has not changed since it was purchased,
4. probability of effectiveness of telemedicine was 0.9 and non-effectiveness was 0.1 whereas the probability of effectiveness of conventional primary healthcare was 0.1 and noneffectiveness was 0.9.
5. the American Dollar (USD) to Ghana cedi exchange rate in the year 2012 averaged US $1=GH₵ 1.8 according to the Bank of Ghana (Bank of Ghana, 2013)

3.15 Dissemination

The study findings were communicated to the District and Regional Directorates of Ghana Health Service, and authorities of the Millennium Villages Projects.

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CHAPTER FOUR - RESULTS

4.0 Introduction

This chapter presents the results of the cost-effectiveness analysis of the pilot telemedicine project relative to the traditional primary health care in the Amansie West District for the period January – December 2013. A number of methods were employed to analyze the results. The capital and variable costs were quantified manually. Annuitization for capital outlays was done with Microsoft Excel 2007. The Average Cost Effectiveness Ratio (ACER), Incremental Cost Effectiveness Ratio (ICER) and Marginal Cost Effectiveness Ratio (MCER) calculations were completed manually without the assistance of CEA specific software. Decision analysis, expected value calculation and sensitivity were done with Microsoft Excel 2007.

4.1 Health Outcome

The primary health outcome for the conventional primary healthcare was defined as the number of unnecessary referrals averted at the selected facilities. A review of available records at the healthcare facilities with the telemedicine operations revealed that a total of 172 patients who received care via tele-consultation during the period January – December 2013. However, based on the assumption that the conventional primary health facilities are poorly resourced, unnecessary referrals averted was zero (0).

Other secondary outcomes which were collected included the number of patients seen at the Out-Patient Department (OPD) and the number of babies delivered. The conventional PHC facilities recorded 7335 patients at the OPD. Similarly, the number of patients who received care at the facilities with telemedicine operations was 6256 for the same period. In both interventions, uncomplicated malaria was the most seen health condition. Over 60% of the OPD attendees represented females.

The CPHc facilities record 145 deliveries while the facilities with telemedicine recorded 194 deliveries during the period under review.

It was further observed that in both areas of the two interventions about 85% of patients visited healthcare facilities with valid National Health Insurance cards.

4.2 Costing

The American Dollar (USD) to Ghana cedi exchange rate in the year 2012 averaged US $1=GH₵ 1.8 according to the Bank of Ghana (Bank of Ghana, 2013).

4.2.1 Cost of Conventional Primary Healthcare Telemedicine

Table 1 shows detailed explanation of the capital and variable cost of the telemedicine programme. The Building is a composite of the facilities at Manso Ankam and Manso Abore. In consultation with the District Health Directorate, a plot of land was estimated to cost GH₵6,000.00 equivalent to $3,658.54 assuming exchange rate of $1=GH₵1.81 as stated in the methodology. Additionally, a CHPS compound was valued to cost GH₵250,000.00 whiles a Health Centre was valued at GH₵350,000.00. Table 2 provides shows detailed explanation of the capital and recurrent cost of the conventional primary healthcare.

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Table 2: Cost of Conventional Primary healthcare

No.	Item	Quantity	Unit Price ₵	Period/Months	Total ₵	Total $
	Capital Cost					
1.	Building	1	621000	1	621000.00	343093.92
	Primary Healthcare Equipment					
2.	Thermometer	8	12	1	96.00	53.04
3.	Sphygmanometer	5	250	1	1250.00	690.61
4.	Adult weighing scale	3	300	1	900.00	497.24
5.	Baby Scale	2	300	1	600.00	331.49
6.	Stethoscope	4	100.00	1	400.00	220.99
	Sub-total					**1793.37**
7.	Desktop Computers	2	1300	1	2600.00	1436.46
8.	Printer(3 in 1)	1	498	1	498.00	275.14
9.	Bed	21	1200	1	25200.00	13922.65

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10.	Tables	12	350	1	4200.00	2320.44
11.	Baby's cot	2	400	1	800.00	441.99
12.	Microscope	2	2460	1	4920.00	2718.23
13.	Trolley	5	800	1	4000.00	2209.94
14.	Delivery beds	2	1800	1	3600.00	1988.95
15.	Benches	24	50	1	1200.00	662.98
16.	Veronica bucket	5	90	1	450.00	248.62
17.	Gas stove	1	300	1	300.00	165.75
18.	Treatment Instrument	2	950	1	1900.00	1049.72
19.	Delivery instruments set	2	1100	1	2200.00	1215.47
20.	Bathroom scale	1	150	1	150	82.87
21.	Vaccine Carriers	7	100	1	700.00	386.74
22.	Glucometer	2	230	1	460.00	254.14
23.	Autoclave	2	1200	1	2400.00	1325.97

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24.	Drip Stand			10	100	1	1000.00	552.49	
25.	Wheel Chair			4	276	1	1104.00	609.94	
26.	Delivery boots	2	85	1	170.00	93.92			
27.	Generator	1	2700	1	2700.00	1491.71			
28.	Dustbins	7	160	1	1120.00	618.78			
29.	Chairs	36	150	1	5400.00	2983.43			
30.	Ceiling Fan	20	120	1	2400.00	1325.97			
31.	Lockers `	6	1500	1	9000.00	4972.38			
32.	Refrigerators	2	1480	1	2960.00	1635.36			
33.	Screens	5	700	1	3500.00	1933.70			
34.	Mattress	18	373	1	6714.00	3709.39			
35.	Airconditioner	1	2750	1	2750.00	1519.34			
36.	Monitor	1	10,000	1	10000.00	5524.86			
37.	Centrifuge	1	950.00	1	950.00	524.86			
38.	Colorimeter	1	1,000	1	1000.00	552.49			

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39.	Poly-tank	4	765.00	1	3060.00	1690.61	
40.	Borehole	1	10000	1	10000.00	5524.86	
	Sub-total						65970.17
	Total Capital Coast						**410857.46**
	Variable						
	Salary						
41.	Physician assistant	1	2,027.68	12	24332.16	13443.18	
42.	Staff Nurse	2	1651.1	12	39626.40	21893.04	
43.	Enrolled nurse	11	1033.15	12	136375.80	75345.75	
44.	Staff Midwife	1	1,601.43	12	19217.16	10617.22	
45.	Community health nurse	6	1033.15	12	74386.80	41097.68	
46.	Laboratory Technician	1	1651.1	12	19813.20	10946.52	
47.	Dispensary Assistant	1	1,656.00	12	19872.00	10979.01	
48.	Senior Ward Assistant	1	1065.19	12	12782.28	7062.03	
49.	Ward assistant	1	634.81	12	7617.72	4208.69	
50.	Orderly	2	634.81	12	15235.44	8417.37	

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51.	Security men	2	634.81	12	15235.44	8417.37
52.	Drugs	1	55438.20	1	55438.20	30628.84
53.	Non-Drugs	1	45447.78	1	45447.78	25109.27

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54.	Maintenance	1	19447.64	1	19477.64	10761.13		
	Utilities							
55.	Water	1	1440	1	1440	795.58		
56.	Electricity	1	6000	1	6000	3314.92	Total Variable Cost	283037.58
	Total Cost							**693,895.04**

Source: Field Data, 2015

4.2.2 Cost of Telemedicine

Table 3 shows detailed explanation of the capital and variable cost of the telemedicine programme. The Building is a composite of theTele-consultation centre which was located at the St. Martins Catholic Hospital, Keniago and Tontokrom Health Centres. In consultation with the District Health Directorate, a plot of land was estimated to cost GH₵6,000.00 equivalent to $3,658.54 assuming exchange rate of $1=GH₵1.81 as stated in the methodology. Additionally, a CHPS compound was valued to cost GH₵250,000.00 whiles a Health Centre was valued at GH₵350,000.00.

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Table 3: Cost of Telemedicine

No.	Item	Quantity	Unit Price ₵	Period/Months	Total ₵	Total $
	Capital Cost					
1.	**Building**	1	770000	1	770000	**425414.4**
	Telemedicine Equipment					
	Tele-Consultation Equipment	1	18100.00	1	18100	10000
2.	Mobile Phones	215	300.00	1	64500	35635.36
3.	Installation Cost	1	9050.00	1	9050	5000
4.	Furniture	1	5000.00	1	5000	2762.43
5.	Solar Backup	1	5430.00	1	5430	3000
	Sub-total					**56397.79**
	Primary Healthcare Equipment					
6.	Adult weighing scale	4	300.00	1	1200	662.98
7.	Thermometer	6	12.00		72	39.78

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8.	Shygmanometer	4	250.00	1000	552.49

			1		
		1			
			1		
9. Plastic Chairs	4	50.00		200	110.50
10. Baby weighing scale	4	300.00	1	1200	662.98
11. Stethoscope	5	100.00	1	500	276.24
Sub-total					**2304.97**
12. Table	15	350.00	1	5250.00	2900.55
13. Cupboard	7	450.00	1	3150.00	1740.33
14. Drug shelve	10	350.00	1	3500.00	1933.70
15. Chair	14	150.00	1	2100.00	1160.22
16. Patient Bed	21	1200.00	1	25200.00	13922.65
17. Mattress	21	373	1	7833	4327.62
18. Bench	15	50.00	1	750.00	414.36
19. Small & Needle bin	20	40.00	1	800.00	441.99
20. Stadiometer	1	200.00	1	200.00	110.50
21. Refridgerator	1	1650.00	1	1650.00	911.60

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22. Vaccine carriers	5	100.00	500.00	276.24

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23. Printer	1	498.00	498.00	275.14

24. Fan	12	120.00	1	1440.00	795.58
25. Swivel Chair	3	280	1	840.00	464.09
26. Drip stand	16	100.00	1	1600.00	883.98
27. Delivery bed	4	1800.00	1	7200.00	3977.90
28. Baby scot	3	400.00	1	1200.00	662.98
29. Delivery boot	2	80.00	1	160.00	88.40
30. Veronica bucket	3	90.00	1	270.00	149.17
31. Delivery instrument set	2	1100	1	2200.00	1215.45
32. Treatment Instruments	2	950	1	1900.00	1049.72
33. Laminator	1	135	1	135.00	74.59
34. Screens	4	700.00	1	2800.00	1546.96
35. Autoclave	2	1200	1	2400.00	1325.97
36. Gas stove	1	300	1	300.00	165.75
37. Wheel chair	1	276.00	1	276.00	152.49

							1
							1
38.	Trolley	6	800.00	4800.00	2651.93		
39.	Couch	2	820	1640.00	906.08		
40.	Cabinet	1	700.00	700.00	386.74		
	Sub-total						**44912.71**
	Total Capital Cost						**529029.83**
	Variable						
	Allowances						
41.	TCC Staff	1	3600.00	12	43200.00	23867.40	
42.	Community Health Workers	1	1033.31	12	136396.9	6850.67	
43.	E-health Administrator	1	2715.00	12	32580.00	18000.00	
	Salaries						
44.	Senior Midwife Officer	2	2200.08	12	52801.92	29172.33	
45.	Community Health Nurse	3	1033.15	12	37193.4	20548.84	
46.	Enrolled Nurse	3	1033.15	12	37193.4	20548.84	
47.	Senior Technical officer	1	1651.10	12	19813.2	10946.52	

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48.	Security officer	2	634.81	12	15235.44	8417.37	
49.	Cleaner	2	634.81	12	15235.44	8417.37	
50.	Orderly	1	634.81	12	7617.72	4208.69	
51.	Drugs	1	45503.20	1	45503.20	25139.89	
52.	Non drugs	1	14407.20	1	14407.20	7959.78	
56	Maintenance	1	1000.00	12	12000.00	6629.83	
57	Utilities @ TCC	1	100.00	12	1200.00	662.98	
58	Data Bundle	1	60.00	12	720.00	397.79	
59	Health Staff Airtime	1	100.00	12	1200.00	662.98	
60	TCC Airtime	1	150.00	12	1800.00	994.48	
	Total variable cost						**194950.63**
	Total Cost of Telemedicine						**723980.46**

Source: Field Data, 2015

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4.3 Annuitization

Telemedicine equipment was annuitized for over a seven year period and primary health equipment was over five years as stated in the methodology chapter. A discount rate of 3% was used as proposed by the U.S. Panel on Cost Effectiveness in Health Medicine. The formula below was utilized to calculate the annuitized values for the capital assets.

First the Annuity Factor (AF) was calculated.

$$AF = \frac{1 - \frac{1}{(1+i)^n}}{i}$$

n= length of item's useful years i=

discount rate

Second the Equipment Annual Cost (EAC) was calculated.

$$EAC = \frac{PC}{AF}$$

PC= Purchase Price

Buildings in both interventions were annuitized for fifty (50) years (Malik et al., 2015). Telemedicine equipment was also annuitized for seven (7) years. Primary healthcare equipments, that is, items 7-12 on table 1 were annuitized for two years (2) while primary health care items 13-42 were assumed to have ten (10) years life of usefulness (Malik et al., 2015).

Table

4: Annualized Capital Cost

Healthcare Strategy	Capital Cost			
	Building ($)	Telemedicine Equipment ($)	Primary Health equipment ($)	Total ($)
TM	16533.79	9052.61	6469.87	32056.27
CPHc	13334.39	N/A	8670.95	22005.34

Source: Field Data N/A= Not Applicable

The above Table 4 shows the annualized capital cost of telemedicine was $32,056.27 and the conventional mode was $22,005.34

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Table

5: Annualized Total Cost of Primary Healthcare Strategies

Item	**Conventional PHC**	**Telemedicine**
Capital	($)	($)
Building	13334.39	16533.79
Telemedicine equipment	N/A	9052.61
Primary Health Equipment	8670.95	6469.87
Recurrent		
Salaries & Allowances	212,427.85	150978.03
Drugs	30,628.84	25,139.89
Non-Drugs	25,109.27	7,959.78
Maintenance	10761.13	6629.83
Utilities	4110.50	2187.85
Airtime & Data Bundle	N/A	2055.44
Total	**305042.93**	**227007.90**

Source: Field Data N/A= Not Applicable

Table 5 shows the total cost of both Telemedicine and the Conventional modes of PHC delivery. It is evident that variable costs in the two strategies constitute 86.91% and 92.81% respectively of total cost.

6: Proportion of Major Cost Items to Total Cost

Item	**Healthcare Strategies**	
	Conventional (%)	**Telemedicine (%)**

Table

Salaries & Allowances	69.64	66.51
Drugs	10.04	11.07.
Non-Drugs	8.23	3.51
Capital items	7.21	14.21

Source: Field Data **N/A=Not Applicable**

Table 6 shows that personnel emoluments constitute an average of 68% of the total cost of implementing either of the healthcare strategies. Expenditures on Drug consumables also averaged 10.5% in both strategies. Expenditure on capital items was almost twice in telemedicine as much as it was in the conventional primary health care.

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4.4 Average Cost Effectiveness Ratio (ACER)

This index refers to dividing to the total cost of the intervention by the total effect of the intervention. The ACER is the ratio of the net costs to the health outcome.

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Table 7: Average Cost Effectiveness Ratio (ACER)

Healthcare Strategy	Cost ($)	Effect	ACER (Cost÷# of referrals avoided)
TM	227006.90	172	1319.81
CPHc	305042.93	0	-

Source: Field Data

Table 7 shows that it cost $1,319.81 per every unnecessary referral avoided through the telemedicine intervention.

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4.5 Incremental Cost Effectiveness Ratio (ICER)

The following equation was used to calculate the ICER for the telemedicine programme.

$$ICER = \frac{\text{Cost of Telemedine} - \text{cost of conventional Primary Healthcare}}{\text{number of patients seen via Telemedicine} - \text{number of seen via CPH}}$$

Table 8: Incremental Cost-Effectiveness Ratio

Healthcare strategy	Cost	Effects	Incremental cost	Incremental effects	ICER
CPHc	305042.93	0	305042.93	0	-
TM	227006.90	172	-78036.03	172	-453.70

Source: Field Data

Table 6 shows that telemedicine has ICER of -$453.70. The calculated ICER means telemedicine is cost effective, assuming the WHO recommended Cost-Effectiveness thresholds (Edejer, 2003) and Ghana's Gross Domestic Product per capita which was $1.668 in the year 2013 (Service, 2013). The WHO criterion uses Gross Domestic Product (GDP) per capita of a country as a readily available indicator to derive the following three categories of cost-effectiveness: Highly cost-effective (less than GDP per capita); Cost-effective (between one and three times GDP per capita); and Not cost-effective (more than three times GDP per capita). The negative sign means telemedicine is also cost saving. Unnecessary referrals are avoided at a cost of $453.70 less relative to the other healthcare strategy.

4.6 Marginal Cost Effectiveness Ratio (MCER)

The MCER shows changes as a result of expanding the telemedicine programme. This index is very important because of the huge initial capital expenditure involved in the telemedicine programme. Moreover, the salaries and allowances associated with the programme are not

based on the amount of services provided. Hence overall cost of the programme will not be significantly affected by increasing the number of people who have access to telemedicine.

The MCER was calculated based on 50% increase in the averted unnecessary referrals. With this assumption, expenditure items such as building. telemedicine equipment, primary health equipment and salaries and remained constant. However, all other recurrent expenditure items increased proportionately.

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Table 9: Cost of Telemedicine with 50% increase in Utilization

Item	Cost ($)
Capital	
Building	16533.79
Telemedicine Equipment	9052.61
Primary Health Equipment	6469.87
Recurrent	
Salaries & Allowance	150978.03
Drugs	37709.84
Non-Drugs	11939.67
Maintenance	9944.75
Utilities	3281.78
Airtime & Data Bundle	3083.16
Total	**248993.5**

Source: Field Data

Table 9 shows the cost of the expanded telemedicine programme. The new cost of the telemedicine programme was $248,993.5 assuming there was a 50% rise in the utilization of telemedicine services.

The formula below is used to calculate for the MCER.

$$\text{MCER} = \frac{\text{Cost of expanded telemedicine programme} - \text{Cost of original telemedicine programme}}{\text{Effect of expanded telemedicine programme} - \text{Effects of original telemedicine}}$$

Table 10: Marginal Cost Effectiveness Ratio

Healthcare strategy	Cost ($)	Effect	Net cost	Net effect	MCER
Telemedicine programme	227007.9	172	-	-	-
Expanded Telemedicine	248993.5	258	21985.6	86	255.65

Source: Field Data

The value of the MCER $255.65 compared to the ACER of $1,319.81indicates that expanding the programme utilization by 50% results in a 80.63% reduction in the cost per effectiveness gained.

4.7 Decision Analysis

Microsoft Excel 2007 was used to conduct a decision analysis and subsequent expected value calculation. The decision analysis was done to provide policy makers with facts upon which decisions could be taken relative to which intervention to implement. The expected value is calculated so uncertainties about interventions can be compared. The alternative with the highest expected value is preferred to the other alternative. The decision tree Figure 1 was constructed in MS Excel 2007. The decision node was defined as Primary Healthcare Strategies. The two healthcare strategies were the Conventional Primary Healthcare (CPHc) and Telemedicine (TM). Each strategy had one chance node with two possible events; an effective outcome or not effective outcome. Each chance node ended with a terminal node.

The cost for each terminal node equals cost per each referral avoided.

The probability for the effective outcome branch of the telemedicine strategy was 0.9 for effectiveness and 0.1 for non-effectiveness. The probabilities were selected based on the based

on the fact that the TCC was manned twenty-four by doctors and senior nurses. The probability of the branch of the Conventional strategy being was assumed to be 0.1 and not being effective 0.9 based on the doctor and nurse to patient ratio (Peacefmonline.com, 2014).

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The cost for the telemedicine terminal node was $1319.81 and that for the conventional strategy was $0.

0.1
Effectiveness

305042.9

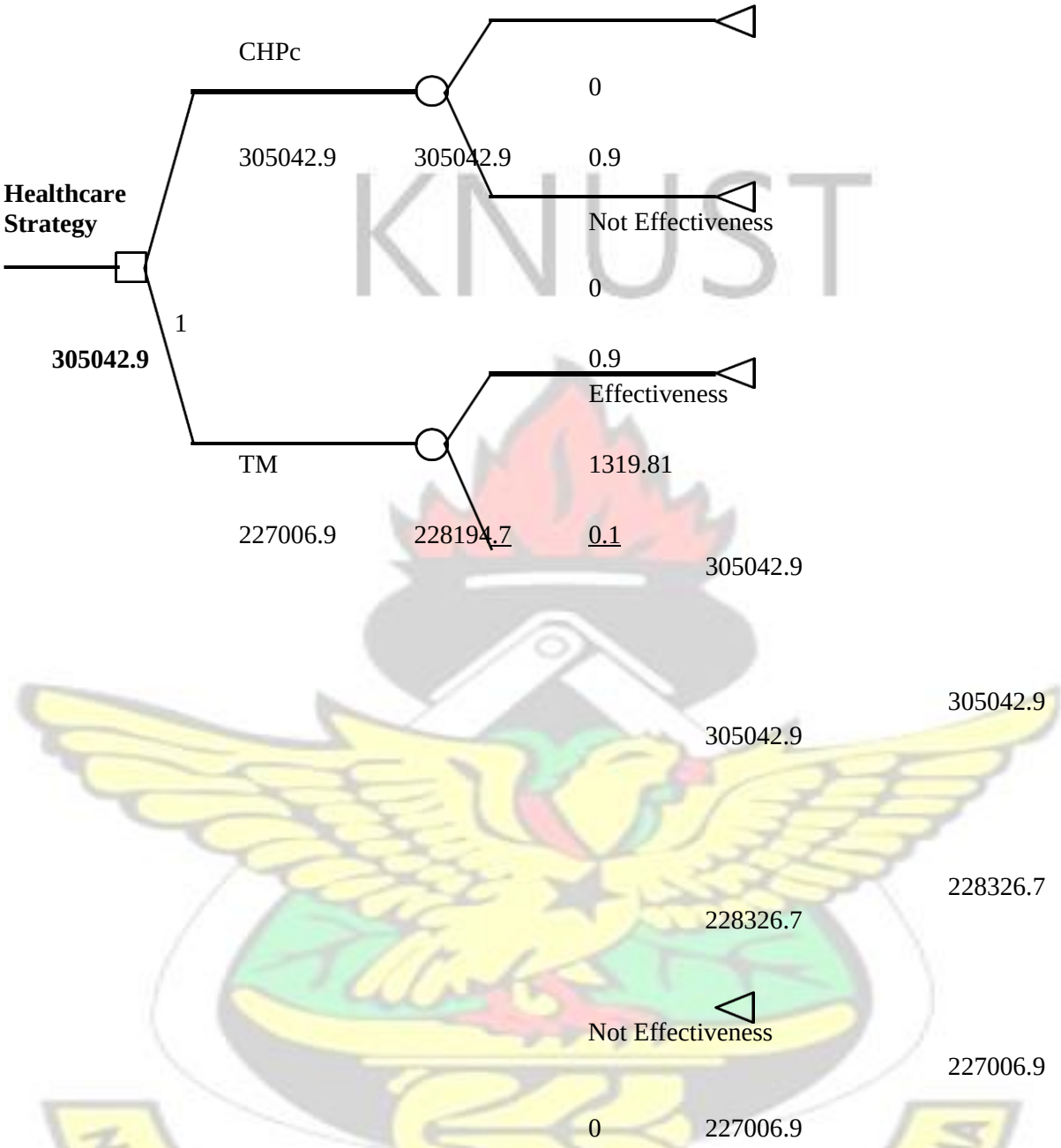

Figure 2: Decision Tree Analysis

The small square at the top left represents the decision to select among the two available primary healthcare delivery alternatives; namely TM and the CPHc. The costs for each of the two alternative strategies are shown on the branches for those alternatives. At the right of the programme costs are small circles which represent the uncertainty about whether the development outcome will be a success or a failure.

The results of the EV calculation are shown in Figure 1. Ms Excel 2007 selected conventional primary healthcare as the option providing the best utility ($3045042.93 versus $227006.9 per referral avoided). However, since our focus is on the least cost with maximum output, telemedicine would be the most preferred strategy.

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4.8 Sensitivity Analysis

This analysis was conducted to determine whether results are not sensitive to plausible changes in some parameters in the model. Microsoft Excel 2007 was used to perform a oneway sensitivity. The telemedicine decision option was tested over plausible changes in parameters; namely the effectiveness of the conventional primary healthcare and the discount rate.

4.8.1 Sensitivity Analysis with Effectiveness of Conventional Primary Healthcare

The effectivness of the conventional primary healthcare was varied over a range of 0 to 200 unnecessary referrals averted holding all other variables in the model constant. Figure 1 depicts the responsiveness of the ICER to changes in the effectiveness of the conventional primary healthcare delivery. The effectiveness of the CPHc is represented by the blue bars whereas the responses of the ICER are represented by the red bars. It can be observed from the diagram that the ICER remains both cost effective and cost saving as long as the telemedicine was more effective than the conventional method. Hoever, immediately the effectiveness of the conventional primary healthcare exceeded that of telemdicine, telemedicine became cost ineffective; holding all other variables constant.

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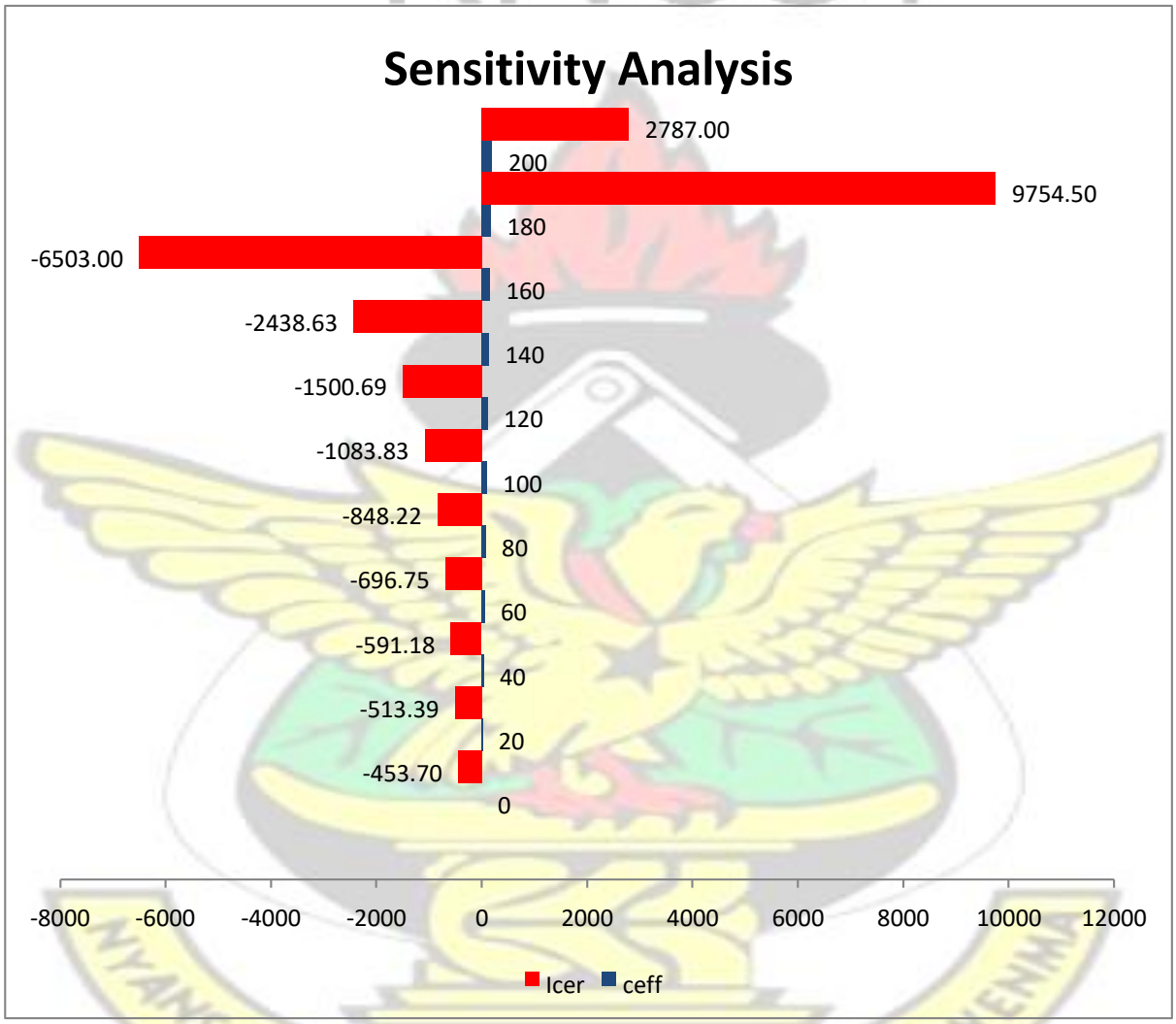

Figure 3: Sensitivity Analysis with Changes in the Effectiveness of the Conventional Primary Healthcare

4.8.2 Sensitivity Analysis with 5% Discount rate

The second paramaneter was the assumption of a new discount rate of 5%. This resulted in changes in the the total cost of both healthcare strategies. Table 11 shows increases in the changes in the discount rate from 3% to 5% caused the annualized cost of both strategies to increase to $311,346.78 and $235,058.5 for CPHc and TM respectively.

Consequently, incremental cost of the two strategies changed from the original -$453.70 to -$443.54 holding all the variables in the model constant.

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Table 11: Sensitivity Analysis with 3% and 5% Discount Rate

Item	Conventional		Telemedicine	
	3%	5%	3%	5%
Capital				
Building	13334.39	18799.67	16533.79	23310.38
Telemedicine equipment	N/A	N/A	9052.61	9740.55
Primary Health Equipment	8670.95	9509.54	6469.87	7056.94
Recurrent				
Salaries & Allowances	212,427.85	212,427.85	150978.03	168449.04
Drugs	30,628.84	30,628.84	25,139.89	25,139.89
Non-Drugs	25,109.27	25,109.27	7,959.78	7,959.78
Maintenance	10761.13	10761.13	6629.83	6629.83
Utilities	4110.50	4110.50	2187.85	2187.85
Airtime & Data Bundle	N/A	N/A	2055.44	2055.44
Total	**305042.93**	**311346.78**	**227007.90**	**235058.5**

Source: Field Data

Figure 4 graphically shows the sensitivity of the ICER to changes in the discount rate. Changes in discount rate from 3% to 5% resulted in change in incremental cost from -$76,035 to -$76,288.28. The change in discount rate is represented by the blue bar while the change in ICER is represented by the red bar.

It is evident from Figure 3 that telemedicine remains cost effecive and cost saving nothwithstanding changes in the discount rate; holding all other variables in the model constant.

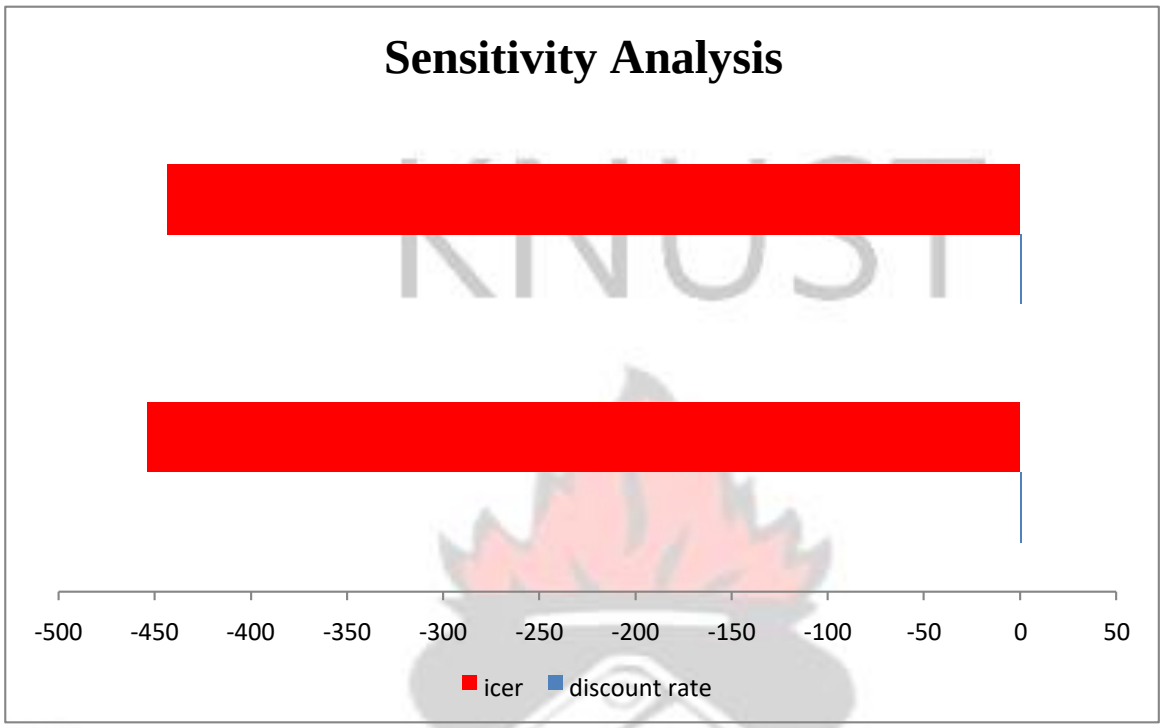

Figure 4: Sensitivity Analysis with 3% and 5% Discount rate

CHAPTER FIVE – DISCUSSION

5.0 Introduction

This chapter focuses on the findings of the study, the research objectives and the research questions relatives to previous studies conducted. The two main variables studied were the cost and effectiveness of two alternative primary healthcare delivery strategies.

5.1 Cost of Conventional Primary Healthcare

Variable cost accounted for the greater portion of the total annualized cost. It was found that the overall variable cost constituted 92.79% of the total annualized cost. This is comparable to the cost of providing primary healthcare in Northern India (Anand et al., 1993). Salaries constituted 69.64% of the total annualized cost of the conventional primary healthcare; this finding highlights the significance of the healthcare staff emoluments. A similar observation

was made of about staff compensation in study carried out in Ghana. It was noted that salaries ranged between 40% and 60% of the total cost providing healthcare (Aboagye et al., 2010). Studies in Northern India have also shown salaries to represent about 62% of the total cost of providing primary healthcare (Anand et al., 1993). In another study of four health centers in Albania, salaries averaged about 80% of the total cost of primary healthcare (Fairbank, 2004). This emphasizes the need to pay particular attention to this budget item as it has the potential to destabilize the smooth delivery of healthcare.

The capital cost of the conventional primary healthcare was 7.21% of the total annualized cost of which 60.60% was incurred on buildings. This finding is comparable to what was found in Bangladesh where building was identified to be 84.6% of the capital cost of proving primary healthcare. This same study highlighted the significance of salaries and allowances in the provision of primary healthcare as that stood at 65.2% of the total recurrent cost (Hussain, 1983).

5.2 Cost of telemedicine

The total cost of telemedicine for primary health was $723,980.46 while the annualized total cost was $227,006.90. Although the total annualized cost of telemedicine is less than that of the conventional primary healthcare, the capital cost of telemedicine was twice as much as that of the conventional primary healthcare. This highlights the capital intensive nature of telemedicine as a strategy for primary healthcare delivery relative to the conventional approach (McIntosh and Cairns, 1997). Buildings constitute 51.58% and telemedicine equipment 28.24% of the annualized capital cost.

5.3 Effectiveness of conventional primary healthcare

There is significant evidence supporting the connection between PHC and better health outcomes (Macinko et al., 2003). However, this was the not the case as this study sought to measure. It was established that patients were immediately referred once their condition appeared to be above the expertise of the health professionals providing care at the community. Patients were therefore left to travel minimum distance of about 15kilometers to a maximum of 40kilometers to the referral centre. The deplorable nature of the roads coupled with limited access to means of transport and high cost of transportation in effect discourage people seeking healthcare at the referral center; thus, resort to unapproved places for care and self medication. In another study, lack of competencies among health workers regarding family focus was identified as a barrier to a successful PHC implementation (Mosquera et al., 2012). The provision of primary healthcare has sometimes been non-effective partly due to the extremely poor quality care and even in some cases no care provided by health centers; thereby forcing patients to ignore these facilities and seek care directly at referral hospitals (Gafar, 2005).

5.4 Effectiveness of telemedicine

Previous studies have been inconclusive on the cost-effectiveness of telemedicine; however, no study has shown it worsens health outcome. This study suggests telemedicine has likely positive consequences for health outcomes. Telemedicine was successful in avoiding unnecessary referral of 172 to the St. Martin's Catholic Hospital at Agroyesum. With its inherent ability to provide care over a distance, patients are spared the inconveniences associated with travelling to seek care at a higher level facility. Hence savings even accrue to primary to clients (Bashshur, 1995). This impact helps to improve upon the efficiency of the health system as well as on the well being of the patients. This does not differ from other

telemedicine projects which have been studied (Ekeland et al., 2010). Previous studies have shown telemedicine improve health outcomes (Pyne et al., 2010).

5.5 Cost effectiveness of telemedicine

The results of the study show that telemedicine is cost effective and cost saving with an ICER of -$453.70 per unnecessary referral avoided. However, the cost-effectiveness or otherwise of telemedicine depend on several interdependent factors. The most crucial is the measure of effectiveness, but also the prices of equipment, the cost of the alternative method and the assumptions (Dzedzelava and Bergmo, 1996). This assertion was confirmed by the one-way sensitivity analysis which was performed for two parameters in the model. It was revealed that improvement in the effectiveness of the alternative strategy could impact negatively on the cost-effectiveness of telemedicine with an ICER of $2160.72 holding other variables constant. On the contrary, changes in the discount rate from 3% to 5% does not affect the cost-ineffectiveness of telemedicine but only changes the ICER from -$453.70 to -$443.54.

The MCER of $ 293.27shows that increased utilization of telemedicine services reduces the cost per effect by 16.62%. This calls the need for more education of patient on the telemedicine services taking cognizance of the potential influence of prevailing societal culture. A study revealed that patient perception of high sense of privacy and personal control is associated with telemedicine services, hence their patronage (Hailey, 2005).

However, in case of non-utilization of services, the cost of telemedicine equipment which is 28.23% will be sunk cost.

CHAPTER SIX- CONCLUSION AND RECOMMENDATIONS

6.0 Introduction

This chapter summarizes the main thrust and key findings of the study. It also presents recommendations to be considered by appropriate authorities.

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6.1 Conclusion

6.1.1 Cost of Healthcare strategies

The total cost of delivering primary healthcare through telemedicine is greater than the conventional approach; however when the capital costs of the two approaches are annualized, the conventional approach rather becomes very expensive compared to the telemedicine strategy.

6.1.2 Effects of healthcare strategies The study proved telemedicine to be more effective relative to the conventional approach in terms of averting unnecessary referrals of patients to the District Hospital, St. Martin's Catholic Hospital.

6.1.3 Cost-Effectiveness of Telemedicine

This cost-effectiveness analysis was designed to evaluate the expected benefits of the initial pilot of the telemedicine programme for primary healthcare delivery in the Amansie-West District.

Our results using Decision analysis and sensitivity analysis in MS Excel 2007 showed the telemedicine strategy achieved higher outcomes in terms of the unnecessary referrals avoided. Unnecessary referral was avoided at lower cost compared with the conventional primary healthcare strategy. All sensitivity analysis threshold results, with the exception of the effectiveness of the conventional primary healthcare and also the MCER, were less than the original model value. These results imply that the model was robust and therefore accurate.

In addition, the follow-up one-way sensitivity analyses showed one important factor influenced the choice of strategies: the number unnecessary referrals avoided through the conventional strategy. This factor might be used to determine whether a telemedicine programme is effective in a particular setting.

Although this study could not quantify the clinical effectiveness of telemedicine in terms of morbidity and mortality, telemedicine has shown to be useful in terms accessibility to healthcare and patient management. This is suggestive that telemedicine could have indirect influence on quality of care improvement and patient satisfaction.

Studies on telemedicine have most often been disease specific but this project could not perform similar because first the telemedicine programme was target at particular health condition; but rather for comprehensive primary healthcare. Secondly, we could not identify well-stratified reports for cases seen via teleconsultation and this is partly due to the original design of the programme.

There are several limitations inherent in our study. First, not all data we required were available in the published literature, especially for the detailed cost on both the telemedicine and the conventional primary health care. Secondly, the perspective used for the costing could be broadened to include patients and the society at large in future studies

Poverty, poor road infrastructure and inadequate health professionals and services present significant barriers to obtaining comprehensive primary for residents of Amansie West, hence rural Ghana. This cost-effectiveness analysis demonstrates telemedicine holds great promise in reducing the cost of primary health care and the tendency to seek alternative care from unauthorized institutions and individuals.

6.2 Recommendation

The numerous healthcare demands require investment of scarce resources to produce services to meet the needs of communities. The limited resources relative to the healthcare needs thus makes it imperative for necessary economic evaluation to be done to establish value for money basis as part of the decision making criteria prior to any investment.

6.2.1 The Ministry of Health (MOH)/Ghana Health Service (GHS)

It is recommended that the GHS/MOH considers scaling up the telemedicine programme to cover the entire Amansie-West District as value for money has been demonstrated by this study.

6.2.2 Millennium Villages Projects (MVP) Organization

It also recommended that the MVP organization uses the findings of this study to convince MOH/GHS and other development partners on the need for investments into telemedicine.

6.2.3 Development Partners

Development Partners such as Novartis Foundation for Sustainable Development are entreated to consider the findings of this study as evidence of value for money for their investment.

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APPENDICES

Appendix A1 – Conventional Primary Healthcare Data Collection Instrument

No	Item	Cost
1.	**Capital Cost**	
2.	Building	
3.	**Primary Healthcare Equipment**	
4.	Thermometer	
5.	Sphygmanometer	
6.	Adult weighing scale	
7.	Baby Scale	
8.	Stethoscope	
9.	**Sub-total**	
10.	Desktop Computers	
11.	Printer(3 in 1)	
12.	Bed	
13.	Tables	
14.	Baby's cot	
15.	Microscope	
16.	Trolley	
17.	Delivery beds	

18.	Benches	
19.	Veronica bucket	
20.	Gas stove	
21.	Treatment Instrument	
22.	Delivery instruments set	
23.	Bathroom scale	
24.	Vaccine Carriers	
25.	Glucometer	
26.	Autoclave	
27.	Drip Stand	
28.	Wheel Chair	
29.	Delivery boots	
30.	Generator	
31.	Dustbins	
32.	Chairs	
33.	Ceiling Fan	
34.	Lockers `	
35.	Refrigerators	
36.	Screens	
37.	Mattress	
38.	Airconditioner	
39.	Monitor	
40.	Centrifuge	
41.	Colorimeter	
42.	Poly-tank	
43.	Borehole	
44.	**Sub-total**	
45.	**Total Capital Coast**	
46.	**Variable**	
47.	**Salary**	
48.	Physician assistant	
49.	Staff Nurse	
50.	Enrolled nurse	
51.	Staff Midwife	
52.	Community health nurse	
53.	Laboratory Technician	
54.	Dispensary Assistant	
55.	Senior Ward Assistant	
56.	Ward assistant	
57.	Orderly	
58.	Security men	

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59.	Drugs	
60.	Non-Drugs	
61.	Maintenance	
62.	**Utilities**	
63.	Water	
64.	Electricity	
65.	Total Variable Cost	
66.	**Total Cost**	

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Appendix A2- Telemedicine Data Collection Instrument

No	Item	Cost
1.	**Capital Cost**	
2.	**Building**	
3.	**Telemedicine Equipment**	
4.	Tele-Consultation Equipment	
5.	Mobile Phones	
6.	Installation Cost	
7.	Furniture	
8.	Solar Backup	
9.	**Sub-total**	
10.	**Primary Healthcare Equipment**	
11.	Adult weighing scale	
12.	Thermometer	
13.	Shygmanometer	
14.	Plastic Chairs	

15.	Baby weighing scale	
16.	Stethoscope	
17.	**Sub-total**	
18.	Table	
19.	Cupboard	
20.	Drug shelve	
21.	Chair	
22.	Patient Bed	
23.	Mattress	
24.	Bench	
25.	Small & Needle bin	
26.	Stadiometer	
27.	Refridgerator	
28.	Vaccine carriers	
29.	Printer	
30.	Fan	
31.	Swivel Chair	
32.	Drip stand	
33.	Delivery bed	
34.	Baby scot	
35.	Delivery boot	
36.	Veronica bucket	
37.	Delivery instrument set	
38.	Treatment Instruments	
39.	Laminator	
40.	Screens	
41.	Autoclave	
42.	Gas stove	
43.	Wheel chair	
44.	Trolley	
45.	Couch	
46.	Cabinet	
47.	**Sub-total**	
48.	**Total Capital Cost**	
49.	**Variable**	
	Allowances	
50.	TCC Staff	
51.	Community Health Workers	
52.	E-health Administrator	
	Salaries	
53.	Senior Midwife Officer	

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54.	Community Health Nurse	
55.	Enrolled Nurse	
56.	Senior Technical officer	
57.	Security officer	
58.	Cleaner	
59.	Orderly	
60.	Drugs	
61.	Non drugs	
62.	Maintenance	
63.	Utilities @ TCC	
64.	Data Bundle	
65.	Health Staff Airtime	
66.	TCC Airtime	
67.	**Total variable cost**	
68.	**Total Cost of Telemedicine**	

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Appendix B – Ethical Approval

KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY
COLLEGE OF HEALTH SCIENCES
SCHOOL OF MEDICAL SCIENCES / KOMFO ANOKYE TEACHING HOSPITAL
COMMITTEE ON HUMAN RESEARCH, PUBLICATION AND ETHICS

Our Ref: CHRPE/AP/232/15

29th May, 2015.

Dr. Peter Agyei-Baffour
School of Public Health
College of Health Sciences
KNUST-KUMASI.

Dear Sir,

LETTER OF APPROVAL

Protocol Title: "Cost-Effectiveness Analysis of Telemedicine for Primary Healthcare in the Amansie West District, Ghana."

Proposed Site: Amansie West District, Ghana.

Sponsor: ***Principal Investigator.***

Your submission to the Committee on Human Research, Publications and Ethics on the above named protocol refers.

The Committee reviewed the following documents:

- A notification letter of 20th February, 2014 from the School of Public Health seeking permission to conduct the study in the Amansie West District (study site) which was approved.
- A Completed CHRPE Application Form.
- Research Protocol.
- Questionnaire.

The Committee has considered the ethical merit of your submission and approved the protocol. The approval is for a fixed period of one year, renewable annually thereafter. The Committee may however, suspend or withdraw ethical approval at any time if your study is found to contravene the approved protocol.

Data gathered for the study should be used for the approved purposes only. Permission should be sought from the Committee if any amendment to the protocol or use, other than submitted, is made of your research data.

The Committee should be notified of the actual start date of the project and would expect a report on your study, annually or at the close of the project, whichever one comes first. It should also be informed of any publication arising from the study.

Thank you Sir, for your application.

Yours faithfully,

Rev. Prof. John Appiah-Poku
Honorary Secretary
FOR: CHAIRMAN

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