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DEPARTMENT OF EPIDEMIOLOGY AND BIostatISTICS

KNUST

**THE USE OF MOBILE PHONES AS A BEHAVIOUR CHANGE
COMMUNICATION AND SURVEILLANCE TOOL FOR THE
PREVENTION OF MALARIA AND OTHER FEBRILE ILLNESSES
AMONG CHILDREN UNDER-FIVE AT THE ASANTE AKYIM NORTH
DISTRICT OF GHANA**

BY

ALIYU MOHAMMED

JULY, 2018

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**BY
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(MPH POPULATION AND REPRODUCTIVE HEALTH)**

**A THESIS SUBMITTED TO THE DEPARTMENT OF EPIDEMIOLOGY AND
BIOSTATISTICS, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND
TECHNOLOGY, KUMASI IN PARTIAL FULFILMENT OF THE
REQUIREMENTS FOR THE DEGREE OF
DOCTOR OF PHILOSOPHY IN PUBLIC HEALTH**

JULY, 2018

KNUST



DECLARATION

I hereby declare that except for references to other people's work which have been duly acknowledged, this work is the result of the original research work taken by me under supervision. It contains no materials previously published by another person which has been accepted for the award of any degree elsewhere.

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DATE

DEDICATION

I dedicate this thesis to my dear parents (Mohammed Abdul Wahab and Beatrice Asante), my wife (Gladys Buruwaa Aniagyie) and child (Jamal Abdul Wahab) for all the encouragement you gave me to get this thesis completed.

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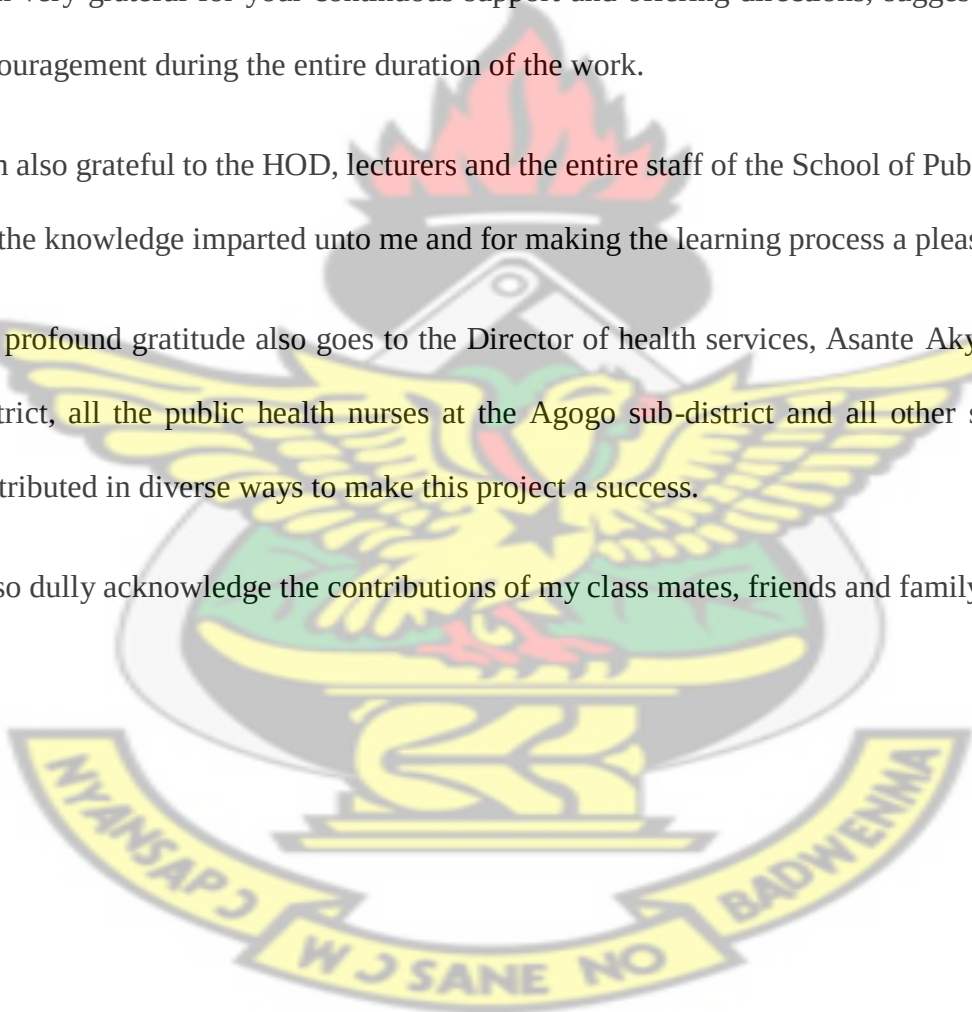
I am very grateful to the Almighty Allah for His divine grace and protection throughout my stay on KNUST campus and for the knowledge He gave me to successfully complete this programme.

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ABSTRACT

BACKGROUND: Worldwide, millions of children under-five continue to die before their fifth birthday due to preventable infectious diseases including malaria, pneumonia and diarrhoea; sub-Saharan Africa alone accounts for almost half of these deaths. The situation is not different in Ghana, where the under-five mortality rate in 2014 was reported to be 60 per 1,000 live births. Existing evidence suggests that the practice of healthy behaviours by families and communities, coupled with early diagnosis and treatment of childhood febrile illnesses could greatly accelerate reductions in under-five mortality. Mobile technology has been suggested to improve health outcomes by supporting the delivery of health services, even in the most remote and resource poor settings in developing countries. Despite its demonstrated applicability to the health sector, empirical evidence to support its usefulness as a Behaviour Change Communication (BCC) and surveillance tool is fraught with continuous scepticism.

OBJECTIVE: This study aimed to assess the effect of delivering BCC intervention via mobile phones on malaria prevalence in children under-five at the Asante Akyim North District. Additionally, the feasibility of use of mobile technology for monitoring common childhood disease symptoms was assessed.

METHODS: A Quasi-experimental nonequivalent study design was employed using a random sample of 334 caregivers with children under-five from two sub-districts of the Asante Akyim North district and assigned to either an intervention or control group. Caregivers in the intervention group received bi-weekly voice SMS on malaria for twelve months. They were also given a toll-free health line to call and report disease symptoms of their sick children during the period of the intervention. The effect of the intervention on prevalence of malaria in the children, knowledge on malaria and health behaviours of caregivers were assessed using logistic regression and nearest neighbour propensity score matching analysis to estimate the treatment effect ($ATET_{nn}$) using Stata 13. Spatial distribution of childhood malaria cases were also geo-statistically assessed using ArcGIS 10.2. The feasibility of the mobile technology for monitoring disease symptoms and providing valid data was assessed using Cohen Kappa statistics and predictive values.

RESULTS: Among children under-five whose caregivers received the intervention, malaria prevalence significantly decreased from 73.9% at baseline to 43.5% at endline

($p < 0.001$) compared with children in the control group, where a reduction of 76.1% to 58.9% ($p < 0.001$) was observed. Children whose caregivers received the intervention were significantly less likely (odds ratio [AOR] = 0.53, p -value ≤ 0.01 , 95% CI = 0.34, 0.83) to experience malaria compared with children in the control group. The spatial distribution of malaria revealed significantly high-cluster areas in the control site and low-cluster areas in the intervention site at post-intervention. The post intervention treatment effect showed a statistically significant reduction in malaria prevalence ($ATET_{nn} = -0.170$, $t_{nn} = -3.07$, 95% CI = -0.28, -0.03) compared to the baseline estimate ($ATET_{nn} = -0.02$, $t_{nn} = -0.26$, 95% CI = -0.14, 0.09). Receiving the intervention significantly improved the knowledge (odds ratio [AOR] = 1.81, 95% CI = 1.09, 2.99) and health behaviours: attitude (odds ratio [AOR] = 2.58, p -value ≤ 0.001 , 95% CI = 1.61, 4.15) and behaviour (odds ratio [AOR] = 2.03, p -value ≤ 0.01 , 95% CI = 1.29, 3.19) of caregivers in the intervention group compared with caregivers in the control group. Additionally, with the aid of the mobile phone technology, based on phone calls from caregivers, a total of 52 potential childhood cases were identified. Common symptoms reported included fever (46.0%, $n=24$), cough (52.1%, $n=25$), diarrhoea (40.0%, $n=18$) and vomiting (39.2%, $n=20$). An assessment of the validity of the symptom reports between the mobile technology and that of clinician's revealed the highest agreement for fever (percentage agreement, 84.9%, $\kappa=0.70$, $p < 0.001$, sensitivity=86.7%, NPV=88.2%), good agreement for diarrhoea (percentage agreement, 74.2%, $\kappa=0.44$, $p < 0.007$, sensitivity=70.0%, NPV=84.2%) and vomiting (percentage agreement, 73.7%, $\kappa=0.46$, $p < 0.002$, sensitivity=68.8%, NPV=77.3%), with cough showing a fair agreement (percentage agreement, 67.7%, $\kappa=0.37$, $p < 0.0129$, sensitivity=80.0%, NPV=78.6%).

CONCLUSION: The findings of the study provide support for using mobile phone technology as a BCC tool for disseminating health messages to caregivers in a bid to reduce malaria incidence and mortality in children under-five, and monitoring symptoms of childhood illnesses. Further research could assess the cost-benefit of implementing this intervention on a larger scale.

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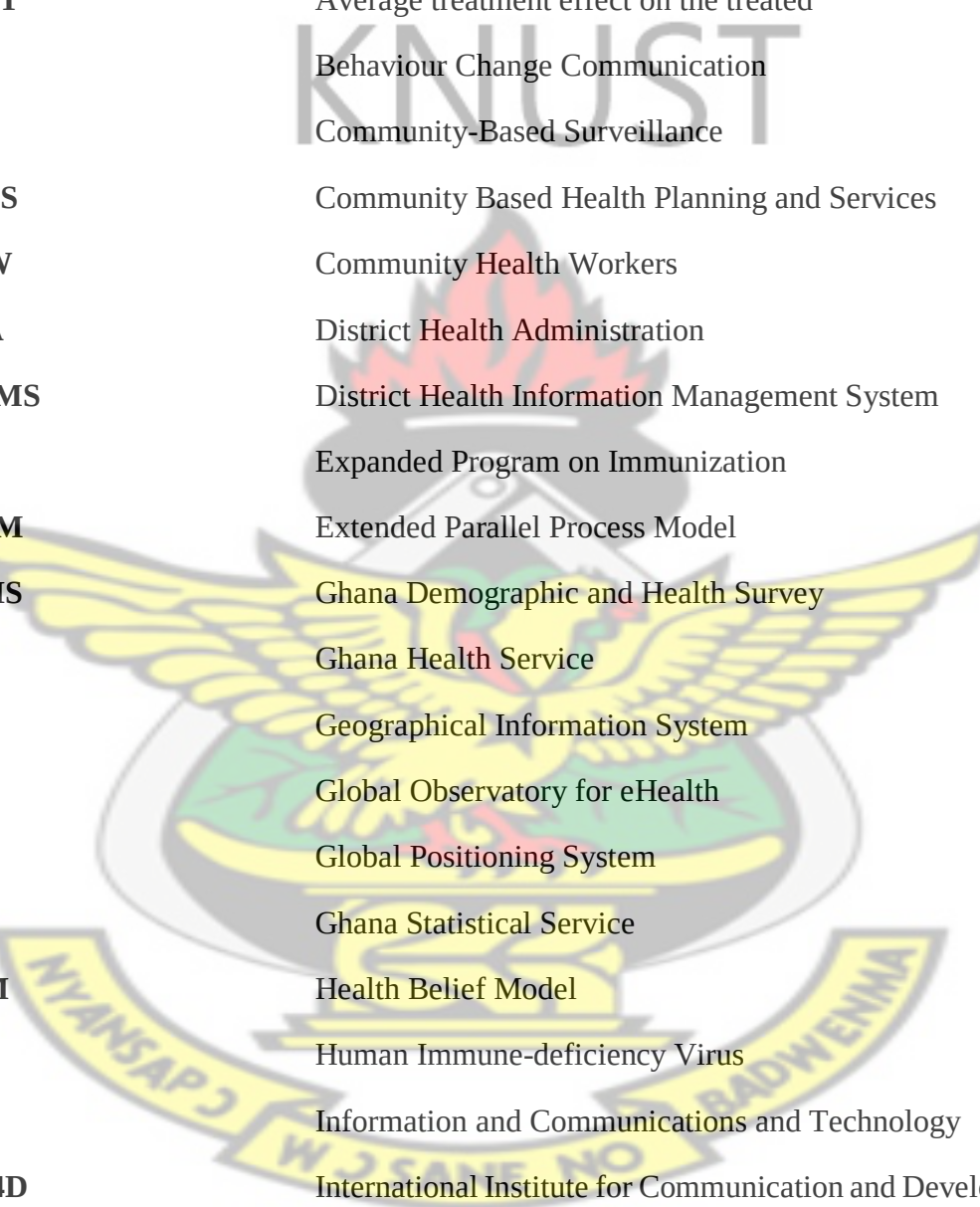
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ABBREVIATIONS/ACRONYMS



ACT	Artemisinin-based Combination Therapy
AIDS	Acquired Immune-Deficiency Syndrome
ANC	Antenatal Care
ATET	Average treatment effect on the treated
BCC	Behaviour Change Communication
CBS	Community-Based Surveillance
CHPS	Community Based Health Planning and Services
CHW	Community Health Workers
DHA	District Health Administration
DHIMS	District Health Information Management System
EPI	Expanded Program on Immunization
EPPM	Extended Parallel Process Model
GDHS	Ghana Demographic and Health Survey
GHS	Ghana Health Service
GIS	Geographical Information System
GOe	Global Observatory for eHealth
GPS	Global Positioning System
GSS	Ghana Statistical Service
HBM	Health Belief Model
HIV	Human Immune-deficiency Virus
ICT	Information and Communications and Technology
ICT4D	International Institute for Communication and Development for Accelerated Development
IDSr	Integrated Disease Surveillance and Response
IDW	Inverse Distance Weighting
IICD	International Institute for Communication and Development

IMCI	Integrated Management of Childhood Illness
ITN	Insecticide-treated nets
IVR	Interactive Voice Response
LISA	Local Indicators of Spatial Association
MDG	Millennium Development Goal
mHealth	Mobile Health
mHISS	Mobile phone-based Health Information and Surveillance System
MIS	Malaria Indicator Survey
MoH	Ministry of Health
NMCP	National Malaria Control Programme
NGO	Non-Governmental Organisation
NPV	Negative Predictive Value
ODK	Open Data Kit
PPV	Positive Predictive Value
PSM	Propensity Score Matching
QOL	Quality of Life
RBM	Roll Back Malaria
RDT	Rapid Diagnostic Test
SDG	Sustainable Development Goal
SMS	Short Message Service
SSA	Sub-Saharan Africa
U5MR	Under-five Mortality Rate
UNFPA	United Nations Population Fund
UNICEF	United Nations Children's Fund
VHF	Viral Hemorrhagic Fevers
WHO	World Health Organisation

CHAPTER ONE

1.0 INTRODUCTION

1.1 OVERVIEW

Child mortality and morbidity are vastly higher in low income countries and represent a source of global health inequality. Thus, improving the health of children has been a continuing goal of national health programmes in many developing countries. Though child survival had been a focus of the public health community for over the last two decades, it is still relevant and deeply rooted in national health agendas of developing countries like Ghana.

With the current global need of providing evidence of mobile Health (mHealth) impact on health outcomes, this study primarily examines the use of a mobile phone-based technology as a Behaviour Change Communication (BCC) tool for improving health behaviours of caregivers of children under-five, with the aim of reducing malaria prevalence in children under-five years. The study also sought to establish and provide evidence on the surveillance potential of mHealth technology, known as the Mobile phone-based Health Information and Surveillance System (mHISS) by assessing its feasibility for monitoring the pattern and distribution of disease symptoms of children, in line with the Integrated Disease Surveillance and Response (IDSR) strategy.

This chapter has seven major sections beside the overview (Section 1.1). Section 1.2 and 1.3 introduces the background and discusses the problem of child mortality and morbidity in the context of global, sub-Saharan Africa, Ghana. The subsections discuss the need for behaviour change communication (BCC) and introduce the concept of electronic health (eHealth) and mobile health (mHealth). The core functionality of mHISS is briefly described in this section. The problem statement and study rationale, which gives an

account of the magnitude of the problem and the relevance of the study are discussed in sections 1.3 and 1.4, respectively. Section 1.5 introduces the conceptual framework which describes the most discussed behavioural and child survival models, and their relevance to the current study. Collectively, a proposed theoretical guideline for the study is described and used as a guide. The research questions and objectives are provided in sections 1.6 and 1.7, respectively. The profile of the study area is also provided in section 1.8.

1.2 BACKGROUND

Worldwide, millions of children under-five continue to die before their fifth birthday, with almost all of such deaths occurring in developing countries; sub-Saharan Africa alone accounts for almost half of these deaths (Black et al., 2003; Boerma et al., 2015; The Bellagio Study Group on Child, 2003; UNICEF., 2009). In sub-Saharan Africa, under-five mortality was estimated to be above 150/1000, with malaria and pneumonia contributing 20–26% of the total under-five mortality in malaria endemic countries like Ghana (Black et al., 2003). In 2013, a global estimate of 6.3 million liveborn children worldwide died before the age of 5 years (Liu et al., 2015), showing a decreased in the number from 9.9 million in 2000. This reflects the efforts that countries put in to improve child survival. However, the current estimate still reveals a staggering global under-five mortality rate (U5MR) of 43 per 1000 live births in 2015 (5.9 million children under-five deaths), declining by 53% between 1990 and 2015 (WHO, 2015a). Moreover, the African Region alone accounted for 47% of these deaths (WHO, 2015a). According to the WHO and the Maternal and Child Epidemiology Estimation (WHO-MCEE) Group, about half of the 5.9 million deaths that occurred in 2015 were caused by preventable infectious diseases and conditions such as pneumonia, diarrhoea, malaria, meningitis, tetanus, HIV and measles (WHO, 2015a). Malaria alone, accounted for about 5% of all deaths in children under-five (WHO, 2015a). With little variation in the 2015 WHO-MCEE estimates, Liu and

colleagues (2013) revealed that 51.8% of children under-five (3.257 million out of the 6.3 million under-five deaths) died of infectious causes. Pneumonia was responsible for 14.9%, followed by diarrhoea (9.2%) and malaria (7.3%) of the total deaths in children younger than 5 years (Liu et al., 2015). Nevertheless, between the period of 1990 and 2015, a substantial decline in U5MR was observed in the Western Pacific Region (74%), with the African (54%) and the Eastern Mediterranean Region (48%) recording the smallest declines (WHO, 2015a).

In spite of global progress in reducing child mortality, with the Millennium Development Goal (MDG) 4 not fully achieved, a more sustainable goal was essential to continue the unfinished agenda of ending preventable child death. A comprehensive set of targets which sought to address the health and well-being of women, children and adolescents was adopted under the Sustainable Development Goals (SDGs) (WHO, 2015a). The SDG 3.2 seeks to end preventable deaths of newborns and children under five, with national target of no more than 25 deaths per 1000 live births for U5MR. However, in order to achieve this target of under-five deaths of 25 or fewer deaths per 1,000 live births by the year 2030, 47 countries need to intensify their progress. A total of 30 countries, among these must at least increase their current rate of reduction by twofold, while 11 of the 30 countries must at least increase their current rate of reduction by threefold (UNICEF, 2015).

1.2.1 Global efforts at improving child survival

Over the past years, organisations such as the World Health Organization (WHO), United Nations Development Programme (UNFPA), United Nations International Children's Emergency Fund (UNICEF), the Global Alliance for Vaccines and Immunization, Inter-agency Group for Child Mortality Estimation, the Malaria Monitoring and Evaluation Reference Group, the Alma-Ata Working Group and others have worked individually or collectively to reduce the global burden of child mortality. Universal coverage of 23

interventions including breastfeeding, Insecticide Treated Materials (ITMs), complementary feeding, water, sanitation and hygiene, Oral Rehydration Therapy (ORT), antibiotics for pneumonia among others were put forward to prevent many deaths in children under five. It was revealed that effective implementation of the 23 interventions could reduce child mortality by 66% if they reached universal coverage (Bhutta et al., 2008; Boschi-Pinto et al., 2009; Jones et al., 2003). More so, in 2013, an Evidence Summit was also organized in Washington, DC by the United States Agency for International Development (USAID), in collaboration with UNICEF and other partners in June 2013, on Enhancing Child Survival and Development in Lower- and Middle-Income Countries by Achieving Population-Level Behaviour Change. Central to the goal of the summit was to identify evidence-based interventions to change caregivers' behaviours of populations in lower- and middle-income countries in order to reduce morbidity and mortality in children under the age of five years (Fox and Obregón, 2014; Pablos-Méndez and Fox, 2012).

In spite of these initiatives, a host of factors such as lack of access to health care, adequate sanitation and safe water as well as poverty and inadequate child protection, have mostly impeded a child's survival chances, in some cases affecting his or her physical, emotional, social, and intellectual progress (Ahmad et al., 2000; Bryce, 2002). Malaria is one of the major contributors of child death and continues to pose enormous threat to the survival of children less than five years, especially in developing countries. The current global estimate of malaria deaths in children under five years revealed a reduction from 723,000 in 2000 to 306,000 in 2015 (WHO, 2016). The WHO African Region recorded the bulk of this decrease, with the estimated number of deaths falling from 694,000 in 2000 to 292,000 in 2015 (WHO, 2016). As a result, malaria ceased to be the leading cause of death among children in sub-Saharan Africa. However, in the same year, malaria was found to be the

fourth highest cause of death, accounting for 10% of child deaths in sub-Saharan Africa (WHO, 2016). Nonetheless, malaria still remains a major contributor of child death, particularly in sub-Saharan Africa, taking the life of a child every 2 minutes, making it the fourth highest cause of death, accounting for 10% of child deaths in sub-Saharan Africa (WHO, 2016).

1.2.2 Child survival in Ghana

According to the 2014 Ghana Demographic and Health Survey report (GDHS), Ghana's under-five mortality rate is 60 per 1,000 live births (GSS et al., 2015). These deaths are caused by easily manageable or preventable diseases such as malaria, pneumonia, measles, diarrhoeal diseases (or a combination of such diseases) with malnutrition playing a substantial role in under-five mortality burden. Hence, as part of the efforts to control malaria in the country, Ghana adopted the Roll Back Malaria (RBM) Initiative in 1999 to implement a combination of curative and preventive interventions. With a major focus particularly on pregnant women and children under-five, the initiative provided insecticide-treated mosquito nets (ITNs) and prompt, effective treatment for malaria. In spite of these initiatives, malaria continues to pose a major threat to the health of children in many developing countries like Ghana (WHO, 2016). There is, however, a good chance of survival if appropriate medical intervention is provided in a timely manner. Empirical evidence demonstrates that a set of inexpensive essential interventions can prevent the most of under-five deaths. But these interventions still do not have the necessary reach and quality, especially in resource-constrained settings (UNICEF, 2013).

It is well established that most children who experience febrile illnesses in malaria endemic areas do not have access to primary healthcare facilities (Deressa et al., 2007). It is also known that less than 20% of children with febrile episodes visit health facilities (Bremam, 2001). Earlier surveys such as that conducted by McCombie (1996) have shown

that by the time most febrile patients reach health care facilities, several days had elapsed since the onset of the symptoms and the likelihood of the disease to progress to severe form was very high. As most malaria associated deaths among children occur within 2–3 days of the onset of illness (Greenwood et al., 1987) and at home without receiving appropriate medical care (Mwenesi, 2005), early diagnosis and prompt treatment is critical in reducing mortality. Focus on bringing community-based interventions, such as the administration of anti-malarial drugs, closer to home and at village levels to all febrile children living in malaria endemic areas had been the main strategy to reduce malaria burden among children (WHO, 2005a).

However, prompt diagnosis and treatment of febrile illnesses among children under-five is usually undermined by inadequate knowledge about condition of the child and poor health seeking behaviours among caregivers. A study conducted by Combs and colleagues (2012) attributed the underlying causes of poor health among children to limited availability of timely and reliable health information for decision-making and poor access to and use of health facilities. This clearly suggests that knowledge about the condition of the child and behaviour change play a pivotal role in improving healthcare access and child survival.

1.2.3 Behaviour Change Communication

In order to prevent early childhood death and improve survival, caregivers must change their behaviour. The practice of healthy behaviours by families and communities (e.g., using oral rehydration, completing vaccinations, spacing pregnancies, breast feeding, and handwashing) could intensely accelerate reductions in under-5 mortality (Black et al., 2003; Lozano et al., 2011; Rajaratnam et al., 2010).

Behaviour Change Communication (BCC) intervention, which involves the strategic use of communication to promote positive health outcomes based on proven theories and

models of behaviour change, plays an integral role in relishing good health seeking behaviours among caregivers. Behaviour Change Communication is defined as any intervention with individuals or communities to develop communication strategies to promote positive behaviours appropriate to their settings to provide a supportive environment enabling people to initiate and sustain the desired behaviours, such as sleeping under insecticide- treated bed nets (ITN) (Mendis, 2012). Previously known as Information-Education-Communication (IEC), BCC programmes are designed to bring about behaviours that will improve health status. The programme involves the use of wide range interventions that fall into three main categories: Mass media (television, radio, the internet, print material); Interpersonal communication (client-provider interaction, group presentations); and Community mobilization.

Strong evidence suggests that BCC programmes can improve malaria prevention. Evidence-based and theory-driven BCC interventions form a key part of all types of health promotion and disease prevention. It has been revealed with consistency that BCC programmes significantly improve health behaviours, particularly in the areas of family planning and HIV prevention (Bertrand et al., 2006; Wakefield et al., 2010), hygiene and sanitation (Curtis et al., 2001; Scott et al., 2007) as well as nutrition (Bhutta et al., 2008). A study conducted by Bowen (2013) using propensity score matching from cross-sectional dataset revealed a 10-15 percentage points higher net use among those exposed to malaria messages. Evidence gathered from a study by Witte and Allen (2000) further suggests that high threat and high efficacy messages generally produce the most positive impact on behaviours, whereas low threat, low efficacy messages produce the least positive impact on behaviours (Witte and Allen, 2000).

Most often, mass media campaigns that seek to promote health behaviour change uses threat or fear appeal tactics (Wong, 2009). Threat appeals are often used in social marketing campaigns to notify people about a potential health risk and to persuade them into curtailing undesired behaviours (Henley et al., 2002; Roskos-Ewoldsen et al., 2004). By describing the negative consequences of certain risk actions, e.g., lung cancer for smokers, social marketers aim to scare people into doing what the message prescribes (Witte, 1992a). For example, studies have shown that for malaria specifically, exposure to messages, perception of risk, self-efficacy, response efficacy, and knowledge of malaria transmission and symptoms are associated with preventive behaviours (Atkinson et al., 2009; Lover et al., 2011; Macintyre et al., 2006; Panter-Brick et al., 2006). This therefore strengthens the need to pragmatically device interventions that are geared towards promoting healthy behaviours among caregivers.

In the meantime, a common goal among global initiatives is to successfully deliver interventions at scale through continued global and local engagement, especially through innovative approaches that hold great potential for accelerating progress. This appears particularly vital as the world now moves from the era of the Millennium Development Goals (MDGs) to the achievement of Sustainable Development Goals (SDGs) (WHO, 2015a). The health sector therefore require timely and reliable information for planning and evaluating interventions, particularly as the world move into an era where information and communication technologies (ICT) play a vital role in the healthcare provision (Bashshur et al., 2009; Gagnon et al., 2013, 2012).

1.2.4 Electronic Health

Electronic Health (eHealth) holds the potential to improve several challenges that plague healthcare systems by supporting coordinated and evidence-based care, facilitating community based health services and enabling individuals to access health information

and support. As such, eHealth has attracted considerable attention as a potential health information and surveillance tool for the control of childhood illnesses in developing countries and research to assess its impact on child health outcomes is on the ascendency. Information and communication technologies (ICTs) are used in healthcare systems to support clinical care, provide the general public with health information and the health professionals with scientific information. They also assist with administrative functions; provide a platform for publishing and health alert dissemination (Ganapathy, 2007).

Numerous definitions of eHealth have been put forward. However, WHO defines eHealth, simply as the use of ICTs for health. In a broader context, WHO defines eHealth as the cost-effective and secure use of ICT in support of health and health related fields, including health care services, health surveillance, health literature, health education, knowledge and research. The four major components of eHealth include Mobile Health (mHealth), Health Information Systems (HIS), Telemedicine and Distance Learning (eLearning) (WHO, 2006a). The World Health Organization's strategy on eHealth focuses on strengthening health systems in countries; fostering public-private partnerships in ICT research and development for health; supporting capacity building for eHealth application in Member States; and development and use of norms and standards (WHO, 2006a).

1.2.4.1 The Global state of Electronic Health

Recognizing the rapid transformation of eHealth in the delivery of health services and systems around the world, in May 2005, the Resolution WHA58.28 was adopted by the World Health Assembly; which establishes an eHealth strategy for WHO. The decision urged Member States to plan for appropriate eHealth services in their countries. The World Health Organization in the same year launched the Global Observatory for eHealth (GOe), an initiative dedicated to the study of eHealth. The Observatory's mission is to improve health by providing Member States with strategic information and guidance on effective

practices and standards in eHealth. Assessing the state of eHealth in 112 countries, which focused on the processes and outcomes in key eHealth action lines previously identified by the World Summit for the Information Society (WSIS), the Observatory revealed that countries in the high- and upper-middle income groups are more advanced in their eHealth development than those in the lower-middle and low-income groups (WHO, 2006a). Providing an overview of governance bodies in eHealth, the survey revealed that roughly one in two countries reported to have some mechanisms in place. The Western Pacific and European Regions are more developed in this area with between 70% and 80% of responding countries having established mechanisms. The African and Eastern Mediterranean Regions recorded the lowest number of established eHealth governance mechanisms - 40% and 50%, respectively (WHO, 2006a).

The eHealth community according to the report needs to examine how ICT can be used to improve efficiencies in the delivery of basic health services; and to prevent eHealth from being driven by “technology push” rather than by needs-based and evidence-led “technology pull” (WHO, 2006a). Possibly the difficulty is to provide evidence that eHealth can improve health system performance and access to knowledge, support decision-making and lead to better outcomes for patients.

1.2.4.2 Mobile Health

Rapid advances in mobile technologies and applications offer a revolutionary opportunity to transform and strengthen health service delivery across the globe. The widespread use of mobile phones offers a solution that could aid in overcoming the weaknesses in delivering health messages, potentially leading to enhanced delivery of health services and better health outcomes (Zurovac et al., 2012). The use of mobile and wireless technologies to support the achievement of health objectives has risen in recent times, with the growth in coverage of mobile cellular networks continuing to increase. According to the

International Telecommunication Union (ITU), there are over 5 billion wireless subscribers, with over 70% of them residing in low and middle income countries (WHO, 2011a).

Mobile Health, according to the GOe, is the practice of medical and public health supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices (WHO, 2011a). It involves the use and capitalization on a mobile phone's core utility of voice and short messaging service (SMS) as well as more complex functionalities and applications including general packet radio service (GPRS), global positioning system (GPS), and Bluetooth technology.

In 2009, Global Observatory for eHealth sought to determine the status of mHealth in Member States. The survey reported on four major aspects of mHealth: adoption of initiatives, types of initiatives, status of evaluation, and barriers to implementation. Categories such as health call centres, patient monitoring, mobile patient records, emergency toll-free telephone services, surveillance, managing emergencies and disasters, mobile telemedicine, appointment reminders, community mobilization and health promotion, treatment compliance, information access, health surveys and data collection, health awareness raising and decision support systems were surveyed. The survey revealed an upsurge of mHealth activity. The majority of Member States (83%) reported offering at least one type of mHealth service. The four most frequently reported mHealth initiatives were: health call centres (59%), emergency toll-free telephone services (55%), managing emergencies and disasters (54%), and mobile telemedicine (49%) (WHO, 2011a).

Consistent with the 2005 eHealth trends, higher-income countries showed more mHealth activity than lower-income countries. Countries in the European Region are currently the most active and those in the African Region the least active. Mobile health is most easily

incorporated into processes and services which historically use voice communication through conventional telephone networks. The least frequently seen was the use of mHealth in surveillance, raising public awareness and decision support systems. Not surprising, these require enhanced capabilities and infrastructure to implement, and therefore may not have been priority for financially challenged countries like Ghana (WHO, 2011a).

1.2.1.3 Mobile Health and disease surveillance

Despite the potential of mHealth in improving health system, its use as a surveillance tool is still met with sheer uncertainty. Disease-specific programmes continue to implement their own separate surveillance systems thus leading to a proliferation of indicators and laborious reporting requirements as well as unacceptable extra administrative burden on health staff (Chen et al., 2004). As a potential solution, the World Health Organization Regional Office for Africa (WHO-AFRO) in 1998, initiated a strategy for overall strengthening of disease surveillance in sub-Saharan Africa called Integrated Disease Surveillance and Response (IDSR). The primary goals of the IDSR strategy were the integration of multiple existing vertical surveillance systems and linking surveillance data to public health action (Kaboré et al., 2001).

In spite of this, the health system in Ghana faced major outbreaks of cholera, yellow fever and meningococcal meningitis during the 1990s (CDC-UNF, 2003). As a result, the National Surveillance Unit (NSU) was created in 1998 to coordinate communicable diseases surveillance. In 2002, Ghana adopted and implemented the first IDSR technical guidelines. This guideline, initiated by the World Health Organization Regional Office for Africa (WHO-AFRO), was proposed to provide a solution to the proliferation of indicators and arduous reporting of surveillance systems which usually put extra administrative

burden on health staff (Chen et al., 2004). However, the increased number of diseases reflects the added requirements of the International Health Regulations (IHR 2005), which required Member States to strengthen their existing capacity for disease surveillance and response using the IDSR strategy (Kasolo et al., 2013). Weak health systems with inadequate infrastructure may not be effective in monitoring diseases (Adokiya et al., 2015). More recently, Ghana introduced a web-based electronic system known as the District Health Information Management System II (DHIMS2) with an overall goal of reducing the reporting burden and to improve data quality and reliability (Mutale et al., 2013). However, since its inception, the system has not been widely implemented especially at the lower levels of the healthcare system.

Recognising the rapid advancement and the potential of mobile technology as a surveillance tool, the GOE conducted a survey to determine the global status of mHealth activities. Completed by 114 Member States, the result of the survey revealed higher mHealth surveillance activity in Africa and South-East Asia compared with other continents. The mHealth surveillance activity was more prevalent in countries in the low-income (40%) and lower-middle income groups (27%) than those in the higher-income groups. The African and South-East Asia Regions recorded the highest percentages for surveillance initiatives (41% and 38%, respectively) (WHO, 2011a). Following the analysis of the survey results by the GOE, WHO provided recommended steps Member States have to take to capitalize on the potential of ICTs. One major step was the creation of national agencies to coordinate eHealth initiatives, ensuring they are appropriate to local contexts, cost-effective, consistently evaluated, and adequately funded as part of integrated health service delivery.

In Ghana, although the number of mobile phone users exceeds 27 million, covering both urban and remote regions (National Communications Authority, 2016), the use of mobile technology in the health sector has not received the necessary attention. Although the ICT policy was formulated in July 2005 to reduce the inequalities between the rural and urban centres in accessing healthcare services and the digital health divide (Alemna and Sam, 2006; Dzidonu, 2003), implementation strategies has not been adequate. In July 2010, a National eHealth Strategy was launch by the government of Ghana to exploit the benefits of information technology for the health sector. It had three main components; streamlining the regulatory framework for health data and information management, building the capacity of the health sector for wider applications to provide eHealth solution in the health sector, improving access and bridging equity gap in the health sector through the use of information and telecommunication technology and move towards paperless records and reporting systems (Afagbedzi et al., 2013).

Hence, in order to provide empirical evidence and inform policy about the relevance of mHealth to the health sector, the current study employed two basic eHealth components (mobile phones and an Interactive Voice Response (IVR) system). Using these components, a Mobile phone-based Health Information and Surveillance System (mHISS) was established by a group of medical, public health and mHealth experts from Ghana, Netherlands and Germany, in collaboration with the Ghana Health Service, to provide valuable health information via mobile phones to caregivers independent of time and geography, given mobile network availability. The system, which is web-based has an IVR component which provides an opportunity for delivering health messages on malaria (Short Message Service (SMS)) to caregivers and for monitoring disease symptoms of children less than five years – the former, to improve health behaviours of caregivers and the latter, for identifying spatio-temporal development of childhood disease symptoms.

The system is automated, based on a clinical algorithm, so that after answering a set of questions, data on current disease symptoms and geo-location are gathered, while recommending steps to be taken by its users. The number and type of such requests from a distinct area and time allows for the derivation of continuous data on fluctuations of health parameters and to display real-time spatio-temporal developments on a disease map. The system therefore provides an automated real-time syndrome-specific surveillance and early alerting system as shown in Figure 1.1. Ultimately, this study reports on how the mHealth system can be deployed to improve caregiver knowledge about the causes and prevention of malaria, influence their health behaviours, prevent malaria in children under five, and monitor disease symptoms of children.

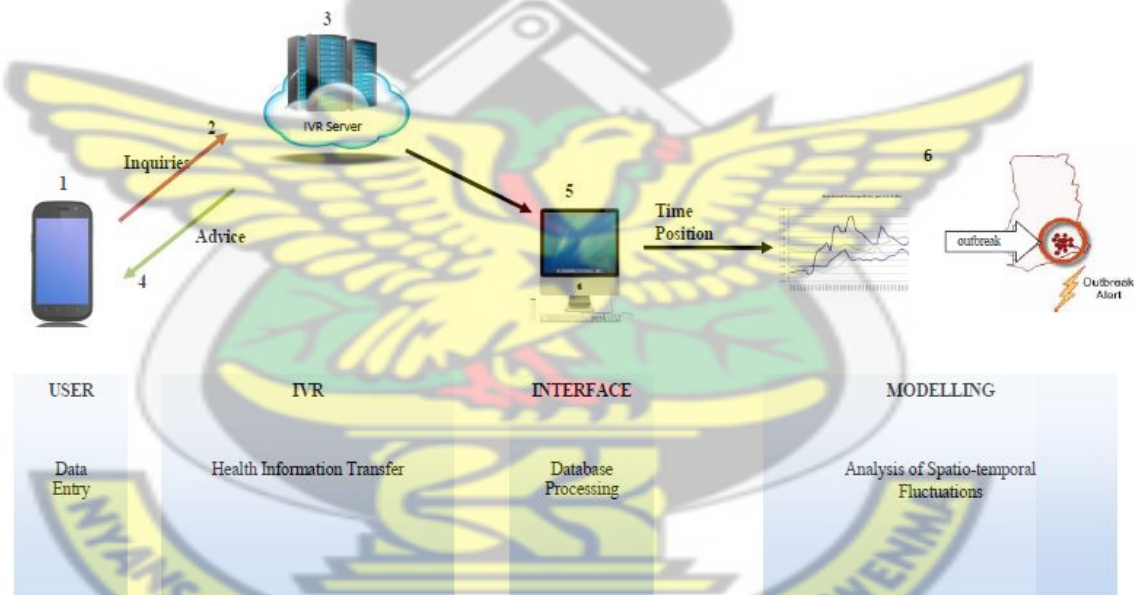


Figure 1.1: eHealth Information Transfer and Surveillance System Setup

1.3 PROBLEM STATEMENT

Despite the global concerted effort to achieve the target of reducing under-five deaths by 25 per 1,000 livebirths as indicated in the Sustainable Development Goals (SDGs) report, children under-five continue to die from preventable diseases (WHO, 2015a).

Although considerable progress has been made in the past two decades towards achieving the MDG 4, there still remains a gap between aspirations and desired results, though the number of under-five deaths worldwide declined from nearly 12.7 million in 1990 to 5.9 million in 2015 (You et al., 2015). Pneumonia and malaria continue to contribute to the burden of morbidity and mortality in children under-five in sub-Saharan Africa (Black et al., 2010; Kinney et al., 2010). In Ghana, malaria is known to be among the most common cause of death in children under-five years, accounting for about 61% of hospital admissions of children under five years and an estimated 25% of under-five mortality (UNICEF, 2007).

Policies to control malaria emphasize prompt and appropriate treatment including the Integrated Management of Childhood Illness (IMCI) strategy (WHO, 2001). In Ghana, as in other parts of sub-Saharan Africa, where malaria is known to be potentially fatal, early and effective treatment saves lives by preventing disease progression to severe malaria (Breman et al., 2006). This however requires timely and accurate diagnosis; use of efficacious drugs; education of patients and their families about the disease, home management, and prevention; and referral to higher levels of the health system.

As indicated in the Africa Malaria Report (WHO/UNICEF, 2003), it is expected that high fever would motivate most caregivers to seek treatment for life-threatening illnesses in children (WHO, 2003). This is always influenced by several factors especially in rural areas. Treatment-seeking behaviour is related to cultural beliefs about the cause and cure of illness (Oberländer and Elverdan, 2000). Studies have also found the choice of treatment source to be influenced by accessibility, disease type and severity, patient's gender and parents' education level (Ahmad et al., 2000; Müller et al., 2003). Earlier studies also indicated the most commonly reported reasons for delayed use or failure to use of public

health facilities to be distance to the health facility, inadequate drug stocks and lack of money to pay for services (Jowett et al., 2000; Rutherford et al., 2010; Williams and Jones, 2004). These evidences are reinforced by studies conducted in many rural areas in developing countries like Ghana, Tanzania, Cameroon and Mali (Agbenyo et al., 2017; O'Donnell, 2007). The health facilities in these areas are usually not readily accessible to much of the population (Schellenberg et al., 2003), and the health needs of large numbers of sick children are met through the informal sector, including community health workers (CHWs), drug sellers, and traditional healers (WHO and UNICEF, 2004). Since access to health facilities is limited and children also die at home (WHO and UNICEF, 2004; UNICEF, 2003), new and innovative approaches to reducing childhood mortality will require interventions implemented at the community level. The WHO and UNICEF therefore recommended that where malaria and pneumonia are major killers, their treatment should be integrated in community case management activities (Källander et al., 2008). In line with this recommendation, community-level interventions to strengthen home management of children with fever are being promoted in an effort to improve access to prompt treatment, particularly in isolated rural areas (Marsh et al., 2004; WHO, 2003). An earlier study demonstrated that home treatment of malaria improves timely treatment (Sirima et al., 2003). However, a study conducted in four counties including Burkina Faso, Ghana, Nigeria and Uganda on treatment-seeking behaviours revealed that most malaria episodes are first treated at home using shop-bought drugs (Gyapong et al., 2007).

One important strategy to prevent people from the risk of malaria infection is the use of insecticide treated mosquito net (ITNs). The use of bed nets, especially the ITNs are known to reduce malaria transmission by at least 60% and child mortality by 20% when used properly (Akande and Musa, 2005; WHO, 2003). However, studies also revealed that a substantial number of households with an ITN continue to report that they do not use them

(Macintyre et al., 2011; Vanden et al., 2010). Qualitative studies in many settings have consistently uncovered attitudes and beliefs unrelated to access and availability that contribute to decisions to not sleep under a bed net (Baume et al., 2009; Nankinga et al., 2012; Pulford et al., 2011). Anecdotal reports from the field also indicate that households sometimes repurpose usable ITNs for other household uses. These findings suggest that BCC programmes could play a vital role in altering these attitudes and behaviours among caregivers which can aid in promoting positive health seeking behaviours and effective use of ITNs. An extensive body of literature provides evidence on the effectiveness of BCC for increasing a range of positive health behaviours (Vaughan and Rogers, 2000; Westoff et al., 2011).

Despite these evidences, the widespread use of BCC approaches for improving health seeking behaviours and promoting ITN usage is hampered by continued skepticism regarding their effectiveness. In addition, although BCC programme is a proven intervention, mainstream evaluations of BCC have been focused on other health areas, including family planning and HIV (Snyder, 2007; Wakefield et al., 2010). In Ghana, most BCC programmes are not theory-driven. Consequently, evidence of their effect on health behaviours especially among caregivers is lacking. At the Asante Akyim North District, located in a region with high under-five mortality rate and malaria prevalence, evidence on the impact of BCC campaigns which is mostly conducted during Child Welfare Clinics (CWC), on childhood malaria is lacking. Consequently, the effectiveness of mass media campaigns which are important first step in raising awareness about health in the country is unclear and sometimes questioned.

It has been established that timely and appropriate healthcare seeking behaviours among caregivers can have a significant impact on child survival (Assefa et al., 2008). However,

inadequate knowledge and poor health seeking behaviours among caregivers of children under-five are well documented and have been attributed mainly to not recognizing signs and seeking immediate care for childhood illness (Mehan et al., 2010). An earlier study suggested that 63%-83% of the caregivers relied on home care the last time their children under-five experienced fever, diarrhoea and cough (Stuyft et al., 1996). Since health behaviours may be influenced by attitudinal and behavioural norms (perceived threat and efficacy factors), the study seeks to assess how the use of mobile technology can result in adoption of protective health behaviours by caregivers, which could translate into a reduction in malaria among children under-five.

Questions therefore remain regarding the effectiveness of BCC programmes and their effect on health seeking behaviours, which can translate into either delay or prompt use of appropriate healthcare services. Furthermore, evidence of mobile phone technology as an intervention tool has been documented in many countries to support management of hypertension, diabetes, asthma and HIV treatment (Cole-Lewis and Kershaw, 2010; Fjeldsoe et al., 2009; Leach-Lemens, 2009). However, evidence of its effect on knowledge about malaria, health behaviours and malaria prevalence is limited. Most mHealth interventions lack a foundation of basic evidence let alone a foundation that would permit evidence-based scale up (Collins, 2012). For example, in Uganda, between the period of 2008 and 2009 approximately 23 of 36 mHealth initiatives did not move beyond the pilot phase (Lemaire, 2011). Invariably, little is known about the impacts of mHealth due to the lack of high quality and peer reviewed randomized trials (Tomlinson et al., 2013). Furthermore, a systematic review by Zurovac and colleagues (2012) assessing the use of SMS messaging for the control of malaria in Africa concluded that few studies have demonstrated the impact of mHealth in malaria control.

With prompt identification and treatment being one of the key strategies for eliminating malaria, an effective disease-management system should exist to enable rapid and accurate case detection especially in rural areas where healthcare resources are limited. Most surveillance systems are generally known to be constrained by time-consuming and error-prone paper-based data collection followed by manual data entry. In Ghana, the paper-based IDSR strategy reported through the District Health Information Management System (DHIMS2) network has been described to be generally inefficient and error-prone with low completeness (Pascoe et al., 2012). Data transfer may take months to reach a level at which they can be analysed and lack of human resources to accomplish analysis often leads to further delays and often underuse of surveillance data. Consequently, monitoring childhood diseases in real time and timely response seem realistically impossible. Currently, evidence regarding the feasibility and effectiveness on the use of mobile technology as a surveillance tool is currently lacking. Hence, this study through this intervention could possibly at least provide the evidence. Therefore, this current study also sought to assess feasibility of using mobile technology for monitoring common childhood febrile illnesses based on reported symptoms.

1.4 STUDY RATIONALE

The global challenge of meeting the targets of the Sustainable Development Goals (SDG) creates the need for ICT support in the health sector. Hence, reliable information and effective communication are therefore crucial elements in health institutions, disease monitoring and prevention, public health systems, and health care generally. Information and communication technology can be an essential tool in combating disease, promoting individual health and making health systems more effective and efficient. It can be particularly powerful in monitoring the outbreak and spread of disease, disseminating health information (including information about health-promoting and disease-preventing

individual behaviour), and providing training, information and long-distance support to health care practitioners. However, a challenge for developing countries is to ensure that ICT is effectively mobilized to improve health outcomes and combat disease among the poorest and most remote populations (Afarikumah, 2014). This is an area where the potential for effective use of the full range of eHealth is particularly greatly needed.

Improving child survival requires investment in approaches such as mHealth that will empower the rural poor, giving them the tools to recognize the signs and symptoms of malaria and to take prompt and appropriate action – thereby preventing death. Although Ghana made modest improvement with MDG 4 (UNDP, 2015), child survival interventions and efforts at reducing mortality are lagging. Weak health systems exacerbated by continuing challenges in developing and retaining the requisite human resource for health, lack of access to basic proven interventions and the large burden of endemic diseases coupled with challenges of malnutrition in the country conspire to reverse some of the fragile gains made within the last few years (WHO, 2013a). Community-level interventions which aimed at strengthening home management of children with fever have been promoted in an effort to improve access to prompt treatment, particularly in isolated rural areas (Marsh et al. 2004; WHO 2003). A number of studies have demonstrated that home treatment of malaria improves timely treatment (Sirima et al., 2003). However, such programmes are not widely implemented in Ghana. Prompt treatment with effective antimalarial therapy is therefore essential and African leaders have committed to ensuring that at least 80% of malaria episodes are adequately treated within 24 hours of onset of symptoms (Roll Back Malaria, 2005). Nonetheless, it is well known that individuals are more likely to start with self-treatment at home as this allows them to minimize expenditure (Nyamongo, 2002; Théra et al., 2000). These treatments are

usually wrong and could lead to health complications. Interventions which are geared towards improving these behaviours are therefore paramount.

However, in order to improve the health behaviours and promote the use of ITNs among caregivers of children under-five, healthcare providers need effective ways to encourage them to make informed decisions and adopt healthy behaviours in order to prevent the onset of malaria and many of the other leading causes of child mortality. The amount of information, encouragement and support that can be conveyed to individuals during face-to-face consultations or through traditional media such as leaflets is limited, but mobile technologies such as mobile phones and portable computers have the potential to transform the delivery of health messages. These increasingly popular technologies can be used to deliver health messages to people anywhere and at the most relevant times. Consequently, text messaging is known to hold great potential as a tool for delivering behavioural interventions that have the capacity to reach the bulk of the population including those in the remote areas (Scott-Sheldon et al., 2016). Interventions delivered through text messaging have been shown to be cost effective (Guerriero et al., 2013), and eliminate many barriers to accessing traditional treatments. For example, studies have shown that regular motivational text messages sent to patients have resulted in adoption of healthy behaviours (Buhi et al., 2013; Orr and King, 2015). A systematic review by Poorman and colleagues (2015) on the use of text messaging on maternal and child health suggests that theory-driven interventions compared to informational language are more likely to be successful (Poorman et al., 2015). However, little is known about the effect of a theory-driven mobile technology on knowledge about malaria, health behaviours and overall impact on childhood malaria prevalence.

This study therefore, examined the effect of theory-driven behaviour change messages with the aid of mobile phone technology on health behaviours of caregivers. By raising

awareness of the negative consequences of malaria in children under-five, caregivers can adopt preventive behaviours. With intermediate health outcomes such as increase in knowledge about malaria and improved health behaviours, the study aimed to provide evidence on how mHealth intervention can cause a reduction in malaria prevalence among children under-five. In addition, as an important component of disease control, the spatial and temporal patterns of malaria transmission at the local level in semi-arid and highland regions in Africa, and particularly in Ghana, have not been well explored or correctly defined. Such research is also important in developing dynamic and area-specific risk maps to identify locations and populations at highest risk for appropriate planning and implementation of targeted and epidemiologically sound preventive and control measures against the disease.

Understanding how behaviour change takes place cognitively as well as uncovering potential individual differences may substantially increase our understanding on how promotional messages should be constructed and deployed, in order to effectively prompt a desired behavioural response. Therefore, augmented with a system which provides near-real time disease symptoms of children, the theory-driven mHealth intervention deployed using mobile technology, not only can it encourage continuous protective behaviours when the risk of malaria is greatly reduced, can improve our understanding on how perceptions and behaviours change over time. This could provide stakeholders and policy makers with vital information and effective approach to successfully eliminate malaria and control preventable childhood diseases in the country.

1.5 CONCEPTUAL FRAMEWORK

The study considered a number of theoretical frameworks that seek to explain the pathway leading to child survival. However, based on the study's focus of examining the use of mobile phone technology as a behaviour change tool, two frequently used behaviour

change models together with two other child survival models that seek to explain the influence of health seeking behaviours and household practices were considered.

1.5.1 Behaviour Change Models

To examine the behavioural aspect of the study, the Health Belief Model (HBM) and the Extended Parallel Process Model (EPPM) were considered.

Health Belief Model (HBM)

The HBM, developed in the 1950s to investigate why people fail to undertake preventive health measures, is one of the most commonly used theory in health education and health promotion (Lewis and Rimer, 2002). The underlying concept of the theory is that health behaviour is determined by personal beliefs or perceptions about a disease and the strategies available to decrease its occurrence (Hochbaum, 1958). It further states that an individual's likelihood of engaging in a health related behaviour is determined by his/her perception of the following six variables: *Perceived susceptibility* (perceived risk for contracting the health condition of concern); *Perceived severity* (perception of the consequence of contracting the health condition of concern); *Perceived benefit* (perception of the good things that could happen from undertaking specific behaviours); *Perceived barrier* (perception of the difficulties and cost of performing behaviours); *Cue to action* (exposure to factors that prompt action); and *Self-efficacy* (confidence in one's ability to perform the new health behaviour) (Orji et al., 2012b). Modifying variables such as education level, culture, past experience and skills can affect the four major constructs of perception as shown in Figure 1.2. HBM has been adapted and successfully applied in the design of health interventions (Orji et al., 2012a; Peng, 2009).

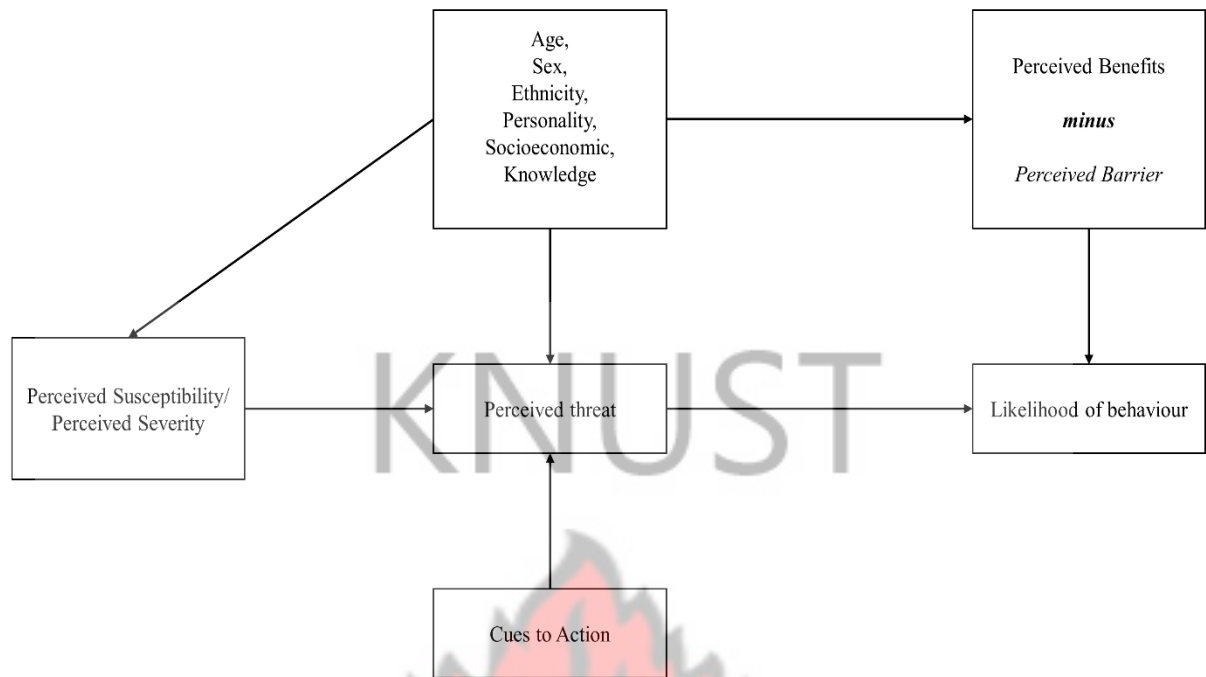


Figure 1.2: Health Belief Model

Source: Glanz and colleagues (2008)

Despite the success of HBM in predicting a range of behaviours with health outcomes, previous research shows that HBM's determinants are insufficient predictors of behaviour (Norman and Brain, 2005). This according to Cohen (1992) is due to two main limitations: low predictive capability of the determinants; their small effect size; and the lack of clear rules for the combination of the variables and the relationships between them. On the average, HBM's determinants predict approximately 20% ($R^2 < 0.21$) of variance in healthy behaviour, leaving 80% of the variance unaccounted for (Cohen, 1992).

Extended Parallel Process Model (EPPM)

As an alternative, the EPPM developed by Witte's (1992) describes how rational considerations (efficacy beliefs) and emotional reactions (fear of a health threat) combine to determine behavioural decisions [Figure 1.3]. The extent to which a person feels threatened by a health issue determines his or her motivation to act, while one's confidence to effectively reduce or prevent the threat determines the action itself.

	High Efficacy Belief in effectiveness of solutions and confidence to practice them	Low Efficacy Doubts about effectiveness of solutions about one's ability to practice them
High Threat Belief that the threat is harmful and that one is at-risk	Danger Control People take protective action to avoid or reduce the threat. <i>Strategy: Provide calls to action</i>	Fear Control People are too afraid to act, just try to reduce their fear and feel better. <i>Strategy: Educate about solutions</i>
Low Threat Belief that the threat is trivial and that one is not at-risk	Lesser Amount of Danger Control People know what to do but are not really motivated to do much. <i>Strategy: Educate about risk</i>	No Response People don't feel at risk and don't know what to do about it anyway. <i>Strategy: Educate about risk and about solutions</i>

Figure 1.3: Extended Parallel Process Model

Source: Extended Parallel Process Model (Witte's, 1992)

According to the EPPM, which incorporates Leventhal (1971) 'Parallel Process Model' and Rogers (1975) 'Protection Motivation Theory', two parallel message appraisals occur when someone is exposed to a threat appeal message - threat and efficacy appraisal. Threat appraisal involves the assessment of severity (i.e. how severe the negative consequences are) and susceptibility to the threat (i.e. how vulnerable an individual perceives a threat). The individual has to perceive the threat as severe and to be at risk in order for the threat appeal to produce the necessary fear to motivate action. The efficacy appraisal involves the assessment of response efficacy (i.e. the belief that the recommended behaviour is actually effective to avert the threat) and self-efficacy (i.e. the belief to be able to perform the recommended behaviour).

The EPPM, adopted in this study, helps to predict whether fear of a health risk such as malaria can cause either adaptive, self-protective actions or maladaptive, self-defeating actions. When perceptions of a threat are strong and perceived levels of efficacy are high,

the model predicts self-protective behaviour. When perceptions of a threat are strong, but perceived levels of efficacy are low, the model predicts maladaptive denial or rejection of protective behaviours. By examining the threat and efficacy variables, individuals in an intended audience can be classified as having either high or low levels of perceived efficacy and either high or low levels of perceived threat. As a result, fear messages alone without efficacy messages can result in maladaptive Fear Control, rather than protective Danger Control, which is associated with positive behaviour change (Maloney et al., 2011; Witte, 1992a; Wong and Cappella, 2009a).

1.5.2 Determinants of child survival

To explain the pathways leading to child survival, and the role of knowledge acquisition and behaviour change, two popular theories were also considered: The Mosley and Chen (1984) model and the extended model of care by UNICEF.

The Mosley and Chen Model of child survival

The Mosley and Chen (1984) model identifies a set of socioeconomic determinants at the individual, household and community levels which operates through five sets of proximate or intermediate determinants to influence child mortality [Figure 1.4]. The proximate determinants such as maternal factors, environmental contamination, nutrient deficiency and injury, influence the rate of change of healthy individuals toward sickness, while the personal illness control factors, through prevention, influence both the rate of illness and the rate of recovery. The state of sickness such as malaria by a child for example is in essence transient: either the child recovers or experiences a permanent consequence (or other disability) and/or death.

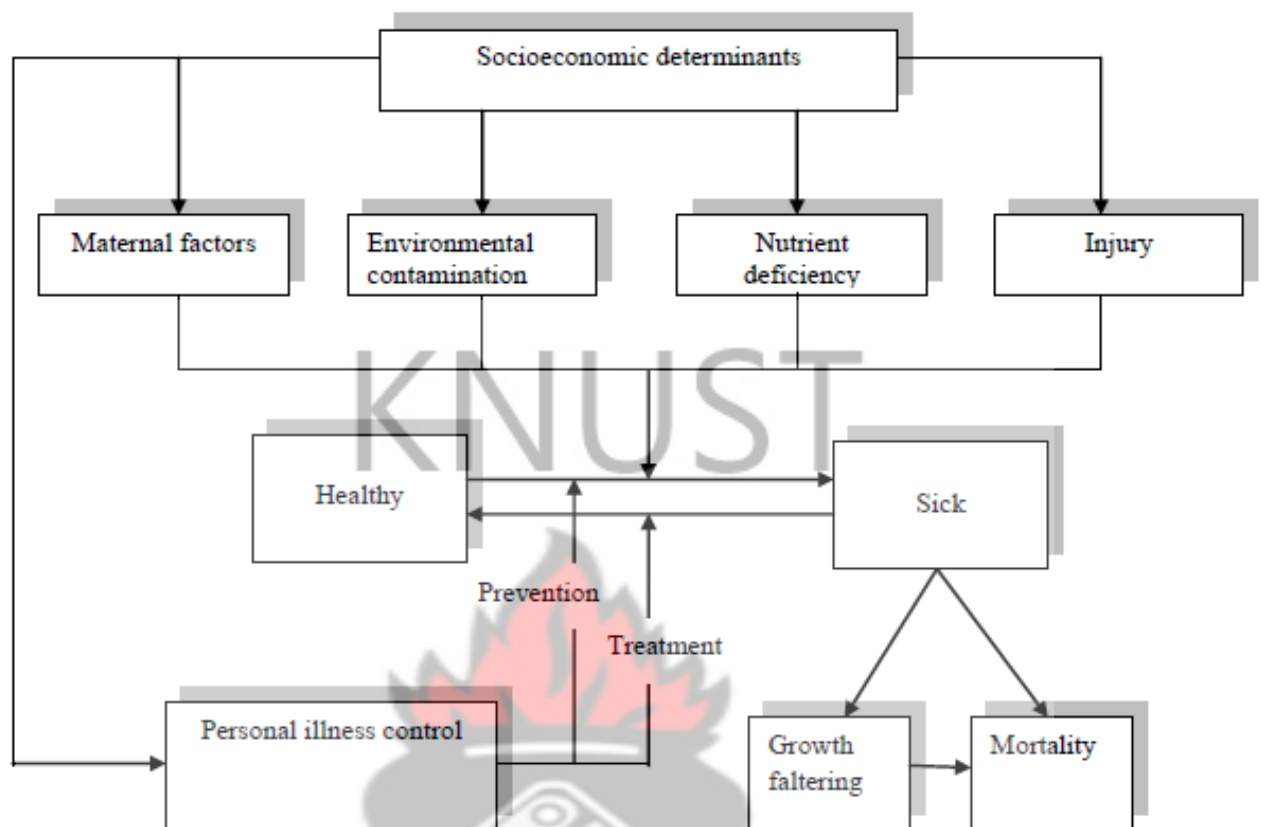


Figure 1.4: The Mosley and Chen Model of child survival

Source: Mosley and Chen, 1984

As one of the fundamental points of reference of this study, two of the five proximate factors such as maternal factors (age at birth, parity and birth intervals) and personal illness control (preventive measures such as ITN use and malaria prophylaxis) as well as individual factors (exogenous) such as skills and education level have consistently been associated with child survival (Stallings, 2004). Of major interest is maternal education level, which could play a key role in knowledge acquisition leading to behaviour change. Maternal education therefore affect child survival by influencing her choices and increasing her skills in health care practice related to preventive care and disease management (Kinfu, 2017).

The Extended Model of care

Similar to the socio-economic determinants described by Mosley and Chen, the UNICEF model recognizes pathways that act through proximate variables to influence child survival [Figure 1.5]. Education, knowledge, and beliefs represent the capacity of the caregiver to provide appropriate care. The physical and mental health (self-confidence, and lack of stress and depression) of the caregiver represent individual-level factors that facilitate the translation of capacity to behaviour. In addition, autonomy, workload, and social support are facilitating conditions in the family and community. Some of these resource categories have been investigated extensively, whereas others have been investigated primarily in developed countries (Engle et al., 1999).

Noteworthy is the health seeking behaviour, a proximate determining factor in the model. Care-giving behaviours can be seen as both preventive health care (e.g. use of malaria prophylaxis) as well as health seeking behaviours in the event of morbidity. The effects of education on health care seeking behaviours are well documented and established. Previous studies have revealed that maternal education affects a child's health through its effect on her health care seeking behaviours. Better educated women are more likely to utilize available healthcare and community service facilities than women with no education (Emelumadu et al., 2014; Olaitan et al., 2017).

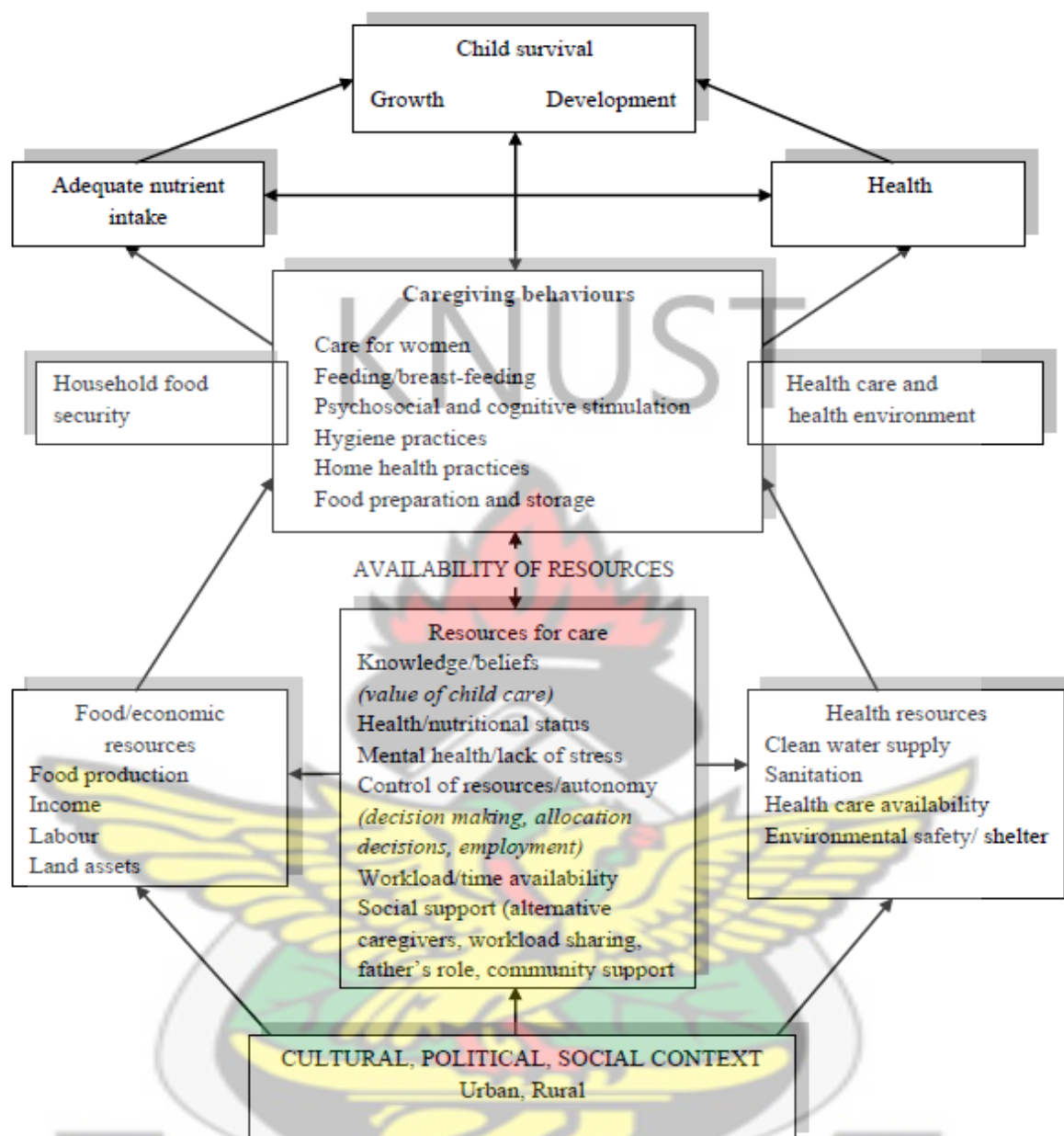


Figure 1.5: The extended model of care

Source: UNICEF (1990)

Altogether, the current study presents a theoretical guideline which acknowledges and incorporates the relevant aspects of the behaviour change and child survival models discussed as shown in Figure 1.6. Knowledge acquisition and behaviour change are considered key contributors to child survival. These two major components, explained by the behaviour change and child survival models, can be achieved if caregiver behaviours

are positively influenced. The outcome could be a reduction in childhood febrile illness related to malaria and healthcare utilisation improvement. However, to achieve this, the mHISS is used as a BCC tool for delivering health messages in order to improve caregiver knowledge and health behaviours based on the EPPM. At the same time, caregivers could access the IVR-based system for health advice on what to do when the child is ill, after describing the disease symptoms experienced. This provides time series data in near-real time which allows for the monitoring of trends and patterns of childhood febrile illnesses such as malaria, respiratory tract infection (RTI) and diarrhoeal diseases. In effect, the use of mobile technology, not only would it improve caregiver knowledge about malaria, healthcare seeking behaviour and utilization, monitoring of childhood febrile illness but will aid in the reduction of malaria which could ultimately lead to improved childhood under-five morbidity and mortality outcomes.

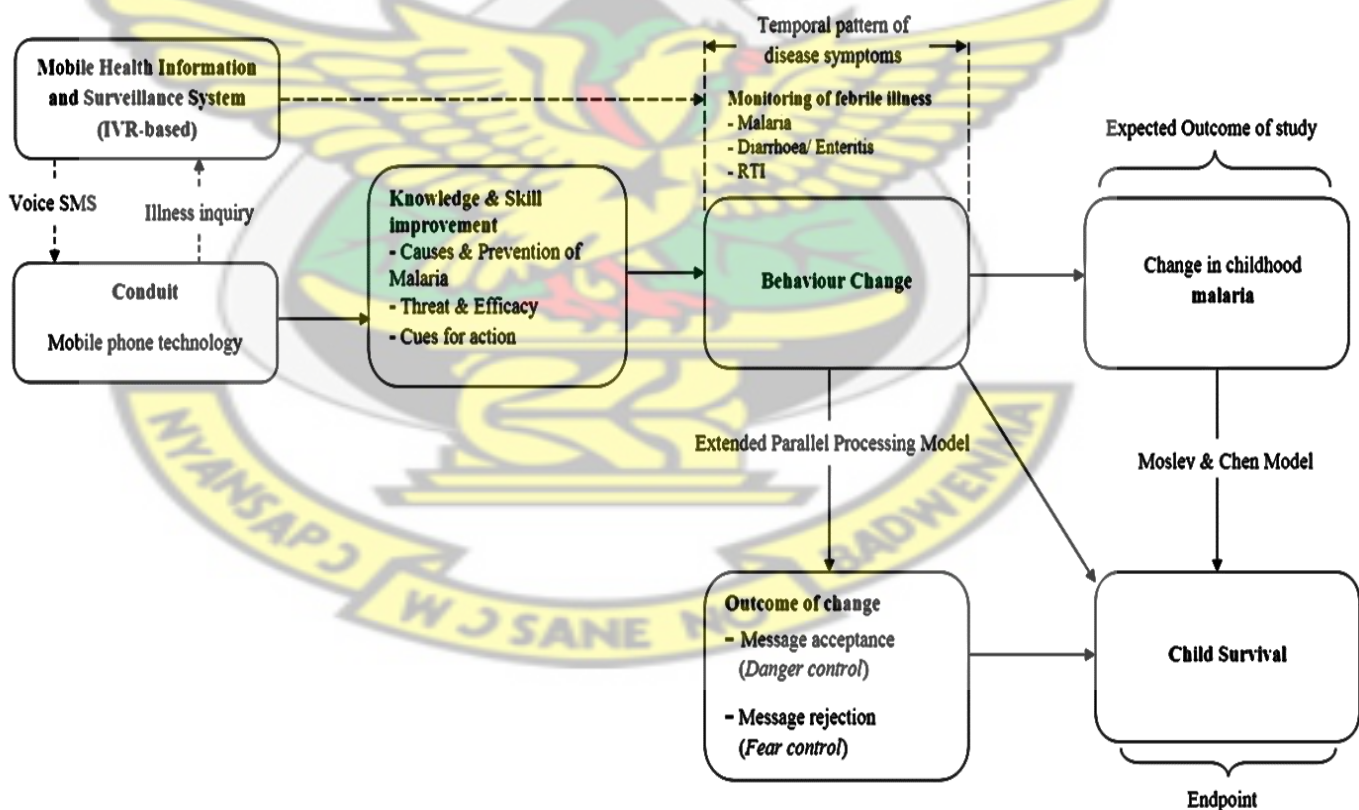


Figure 1.6: Theoretical Guideline of Study

Source: Author's construct

1.6 RESEARCH QUESTIONS

Based on the proposed conceptual framework which described how mobile phone-based technology could be deployed to improve child health outcomes, the main questions addressed in this study include:

1. Does the prevalence of malaria among children under-five differ between caregivers who receive the intervention and caregivers who do not receive the intervention?
2. What is the effect of using mobile phone-based technology as BCC tool on malaria prevalence among children under-five?
3. Can the use of mobile phone-based technology as a BCC tool, improve the knowledge about malaria among caregivers of children under-five?
4. Can the use of mobile phone-based technology improve the health behaviours of caregivers of children under-five exposed to BCC messages on malaria?
5. How can mobile technology be used to monitor common childhood febrile illnesses of children under-five?

1.7 AIMS AND OBJECTIVES

This study conducted in the Asante Akyim North District, of the Ashanti region, aimed to determine the effect of theory-driven mHealth intervention delivered in a form voice SMS using a mobile phone-based system on prevalence of malaria among children under-five, and health behaviours of caregivers. The study also aimed to assess the surveillance potential of the system for monitoring symptoms of common childhood febrile illnesses.

1.7.1 Specific objectives and hypotheses

1. To determine the prevalence of malaria and associated spatio-temporal pattern before and after the mHealth intervention among children under-five.

Hypothesis (Ho₁): The prevalence of malaria do not differ among caregivers who received the intervention and caregivers who did not receive the intervention.

Hypothesis (Ho₂): There is no spatial clustering of malaria cases in children under-five before and after the intervention.

2. To examine the effect of using mobile phone-based technology as BCC tool on caregivers' health behaviours on childhood malaria prevalence before and after the intervention.

Hypothesis (Ho₃): Fear appeal messages delivered using mobile technology do not have any effect on childhood malaria outcome.

3. To assess the effect of using mobile phone-based technology as BCC tool on knowledge about malaria among caregivers of children under-five.

Hypothesis (Ho₄): There is no difference in knowledge about malaria among the intervention and control group, before and after the intervention.

4. To examine the effect of delivering BCC messages via mobile phones on health behaviours of caregivers of children under-five.

Hypothesis (Ho₅): Fear appeal messages delivered using mobile technology do not have any effect on health behaviours of caregivers.

5. To assess the feasibility of using mobile technology for monitoring common childhood febrile illnesses.

1.8 SCOPE OF STUDY

The study was limited to two major components – mHealth for BCC and surveillance of common childhood febrile disease illnesses. The primary focus of the study was primarily on how mHealth intervention can be strategically deployed to influence the health

behaviours of caregivers, known to have substantial influence on child survival, by delivering fear appeal messages regarding the negative effect of malaria and prevention strategies via mobile phone, in the form of voice SMS. The effect, before and after introducing the mHealth intervention on malaria prevalence in children under-five, knowledge about the causes and prevention of malaria and health behaviours among caregivers were examined. The study also focused on evaluating the mHealth tool for monitoring common childhood disease symptoms, by relying on self-reports data obtained from caregivers of sick children.

1.9 ORGANIZATION OF STUDY

Chapter 1 outlines the problem of child death, in the World, Africa and in Ghana. Particular emphasis was placed on the various impacts of malaria on Africa and Ghana and the nature of international and national responses to the disease in children under five years. The chapter then discusses the role of BCC and the surveillance potential of eHealth strategies. The background of the mHealth programme employed in the study was also introduced.

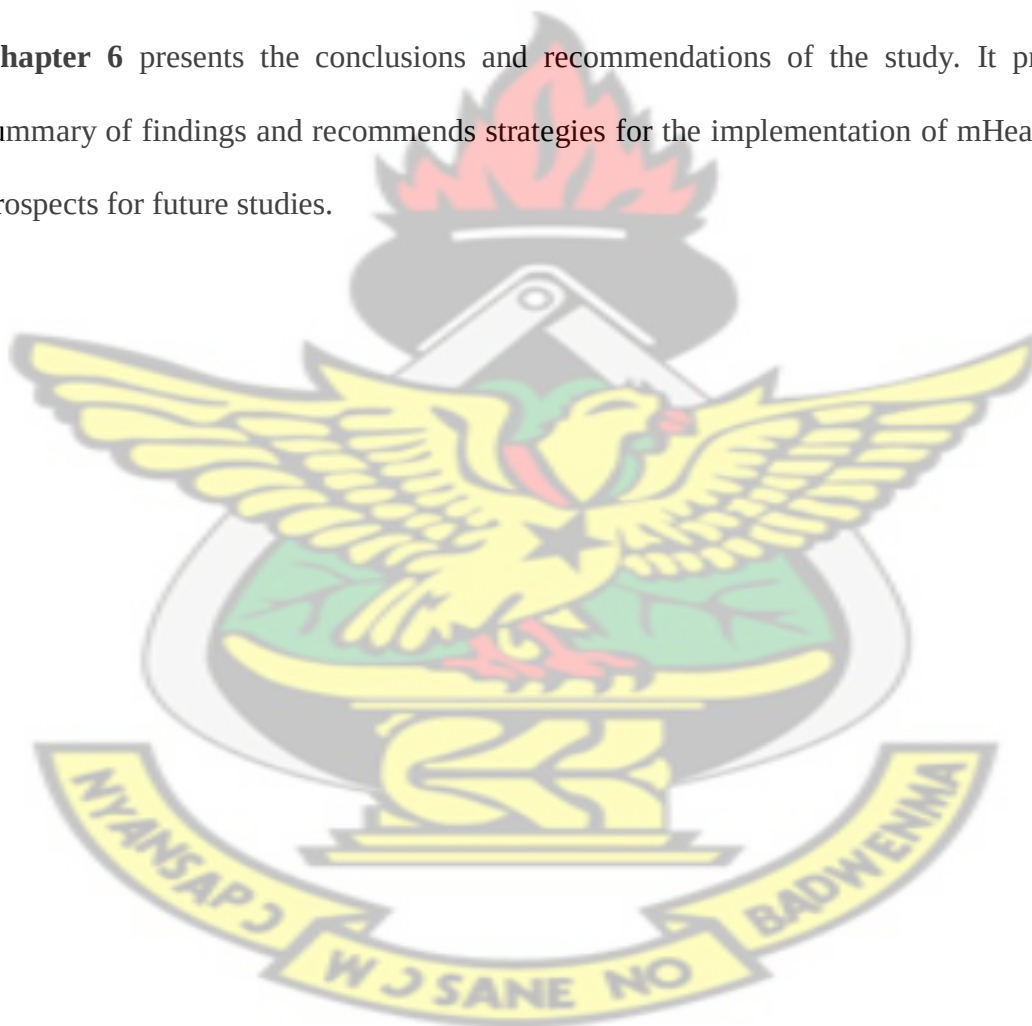
Chapter 2 examines a broad range of literatures. The first section deals with theory-based approaches to BBC interventions and their effect on health behaviours, with emphasis also placed on their influence on knowledge about malaria. The second deals with interventions that employs the use of mHealth interventions for knowledge improvement, BCC and surveillance.

Chapter 3 describes the methods employed in the study. The different methodological and practical approaches that were considered when designing the interventional study are described. It discusses and justifies briefly, the various approaches used in gathering data statistical methods employed.

Chapter 4 presents the results of the study. These include a detailed description of the effect and impact of the mHealth intervention regarding malaria in children under-five and an evaluation of the disease monitoring capacity of the mHealth tool.

Chapter 5 provides a discussion of the findings. The discussion reviews the implications of the mHealth intervention. It draws together the lessons learned from the intervention and sets these findings within the context of a wider literature while assessing implications for the health sector in Ghana and more generally.

Chapter 6 presents the conclusions and recommendations of the study. It provides summary of findings and recommends strategies for the implementation of mHealth and prospects for future studies.



CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 OVERVIEW

This chapter re-examines an extensive collection of literature relevant to this study. Edged predominantly by the subject of child health, BCC theories and surveillance, the focal point of the review was eHealth and mHealth. Emphases are placed on their overall contribution to the healthcare services, and an ultimate effect on malaria in children and behaviour change among caregivers. EndNote software was used to undertake a systematic search of scientific literature; enabling the design of a database into which details of referenced literature were saved for use. Relevant literatures were identified through a systematic search of databases such as PubMed, HINARI, MEDLINE, and Google Scholar. Websites of major child health agencies such as WHO, USAID and UNICEF were also considered. Some of the key terms used in the search were “eHealth,” “mHealth,” “child survival,” “behaviour change communication,” “HBM,” “EPPM,” “health seeking behaviour,” “surveillance” and “child health in Ghana.” Combinations of these key terms were also searched.

2.2 Electronic Health

Electronic health, which involves the use of ICT in health, have been used in health programmes to support and strengthen health systems. Electronic health, include facets of both technology and health. It is a broad concept engorged with terms such as electronic health records; mobile health (e.g. apps, wearable technologies, medical devices); telehealth or telemedicine (whereby a health care worker can be consulted by a patient on the computer, a phone or a tablet); health-related e-learning (training and educating both a broader audience and the health workforce using technology and media); social media for

health (social online communication channels); and health data analysis (transformation of data to provide insights and evidence for decision- and policy-making). As adoption of eHealth applications grow, an evidence-based approach to the development and dissemination of these resources is necessary to ensure that they have a positive impact on individual and public health. The internet and related digital technologies have spawned the burgeoning growth of an information revolution in health care. Emerging evidence provides support for the beneficial effects of online interactive eHealth programmes, although many challenges remain with respect to research approaches to methodology, implementation, and evaluation (Ahern, 2007).

2.2.1 The state of Electronic Health in Ghana

In July, 2010, the Government of Ghana launched the national eHealth strategy. The key strategies under the national eHealth strategy include; streamlining the regulatory framework for health data and information management, building sector capacity for wider application of eHealth solutions in the health sector, increasing access and bridging equity gap in the health sector through the use of Information and Communication Technology, and towards a paperless records and reporting system. Since then, there has been an upsurge of eHealth projects in the country. These include:

i. SENE PDA

The project, which started in 2004, aimed to use information technology to improve service delivery at the lowest level of service delivery – Community-based Health Planning and Services (CHPS) zones. It is one of the pioneer mobile health projects in Ghana. The project used customized software created on a java platform and installed on the PDA to collect clients' data. The project reported an improvement in reporting immunization coverage in the District (Ofosu and Nyonator, 2013).

ii. *Telemedicine*

In an effort to strengthen human resources in rural areas and to improve the quality of primary healthcare, the Novartis Foundation for Sustainable Development, in cooperation with the Millennium Villages Project (MVP), the Ministry of Health and the Ministry of Communications in Ghana, National Health Insurance Agency Ghana, Ghana Health Service, and Ghana Medical Association, initiated a Telemedicine Project in Bonsaaso cluster in Ghana. The project aimed to (1) improve access and availability of healthcare services and (2) reduce unnecessary transportation and improve the referral system in rural areas. The impact of the project is routinely measured, with the aim of expanding teleconsultation services to the regional level and providing support to health workers beyond the Millennium Village cluster.

iii. *Mobile Technology for Community Health (MOTeCH)*

The project aimed to determine how to use mobile phones to increase the quantity and quality of prenatal and neonatal care in rural Ghana, with a goal of improving the health of pregnant women and young children in the Upper East Region of Ghana. The software employed by the project has an in-built functionality for mobile phone-based data collection software, an electronic medical record system, and an Interactive Voice Response application. MoTeCH is an initial step for an iterative process of health information systems improvement in poor, rural regions around the world, by providing timely and accessible health information to the key participants of the health care systems (MacLeod et al., 2012).

iv. *Pan African eNETWORK*

The PAN African E-network is a joint initiative between the Indian Government and the African Union to establish linkages in tele-education, telemedicine and other forms of

information exchange between institutions in India and Africa. There are 33 countries currently involved in this project and the first step has already covered learning centers and patient-end hospitals in countries including Benin, Burkina Faso, The Gambia, Ghana, Ethiopia, Nigeria, Rwanda, Senegal and Seychelles. More so, this would provide Tele-Medicine services by way of on line medical consultation to the medical practitioners at the Patient End Location in Africa by Indian Medical specialists in various disciplines/specialties selected by African Union for its Member States.

v. ***Onetouch Medicareline***

The Ghana Medical Association (GMA) in collaboration with OneTouch Telecom in 2001 initiated the Onetouch Medicareline, which provided doctors in Ghana with free mobile phone calls and text messages to other members of the medical community. It focused on reducing logistical and economic barriers to mobile phone use rather than on technological innovation. A medical doctor registered with the GMA receives a OneTouch GSM SIM which can be used with a privately-purchased mobile phone. Using this, the physician could call other program participants free of personal charge. The first phase of the programme resulted in a high adoption rate, with approximately, 1700 of 2000 medical doctors. Over 2 million calls were made (Luk, Rowena et al., 2009).

vi. ***Moorfields /Korle-Bu Eye Centre***

A Web-based service was set up to link subspecialist ophthalmologists with those seeking advice on particular clinical problems in ophthalmology. The service operated between countries, with centres in Malaysia, Ghana, Tanzania, South Africa and Gambia seeking advice from Moorfields Eye Hospital in the UK. During the first 12 months, 132 cases were posted to the Website from five of the six centres participating. The rate of case referral rose to about 12–14 cases per month by the end of the study. Overall, 24% of referrals did not use images. The main problem was the amount of Internet down-time in

each of the locations. The main benefit was safe and reliable access to specialist advice for practitioners (Kennedy et al., 2006).

Other eHealth projects conducted in Ghana include the Disease Control/WHO, USAID-Deliver Project, Early Warning Systems-Focus Region Project, Ehealth Initiative, Vodaphone Healthline Project and Mahiri Mobile. However, of interest to this study is the usefulness of mHealth to the health sector.

2.3 Global Mobile Health (mHealth) initiatives

Mobile health, the practice of medicine and public health supported by mobile devices (Adibi, 2015), have moved beyond just calls. Short messaging service (SMS) text and voice messaging have been key to their use which include, mobile Internet browsing, Voice over Internet Protocol (VoIP) services (e.g. Skype), instant messaging services and broad diversity of device-based software applications (commonly acknowledged as ‘apps’). These myriad functionalities offer a range of prospects for mHealth interventions.

Studies have documented the usefulness of mobile phone technology in different fields in the health sector. For example in clinical care mobile phones have been used to control blood sugar levels in children with diabetes (Allen et al., 2002; Handfield et al., 2006). They have also been used to improve compliance of calcium intake among women with osteoporosis (Schousboe et al., 2005). Central to these interventions is the use of SMS messaging, sent through mobile phones. The flexible nature of using it has made it a very popular service, and is used for a diverse range of objectives such as health communication and advertisement. A study conducted by Downer and colleagues (2005) assessed the effect of appointment reminders sent by SMS and found that patient health facility attendance improved. Furthermore, the study revealed that the overall failure to attend (FTA) rate was significantly lower among those who received (14.2%) SMS reminders

than in the group that did not receive (23.4%) any reminder ($p < 0.001$). Other studies have also found SMS use as an effective approach for improving immunization rates (Lieu et al., 1998) and an easy way to allow patients to keep in touch with their health professionals (Pal, 2003). In a broader context, mHealth interventions have also been used for emergency medical response, sensors and point-of-care support, and health promotion tool (Lu et al., 2010; Saxon, 2013).

Emergency medical response

Studies have revealed the usefulness of mHealth tools for minimizing time barriers by facilitating urgent emergency obstetric referrals (Chib et al., 2008; Cole-Ceesay et al., 2010; Lu et al., 2010; Lund et al., 2010). An earlier study supporting this observation involved the Rural Extended Services and Care for Ultimate Emergency Relief (RESCUER) programme conducted in rural Uganda. The project was designed to address the high maternal mortality problem. This was implemented by a district task force, and supported by the Ministry of Health and the United Nations Fund for Population Activities (UNFPA). The programme trained Traditional Birth Attendants (TBAs) on the signs and protocols for pregnancy complications. They were equipped with walkie-talkies, which were linked to health facility units, together with some basic clinical obstetric instruments. The TBAs used the walkie-talkies to notify referral health centres for emergency transport upon recognising delivery-related complications. The maternal mortality rate in the study sites had shown a decrease of approximately 50% of maternal mortality rate, following the intervention, due to increases in referrals to health facilities. A major challenge cited by the author was some logistical issues, which may have compromised the study outcomes (Musoke, 2002). In another related programme which ultimately revealed the complexity of improving processes and obtaining outcomes data, the emergency services departments in the Gambia also equipped TBAs and outreach workers with mobile phones. They were

trained to recognize and refer pregnancy-related complications. The results obtained from the health records of the project revealed improvements to the emergency response system in which 109 patients, mostly pregnant mothers received critical assistance between May 2007 and March 2010 by emergency ambulance service (Cole-Ceesay et al., 2010). A total of 293 resuscitation attempts were also documented. The study, however, failed to provide details on the percentage change, and cited challenges such as low morale of health workers and erratic transportation as factors that limited the efficacy of the programme

Sensors and Point-of-care support

Health systems have employed mHealth tools to address the low number of qualified health personnel and improve the professional solitude of mid- and low-level health workers providing care with minimal guidance (Sloninsky and Mechael, 2008). Sensors and technologies have been developed to transmit and assess diagnostic tests through mobile phones, from modest tests, such as blood glucose measurements for diabetes management to sophisticated assays, such as electrocardiograms (ECGs), in circumstances where the patient and provider are far from one another (Saxon, 2013).

2.4 PREVALENCE OF MALARIA IN CHILDREN UNDER-FIVE

2.4.1 Burden of Malaria among Children under-five in Ghana

In Ghana, malaria is highly endemic and is most prevalent during the raining season. One of the objectives of the 2014 GHDS was to test children aged, 6-59 months for malaria. Capillary blood samples were collected from children in this age category in about half of the households surveyed. Rapid diagnostic test (RDT) was used to test for malaria in the field. A comparison of the 2014 GDHS results with those from the 2011 Ghana MICS survey revealed a reduction in prevalence of malaria in children as measured by RDT from 48% to 36%. However, analysis of blood smears through microscopy showed a lower prevalence of 27%. The difference in prevalence, as reported in the GDHS report could be

attributed to the fact that the child's blood may still have the proteins (antigens) even after the parasites have disappeared. These antigens are able to remain noticeable for two to four weeks, contingent on the sensitivity of the RDT (GSS, 2011). The report also revealed that based on microscopy, the rural areas carried the highest burden, with 53% of children aged 6 – 59 months experiencing malaria compared with urban areas (17%). The prevalence was also higher among the children living in the lowest (60%) and second wealth quintile (55%) compared with children in the highest quintile (6%) (GSS et al., 2015). The result of malaria prevalence by region based on RDT also showed a higher proportion in the Northern (61%) and Upper West (62%), followed by Central (49%), Brong Ahafo (44%) and Western (43%). The least prevalence was recorded in Greater Accra (12%).

Differentials of Malaria Prevalence in Ghana

According to the 2011 MICS Report, patterns in malaria distribution were found in relation to educational and wealth status, and urban/rural residence. The mother's education and household wealth were both inversely associated with malaria among children: 43% of children whose mothers had no education had malaria, compared with only 5% of children whose mothers had secondary or higher education. Likewise, more than half of children (52%) in households in the poorest wealth quintile had malaria, compared to only 3% of children in the richest households. Children in rural areas were three times more likely than their counterparts in urban areas to have malaria (39% compared with 13%, respectively) (GSS, 2011). Malaria prevalence according to microscopy decreased from 42% among children living in the poorest households to 8% among those living in the richest households (GSS et al., 2015).

Malaria Case Management in Ghana

Case management of malaria is one of the key primary strategic areas of malaria control in Ghana. It involves the identification, diagnosis, and prompt treatment of all malaria cases with appropriate and effective antimalarial medicines, outside the clinical setting. In Ghana, an estimated 90% of children with fever are treated at home with drugs that are relatively more accessible from drug vendors compared to health facilities (WHO, 2005b). Malaria is therefore managed mostly in the home through self-medication, with drugs obtained from the unregulated informal private sector (Buabeng et al., 2007). These over-the-counter drugs contribute to inappropriate treatment of febrile illness in children (Okeke et al., 2006) resulting in consequent treatment failures and drug resistance (White, 1999). Existing evidence suggests that malaria-related under-five child mortality usually occurs within 48 hours of illness onset (Newton and Krishna, 1998). Thus, one of the Roll Back Malaria (RBM) programme strategy is to reduce under-five mortality through early diagnosis and appropriate treatment within 24 hours of symptoms onset (WHO, 2005b). However, available evidence indicates that poor physical access to healthcare facilities is one of the major impediments to early diagnostic and curative services in rural Low and Middle-Income Countries (LMICs) (WHO, 2005a).

In malaria endemic areas where at least 70% of fever is due to malaria, evidence suggests that presumptive malaria treatment is more cost effective than prior RDT or microscopy (Rolland et al., 2006). Thus, in such settings, WHO recommends the implementation of home management of uncomplicated malaria (HMM) strategy to reduce malaria-related morbidity and mortality in children under-five (WHO, 2008). Home Management of Malaria implementation primarily involves the education of caregivers about malaria to enable them recognize, assess severity, and initiate early treatment for uncomplicated

malaria in the home using effective medicines that can be obtained from a community resource person, sales outlet, or health facility (WHO, 2005b).

Diagnosis and treatment of malaria in Ghana

In 2010, the Ghana policy with regards to presumptive diagnosis was revised to include a pre-requisite for malaria testing before any treatment. This eventually led to rapid diagnostic test (RDT) kits introduction in the country. In Ghana, malaria diagnosis is based on detection of parasites in the blood using malaria rapid diagnostic tests (MRDT) and microscopy, which are widely available in all public and private health facilities.

Based on the WHO criteria and recommendations, the medication of choice for treatment of uncomplicated malaria in Ghana is artemisinin-based combination therapy (ACT). However, in 2007, the Ministry of Health (MoH) and the Ghana Health Service (GHS) reviewed the anti-malaria drug policy and included dihydroartemisinin–piperaquine (DHAP) and artemether–lumefantrine (AL) as additional options to artesunate–amodiaquine. The changes have since helped to address the identified fallbacks such as adverse reactions of degrees of severity reported across the country (MoH, 2014).

2.4.2 Effect of mHealth intervention on malaria prevalence

The use of mobile phones through which health SMS are delivered has the potential to influence health outcomes. Effective control and management of malaria is considered to be multifaceted, involving routine collection and timely reporting of health facility data. A plethora of studies suggest that health education plays a significant role in community based malaria interventions in SSA. These interventions are mostly delivered through channels including posters, brochures, television, radio, bill boards, flip charts, videos, community health workers and peer-educators (Ayi et al., 2010; Elsheikh, 2007; Kouyaté et al., 2008). Between 2007 and 2008, a pre- and post-interventional study was conducted

by Ayi and colleagues (2010) in Ghana. In the study, trained school teachers with the help of school children disseminated malaria messages with regards to its control to their communities. Comparing the intervention group (105 children, 250 community adults) and the control group (81 children, 133 community adults), the results of the study revealed a statistically significant reduction in parasitic prevalence in the school children from 30.9% to 10.3% ($p = 0.003$). Although, a reduction in malaria prevalence was observed, the study failed to account for pre-existing differences in the intervention and control group that could have accounted for the observed difference. Other related study employing similar approach in other countries also observed a statistically significant contribution of malaria health education on malaria outcome in children (Nonaka et al., 2008; Okabayashi et al., 2006). Using the health promotion concept which involves community participation and empowerment, contextualism, intersectorality, multistrategy, equity, and sustainability (WHO, 1998), an interventional study was conducted by Houeto and Deccache (2008) in a rural community in Benin. This quasi-experimental study was carried out to assess the effect of the health promotion concept on malaria in children. The result of the 27 months interventional survey revealed a statistically significant ($p = 0.008$) reduction of malaria prevalence in the children (Houeto and Deccache, 2008).

Most of these studies however failed to directly assess the resultant effect of delivering health information via mobile phones to caregivers on malaria in children under-five. Identifying a major gap in knowledge in literature, the study sought to assess the effect of delivering health information via mobile phones on prevalence of malaria by employing a more robust study design and a theory-driven BCC approach.

2.4.3 Spatial epidemiology of malaria

Geographical Information Science (GIS) is one of the most notable tools commonly used in health research to inform enabling policy. The use of GIS in disease mapping attempts to understand and recognize spatial patterns to grasp its degree of prevalence, and consequently, associate factors responsible for the pattern. The pattern of geographic data can be characterized as having spatial homogeneity or heterogeneity. Thus, spatial interpolation and dependence can be explained using spatial interpolation and autocorrelation, respectively.

Spatial interpolation

In the recent decade, spatiotemporal interpolation has gained attention in the Geographical Information System (GIS) interpolation research community (Li et al., 2014, 2004; Revesz and Wu, 2006). Spatiotemporal interpolation involves estimation of the unknown values at unsampled points based on known values of surrounding points in space with an adequate level of accuracy (Li and Revesz, 2004). The two of the most commonly used spatial interpolation methods in GIS applications are IDW (Inverse Distance Weighting) and Kriging (De Mesnard, 2013; Li and Heap, 2011). Comparing the two methods, it was found that the performance of IDW was not as good as Kriging (Kravchenko and Bullock, 1999). However, another study found the IDW outperformed Kriging (Weber et al., 1992). Spatial modelling to predict malaria risk for unobserved locations based on existing data from observed locations, which are usually limited or in most cases entirely absent is the basis of most malaria risk maps.

Previous studies indicate that deterministic and geo-statistical interpolation methods are the most commonly used interpolation methods due to their high level accuracy (Yao et al., 2013). The current study, which focuses on one of the deterministic models, IDW interpolation has some advantages including 1) its simplicity and intuitiveness and 2) fast

to compute the interpolated values. However, the main disadvantage of this method is its sensitivity to outliers and sampling configuration (Li et al., 2014).

Spatial autocorrelation

Spatial autocorrelation as a statistical technique has been used extensively to identify geo-spatial hotspot and cold spots of disease incidence (Hassarangsee et al., 2015; Kazembe et al., 2006; Yeshiwondim et al., 2009). Several epidemiological studies have also used spatial analysis to explain the risk of malaria based on the location (Hui et al., 2009; Kleinschmidt et al., 2000; Omumbo et al., 2005; Reid et al., 2010). For example, in a study conducted by Kleinschmidt and colleagues (2014) in Malian among children under 10 years, the researchers, using a two-stage modelling approach to model the risk of malaria found environmental variables as good predictors, explaining about 65% of the variance (Kleinschmidt et al., 2000). Similarly, a study conducted by Appiah and colleagues in Ghana, examined the spatio-temporal distribution of malaria incidence in Ghana. With data on monthly morbidity cases of malaria obtained from public health facilities for the period from 1998-2010, the results showed a non-random spatio-temporal distribution of the disease and the highest incidence was observed in the northern and central part of the country (Appiah et al., 2011). Using spatial autocorrelation analysis, Hui and colleagues found that the incidence of malaria in a Yunnan Province in China was not randomly distributed in the province. However, using the maximum spatial cluster size of $\leq 20\%$ of the total population, the study revealed the existence of spatial clustering in high risk areas of the province, with observed associations between the incidence of malaria (for both *P. vivax* and *P. falciparum*) and climate factors in the cluster areas (Hui et al., 2009).

2.5 KNOWLEDGE ABOUT MALARIA

Exposure to malaria messages is key to improving knowledge about prevention and causes of malaria. Behavioural change communication, which involves dissemination of malaria prevention and treatment messages through various media sources, such as TV, radio, newspapers and magazines, posters, leaflets and brochures, mobile phones and through health workers and community volunteers have been used in many health programmes in Ghana. The basic idea behind BCC interventions is that individuals can act on health-promoting behaviours if communication channels that promote healthy behaviours and supportive environment are effectively deployed (McGuire, 1984). BCC interventions have successfully been used in India to increase knowledge of contraceptive use, immunization and HIV/AIDS (Daniel et al., 2008; Sood et al., 2006).

According to the 2014 GDHS report, majority of the respondents had heard or seen malaria messages on the radio (79%) and TV (64%), with more than one-fifth (27%) reading or seeing malaria messages on a poster, 12% in a newspaper or magazine, and 8% on leaflets or brochures. The report further revealed that 32% of the respondents had heard malaria messages from a health worker and 13% had heard them from a community volunteer (GSS et al., 2015). Additionally, it was revealed that 32% of the respondents had heard malaria messages from a health worker, with 13% hearing them from a community volunteer. This is however a noteworthy drop from the 2008 GDHS figures of 42% and 22%, respectively. Generally, majority (86%) of the respondents correctly identified mosquito bites as a cause of malaria, with only 6% able to correctly identify Plasmodium falciparum, as the cause of malaria. Approximately, one-third (32%) of the respondents recounted that weedy surroundings and stagnant water cause malaria. As a common misconception in Ghana, more than half (56%) of the respondents stated that dirty surroundings cause malaria. Interestingly, the report also revealed that the wealthiest, best-

educated and urban respondents retorted in the affirmative that dirty surroundings as purported, caused malaria (GSS et al., 2015). Also, a higher proportion of the richest Ghanaians (71%) identified “keeping surroundings clean” as a way to protect from malaria, than well-established methods such as sleeping under an ITN (55%) or putting mosquito screens in the window (4%). Also of note is the seeming disconnect between the overall percentage which had earlier identified mosquito bites as a cause of malaria (89%) and the percentage who reported “avoid mosquito bites” as a means of protection (24%).

Using a nationally representative Malaria Indicator Survey in Ethiopia, Hwang and colleagues (2007) in their study, employing a cross-sectional design revealed that knowledge about the causes, symptoms, danger signs and prevention of malaria was approximately 67% among women (n=5,949) and mothers (n=3,447) with children under-five. Their result further revealed that the odds of ITN use increased with increasing knowledge of malaria amongst mothers of children under-five (AOR=1.6; 95% CI=1.1, 2.4) (Hwang et al., 2010). Knowledge was however not found to be significantly associated with seeking health care for children under-five with fever. In a community based descriptive cross-sectional study in Nigeria, Singh and colleagues (2014) found that majority (94%) of the participants had heard about malaria, with majority indicating health workers (26%) and radio/television/newspapers (14%) as their source of information (Singh et al., 2014). In the same study, although more than half of the participants reported mosquito bites (55%) as the cause of symptoms, 19% also indicated germs as the cause of malaria. Majority also reported fever with shivering as a symptom of malaria (Singh et al., 2014). Similarly, a study conducted in Ethiopia also found that majority (84%) of the respondents indicated mosquito bites as the cause of malaria, with the same proportion reporting draining of stagnant waters as their main control strategy (Kaliyaperumal and Yesuf, 2009). In concordance with previous studies, a study conducted in Nepal also found

that majority (86%) of the respondents had heard about malaria, with radio (58%) and television (25%) being their main sources. In the same study, 50% indicated fever with chills as a sign and symptom of malaria, with 73% citing mosquito bite as the cause of malaria transmission. Most of the respondents also cited removal of water collected in ditches as a preventive measure (Joshi and Banjara, 2008). In order to control malaria infection, the authors generally recommended a health education strategy oriented towards effectively improving the knowledge about the disease and adoption of good behavioural practices.

2.5.1 Effect of mHealth intervention on knowledge

Although evidence on the effect of mHealth interventions (primarily SMS-based interventions) on knowledge about malaria is limited, a number of peer reviewed studies have demonstrated its usefulness as a tool for improving knowledge using other mobile devices and mobile applications. For example, in a study conducted by Sharma and colleagues (2011) in India, the researchers compared the effectiveness of two media platforms (mobile phone (text messages) and pamphlets) in improving oral health education among 143 mothers of preschool children. By employing a randomized control trial, the researchers assessed the knowledge, attitude and practices of the mothers at baseline and endline using a structured questionnaire. Text messaging was found to be an effective means of improving oral health education, significantly increasing the knowledge ($p < 0.001$), attitude ($p < 0.001$) and practices ($p < 0.001$) of mothers who received the education messages by text messages compared with those who received the education messages by pamphlets (Sharma et al., 2011). Similarly, a study conducted in Saudi Arabia to assess the effectiveness of a mobile phone-based oral health education programme among mothers of children below 6 years, using paired t-test found a statistically significant ($t=-4.23$, $p < 0.001$) improvement in maternal knowledge 3 months after the

intervention (AlKlayb et al., 2017). In another study conducted in Ghana, the researchers sought to assess the impact of mobile phone text (SMS) messages in encouraging health providers to recommend zinc and ORS instead of antibiotics for the management of uncomplicated childhood diarrhoea. The result of the intervention study revealed that more than 80% of the providers who received the SMS messages and those that did not receive the messages knew that zinc and ORS were the appropriate treatment. However, the SMS intervention which was delivered to 450 of providers in the intervention group, once a week for 8 weeks was found to have a significant influence on their knowledge of appropriate diarrhoea management, improving the recommendation of ORS and zinc for the management of diarrhoea by 9.3% (Woodman et al., 2015).

2.6 Behaviour Change Communication

Effective public health programmes are known to help people maintain and improve health, reduce disease risks, and manage illness generally involve behaviour change at various levels (e.g., individual, organizational, and community) (Glanz and Bishop, 2010). A key goal of behaviour change programmes is to increase individuals' self-efficacy to engage in these health-promoting behaviours (Strecher et al., 1986). Behaviour change communication is mostly employed in supporting interventions like case management improvement, integrated vector management, and programme management by reinforcing all the strategic components of malaria control and prevention. In Ghana, the MoH and the National Malaria Control Programme (NMCP) approved BCC as a crucial approach for ensuring that people living in the country are exposed to messages that increase their knowledge and promote constructive behavioural changes. These often lead to malaria prevention and proper management, such as use of LLINs and seeking proper diagnosis and prompt and effective treatment within 24 hours of diagnosis (GSS et al., 2015).

2.6.1 Theory-Based BCC interventions

A growing body of evidence suggests that public health and health-promotion interventions that are based on social and behavioural science theories are more effective than those lacking a theoretical base (Ammerman et al., 2002; Legler et al., 2002; Noar et al., 2007). It is well known that social, cultural, and economic factors contribute to the development, maintenance, and change of health behaviour patterns (Smedley et al., 2001).

Theories including Health Belief Model (Rosenstock et al., 1988), Social learning Theory (Maisto et al., 1999), Theory of Reasoned Action and Planned Behaviour (Albarracin et al., 2001), Stages of Change (Norcross et al., 2011), Social Learning (Bandura and Walters, 1963) and EPPM (Witte, 1992a) have been formulated to explain the complex nature of behaviour change. However, of interest and the most applicable model of choice for the current study is the EPPM. This theory clearly describes how health messages can strategically be constructed in order to motivate individuals to adopt healthy behaviours.

2.6.2 Constructs of the Extended Parallel Process Model (EPPM)

The essential constructs of the EPPM consists of the following: fear, threat (consist of perceived severity and perceived susceptibility), efficacy (consist of self-efficacy and response efficacy), and two types of responses (danger control and fear control) (Witte, 1992a).

According to the EPPM, when people get scared they are motivated to take action after perceiving a threat to be serious and relevant (Witte, 1994). They are therefore motivated by the fear to take action in order to reduce it. According to the model, there are two general pathways that people take when they become frightened by a perceived threat: they are either motivated to control the danger of the threat or motivated to control their fear regarding the threat [Figure 2.1]. People motivated to control the danger think about

ways to get rid of the threat by consciously thinking about the danger. They usually think about the recommended responses encouraged in the message delivered to them and eventually adopt those as means of controlling the danger. On the contrary, people who are motivated to control their fear do not think about the threat of the danger.

Engaging in either danger control or fear control processes is determined by perceived efficacy, defined by two parameters: response efficacy (one's beliefs about how effective a recommended response is) and self-efficacy (beliefs about one's ability to perform a recommended response). Therefore, high perceived efficacy and high perceived threat promote danger control responses, which involve adoption of message's recommendations on attitude, intention and behaviour change. On the contrary, low perceived efficacy coupled with high perceived threat produces fear control responses which typically occurs at a critical point. People control their fear by defensively avoiding the threat, perceiving the recommended response as manipulation and derogation.

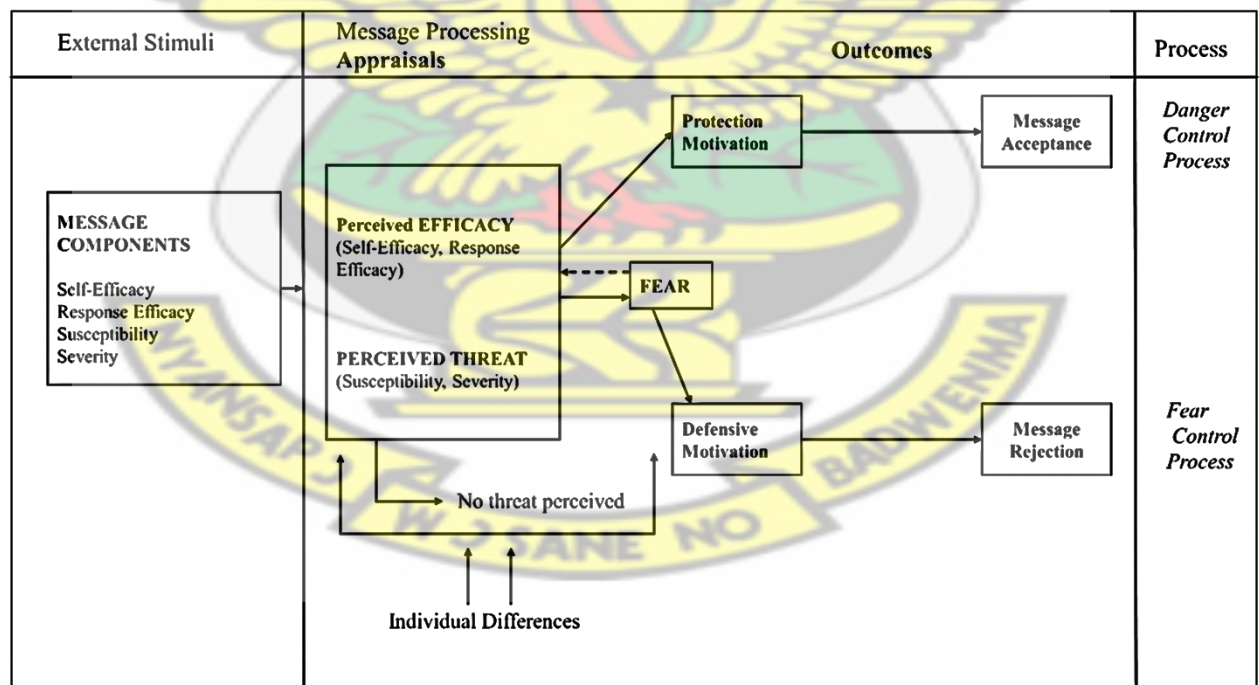


Figure 2.1: The Extended Parallel Process Model by Kim Witte (1998).

In summary, danger control processes lead to acceptance of a health risk message, and fear control processes lead to rejection of a health risk message (Witte, 1993). Therefore, according to the model, the aim of health risk messages is to encourage danger control processes, in which individuals are prompted to think about and adopt recommended responses. Appraisals of threat and efficacy consequently results in one of three outcomes: (a) acceptance of the message (b) rejection of the message or (c) no response (Witte et al., 2001).

2.6.2.1 The Critical Point in EPPM

According to the model, at the critical point, perceptions of threat outweighs perceptions of efficacy, causing individuals to move from danger control to fear control processes. Consequently, at the critical point individuals begin to believe they are incapable of controlling or effectively averting the threat; thus, instead turn to control their fear. Though the precise numerical value of the critical point differs across issues, populations, and individuals, using a value, known as the discriminating value it is possible to distinguish between people engaging in danger control processes and people engaging in fear control processes (Witte, 1996).

$$\text{Discriminating value} = (Z \text{ for perceived efficacy}) - (Z \text{ for perceived threat})$$

2.6.2.2 Empirical Support for EPPM

The initial context in which the EPPM was applied was in the area of AIDS prevention and condom use. The study was carried out to explore the cognitive and emotional mechanisms underlying the success and failure of fear appeals in the context of AIDS prevention. Using a public health service brochure which contained threat appeal messages of AIDS and a message about the effectiveness of condom use, the study involved sexually active unmarried undergraduate students who knew little about AIDS. Using Cohen and

colleagues (2013) procedures for calculating path model coefficients and significance, the study tested the hypothesis including *fear arousal will be greater as threat increases when perceived efficacy is low, than when perceived efficacy is high, and that fear is positively associated with message rejection outcomes*. The result of the study generally offered some level of support for the model and revealed that fear is associated with fear control responses and is not directly related to danger control responses, and when efficacy beliefs are strong, perceived threat facilitates the relationship between the emotion fear and behaviour (Witte, 1992a). Consistent with the previous study, Witte (1996) in a study aimed at developing and validating the Risk Behaviour Diagnosis (RBD) scale revealed that the combined predictors categorized the groups fairly well, with 62% of the participants classified correctly into fear control or danger control. In sum, the discriminant analysis revealed a pattern of consistency with the EPPM hypotheses in that all the danger control responses (attitudes= 0.82 and intentions=0.70) had positive values while fear control responses (derogation (-0.25) and perceived manipulation (-0.19) had negative values when separating the values when discriminating the groups (Witte, 1996). On the basis of previous research conducted along different health subjects, the model suggests that:

1. If the target audience are currently engaging in fear control process, the recommended message should be focused more on efficacy in order to counteract the existing high levels of perceived threat.
2. If the target audience are currently engaging in danger control process, the recommended message should be focused on persistent threat and efficacy.

The theory has been applied in more than 50 studies across different context and population, and has consistently been supported in all these studies as described in a meta-analysis (Witte and Allen, 2000). The model has been applied in a number of health

campaigns including skin cancer (Stephenson and Witte, 1998), breast cancer (Kline, 1995), teenage pregnancy (Witte, 1997) and radon awareness (Witte et al., 1998). Different populations including prostitutes (Witte, 1998), college students (Witte, 1994), and African Americans (Witte, 1996) have also been the focus of EPPM.

In a recent study conducted by Muthusamy and colleagues (2009), the EPPM was applied to examine the effect of fear appeal messages in an already existing high-fear situation. The experimental study conducted in Namibia was carried out to test the core indicators (high threat and low threat; high efficacy and no efficacy) of the model using the equivalence test of analysis in the context of HIV/AIDS. Acknowledging the pre-existing fear due to sufficient awareness about the threat of HIV/AIDS among the study participants, who were undergraduate college students, the researchers exposed them to both threat (e.g. showing graphic pictures of the later stages of AIDS victims) and efficacy (e.g. effectiveness of condom use in the prevention of HIV/AIDS) messages. Using a Likert scale measurement, the results of the study revealed that of the 434 participants, a larger proportion strongly agreed (48%) or agreed (30%) with the statement that that they were “terrified” of HIV/AIDS. The correlation analysis revealed that fear was not associated with attitudes, intentions, or behaviour ($r > 0.10$). However, perceived threat was found to be significantly correlated with attitudes ($r = 0.11$), and behaviours ($r = 0$) but not with intentions ($r = 0.06$). Based on the equivalence tests, the authors of the study concluded that the use of fear appeals to influence audience with pre-existing fear of a threat is not advisable and usually unproductive.

Similarly, using a between- and within-group experimental design, a study conducted by Gore and Bracken (2005) among college students also applied the EPPM, in the context of meningitis. Participants were exposed to either high-threat/no-efficacy ($n = 74$) or high-efficacy/no-threat ($n = 71$) health risk message by an individual who had adequate

knowledge about meningitis after being randomized into 8 groups containing 15- 25 students in a classroom. A pre-and posttest questionnaires were administered to assess their stage of behaviour change. After assessing the discriminating value (efficacy values minus threat values), the result revealed that participants who were initially in fear control ($M=-10.30$) changed to danger control ($M=5.51$) after exposure to the high efficacy/no-threat message. The result further revealed that those who were already in fear control ($M=-9.50$) and exposed to high-threat/no-efficacy message further drifted into higher fear control ($M=-16.18$), indicating a higher state of maladaptive defensive avoidance of the threat (meningitis). Also, the result showed that participants who were initially in danger control ($M=6.10$) and exposed to high-threat/no-efficacy message, changed to fear control ($M=-7.13$). However, the study revealed that exposure to high-efficacy/no-threat message, did not show significant improvement in participants' danger control outcome (from $M=6.59$ to 6.49). With support for the tenets of the EPPM, the authors concluded that a minimal amount of threat is required in a health risk message to change the behaviour of the target audience toward the desired protective measures and that threat messages scares the target audience into fear control.

Using a factorial graph, Brengman (2010) in his study revealed how threat-appeal messages could influence individuals who live a sedentary life by visually separating them into 4 different groups. A sample of 30 sedentary workers were used to assess how these threat-appeal messages could influence their intention to engage in physical exercise. These messages were conveyed through notebook computer or email, after which their intentions were assessed. Using single-subject ANOVA, the result of the study showed a mixed interaction effect for the 4 different clusters. In cluster 1 and cluster 2, respondents appeared to have reacted to the message by having an intention to exercise; in cluster 2, efficacy messages had an influence on their intention to exercise; and in cluster 4,

respondents seemed unmoved to the threat and efficacy message, hence did not have any intention to exercise. It was concluded in the study that different threat-appeal messages are required for an effective health campaigns.

In a related study, Wong and Cappella (2009) using a nationally representative sample of 555 adult smokers aged 18-87, assessed the effect of threat and efficacy messages on the intention of smoking cessation. Participants of the study were recruited through a random digit dialing (RDD) procedure. Based on the type of message, participants were grouped into five experimental situations. The results of the study revealed a significant effect of three high threat messages on perceived threat of the message, with the mean (M) ranging from 2.60 – 2.63. Similarly, two high threat messages were found to be significantly related with perceived message efficacy (M = 1.4 and 1.75). In the multiple linear regression model, a significant positive interaction effect between message threat and perceived level of message efficacy ($\beta=0.11$, $p<0.05$) was found to be positively related with intention to seek help for quitting. As hypothesized in the study and confirmed by the EPPM (Witte, 1992a), the test result further revealed that high perceived message threat and high perceived levels of message efficacy (M=2.27) lead to greater intentions to seek help for quitting compared to those whose perception about the message efficacy was low (M=1.61, $p<.001$). The study further revealed that as a function of perceived level of messages efficacy, intentions to quit smoking did not vary when message threat was low. The study has shown that behaviour change which occurs after appraisal of threat and efficacy of message leads to intention to reduce the threat when perceived efficacy and threat are high.

Overall, the study of human behaviour in itself is complex. Studies that employed the between- and or within-group experimental study failed to account for the complexity of

human interaction, which is known to lead to spurious effect or the “demand effect” (Rosenthal, 1976; White, 1977). Previous studies have also failed to provide evidence on how a changed behaviour can be sustained. Nonetheless, the use of the EPPM have justifiably been proven to offer good empirical basis and support for the effect fear appeals have on health behaviour according to the author of the model (Witte & Allen, 2000; Witte, Meyer & Martell, 2001). Meta-analyses have consistently found fear appeals to be an effective way of promoting attitude and behaviour change ($r = 0.15 - 0.21$) in studies where the mean induction strength ranges from $r = 0.30$ to 0.36 (Witte and Allen, 2000). These theory-driven BCC however did not adopt the use of mobile phones to strategically deliver the health messages, which could help deploy customised messages depending on the stage of change of behaviour of the intended audiences.

2.6.3 Use of mHealth as Behaviour Change and Communication tool

One promising approach is the use of electronic text-messaging to deliver behavioural interventions (Wise and Operario, 2008). It has been reported that BCC are the most predominant of all mHealth interventions and also the most successful. This is because current interventions centre on the use of low-cost SMS texts to reach various audiences. Important short term behaviour changes have been observed, though modest.

2.6.3.1 Client Education and Behaviour Change and Communication

Educational services and campaigns might aim to increase target groups’ knowledge and shift behaviour and norms around different health issues, services, and products. Mobile technologies make people more contactable and as such offer a useful tool to deliver education and improve health-seeking behaviour or health-related lifestyle decisions (Hall et al., 2014). This mHealth approach focuses mainly on the client, offering an innovative conduit to deliver messages, with the intention of improving the knowledge, changing the attitudes and behaviours of target group.

In a study conducted in Thailand to evaluate the cost-effectiveness of different tuberculosis control strategies, which included a family-member, community-member and a health-worker directly observed treatment (DOT) and a mobile phone “contact-reminder” system. These strategies were compared with self-administered treatment (SAT). The result of the study revealed cost savings with family-member DOT (-1\$9 million) due to significantly lower treatment failure rate compared with the SAT. However, the mHealth intervention was not cost-effective, due to a higher associated mortality rate compared with the other treatment strategies. In other words, the intervention fell in a risk-benefit analysis quadrant where the cost-saving was good but health gain was less (Hunchangsith et al., 2012). On the contrary, a retrospective study conducted in South Africa by Broomhead and Mars (2011), using mobile phones observed an improved positive TB outcomes. In the study, an SMS-based mHealth intervention system known as the SIMpill system, was developed to remind patients to take their medication. The system consisted of a device that was attached to a standard pill bottle or blister pack which detect whether patients took their pill or not at the appointed time. This served as a marker for patient taking their medication. Over the 5-year period, the mHealth intervention demonstrated a return on investment (ROI) of 23% which culminated into improved health outcomes and reduced average cost per patient (Broomhead and Mars, 2011).

Other studies on adherence have showed the usefulness of mHealth intervention for reducing viral load amongst HIV patients (Finitsis et al., 2014; Horvath et al., 2012; Lester et al., 2010). As part of a package of adherence interventions, the WHO guidelines strongly recommended the consideration of text messaging for promoting adherence to ART (WHO, 2013b). In the study conducted in Kenya by Lester and colleagues (2010), 538 HIV patients initiating antiretroviral therapy were randomized to mobile phone SMS

intervention or standard care. SMS messages were sent to patients in the intervention group by a nurse and were expected to respond within 48 hours. This randomized control trial study revealed that ART adherence was higher in patients who received the SMS intervention (168/273) compared with patients in the control group (132/265), with a relative risk (RR) for non-adherence of 0·81, 95% CI = 0·69, 0·94; $p=0\cdot006$. Viral loads were also found to be lower among patients in the intervention group (158/275) compared with patients in the control group (128/265), with a RR for virologic failure of 0·84, 95% CI = 0·71, 0·99; $p=0\cdot04$ (Lester et al., 2010). In a related study conducted in Brazil among HIV-infected women, the researchers sought to assess whether mobile SMS messages increases adherence to antiretroviral drug-based treatment regimens. Using an RCT design, the study revealed a compliant of 84.6% in the control group compared with 100.0% in the intervention group. Although a robust study approach was used, the overall sample size of 21 (13 for controls and 8 for intervention) may not be representative enough, hence could obscure the study result (da Costa et al., 2012). In another RCT study conducted in Yaoundé, Cameroon, among HIV-positive clients, aged 21 years and above, the researchers did not find any significant improvement in ART adherence. Similar to the previous study, motivational mobile phone SMS messages were sent to participants in the interventions, with adherence, number of doses missed and pharmacy refill being the primary outcomes. The results of the study generally revealed a non-significant effect of the mHealth intervention on adherence $RR = 1.06$, 95% CI = 0.89, 1.29; $p = 0.542$; reported missed doses ($RR = 1.01$, 95% CI = 0.87, 1.16; $p=0.999$) or number of pharmacy refills (mean difference = 0.1, 95% CI = 0.23, 0.43; $p = 0.617$) (Mbuagbaw et al., 2012). Similarly, a study conducted in China which sought to assess the effect of a biweekly phone call on ART adherence and quality of life (QOL) by randomizing participants into intervention and control groups found no statistically significant effect of the intervention on

adherence. However, significant effect was observed for QOL in areas of physical health ($p = 0.003$), environment ($p = 0.002$), level of independence ($p = 0.018$) and personal beliefs (0.021) (Huang et al., 2013). These studies therefore provide mixed and inconclusive results, although rigorous study design was used. This could be attributed to the differing population, sample size and the procedure employed in carrying out the intervention.

Evidence of mHealth intervention effectiveness for non-communicable diseases have also produced mixed results. An assessment of mHealth-based peer-support group for women with diabetes in a resource-poor setting in South Africa was conducted. This before-and-after study measured health change by examining change in body mass index, health seeking behaviours, blood glucose levels, and coping. The women ($n = 22$) in the study received daily text message reminders from the study team and were also linked to a 'buddy' or peer to encourage each other adopt a healthy lifestyle. Although, the women exchanged 16739 text messages to buddies, the result revealed no evidence of significant change in health over a six-month period (Rotheram-Borus et al., 2012).

2.6.3.2 Health promotion

mHealth tools have been used to support the exchange of information for health promotion that generates and sends short-message service (SMS) to expecting mothers (Jareethum et al., 2008; Kaewkungwal et al., 2010; Lund et al., 2010). Typical examples are the "Better Border and Healthcare Program" in Thailand, which circulated information through SMS concerning antenatal care appointment visits and the expanded program on immunization (EPI) for women along the Thai-Myanmar border (Kaewkungwal et al., 2010). The programme reported an increase in the odds of ontime antenatal visits and EPI for mothers enrolled in the program by 1.91 and 2.13, respectively. In another related programme, known as "Wired Mothers" conducted in Zanzibar, Tanzania, pregnant women were

linked to health units through mobile phones. Reminders on antenatal care appointments were sent to the expectant mothers in order to facilitate access to skilled attendants for obstetric care (Lund et al., 2010). Mobile phone intervention was found to be associated with an increase in skilled delivery attendance, 60% of the women in the intervention group versus 47% in the control group delivered with skilled attendance.

2.7 SURVEILLANCE

Surveillance is defined in many ways. According to one explanation, surveillance means to watch over with great attention, with authority and often with suspicion (Ghag, 2002). The commonly used definition for surveillance is a process of watchfulness over health events which may occur in a population. It has further been defined as the ongoing and systematic collection, analysis, interpretation of health data in the process of describing and monitoring a health event with the objective of supporting the planning, implementation and evaluation of public health interventions and programmes (WHO, 1997). Similarly, it has been described as the monitoring of the behaviour, activities, or other changing information, usually of people for the purpose of influencing, managing, directing, or protecting them (Lyon, 2007). In effect, surveillance helps detect diseases through a homogenous information collection system that can guarantee data quality, analyse, interpretation and response. Effective disease surveillance therefore provides data for monitoring and assessing trends of diseases over time, which is important for prevention and control. It is key for priority setting as it shows the disease burden. In addition, it is a fundamental principle for early detection of outbreaks. Effective control of diseases therefore requires effective response systems, which basically depend on effective disease surveillance. The basis of which is to provide rapid information on priority diseases for public health decision making. Consequently, a surveillance system can be used for monitoring, evaluation and improvement of disease prevention and control programmes.

For monitoring, evaluation and improvement of disease prevention and control programmes.

2.7.1 The Scope of Surveillance

In most disease control programmes, surveillance is one of the pillars of the effective control tools in most countries (Bonita et al., 2006). The scope of surveillance is comprehensive, from early warning systems for rapid response to planned response in the case of chronic diseases, which usually have an extended holdup time between exposure and disease. Most countries like Ghana which adopted the IDSR have guidelines for obligatory reporting of a list of diseases (Bonita et al., 2006). Currently, Ghana has over 20 priority diseases under surveillance [Figure 2.2], with reports being sent to the national surveillance department on a weekly basis. The IDSR strategy in the Ashanti Region, like other regions consists of a community-based surveillance (CBS) system, which involve volunteers reporting unusual health events from communities, and a facility-based surveillance system made up of health facilities. Much of the data flow is upward from the community and facility levels to the district and forwarded to the regional and national levels (GoG et al., 2002). Since 2002, this surveillance strategy has been at the forefront of eradication of diseases such as guinea worm and poliomyelitis, and is used for responding to diseases of epidemic potential including viral hemorrhagic fevers (VHFs), cholera and meningitis. Data from the surveillance system is computed into a district health information management system (DHIMS) for storage and used by health managers to aid in decision-making relating to disease control and surveillance [Figure 2.3]. The IDSR process integrates surveillance with laboratory support, and this is translated into specific public health action. Similar to other disease surveillance strategies, the IDSR has five components which can be evaluated using key indicators to assess their effectiveness. These include their structure, core functions, priority diseases for surveillance,

surveillance quality and support functions (WHO, 2006b). However, implementation of this strategy in Africa depends on the implementation of all parts of the IDSR including coordination, effective communication, laboratory capacity for confirmation of case, disease control officer training, public health nurses, community health nurses, field technicians as well as the availability of sustained and integrated funding for training activities (Sow et al., 2010).

Epidemic-prone diseases
Cholera Diarrhoea with blood (Shigella) Measles Meningococcal meningitis Viral haemorrhagic fevers Yellow fever
Diseases targeted for eradication and elimination
Poliomyelitis (polio) Dracunculiasis Leprosy Neonatal tetanus
Diseases of special public health focus
HIV/AIDS Malaria Tuberculosis
Other diseases of public health importance
Buruli ulcer Diarrhoea in children less than 5 years of age Lymphatic filariasis Viral hepatitis Pneumonia in children less than 5 years of age Onchocerciasis STIs Schistosomiasis Trachoma Yaws

Figure 2.2: Priority diseases for IDSR in Ghana (n=23)

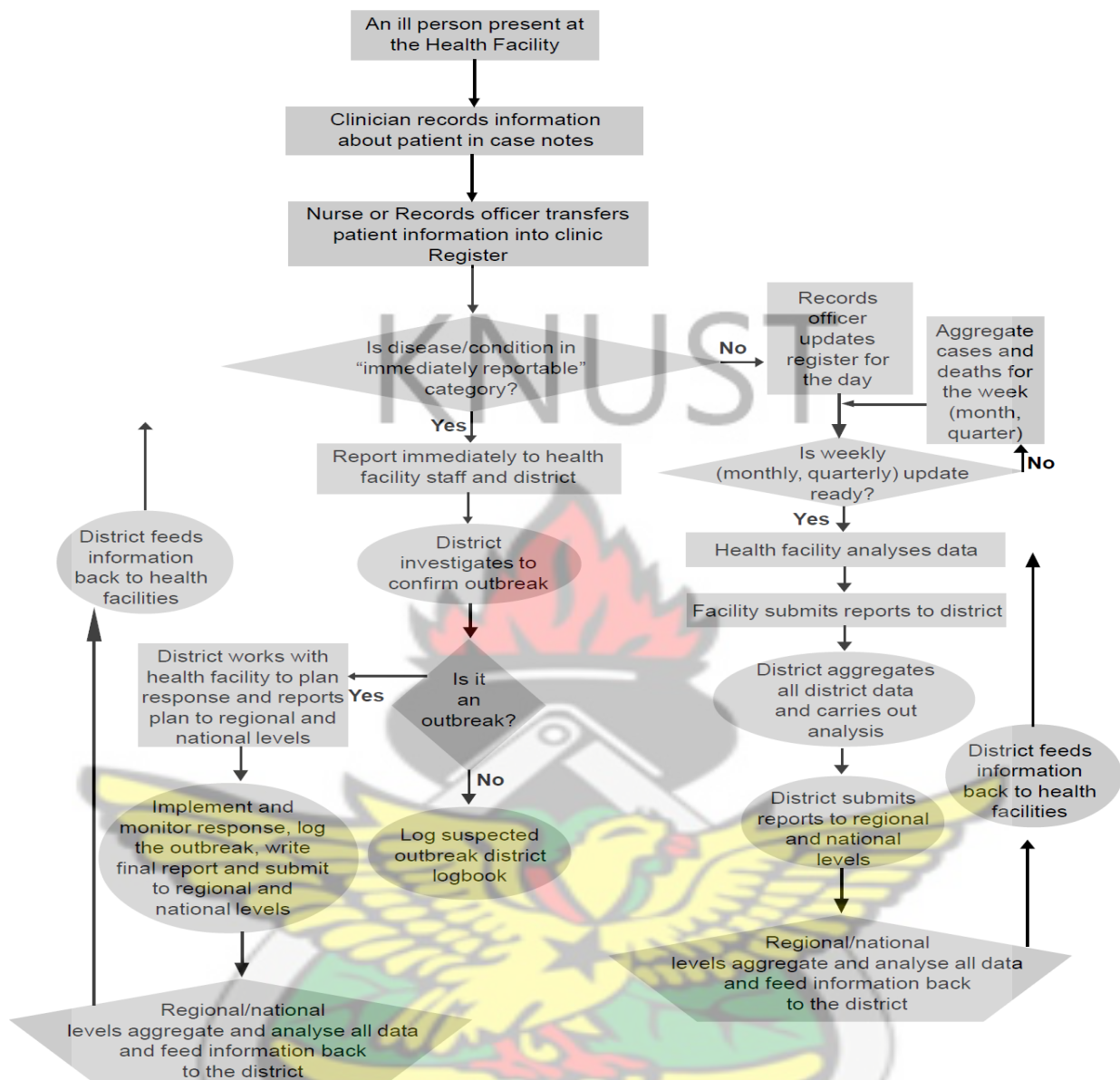


Figure 2.3: Information flow in an Integrated Disease Surveillance System

2.7.2 Surveillance Methods

Passive surveillance

The overall purpose of passive surveillance systems is to assess trends in diseases, risk factors for disease prevention and control (Losos, 1996). This method is likely to underestimate the true burden of illness as many people with these conditions may not seek care. Others may be incorrectly diagnosed or may not receive laboratory testing to confirm a diagnosis.

Active surveillance

This surveillance approach basically requires effort to collect data and confirm diagnoses to ensure more complete reports, such as surveys and outbreak. Though expensive, this method provides the most accurate and timely information, and is mainly suitable for establishing prevalence rates for conditions (Nsubuga et al., 2006).

Syndromic surveillance

An active or passive system that uses case definitions that are based entirely on clinical features without any clinical or laboratory diagnosis (for example, collecting the number of cases of diarrhoea rather than cases of cholera, or “rash illness” rather than measles). Because syndromic surveillance is inexpensive and is faster than systems that require laboratory confirmation, it is often the first kind of surveillance to be adopted in most developing countries (Nsubuga et al., 2006).

2.7.3 mHealth as a Surveillance tool

Applications involving mobile phone and the Internet have been described previously in literature. As noted earlier by Karras and colleagues (2002), phones which are also Java-enabled could be potentially used in disaster response and public health informatics. They highlighted that the technology was fundamentally deployable, portable and that it required minimum orientation to new hardware since most people are comfortable with entering numbers on a phone keypad and pushing the send button (Karras et al., 2002). mHealth tools can therefore be deployed successfully to cater for underreporting of cases and at the same time minimize data loss. However, few studies have successfully used mobile phones for surveillance. One classical example is a study conducted in rural Bandarban district of Bangladesh, which employed the use of mobile phone technology for case detection and management of malaria conducted between June 2010 and June 2012 (Prue et al., 2013). In the study, based on 986 phone calls from ill persons, mobile

phones were used to identify 265 (25%) symptomatic malaria cases out of a total of 509 cases reported in the two years of the study. Similarly, a study conducted by Asimwe and colleagues (2011) used mobile phones to monitor malaria in remote areas of Uganda. Using a mobile phone-based internet technology known as RapidSMS™, health workers in Gulu (with 43 health centres) and Kabale (104 health centre) districts were tasked to report on a number of important indicators covering 14 diseases including several malaria-specific indicators. Positivity rates of rapid diagnostic test was found to be 48% and 71% for Kabale and Gulu, respectively. In another study, Yang and colleagues (2009) used mobile phones as infectious disease surveillance tool for reporting the development of infectious diseases during the Sichuan province earthquake in China (Yang et al., 2009). A total of 495 mobile phones designed to allow inputting and transmitting of infectious disease cases were delivered to local healthcare agencies in the earthquake affected areas. More than half (52.9%) of the total cases reported were done through mobile phones (Yang et al., 2009). In concordance, a mobile phone-based Infectious Disease Surveillance and Analysis System was used to monitor and detect changes that may facilitate early detection of changing risks for emerging infectious diseases in Sri Lanka. The system was developed mainly to monitor disease emergence from animals. Field veterinarians primarily reported animal health information by using mobile phones (Robertson et al., 2010).

New mHealth approaches which employ the use of Interactive Voice Response (IVR) system, an internet-based platform, have provided a new dimension and a great opportunity to collect data and monitor health-related events on a daily basis in near real-time. This approach provides more valid and accurate measures, and making it possible to assess health outcomes, which otherwise would have been cumbersome or otherwise impossible through traditional paper-based data collection system. This approach has been used widely in many health programmes for monitoring behaviours and health outcomes

including chronic disease management, medication compliance, substance abuse, mental illness and post-discharge monitoring of patients (Gawande, 2011; Goldman et al., 2008; Greist et al., 2012; Kaminer et al., 2006; Reidel et al., 2008).

2.8 Interactive Voice Response System (IVR)

The integration of mobile phones and computers have created a vast area of application in healthcare. Interactive voice response (IVR) automated mobile phone technology offer the potential of harnessing self-report formats and of connecting them to a central database to provide nearly universal access from clinics or patients' homes. The system is basically designed to allow a caller to dial into the computer system over a telephone line and access a service running on the computer. The caller may then interact with and receive voice information from the service. The interaction between the users and the system involves numerous voice prompts output by the system and responses thereto input, via the telephone keypad, by the user. Usually, a voice response system provides the proficiency of playing voice prompts which is usually made up of recorded voice sections or dialog created from text and to receive responses. The prompts are generally played as part of a voice menu invoked by the call flow logic. The prompts are usually part of a voice application which is intended to, for example, allow an individual to query information related with their different bank accounts (Pickering, 2005).

Although a number of studies have compared IVR to live interviews, few have looked at IVR in comparison to pencil-and-paper survey administration. IVR can significantly reduce both the patient and administrative burdens of using surveys, while making the administration of a large number of surveys economically feasible and reliable.

2.8.1 Feasibility and reliability of the mobile phone-based automated systems

In the current information age, care is ongoing, customized and centered around the patient. Clinical data is supported by clinical decision support systems, alerts, reminders and evidence. Although IVR have not been fully explored, earlier researches have documented on its use, majority demonstrating its application in the area of monitoring and management of chronic disease, care of special populations and medication management (Heisler et al., 2010). The technology has also been used to collect health information for various health behaviours, including safe sex practices and alcohol use in HIV prevention research (Barta et al., 2008; Schroder et al., 2007). Most studies, however, examined the feasibility and reliability as well as the validity of the mobile phone-based automated system for monitoring of health-related outcomes (Blondin et al., 2010; Brodey et al., 2005; Hettema et al., 2012; Lam et al., 2009; McDaniel et al., 2005).

2.8.2 Chronic Disease Management and Risky Behaviour

In a qualitative study which sought to assess the functions of an automated speech-recognition IVR system for diabetes care, the result of the study revealed the usefulness of the system for providing specific dietary advice, information about Diabetes, self-care, reminders about laboratory test results and appointments, tracking of personal laboratory results and feedback about their self-monitoring (Goldman et al., 2008).

In a similar study conducted in two U.S. Veterans' Affairs (VA) health care facilities, the technology was successfully used in a peer support programme for persons with diabetes. The objective of the study was to compare the effectiveness of a reciprocal diabetes peer support programme (RPS) with nurse care management (NCM) in improving glycemic control in real-world clinical settings. Employing a six-month parallel randomized controlled, using 244 male diabetes patients with a hemoglobin A1c (HbA1c), the study revealed that RPS participants had a mean HbA1c of 8.02% at baseline. This however,

improved to 7.73% at six months (−0.29%) compared with an average increase in HbA1c among NCM participants (7.93 to 8.22 [SD 0.29]). The study observed no differences between groups at follow-up in blood pressure, self-reported medication adherence, or diabetes-specific distress (Heisler et al., 2010). The mobile phone-based system which gave reminders for peer contact was seen as a successful way for diabetes management. Similarly, an earlier study was conducted to assess whether diabetes patients with low-income patients were able and willing to use the mobile phone-based related automated IVR system to provide health status information that could improve the quality of their care. A total of 252 adults with diabetes, 30 of whom spoke Spanish as their primary language were enrolled in the study. The result revealed that half of all the patients completed at least 77% of their attempted assessments, with one-fourth completing at least 91%. Socioeconomic factors such as education and language were strongly associated with patients' likelihood of reporting their self-monitored blood glucose (SMBG) levels data during assessments (Piette et al., 1999). In a related study, Piette and colleagues (2000) examined the effect of this technology with telephone nurse follow-ups as a strategy for improving outcomes such as mental health, self-efficacy, satisfaction with care, and health-related quality of life among low-income patients with diabetes mellitus. Using a sample of 258 respondents, this randomized control trial study revealed that patients in the intervention group at follow-up reported fewer symptoms of depression ($p = 0.023$), greater self-efficacy to conduct self-care activities ($p = 0.006$), and fewer days in bed because of illness ($p = 0.026$) compared with patients receiving usual care (Piette et al., 2000).

Using a convenience sample of HIV-positive individuals attending a university-affiliated infectious diseases clinic, a study conducted in the U.S. assessed the feasibility and reliability of IVR for HIV medication adherence. Participants were asked to call in to an

IVR system to report adherence daily during two weeks of a larger prospective study. The rate of response and patterns were analysed for feasibility and compared to retrospective, self-report timeline follow-back (TFLB) adherence reporting. Using Concordance Correction Coefficient (CCC) and Kappa Coefficient, the study assessed the reliability and level of agreement of IVR and TFLB adherence reports. Majority of the participants (n=52; 82.5%) called in to use the IVR on at least one occasion. In general, participants called in to report on medication adherence of mean 8.87 (SD 5.62) out of the 14 assigned days (63.4%), an indication of a moderate feasibility according to the authors. The results of the CCC ($p=0.78$; 95% CI = 0.74, 0.81) and Kappa ($\kappa=0.02$; 95% CI= -0.30, .34) revealed a poor agreement between the IVR and TFLB methods (Hettema et al., 2012). Compared with another study conducted in a limited resource setting of Uganda, which sought to determine the feasibility and acceptability of IVR, only 12.5% of the weekly IVR assessment calls resulted in successful responses. Adherence data were collected from 19 caregivers of HIV-infected children. In the study, participants received IVR assessment calls once weekly for 3–4 weeks during which they were asked to enter their participant ID on a key pad and then key in the number of missed medication doses in the past 7 days. Weekly completion rates for adherence inquiries were found to be low, ranging from 0–33%. Qualitative interviews with participants revealed several barriers to IVR response and reason for low adherence, mainly due to misinterpretation of personal identification numbers. Other barriers included poor reception, dead batteries, and an inability to correct mistaken key entry (Haberer et al., 2010). In another related study, the researchers sought to test the feasibility and performance of IVR in assessing the sexual behaviour self-reports, comparative to self-administered questionnaire (SAQ) and TFLB methods. A sample of 44 students were recruited at the University of Texas at El Paso and asked to report about their daily sexual behaviours and substance use for 91 days. Follow-ups were

carried out every 3 months to collect data on their sexual behaviours and substance use using a questionnaire reports and by TLFB. In order to allow for a fair comparison between the three data sources, IVR and TLFB self-reports were matched by date. Square root transformation was identified as an appropriate method for count data in order to approximate a normal distribution. Repeated measures such as (M)ANOVAs and t-tests were used. With regard to the overall number of sexual episodes reported, the posthoc analysis comparisons revealed significantly greater self-reports in both IVR and SAQ compared to TLFB at $t = 4.15$, $p > 0.001$, and $t = 3.43$, $p < 0.01$, respectively. Furthermore, self-reports of alcohol consumption were found to be significantly greater in the SAQ compared to the IVR at $t = 2.40$, $p < 0.05$. In the study, gender was found to moderate the effects of the mode of assessment (Schroder et al., 2007). A major limitation of the study was the relatively small and restricted sample size used.

2.8.3 Medication compliance

Interactive Voice Response systems have also shown some promise as a tool for reminding individuals to take medications. With medication compliance having a significant consequence for patient health and care delivery (Haynes et al., 2002; Wahl et al., 2005), Reidal and colleagues (2008) conducted a study to investigate the feasibility and acceptability of using an IVR system for prescription refill and daily medication reminders. A study conducted in Quebec, Canada, used only 39 participants who completed the follow-up interview, although 299 consented. Participants were initially contacted using an IVR system to record their voiceprint, time of day when the IVR calls would be made, phone number to be called, and whether they wanted daily prescription refill reminders and medication reminders. Most of the participants (89.5%) found the clarity of the system's voice to be good or fair, with 87.9% also indicating the volume of the IVR voice to be acceptable. About 71.0% of the participants responded that they had

refilled their medication at the time they received their IVR call, with 14.3% indicating that they found the system helpful for remembering to refill. One major limitation of the study was the small sample size used, which could have led to an underestimation of the effectiveness of the system (Reidel et al., 2008). In another related study conducted in Ottawa, Canada, the researchers assessed the effect of IVR system support for oral anticoagulant management. Using a sample of 226 patients, the system was designed to provide them with information on dosage schedules for anticoagulation therapy, as well as upcoming and missed appointments for blood tests. The system was able to deliver 1211 (77.8%) of 1557 scheduled dosage messages, without further aid from clinic staff. Majority (76.6%) of participants (164/214) opted to continue using the system for their anticoagulation management even after the study had ended. Overall, the system had reduced the workload of the staff by 33.0% (48min/week), a reduction from the baseline of 2.4 hours (Oake et al., 2009). Similarly, an earlier study also provided evidence of the system's capacity of improving medication adherence and blood pressure control among 269 hypertension patients, using a randomized control trial in the U.S. (Friedman et al., 1996).

2.8.4 Substance abuse

With the prevalence of cigarette smoking exceeding 35% for individuals with incomes below the poverty level according to the Centers for Disease Control and Prevention (CDC) in 2003 in the U.S. (CDC, 2003), McDaniel and colleagues (2005) developed an automated system to screen for tobacco use among tobacco users scheduled for primary care visits. The aim of the study was to evaluate the feasibility of the IVR system for identifying tobacco users and smoking cessation intervention for primary care patients. A software known as the TeleHealth, the IVR system, was developed to collect data from patients through a telephone keypad. The system was developed to place calls at

predetermined times before patient's scheduled clinic visit. The system also had strong quit message reminders, prompting physicians to offer assistance for all patients who smoked. Patients who reported smoking were followed-up and asked whether the provider discussed smoking and advised to quit smoking. The result of the study revealed that 55% (1,117) of the initiated calls were answered. With regard to feasibility, the call completion rate was 53%. A total of 421 smokers were identified by the IVR system, out of which 120 were successfully followed-up. The post visit interview revealed that only 48% of the smokers identified after follow-up (58 participants) discussed smoking cessation with their provider. A limitation of the study was the lack of a comparative group which generally limits the results of the study in assessing the effectiveness of the intervention. Nonetheless, the objective of the study of assessing the feasibility of the system was fulfilled (McDaniel et al., 2005). In order to improve the understanding of predictors of relapse among adolescents treated for alcohol and other substance use disorders, Kaminer and colleagues (2006) employed the IVR system. They sought to evaluate the feasibility and acceptability of the system for data collection in adolescents aged 14 – 19 years of age treated for the disorder. Participants were given appointed times to call the system. Using analysis of variance, participant's use of alcohol and drugs during the 14 days of daily monitoring were assessed. The result of the study revealed a higher completion rate of 72% compared with previous studies (Goldman et al., 2008; McDaniel et al., 2005; Schroder et al., 2007). The higher completion rate observed in this study is most likely due to the study population and the use of technology, as substance abuse persons may feel less judged conveying their substance use to a computer than a person. The study also revealed that 59% and 78% of males and females, respectively, used an illicit drug at least once during the 14-day study period. Majority of the males (90%) and females (75%) who reported drinking at least once during that period used an illicit drug at least once during

the same time frame (Kaminer et al., 2006). As with other studies, the relatively small sample size (26 participants) limits the scope of the study when interpreting the results. Although not reported in this study, the validity of system reports have been assessed by Brodey and colleagues (2004). Using the Addiction Severity Index (ASI), they found that the mean correlation and kappa estimates between Internet and IVR and those of clinician interviews was 0.91. The mean kappa coefficient estimate was 0.75. The study concluded that the automated system could reduce labour cost associated with ASI and may also enable longitudinal monitoring of subjects (Brodey et al., 2004).

2.8.5 Monitoring of health outcomes

Readmission of patients is known to be common, affecting 4–25% of patients (Kazaure et al., 2012; Tevis et al., 2014). Considering the risk involved after patients are discharged from hospital, monitoring of patients during this transition becomes an imperative line of action especially when distance is a major limiting factor.

The use of an IVR system for post-discharge monitoring provides an alternative dimension for identifying patients with new or deteriorating health complication, medication problems, or the need to talk to a medical personnel. In a post-discharge IVR feasibility study conducted by Foster and Van Walraven (2007), health conditions of patients were remotely monitored by sending voice messages to them. The objective was to identify all patients with new post-discharge health problems. The study revealed a completion rate of 51.9%, with 26% (20/77) reporting new or worsening symptom or problem with medication. A major limitation of the study was the inability to account for patients who did not respond to the system. These patients may have experienced complications which were not captured by the system, hence leading to under-reporting of new post-discharge symptoms or complications (Forster and Van Walraven, 2007). Using a prospective cohort design, a related study conducted in Canada, used IVR system to identify 9% (25) and

21% (57) of elderly patients with multiple co-morbidities in need of an intervention and medical follow-up, respectively (Forster et al., 2009). In another study conducted in rural north-eastern Alabama among substance users living with HIV/AIDS, Tucker and colleagues (2013) evaluated the use of IVR system for assessing daily HIV medication adherence. The IVR self-monitoring system was designed to carry out daily assessment of prescribed HIV medications taken preceding the day as well as alcohol intake, drug use and sexual activity. Based on the IVR data, the proportions of callers who reported any drug use, drinking, or risky sex were 58.3%, 69.4%, and 69.4%, respectively. About 32% reported adherence rates below the optimal rate of 95%. The system was therefore found to be a useful tool for identifying patients with suboptimal adherence and monitoring medication adherence (Tucker et al., 2013).

2.8.6 Data collection

The IVR technology has also been used in the research field for collecting data. Abu-Hasaballah and colleagues (2007) in their work emphasized the usefulness of this tool in clinical and behavioural research (Abu-Hasaballah et al., 2007). The use of IVR for data collection dates back in 1989, and has since steadily increased over the years (Corkrey and Parkinson, 2002; Searles et al., 2000; Toll et al., 2005). Studies have used the technology for collecting data on symptom monitoring, adverse event reporting and in pharmacotherapy (Hahn and Plane, 2004; Kranzler et al., 2004). In a classical example, Toll and colleagues (2005) in their study sought to collect data on cigarette consumption using the automated system. They collected daily reports of cigarette and alcohol use using IVR system and Timeline Followback (TLFB) methods. They assessed the concordance of the two reports and found that the completion rate for IVR was 49.9% compared to the 93.2% for TLFB. Their study revealed high correlations (ranging from $r = 0.84 - 0.99$ for days 1 to 7) between reports of smoking behaviour, as assessed by IVR and TLFB,

although compliance was higher for TLFB compared with the IVR reports. Their correlation estimate was higher than Searles and colleagues (2000), who revealed the correlation between the two methods to be $r=0.57$ for the aggregate total of at 366 days when they assessed the daily alcohol consumption (Searles et al., 2000).

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CHAPTER THREE

3.0 METHODOLOGY

3.1 INTRODUCTION

This chapter introduces the study method and design. It provides an account of how the survey was conducted. It also provides details of the study tools and techniques used for data collection. The chapter also describes in detail which population was studied, sample size calculation and how the study sample population was selected. A detail account of how both the quantitative and qualitative data were analysed is also provided in this chapter. Definitions of the variables are also described in detail. The relevance of data handling and ethical issues as well as the limitations of the study are also discussed.

3.2 HEALTH PROFILE OF STUDY AREA

The study was carried out in the Asante Akim North district of the Ashanti region of Ghana. The Asante Akim North is one of the newly created districts (2012) in the Ashanti Region. It has a land size of about 600 square kilometers and shares boundaries with Sekyere East, Sekyere Kumawu and Sekyere Afram Plains on the north, south by Asante Akim South, west by Asante Akim Central and east by Kwahu East as shown in Figure 3.1.

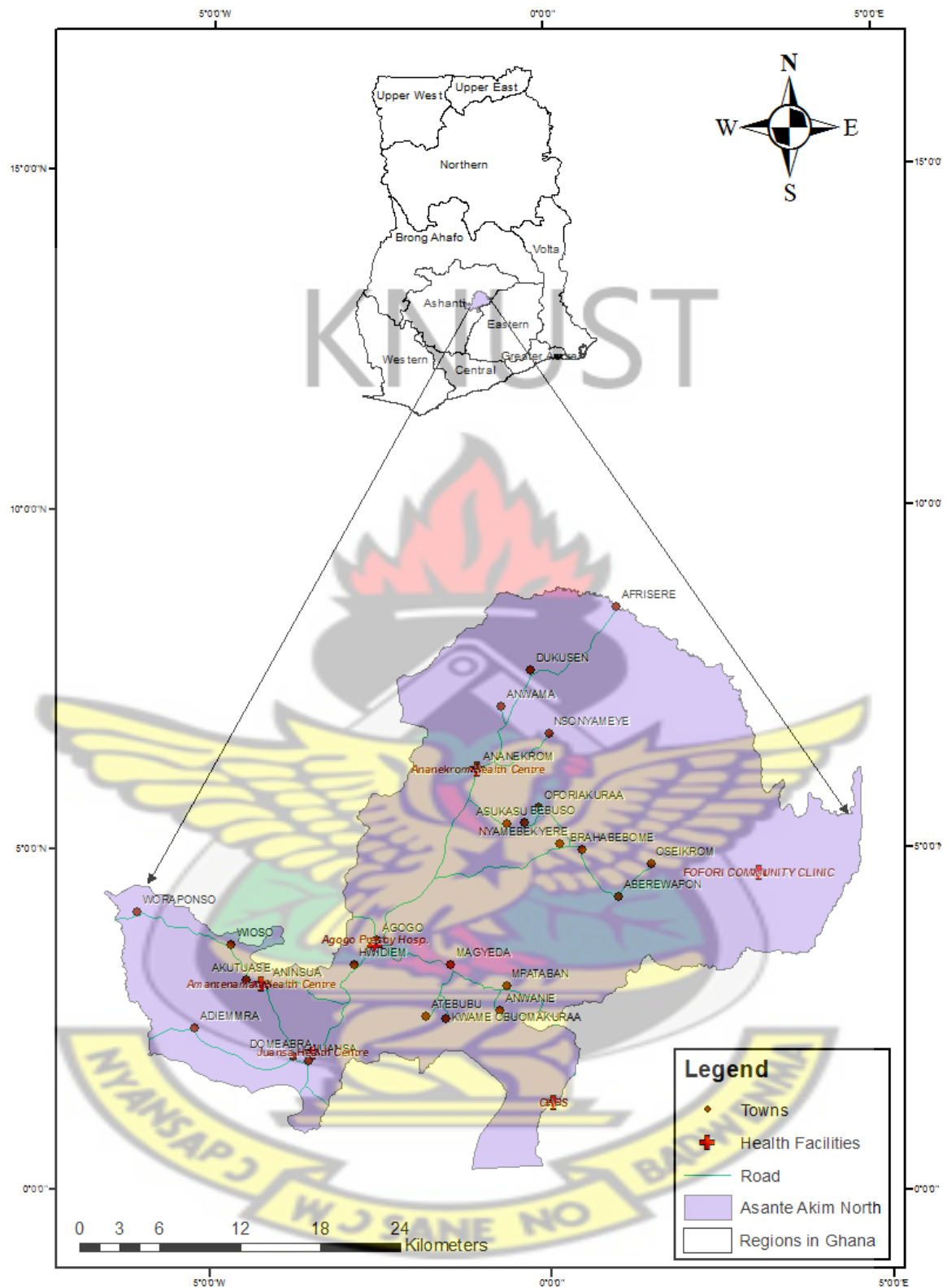


Figure 3.1: Map of Asante Akim North District

Source: Ghana Statistical Service, 2014

3.2.1 Population

It has a projected population of about 81,186, with sixty four (64) communities. The district is operating with twenty two (22) demarcated Community Based Health Planning and Services zones according to electoral areas. The Afram Plains covers about 40% of these communities.

3.2.2 Age-Sex Structure

The population pyramid in Figure 3.2 shows the age – sex structure of the Asante Akim North District. The broad base of the pyramid denotes a youthful population consisting of a large proportion of children under 15 years and a narrow apex made up of a small proportion of elderly persons (65 years and older) in the District. This can be seen by a decline in the bars as the population advances in age. Persons in the age cohort 0-14 years represent 39.9 percent, 15-64 years represent 54.8% and 65 years and above account for 5.3% of the total population in the District. This implies that the District has a greater percentage of labour force since a greater fraction of the population can be found in the economically active group. The trend also shows that males outnumber females from age cohort 0-19 years while females outnumber males from age 20 years and above.

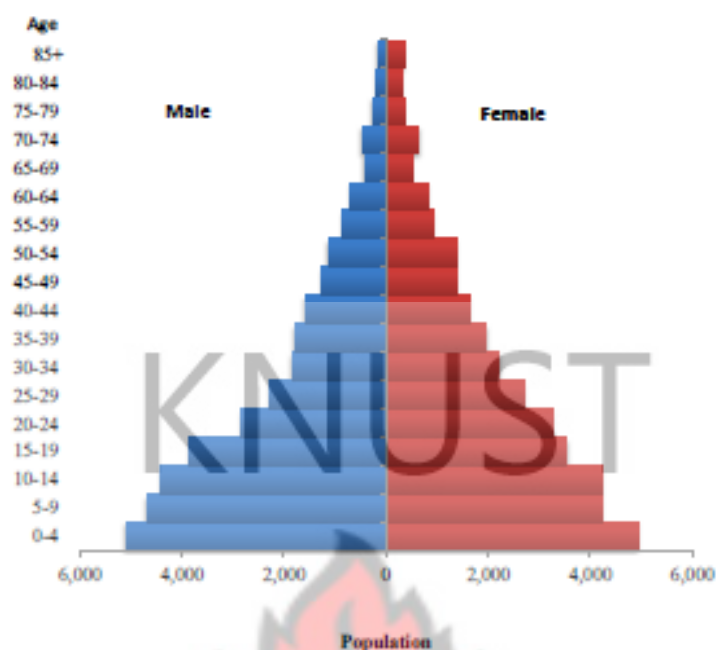


Figure 3.2: Population pyramid

Source: Ghana Statistical Service, 2010 Population and Housing Census

3.2.3 Health

The district is divided into four sub-districts namely; Agogo, Ananekrom, Juansa and Amantenaman. Agogo and Ananekrom sub districts have the Afram Plains where they share borders with Sekyere Afram Plains and Kwahu East districts as shown in Table 3.1.

Table 3.1: Population Distribution per Sub-district-2016

Sub-District	Projected Population	% of the Total
Agogo	45,870	56.5
Ananekrom	10,148	12.5
Juansa	12,827	15.8
Amantenaman	12,340	15.2

Source: GHS-Asante Akyim North District

3.2.4 Ethnic Groups

Majority of the people in the district belongs to the Akan tribe. The minority ethnic groups include Fantis, Ewes, Gas, Moshies, Sissalas, Nzemas, Dagombas and Kussasis and Mamprushies. The predominant language is Twi.

3.2.5 Vegetation

The vegetation is mainly tropical rainforest and savannah grassland. Frequent bush fires have destroyed some of the forest vegetation and are threatening to turn the district into grassland. Due to logging activities of the timber industry and charcoal burning, legal and illegal, the virgin forest is being depleted.

3.2.6 Rainfall

There are two main rainy seasons in the district between mid- March and late June and late August through to November. The first dry season is from December to February with North Easterly winds (That is the harmattan dry winds from the Sahara desert) and the second and shorter dry season from the end of June until August.

3.2.7 Religions and Groups Associations

The major religions are Christianity and Islam. Some practice Paganism. Majority of the people are Christians and belong to the Presbyterian Church. Other organised groups are the Carpenters Association, Ghana Private Road Traffic Union (GPRTU), Hairdressers and Seamstress Associations and other Youth Associations.

3.2.8 Electricity and Water

Hydroelectric power exists in the main towns stretching from Juansa, Domeabra, and Hwidiem to Agogo. Others are Amantenaman, Wioso and other smaller towns. Pipe borne water exists in the main towns. Additionally there are bore holes in most communities which were provided by World Vision Ghana. However some villages have hand dug

wells. The district cannot boast of all communities having good drinking water because some communities still drink from the rivers and streams.

3.2.9 Transportation and Communication

The main forms of commercial transport are passenger buses and taxis. The District Health Administration has no means of transport. However, other decentralized departments mainly use pickups for their daily activities. Motorcycles are also used extensively. Tractors and bicycles are the main forms of transport. A second-class road stretches for about 30 kilometres from Konongo to Agogo. The remaining roads are feeder roads which are mainly in the Afram Plains.

Telephone services, private and commercial are available at Agogo, Hwidiem and Juansa and other smaller towns. There are private communications centres (information centres) in all the sub districts where funerals and other important announcements are made, usually available at Agogo hospital, Ghana Commercial Bank (Agogo) and the Police stations, (Agogo, Juansa).

3.2.10 Banking Services

There is a commercial bank in the capital town of the district in Agogo. There are also two rural banks in Agogo and Juansa.

3.2.11 Main Economic Activities

Majority of the people depend on small-scale farming. Crops produced include tomatoes, cassava, plantain, maize, cocoyam, groundnuts, and yam. Appropriate period of farming during the year is between March and September. Sand winning and chain saw operators operate in the district. Trading in general goods is a major economic activity. Commercial farming is practiced on a small scale and crops planted include cocoa, plantain and maize. Fishing on a small scale is also practiced in the Afram Plains. Charcoal production is the main occupation of the Sissalas in the Afram Plains. However, this activity is degrading

the environment on a large scale. Trading takes place all year round but peaks between August and December.

3.2.12 Traditional Authorities

Traditionally Chiefs and Queen mother's rule the towns and villages. There are three traditional councils centred on the three main towns namely: Agogo, Juansa and Domeabra.

3.2.13 District Administration

The District Assembly is the highest political authority with the Chief Executive as the head. The President of Ghana appointed him and he is re-elected every four years by the assembly members through balloting. Two thirds of the assembly members are also elected every four years through balloting. The remaining one third is appointed by the President. The District Assembly is the policymaking body. It has five sub committees. They are Finance, Social Services, Public Works, Education, and Executive. The District Administration is administered by the Chief Executive and the Coordinating Director who is assisted by two deputies. The Administration has three units namely the Planning, Budget, and the Finance. These are managed by the Planning Officer, Budget Officer and the Finance Officer, respectively [Table 3.2]. Under the new guidelines, as part of the decentralization process, eleven decentralized departments have been created and a director heads each.

Table 3.2: District Administration.

DECENTRALIZED DEPARTMENT	CONSTITUENT DEPARTMENTS.
1. Ghana Education Service	M.O.E., National youth Organizing Council
2. Department of Agriculture	Veterinary Services, Crops Agriculture, Extension, Mechanization, Policy, Planning, Monitoring and Evaluation Division (PPMED)
3. Health Department	Office of the District Director of Health Services, Environmental health under Local Government
4. General Works	Public Works Department, Feeder roads, Rural Housing
5. Community Development and Social Welfare	
6. Physical Planning	Department of Town Planning, Parks and Gardens
7. Finance	Controller and Accountant General
8. Natural Resources	Forestry, Game and Wildlife
9. Trade and Industry	Trade and Cottage Industry
10. Disaster Prevention	Fire Service Department and National Disaster Management organization (NADMO)
11. General Administration	Planning and Co-coordinating Unit, Births and Deaths, Information Services Department, Statistical Service and Co-operatives

Source: GHS-Asante Akyim North District

3.2.13.1 District Administration sources of funding includes the following:

1. Revenue from direct taxation Common fund.
3. European Union funds.
4. Common fund from Government of Ghana
5. Stool lands revenue

3.2.13.3 District Health Administration

The District Health Management Team is responsible for managing health activities in the district. Funds for Health activities are in the form of financial encumbrance and Sector Budget Support (SBS) from Government of Ghana and Internally Generated Funds (IGF) from health facilities.

1.8.13.4 Health Systems and Development

The main health facilities in the four sub-districts are shown in Table 3.3. The district has twenty-two (22) CHPS compound and one (1) private facility.

Table 3.3: Facilities and their location

Facility	Location
Agogo Presbyterian Hospital (Mission)	Agogo
Juansa Health Centre	Juansa
Amantenaman Health Centre	Nyamponase
Ananekrom Health Centre	Ananekrom

Source: GHS-Asante Akyim North District

3.2.13.5 OTHERS

• Chemical Sellers	30
• Trained TBA	47
• Community Based Surveillance Volunteers	71

Table 3.4: Communities and Outreach Sites for Child Welfare Clinic

Sub-district	Number of Communities	Number of Outreach Sites
Agogo	51	33
Juansa	5	7
Amantenaman	8	7
Total	64	47

Source: GHS-Asante Akyim North District

3.2.14 Information Communication Technology

Information and Communication Technologies (ICT) has contributed immensely to the development of human capital and hence increased productivity (Ayensu, 2003). This section outlines the proportion of individuals who own mobile phones and the use of

internet among the population aged 12 years and older as well as household ownership of desktop/laptop computers in the Asante Akim North District.

Ownership of Mobile Phones

The 2010 population and housing census collected data on access to and use of ICT, ownership of mobile phones and fixed line phones from persons 12 years and older. Cellular phones have formally become the most widely used telecommunication tools in the District and their use has been spreading faster than any telecommunication technology. Among persons 12 years and older, 42.1% own mobile phones. Among the male population 12 years and older in the District, more than half (51.6%) own mobile phones, while that of the females is 48.3%.

Use of Internet

The Internet has become a very useful communication facility for people, businesses and organizations. Some of the common uses of the internet include electronic mailing, accessing information, conducting business transactions, social networking and shopping. As shown in Table 1.5, about 3.6 percent of the population 12 years and older in the District use internet facilities. A higher proportion of males constituting 4.8 percent have internet access as compared to 2.3 percent of females.

Table 3.5: Population 12 years and older by mobile phone ownership

Sex	Population 12 years and older		Population having mobile phone		Population using internet facility	
	Number	%	Number	%	Number	%
Total	46,578	100.0	19,619	42.1	1,654	3.6
Male	22,088	100.0	10,135	51.6	1,082	4.8
Female	24,490	100.0	9,484	48.3	572	2.3

Source: Ghana Statistical Service, 2010 Population and Housing Census

3.3 STUDY METHODS AND DESIGN

The study was a community-based quasi-experimental study, which employed a cross-sectional design at baseline and endline at intervention and control sites. The study primarily used a quantitative approach designed to assess the use of a mobile phone-based health information and surveillance system (mHISS) as an intervention tool for the control of malaria in children under-five by delivering health messages by SMS to caregivers with children under the age of five years via mobile phones, and monitoring childhood disease symptoms at the Asante Akyim North District in the Ashanti Region of Ghana. The study was conducted from February, 2016 to March, 2017.

Prior to the start of the survey, one month was dedicated to setting up and testing the mHISS system, which was designed to automatically deliver voice SMS about malaria to caregivers via mobile phone. A team, comprising of the District Health Management Team (DHMT) of Asante Akyim North district together with medical doctors and epidemiologist from Germany and Netherlands assisted with the design and assessment of the system and its content. The appropriateness and feasibility of the mHISS for predicting and providing health advice to caregivers were also discussed during a joint meeting between the researchers and stakeholders within the district.

3.3.1 The Quasi-Experiment

Based on the study design, at baseline caregivers with children under the age of five years in both the intervention and control site were solicited to participate in the study after informed consent was sought. Mobile phone numbers of all caregivers in the intervention site were taken, and in return given a toll-free health-line to call when their wards are not well in order to receive health advice. After agreeing to receive health messages via their phones, bi-weekly behaviour change messages which sought to improve their knowledge

and health behaviours about malaria were delivered to them by voice SMS in their local dialect (*Twi*) via their mobile phones. The behaviour change messages of the study, modelled based on the EPPM, after decades of research in health communication have shown that knowledge is not the only determinant of behaviour. Factors such as exposure to messages, perception of risk, self-efficacy, response efficacy, and social norms play a key role in health decision making. For malaria specifically, exposure to messages, perception of risk, self-efficacy, response efficacy, and knowledge of malaria transmission and symptom have been shown to be associated with preventive behaviours (Alaii et al., 2003; Panter-Brick et al., 2006, Boone et al., 2014). On the other hand, caregivers at the control site did not receive any health messages from the study team. The assumption was that, like the caregivers in the intervention site, they also receive health messages from other sources including radio, television, friends, health workers, etc.

The intervention lasted for twelve months, after which the same caregivers (both intervention and control group) were approached again by the study team to conduct endline assessment. Of the 334 caregivers interviewed at baseline, 10 (6 from intervention site and 4 from control site) could not be followed up after the twelve months intervention period as shown in Figure 3.3.

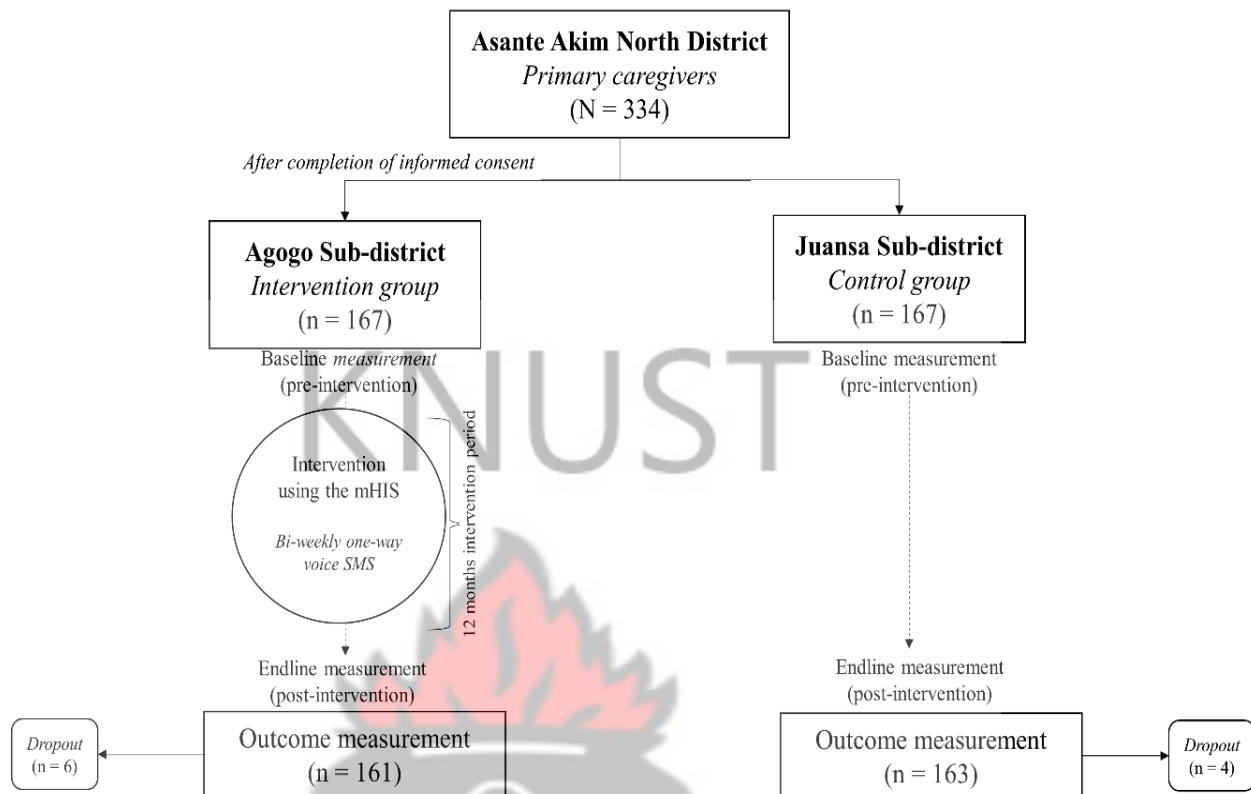


Figure 3.3: Quasi experimental study design

A 3-day training workshop was organized for three research assistants to support data collection in the community. They were trained on how to administer the questionnaire using the ODK collect tool. Significant emphases were placed on understanding the content of the questionnaire, and uniformity of the questions asked in order to avoid bias. Initially captured in English, the questionnaire was translated into the most common language spoken (*Twi*), and retranslated into English in order to ensure reliability of the tool. At the end of the training session, research assistants were provided with mobile phones, a copy of the paper questionnaire for reference and a sheet which had details of the communities to be surveyed. The field coordinator together with one research assistant were responsible for supervising the collection of health facility data.

3.3.2 The Intervention

Development of the mHISS

As the sole intervention tool, the mHISS was developed to 1) deliver *BCC messages on malaria* by voice SMS to caregivers via their mobile phones and 2) *assess disease symptoms* of children and provide health advice to caregivers on what to do with their sick child.

1) BCC messages on malaria

Using the phone numbers obtained from caregivers during recruitment, the mHISS was setup to automatically deliver the BCC messages [Appendix F] to the caregivers at their own convenient time in a form of voice SMS – received in a form of a phone call. Scheduled based on the time indicated by the caregivers, the voice messages on malaria were uploaded into a ‘decision tree’ of the system and automatically delivered to them at the appropriate times. A summary of the number of successful/interrupted, rejected and unanswered SMS were generated by the system. The expected outcome of the BCC messages was an improvement in knowledge about malaria and change in health behaviours of the caregivers through fear appeal as posited by the EPPM. The BCC messages were made up of two components, 1) knowledge about the causes and prevention of malaria and 2) behaviour change (fear appeal) in terms of the threat of malaria and ways of preventing the disease, all geared towards improving their perceived threat and efficacy.

- **Knowledge about the causes and prevention of malaria:** Delivered together with the behaviour change messages, this component described the causes of malaria and the various ways children could be protected from being bitten by a mosquito.
- **Behaviour change:** Based on the constructs of the EPPM, the fear appeal component of the message was strategically modelled and delivered to the

caregivers in order to psychologically and physiologically incite fear among the caregivers. The devastating effect of malaria and recommended responses were described in the messages to reflect the Threat and Efficacy constructs of the EPMM, respectively.

2) Using the mHISS for disease assessment

Developed and operated by a Ghana-based private company called Viamo, the mHealth system was designed to assess symptoms of sick children and provide health advice to caregivers through mobile phones. Caregivers of sick children were provided with tailor-made health information after answering several sequential questions through an IVR. The automated system was based on a clinical algorithm (Figure 3.4), so that after answering a set of questions, data on current disease symptoms and geo-location were gathered. The clinical algorithm was based on the decision trees of the IMCI (WHO, 2005c), and local assessment of clinician's report and recommendation. The clinical algorithm and its translation was developed over a period of 2 years by experts consisting of clinicians, public health experts, epidemiologists/biostatisticians and communication researchers. After placing a call, the system automatically ends it and calls back. After a brief introduction, the system provided instructions for the caregivers to give responses by mostly pressing '1' for a 'yes' response or '2' for a "no" response on their mobile phones. The first set of questions were asked to assess whether the child had any 'danger sign' such as inability to breastfeed or drink or unconscious and had convulsions, taking into consideration the age of the child. The next set of questions were asked to identify the common symptoms of childhood illness including fever, cough and diarrhoea. Further questions were only asked to assess the severity of the child's condition if the caregiver responded 'yes' to the previous question. A caregiver was required to answer all questions asked by the system, so that all symptoms could be captured, and at the end provided with

advice after symptom assessment. This advice was based on the level of severity of a symptom or combinations of symptoms – where ‘A’ denoted severe, ‘B’ moderate, ‘C’ mild and ‘O’ none [Table 3.6]. Where a child fell in more than one category after answering all questions, priority was given to the highest category, and the appropriate advice given. As indicated in the IMCI guideline, all danger signs such as inability to breastfeed or drink, unconscious or convulsions and other combinations of symptoms were all classified as severe by the system. All calls that fell in category ‘A’ were deemed as requiring emergency treatment, and consequently, caregivers were advised by the system in their local dialect (‘Twi’) to take their sick child to the nearest health facility immediately. Similarly, symptoms that fell in the ‘B’ category were deemed to require causal treatment, hence advised by the system to take the sick child to the nearest hospital within 24 hours; and symptoms within the ‘C’ category advised to provide home treatment and take child to the nearest health facility if symptoms persist. The home treatment included the provision of Oral Rehydration Salt (ORS) or paracetamol syrup, depending on the symptom reported. On the other hand, symptom reports that fell in the ‘O’ category meant the system could not assess the underlying cause of illness. In such situations, caregivers were advised to take the sick child to the nearest health facility for further assessment in order to ascertain the condition of the child.

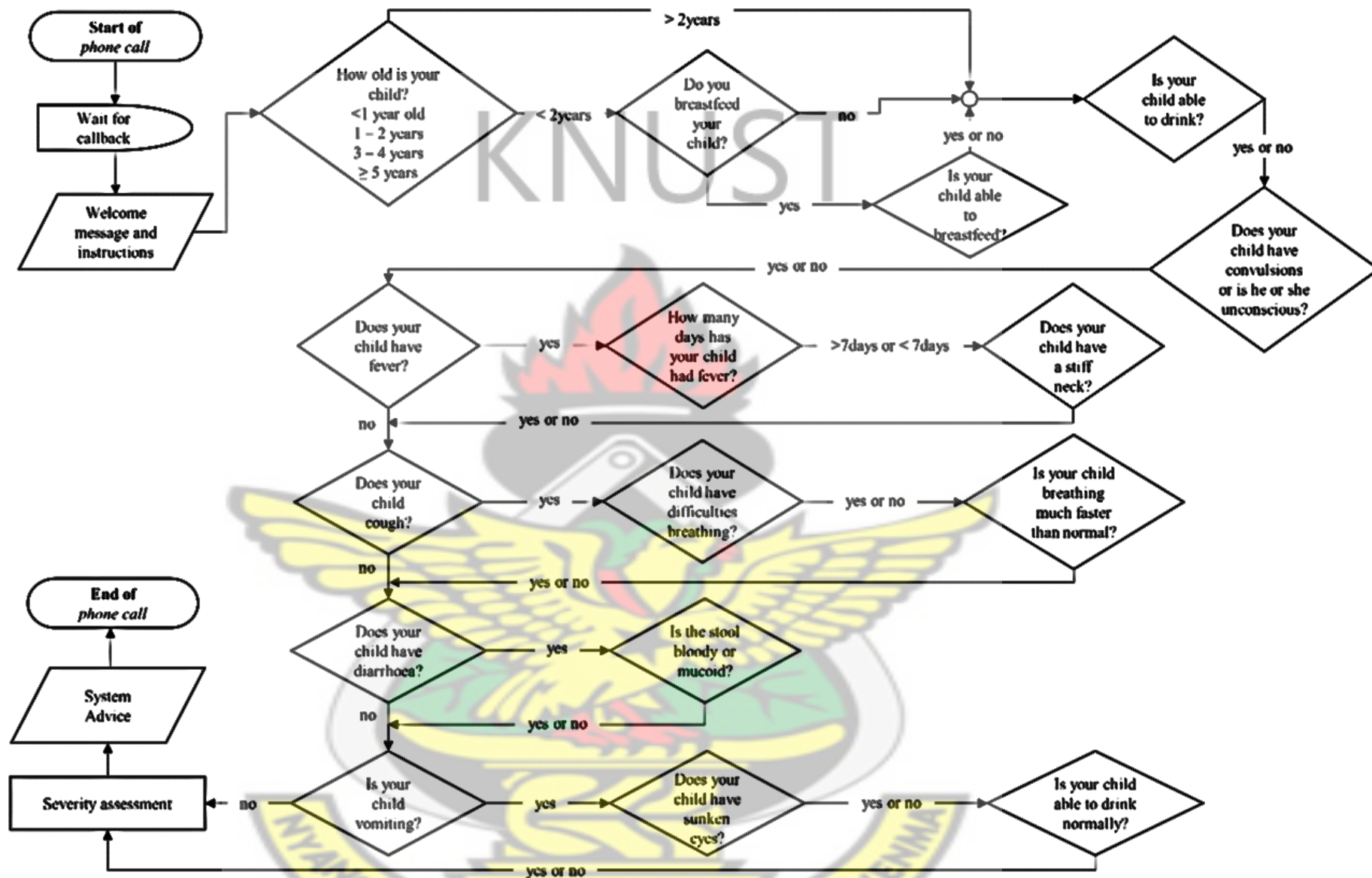


Figure 3.4: IMCI-based clinical algorithm

Table 3.6: Disease symptom category and recommendation provided by the system

Category	Symptom assessment	Symptom combinations	System Advice	Clinician's report
A' Severe	Unable to breastfeed	Unable to breastfeed +/- Any symptom	Requiring emergency treatment: "Take your child to the nearest health facility immediately!"	Emergency treatment: For example intravenous fluids, intravenous antimalarial drugs or hospitalization
	Unable to drink	Unable to drink +/- Any symptom		
	Unconscious or Convulsions	Unconscious or Convulsions +/- Any symptom		
	Severe febrile disease	Fever + [>7 days or <7 days] + stiff neck		
	Severe Respiratory Tract Infection	Cough + difficult breathing + breathing faster than normal		
	Gastrointestinal – Infection with severe dehydration	Diarrhoea + vomiting + [sunken eyes and/or not able to drink normally]		
B' Moderate	Febrile disease	Fever + [>7 days or <7 days] – stiff neck	Requiring causal treatment: "Take your child to the nearest health facility within 24 hours!"	Causal treatment: For example antibiotics, antimalarial (oral form) or follow-up
	Moderate Respiratory Tract Infection	Cough + difficult breathing or breathing faster than normal		
	Dysentery	Diarrhoea + bloody or mucoid stool		
	Gastrointestinal – Infection with some dehydration	[Diarrhoea and/or vomiting] + sunken eyes - not able to drink normally]		
C' Mild	Mild Respiratory Tract Infection	Cough – [difficult breathing + breathing faster than normal]	Requiring home care: "Treat your child at home and assess disease progression carefully!"	Symptomatic treatment: For example nasal drops or paracetamol or follow-up not needed
	Gastrointestinal – Infection with no dehydration	[Diarrhoea and/or vomiting] – [sunken eyes + not able to drink normally]		
O' None	None-categorised symptom combination	No positive symptom indicated	Requiring further assessment: "System unable to determine the underlying cause of your child's condition. Take child to the nearest health facility for further assessment!"	Treatment provided based on type of disease diagnosed.

GI-infection = gastrointestinal infection; RTI = respiratory tract infection

3.4 DATA COLLECTION TECHNIQUES AND TOOLS

3.4.1 Questionnaire-based interview

Pre- and post-intervention questionnaire-based interviews were conducted with all caregivers of children under-five who consented, using both closed and opened-ended questions. Administered through face-to-face interviews, the questionnaire was designed to collect information on socio-demographic characteristics on both the children and caregivers, household characteristics, episodes of febrile illnesses (with major emphasis on malaria), health seeking behaviours of caregivers, knowledge about malaria and constructs of behaviour change. The content of the questionnaire was partially based on the MEASURE DHS tool used to conduct the 2014 GDHS, the Malaria Indicator Survey (MIS), Multiple Indicator Cluster Survey (MICS) and the Roll Back Malaria (RBM) guidelines questions for measuring the effectiveness of malaria BCC interventions (Roll Back Malaria, 2014), together forming a little over 75 questions, which took approximately 30 to 45 minutes per respondent to administer.

The response formats for the behaviour change assessment questions were Likert-type, ranging from 1 (*strongly disagree*) to 5 (*strongly agree*), as employed in earlier studies (McMahan et al., 1998; Witte, 1994, 1992a). Questions measuring the relevant aspects of the EPPM such as perceived severity, susceptibility, self-efficacy and response efficacy were assessed at baseline and repeated at endline. On the other hand, outcome measurements of the theory such as danger control (i.e., attitude, intention and behaviours), fear control (i.e., defensive avoidance, message minimization and message manipulation) and fear were only measured at endline to elicit the effect of the messages on health behaviours of the caregivers. The internal consistency of all constructs, generated using the composite score of the items are shown in Table 3.7.

Table 3.7: Internal consistency of EPPM constructs

Indicator	Number of items	Cronbach's alpha (α)	
		Before	After
<i>THREAT</i>			
Severity	3	0.52	0.68
Susceptibility	5	0.68	0.87
<i>EFFICACY</i>			
Self-efficacy	6	0.62	0.91
Response efficacy	4	0.85	0.90
<i>FEAR</i>	3	—	0.97
<i>DANGER CONTROL RESPONSES</i>			
Attitude	3	—	0.91
Intention	2	—	0.90
Behaviour change	3	—	0.91
<i>FEAR CONTROL RESPONSES</i>			
Defensive avoidance	2	—	0.91
Message minimisation	3	—	0.94
Message manipulation	3	—	0.95

3.4.2 mHISS data

Data on common childhood disease symptoms including fever, cough, vomiting and diarrhoea of a child whose caregiver accessed the system were extracted in csv format, and prepared for further analysis. The average time taken for a caregiver to use the system was 4 minutes. Weekly list of all caregivers who accessed the system was generated for follow-up. Using this list, a validation questionnaire was used to extract data from the health facilities.

3.4.3 Health facility data

In order to validate the data captured by the mHISS and key responses provided during the pre- and post-intervention interviews, secondary data were obtained from health facilities where caregivers sought healthcare for their children. Using a data capturing sheet, data

on the date and time, diagnosis of the sick child (as reported by the clinician) were recorded.

For prevalence assessment of malaria, data on children who experienced fever and were taken to a health facility at baseline and endline were obtained from the health records. Information on whether the case of malaria was RDT or laboratory confirmed were recorded. For caregivers who sought help at a pharmacy or chemical shop, as a proxy, data were collected on whether malaria episode was confirmed by either RDT or whether the child was given antimalarial drug for treatment.

To improve the quality and avoid loss of data, a paperless mobile phone-based data collection tool called the Open Data Kit (ODK) was used – for pre- and post-interview and validation questionnaire. The ODK is made up of three major components – ODK Collect app, aggregate server and mobile phone. The ODK collect is developed with *relevance* and *constraint* commands that help to improve the quality of data by skipping to relevant questions and preventing users from entering extreme values. Developed by a student from the University of Washington, the ODK collect software which uses an aggregate server was installed on three mobile phones, and used by trained research assistants. The research assistants collected data from the selected households and health facilities, and uploaded them on to a highly secured remote server, hosted by Google as illustrated in the Figure 3.5. Data were extracted from the server in csv format and exported to statistical software for analysis.

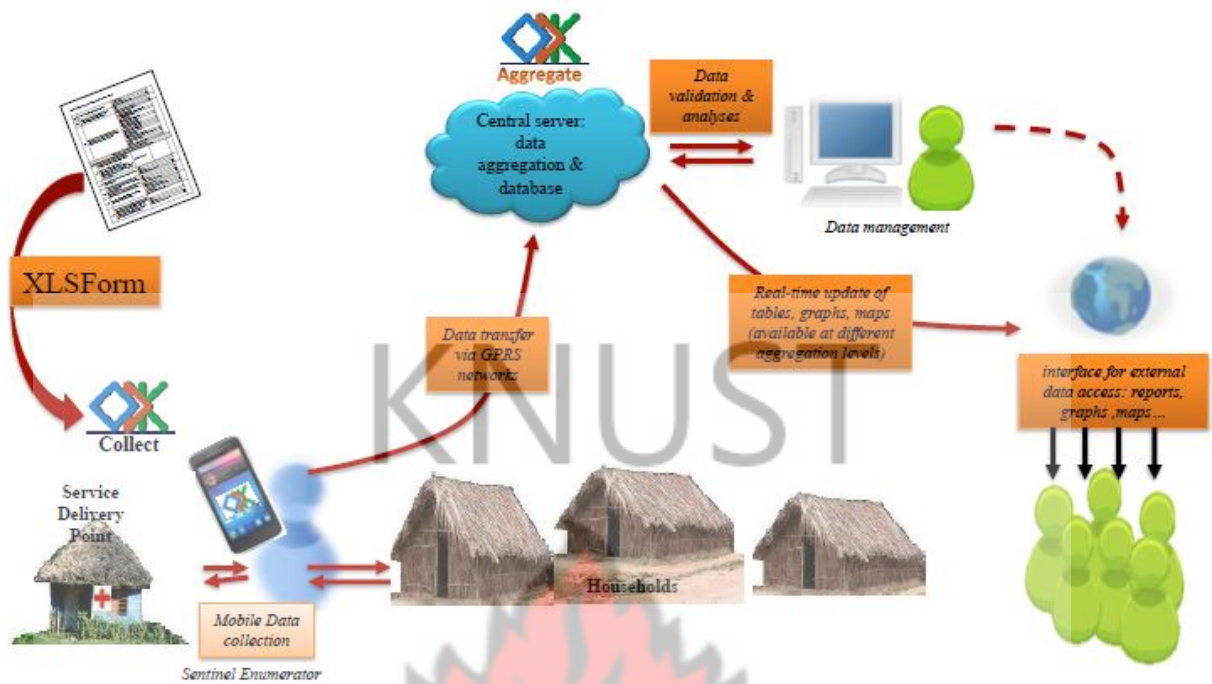


Figure 3.5: ODK system data flow

Source: Author's Construct, 2016

3.5 STUDY POPULATION

The study was carried out in randomly selected communities spread over the intervention and control sites of the Asante Akyim North District. The communities in the two study sites are predominantly small-scale farmers. The household, comprising of all members was the unit of study.

The study population was focused on:

- All children aged 0 – 59 months,
- Caregivers of children aged 0 – 59 months

3.5.1 Inclusion and exclusion criteria

Inclusion criteria

- Caregivers who had access to a mobile phone – either personal phone or owned by a relative

Exclusion criteria

- Caregivers who did not understand either English or the most spoken language of the community (Twi)

3.6 STUDY VARIABLES

A number of indicators derived from the theoretical framework were grouped into dependent and independent variables [Table 3.8]. The dependent variable was malaria, operationalized as the proportion of children who experienced at least one episode of malaria 12 months before or after the introduction of the intervention. The independent variables were socio-demographic characteristics of the children and their caregivers, household characteristics, knowledge about the causes and prevention of malaria and constructs of behaviour change. Indicators used for the evaluation of the mHISS included case recording capacity of the system, validity of data, and quality of data generated.

Table 3.8: Study variables

Variable	Operational Definition	Type of variable	Objective addressed
Dependent variables			
Malaria	Number of children who had malaria at least once, 12 months before and after introducing the intervention.	Binary	1
Independent variables			
Socio-demographic characteristics			
Child characteristics:			
Age	Age in completed years	Continuous	2, 3
Sex	Expressed in terms of male or female	Nominal	2, 3
Caregiver characteristics:			
Age	Age at last birthday	Continues	2, 3
Sex	Expressed in terms of male or female	Nominal	2, 3
Education level	Highest education level attained	Ordinal	2, 3
Marital status	Expressed in terms of single, married, widowed, divorce, separated as at the time of survey	Nominal	2, 3
Occupation	Work performed daily	Binary	2, 3
Parity	Number of liveborn children	Discrete	2, 3
Religion	Faith group of respondent	Nominal	2, 3
Household characteristics:			
Wealth	Wealth quintile (Filmer & Pritchett, 2001)	Ordinal	2,3
Knowledge about malaria	Adequate information about causes, prevention of malaria	Ordinal	3
Behavioural Change Indicators			
Perceived susceptibility	The belief that febrile illnesses or threat (malaria) can actually be experienced by children under-five	Ordinal	4
Perceived severity	The belief of how serious a threat (malaria) can be	Ordinal	4
Self-response	Perception that a proposed action or solution will actually control the threat (malaria)	Ordinal	4
Self-efficacy	Confidence to perform an action to control the threat (malaria)	Ordinal	4
Surveillance system effectiveness:			
Case recording	Number of cases identified and disease symptoms recorded by the voice response system	Discrete	5
Timeliness	Time taken to go through the voice response system	Discrete	5
Data quality	Completeness of data recorded by the voice response system	Nominal	5

3.7 SAMPLING TECHNIQUE AND SAMPLE SIZE

3.7.1 Sampling technique

A two-stage sampling technique was employed in both the intervention and control sites. The first stage involved selection of community clusters and the second stage involved household selection. The Asante-Akyim North District has four sub-districts, of which two were purposively selected (Agogo sub-district as the intervention site and Juansa sub-district as control site). Demarcated based on the Community Based Health Planning and Services (CHPS) zones by the District Health Management Team (DHMT), 18 out of a combined 34 communities in the two selected sub-districts; 10 out of 23 in the intervention site and 8 out of 11 in the control site were considered in the study. In each community visited, all houses were listed in order to obtain a sampling frame. Listing involved identifying all houses and households in each structure or house. Based on the population of under-five in each community, a proportional sample size was calculated and apportioned accordingly [Appendix B]. For each community listed, a random number table was generated, out of which the required sample of households were selected. Only one eligible respondent was selected from each structure. Where a household had more than one eligible caregiver, only one participant was randomly selected to partake in the study. A household was defined as a group of people living in the same dwelling space and who acknowledge the authority of a man or woman whom they mostly depend on for their livelihood. One primary caregiver, in most cases the mother of the child under-five, was chosen to complete the interview after consenting to participate in the study.

3.7.2 Sample Size

With malaria prevalence of approximately 20% in Ashanti region in children under-five (GSS/GHS/ICF Macro, 2014), it was hypothesized that a 15% reduction would be achieved in the intervention group. Given a statistical power of 80% and an alpha error of

0.05, the minimum sample size required in each arm would be 138. However, factoring in an attrition of 20%, a total sample of 334 caregivers with children under-five, 167 in each arm, was sufficient to detect a clinically important difference between the intervention and control group.

3.8 PRE-TESTING AND SENSITIVITY ANALYSIS

Prior to the study, a feasibility study was conducted with 237 caregivers at the children's Out Patient Department (OPD) to test the reliability of the mHISS. The common childhood disease symptoms including cough, fever, diarrhea and vomiting recorded by the mHISS was compared with the clinician's note using Cohen's Kappa to examine the level of agreement (Franke et al., 2018). Sensitivity analysis was conducted to determine how different the two data are. Comparing the symptoms captured by the system and clinician report, it was revealed that the symptom records regarding the concordance of the two reports was highest for cough (percentage agreement 82.3%, kappa=0.64, $p<0.001$, sensitivity=91.5%, NPV=87.4%). Moderate agreement was observed for fever (83.5%, kappa=0.59, $p<0.001$, sensitivity=90.4%, NPV=74.6%) and diarrhoea (84.4%, kappa=0.57, $p<0.001$, sensitivity=86.1%, NPV=96.5%), while vomiting showed reasonable agreement (76.4%, kappa=0.42, $p<0.001$, sensitivity=67.2%, NPV=88.2%). Based on the results, the IVR algorithm was modified to conform to the diagnosis and recommendations of the clinician. The pre- and post-interview questionnaires were also tested with 30 caregivers in a non-participating sub-district of the study district, and changes made where applicable.

3.9 DATA HANDLING

Access to the mHISS data was limited to only the principal investigator who was responsible for managing the system and extracting data from the system for analysis. On

the other hand, the ODK used for pre- and post-interviews as well as validating ensured that the data collected were of high quality. Nonetheless, the field coordinator ensured that at least three survey submissions from each community were checked before being sent to the server. The submitted surveys were mostly checked instantly after submission, usually done after every interview. Survey submissions for each day were usually concatenated manually with previously submitted data in order to ensure data uniformity and prevent data loss. This was done on regular basis and back-up copies saved on an external hard disc for safe keeping. Data were extracted from the aggregate server in csv format and exported to statistical analysis tool.

3.10 DATA ANALYSIS

The questionnaires were pre-coded before the analysis was carried out. The preliminary data analysis involved the comparison of baseline socio-demographic characteristics of the intervention and control group in order to examine whether there existed a statistically significant difference between the two groups. Computed and presented as percentages and means, chi-square/Fischer's exact test was used to examine the pre-existing baseline characteristics difference, with p-values ≤ 0.05 considered as statistically significant.

The pre-existing difference between the intervention and control groups during analysis was controlled to obtain approximately unbiased estimates of the effects of interest. Propensity score matching using the 'nearest neighbour' non-participant approach was used. Matching helped to choose subsamples from the original intervention and control groups in order to make sure that the distributions of the covariates in the matched groups were substantially more similar than in the original groups [Figure 3.6].

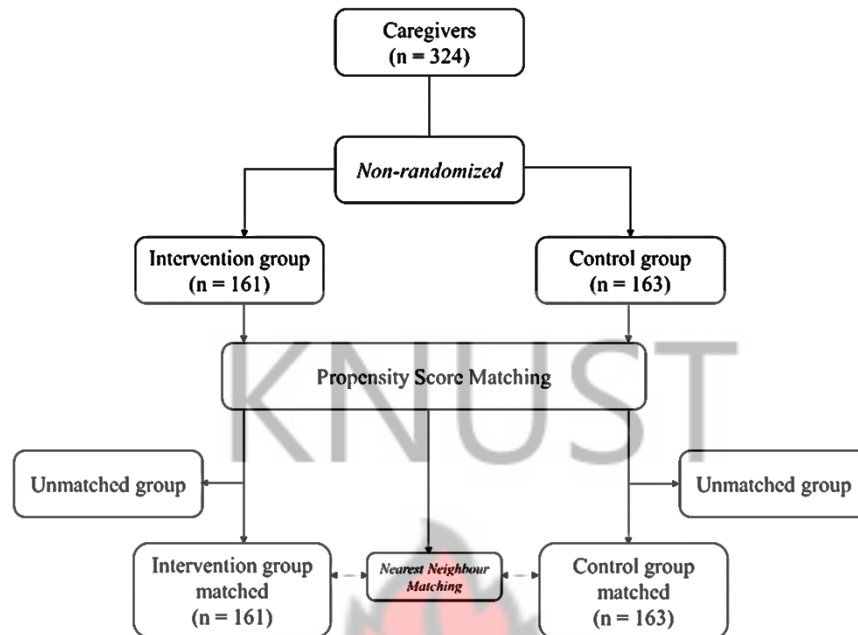


Figure 3.6: Propensity Score Matching using Nearest Neighbour approach

3.10.1 Prevalence and spatial analysis

The prevalence of malaria among the children was estimated twelve months before and after introducing intervention, and the change in prevalence over-time computed using chi-square. Additionally, baseline and endline estimates of the magnitude of association was tested using logistic regression analysis. Hosmer-Lemeshow (H-L) test was carried out to assess the goodness-of-fit of the regression model.

For the spatial analysis, global and local detection methods were used to assess the spatial distribution of malaria cases before and after the intervention. The global method was used to identify the presence of spatial clustering of malaria cases, while the local method was used to further examine the characteristics of the clusters in terms of their location, size and magnitude. Using an extension of Pearson's correlation coefficient (Moran's I), the null hypothesis of no clustering was tested. Local Indicators of Spatial Association (LISA), was used to identify communities with high scores, identified as the hot spots, while communities with low scores were identified as cold spots. ArcGIS 10.3 software, supported with OpenGeoDa was used for mapping and spatial statistical analysis.

3.10.2 Effect of intervention

Quasi-experiments generally lack random assignment. For that reason propensity score matching (PSM) method was employed to estimate the effect of the intervention on malaria prevalence. The PSM, which is the conditional (predicted) probability of receiving treatment given pre-treatment characteristics or covariates is expressed as:

$$e(x_i) = \Pr(z_i = 1 | x_i)$$

and

$$\Pr(z_1, \dots, z_n | x_1, \dots, x_n) = \prod_{i=1}^N e(x_i)^{z_i} \{1 - e(x_i)\}^{1-z_i}$$

Where:

$z_i = 1$ for treatment,

$z_i = 0$ for control and

x_i = vector of observed covariates for the i^{th} subject

That is, for estimated propensity score $e(x_i)$, for subject i , ($i = 1, \dots, N$) is the predicted probability of being assigned to a particular treatment group given a vector of observed covariates x_i (Rosenbaum and Rubin, 1983).

Logistic regression

For this study, the logistic (probit) regression was first used to calculate the propensity scores.

Expressed as:

$$\ln \frac{e(x_i)}{1-e(x_i)} = \ln \frac{\Pr(z_i = 1 | x_i)}{1-\Pr(z_i = 1 | x_i)} = \alpha + \beta^T x_i$$

Where: $e(x_i) = \Pr(z_i = 1 | x_i)$

$$e(x_i) = b_0 + b_1 x_1 + b_2 x_2 + b_3 x_3 + \dots + b_i x_i$$

and

b_0 = intercept

b_i = regression coefficient

x_i = treatment covariates including age (x_1), marital status (x_2) and household wealth (x_3)

Nearest neighbour matching approach

In order to account for the counterfactual outcome; estimating the outcome of the treated if they were not treated ($E(y_1 | P(x), z_i = 0)$), when directly estimating the *average treatment effect on the treated (ATET)*, the nearest neighbour matching approach was used.

This approach was used to compare the caregivers of the control group who had similar characteristics with the treatment group in order to get a good match for comparison.

The nearest neighbour approach was used to simply match the nearest in characteristics of each subject (j) of the control group to a corresponding subject (i) in the treatment group.

Expressed as: $\min || p_i - p_j ||$

After matching on propensity scores, the outcomes of treated and control observations were compared to estimate the *Average treatment effect on the treated (ATET)*.

Expressed as:

$$ATET = E(\Delta | p(x), z_i = 1) = E(y_1 | p(x), z_i = 1) - E(y_0 | p(x), z_i = 0)$$

Where

y = outcome of interest (i.e. y_1 , outcome of the treated ($z_i = 1$) and y_0 , outcome of the control ($z_i = 0$))

$p(x)$ = estimated propensity score for each subject

Hence, for the empirical estimation of *ATET*, each treated observation i was matched with j control observations and their outcomes weighed by w .

Expressed as:

$$ATET = \frac{1}{n_1} \sum_{(z_i=1)} [y_{1,i} - \sum_j w(i,j) y_{0,j}]$$

Difference-in-differences model

The difference-in-differences model using the Kernel propensity score was finally applied to examine the effect of the intervention on the outcomes before (b) and after (a) the experiment.

Expressed as:

$$\begin{aligned} ATET &= E(\Delta_a - \Delta_b | z_i = 1) = \\ &E((y_{1a} - y_{0a}) - (y_{1b} - y_{0b}) | x, z_i = 1) \\ &= E(y_{1a} - y_{1b} | x, z_i = 1) - E(y_{0a} - y_{0b} | x, z_i = 1) \end{aligned}$$

Where

y_{1a} = outcome after the treatment for the treated group,

y_{1b} = outcome before the treatment for the treated group,

y_{0a} = outcome after the treatment for the control group,

y_{0b} = outcome before the treatment for the control group.

3.10.3 Knowledge about malaria

Assessment of knowledge about malaria is mostly based on a common principle of using questions on causes and prevention of malaria (Abate et al., 2013; Adebayo et al., 2015; Fuge et al., 2015; Obol et al., 2011). This study employed a similar approach. Using the mean score as the reference point, respondents whose scores were equal to or above the sample mean score were considered to have adequate knowledge while those whose score were below the mean score were considered to have inadequate knowledge. The multiple choice questions were coded as 1 for yes and 0 for no, for each response. An index score was calculated separately for each respondent for causes (9-point maximum score) and prevention (14-point maximum score) questions by adding all the scores for each respondent across all the questions. An overall knowledge score with a maximum of 23-

point score was then estimated. Chi-square test was used to examine whether there existed any statistically significant difference in the knowledge score between the intervention and control group at baseline and endline. Logistic regression was further used to examine the magnitude of association between the intervention and knowledge about malaria, adjusting for covariates including age, marital status, education level and household wealth.

3.10.4 Behaviour change

In order to assess the effectiveness of the intervention, a series of statistical analysis was conducted. First, three of the propositions of the behaviour change model (EPPM) were re-examined using Pearson correlation and Hayes (2013) mediation analysis. With a focus on three of the twelve EPPM propositions, which received mixed support, Pearson correlation was used to test the relationships between the constructs of the model for two of the propositions (2 and 6) – threat and danger control, and fear and fear control. Mediation analysis was performed to test proposition 7 using PROCESS (Hayes, 2013) in SPSS version 20 software. The existence of decomposition of the total effect and a 95% bootstrap confidence interval which does not contain zero, was used to confirm that the total effect and direct effects are significantly different (Hayes, 2013). The Sobel test (normal theory test) was further used to test whether the two pathways in the mediation analysis were significantly different. Before performing the mediation analysis, the homogeneity of the data and the homoscedastic nature of the residual distribution were examined as shown in the scatter plot [Appendix C]. Most of the points were within range, hence appropriate for the Process mediation analysis (Hayes, 2013).

Cronbach's alpha (α) was used to examine the internal consistency of the 5-point likert scale questionnaire used for measuring all components of the EPPM model. Items representing the same construct were averaged to compute a composite score. Confirmatory factor analysis revealed that the overall threat, efficacy, fear, danger and fear

control scales were unidimensional, with 8 components extracted from the factors. The estimated Kaiser-Meyer-Olkin (KMO) was 0.912, with a significant Bartlett's Test of $p < 0.001$, an indication that all of the items measured the same construct [Appendix D]. Median split was employed to separate participants with high perceived threat/efficacy beliefs from those with low perceived threat/efficacy, and their differences at baseline and endline for both the intervention and control group computed. Chi-square test was used to examine whether there was a statistically significant change in perceived threat and efficacy among the intervention and control groups. Finally, using logistic regression analysis, the predictive effect of receiving the treatment on outcomes of behaviour change were examined by computing the adjusted odds ratios (AOR).

3.10.5 mHISS data

Disease symptoms captured by the system were expressed as percentages. The validity of the symptom reports were examined using Cohen kappa coefficient (k), which tested the percentage agreement and the corresponding 95% confidence interval. The values of $p < 0.05$ were considered significant. Kappa value of 0.75 or higher was considered as excellent reliability, 0.40 and 0.74 as good reliability and < 0.40 as poor reliability (Fleiss et al., 2003). Sensitivity and Specificity tests were also computed and presented as percentages.

STATA version 13 for Windows (STATA Corp., College Station, Texas, United States) was predominantly used for all analysis, with the exception of the mediation and spatial analysis, in which case the Statistical Package for the Social Sciences (SPSS) version 20 software was used.

3.11 ETHICAL CONSIDERATIONS

Ethical clearance for the study was obtained from the Kwame Nkrumah University of Science and Technology (KNUST)/Komfo Anokye Teaching Hospital (KATH) Committee on Human Research, Publications and Ethics (CHRPE/AP/405/16) [Appendix G]. In addition to this, clearance was also sought from the District Health Administration (DHA) of the Asante Akyim North District. Permission from the respective leaders of the communities including the chief and community leaders was also sought. Once all these approvals were granted, at the household level, informed consent was obtained from the caregivers and assent from their children. Provisions were made in the ODK software for the caregivers to check a box or sign on the phone to signify their approval to participate in the study. The caregivers were assured that the data collected would be used only for the purpose of the study.

3.12 ASSUMPTIONS

The first assumption of the study was that respondents understand the questions asked and their answers were accurate and a true reflection of their experiences. The second was that the selected study population was a true representation of the larger population from which accurate findings were made. Finally, disease symptom reports obtained from the mHISS were assumed to be true of the children who were sick and required medical attention.

CHAPTER FOUR

4.0 RESULTS

4.1 INTRODUCTION

Based on the focus of the study, data were obtained from households, the mHISS system and two health facilities (Agogo Presbyterian Hospital and Juansa Health Centre) as well as pharmacy/chemical shops were considered. Major emphasis was placed on examining the effect of the mHealth intervention on key parameters including malaria prevalence, knowledge about malaria and behaviour change, as well as the capacity of the system to correctly capture disease symptoms of children under-five. Various analysis including PSM, DiD, mediation and multivariate logistic regression were applied to examine the effect of the intervention. The chapter is broken into five major sections that report on the demographic characteristics of the study participants, prevalence of malaria and associated spatial epidemiology, overall effect of the intervention, knowledge about malaria, behaviour change and evaluation of the mHISS system.

4.2 BASELINE SOCIO-DEMOGRAPHIC CHARACTERISTICS OF STUDY PARTICIPANTS

The sample characteristics of participants at baseline are shown in Table 4.1. The characteristics of the children, caregivers as well as the households are first described and the intervention and control group compared. Chi-square/Fischer's exact test was conducted to examine pre-existing socio-demographic differences between the intervention and control group. Statistically significant pre-existing differences was found to exist between the two groups with respect to the age of the child ($p=0.002$), marital status ($p<0.001$) and household wealth ($p=0.002$). The mean age of the children involved in the study was 2 years ($SD=2.3$), with both the intervention and control group recording

almost a similar mean age of 2 years; 2.4 (SD=1.1) and 2.3 (SD=1.3) respectively. More than half (55.6%) of the children were female, with the intervention group having 55.9% females compared with 55.2% in control group. With regard to caregiver characteristics, 47.8% of the caregivers in the intervention group were aged 21 – 30 years compared with 44.8% of the controls in the same age group. Nearly sixty-percent (59.6%) of the caregivers in the intervention group were married compared with 48.5% of the controls. Over ninety percent (92.9%) of the caregivers were Christians, with approximately equal proportion (60.3% of the intervention and 63.2% of the control group) having Middle or JHS as their highest level of education. The mean number of children under-five a caregiver had was 1.5 (SD=0.7) and 1.4 (SD=0.6) for the intervention and control group, respectively. With regard to the household wealth, more than one-fifth (27.6%) of caregivers in the control group were poor compared with about one-tenth (12.4%) of caregivers in the intervention group.

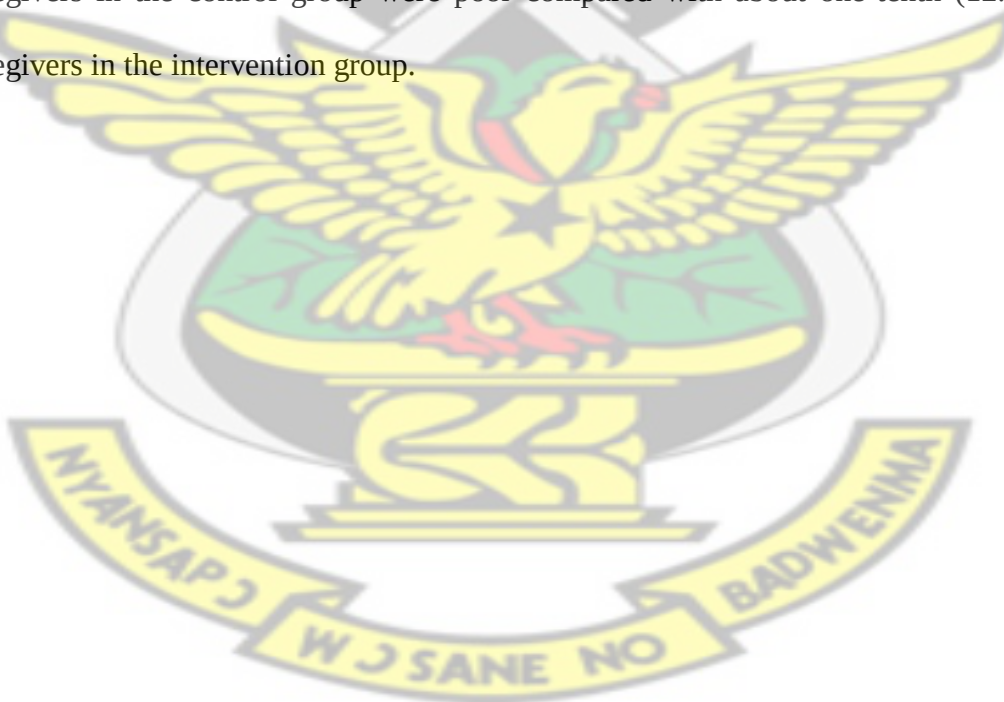


Table 4.1: Differences in Socio-demographic characteristics

Variable	Intervention n=161 (%)	Control n=163 (%)	Total (%)	χ^2 (p-value)
Child characteristics				
Age of child <5 years				0.002
≤ 1	36 (22.4)	58 (35.6)	94 (29.1)	
2	70 (43.5)	41 (25.2)	111 (34.3)	
3	29 (18.0)	27 (16.6)	56 (17.3)	
4	15 (9.3)	28 (17.2)	43 (13.7)	
<5	11 (6.8)	9 (5.5)	20 (6.2)	
Total	161 (100.0)	163 (100.0)	324 (100.0)	
Mean age (SD)	2.4 (1.13)	2.3 (1.27)	2.3 (1.20)	
Sex of index child				0.901
Male	71 (44.1)	73 (44.8)	144 (44.4)	
Female	90 (55.9)	90 (55.2)	180 (55.6)	
Total	161 (100.0)	163 (100.0)	324 (100.0)	
Caregiver characteristics				
Age (years)				0.226
<20	9 (5.6)	18 (11.0)	27 (8.3)	
21 – 30	77 (47.8)	73 (44.8)	150 (46.3)	
31 – 40	59 (36.7)	51 (31.3)	110 (34.0)	
41+	16 (9.9)	21 (12.9)	37 (11.4)	
Total	161 (100.0)	163 (100.0)	324 (100.0)	
Mean age (SD)	31.3 (7.9)	31.3 (9.9)	31.2 (0.50)	
Marital status				<0.001
Divorced	5 (3.1)	12 (7.4)	17 (5.3)	
Separated	25 (15.5)	10 (6.1)	35 (10.8)	
Married	96 (59.6)	79 (48.5)	175 (54.0)	
Never married	21 (13.4)	51 (31.3)	72 (22.2)	
Cohabitation	14 (8.7)	11 (6.8)	25 (7.7)	
Total	161 (100.0)	163 (100.0)	324 (100.0)	
Religion				0.853
Christian	150 (93.2)	151 (92.6)	301 (92.9)	
Muslim	11 (6.8)	12 (7.4)	23 (7.1)	
Total	161 (100.0)	163 (324)	324 (100.0)	
Education level†				0.566
No formal education	11 (6.8)	14 (8.6)	25 (7.7)	
Primary	31 (19.3)	21 (12.9)	52 (16.1)	
Middle/ JHS	97 (60.3)	103 (63.2)	200 (61.7)	
Secondary	19 (11.8)	20 (12.3)	39 (12.0)	
Tertiary	3 (1.9)	5 (3.1)	8 (2.5)	
Total	161 (100.0)	163 (100.0)	324 (100.0)	
Parity				0.360
1	98 (60.9)	111 (68.1)	209 (64.5)	
2	54 (33.5)	43 (26.3)	97 (29.9)	
3	9 (5.6)	9 (5.5)	18 (5.6)	
Total	161 (100.0)	163 (100.0)	324 (100.0)	
Mean (SD)	1.5 (0.7)	1.4 (0.6)	1.4 (0.6)	
Household Wealth Index				0.002
Quintile 1(lowest)	20 (12.4)	45 (27.6)	65 (20.1)	
Quintile 2	35 (21.7)	35 (21.5)	70 (21.6)	
Quintile 3	28 (17.4)	34 (20.9)	62 (19.1)	
Quintile 4	40 (24.8)	23 (14.1)	63 (19.4)	
Quintile 5	38 (23.6)	26 (16.0)	64 (19.8)	
Total	161 (324)	163 (100.0)	324 (100.0)	

† Estimated using Fischer's exact test

Source: Field Data, 2016

4.3 PREVALENCE AND SPATIAL EPIDEMIOLOGY OF MALARIA

4.3.1 Prevalence of Malaria

The prevalence of malaria was estimated as the proportion of children under-five who had malaria, 12 months preceding the intervention and 12 months after the introduction of the intervention. A total of 217 (89.3%) and 151 (90%) cases of malaria were confirmed from health facility records at baseline and endline, respectively. The remaining 10.7% at baseline and 10.0% at endline were febrile cases treated at home with anti-malaria.

The proportion of children under-five who experienced malaria 12 months preceding the time of the intervention was 75.0% - 73.9% for the intervention group and 76.1% for the control group. The chi-square estimate at pre-intervention revealed a non-significant difference ($p=0.653$) between the intervention and control group as shown in Table 4.2. On the other hand, a statistically significant difference ($p=0.006$) between the two groups was observed at post-intervention, with 43.5% of the children in the intervention group experiencing malaria compared with 58.9% in the control group. The overall prevalence of malaria at post-intervention was 51.2%.

Examining the change in malaria prevalence in the intervention group by comparing baseline and endline data, the study revealed a statistically significant difference ($p<0.001$), with a percentage reduction of 30.4% (95% CI = 20.2, 40.6) as shown in Table 4.3. Comparatively, a statistically significant reduction of malaria prevalence was also observed in the control group (17.2%; $p<0.001$; 95% CI = 7.6, 26.7).

Furthermore, the estimated predictive effect of the intervention using logistic regression revealed a statistically significant effect at endline compared to the baseline estimate. Children whose caregivers received the intervention were found to be significantly less likely (AOR=0.54, 95% CI=0.34, 0.83) to experience an episode of malaria compared with children whose caregivers did not receive the intervention, after adjusting for only age and

education level of the caregivers in order to achieve a statistically significant model (LR= 8.16, $p=0.005$) [Table 4.4].

The goodness-of-fit test, which provides information on whether the predicted probability deviates from the observed probabilities in a way that the binary distribution does not predict, was used to assess how well the estimated probability described the data. The Hosmer-Lemeshow (H-L) estimate revealed that the observed counts and those predicted by the model are close (baseline; $p=0.64$ and endline; $p=0.15$), hence the model describes the data well [Table 4.4].



Table 4.2: Difference in malaria prevalence at baseline and endline

Indicator	Baseline				Endline			
	Intervention n (%)	Control n (%)	Total n (%)	χ^2 (p-value)	Intervention n (%)	Control n (%)	Total n (%)	χ^2 (p-value)
Prevalence of malaria				0.653				0.006
Yes	119 (73.9)	124 (76.1)	243 (75.0)		70 (43.5)	96 (58.9)	166 (51.2)	
No	42 (26.1)	39 (23.9)	81 (25.0)		91 (56.5)	67 (41.1)	158 (48.8)	
Total	161 (100.0)	163 (100.0)	324 (100.0)		161 (100.0)	163 (100.0)	324 (100.0)	

Source: Field Data, 2016

Table 4.3: Prevalence of malaria

Indicator	Intervention site (Agogo)					Control site (Juansa)				
	Baseline n (%)	Endline n (%)	Diff. n (%)	p-value	95% CI	Baseline n (%)	Endline n (%)	Diff. n (%)	p-value	95% CI
Prevalence of malaria										
Yes	119 (73.9)	70 (43.5)	49 (30.4)	<0.001	20.2, 40.6	124 (76.1)	96 (58.9)	28 (17.2)	<0.001	7.6, 26.7
No	42 (26.1)	91 (56.5)				39 (23.9)	67 (41.1)			
Total	161 (100.0)	161 (100.0)				163 (100.0)	163 (100.0)			

Source: Field Data, 2016

Table 4.4 Bivariate and multivariate logistic regression of intervention effect on malaria prevalence

Covariate	Baseline				Endline			
	OR	95% CI	AOR†	95% CI	OR	95% CI	AOR†	95% CI
Control [ref]	1.0		1.0		1.0		1.0	
Intervention	0.89	0.54, 1.47	0.86	0.52, 1.45	0.54**	0.35, 0.83	0.53**	0.34, 0.83
LR	0.20		6.79		7.74**		8.16**	
H-L p-value	-		0.64		-		0.15	

*indicates $p < 0.05$, ** significant at $p < 0.01$, *** significant at $p < 0.001$; †Adjusted for caregiver age and education; [ref] Reference category; Hosmer-Lemeshow (H-L) test of goodness-of-fit.

Source: Field Data, 2016



4.3.2 Spatial epidemiology of Malaria

In order to geo-spatially predict the risk of malaria and examine the randomness of the observed spatial pattern of childhood malaria cases before and after the intervention, the IDW interpolation and spatial autocorrelation (global and local) analysis were employed, respectively.

4.3.2.1 Pre-intervention

As the first line of analysis, the baseline prediction map (IDW) [Figure 4.1] revealed approximately a homogeneous distribution of malaria cases in both the intervention and control sites. This implies that individuals living in close proximity to areas dominated with malaria cases were at risk of developing the disease. Further analysis using Global Moran's I to assess malaria clustering pattern revealed the non-existence of statistically significant clustering at baseline (Moran's I = -0.005891, $p=0.62$) – a confirmation of homogeneous distribution of malaria cases. In other words, given the z-score of -0.494, considering the Euclidean distances between observed values of the attribute, the observed pattern of spatial distribution of malaria in children under-five at baseline does not appear to be significantly different than random as shown in Figure 4.2.

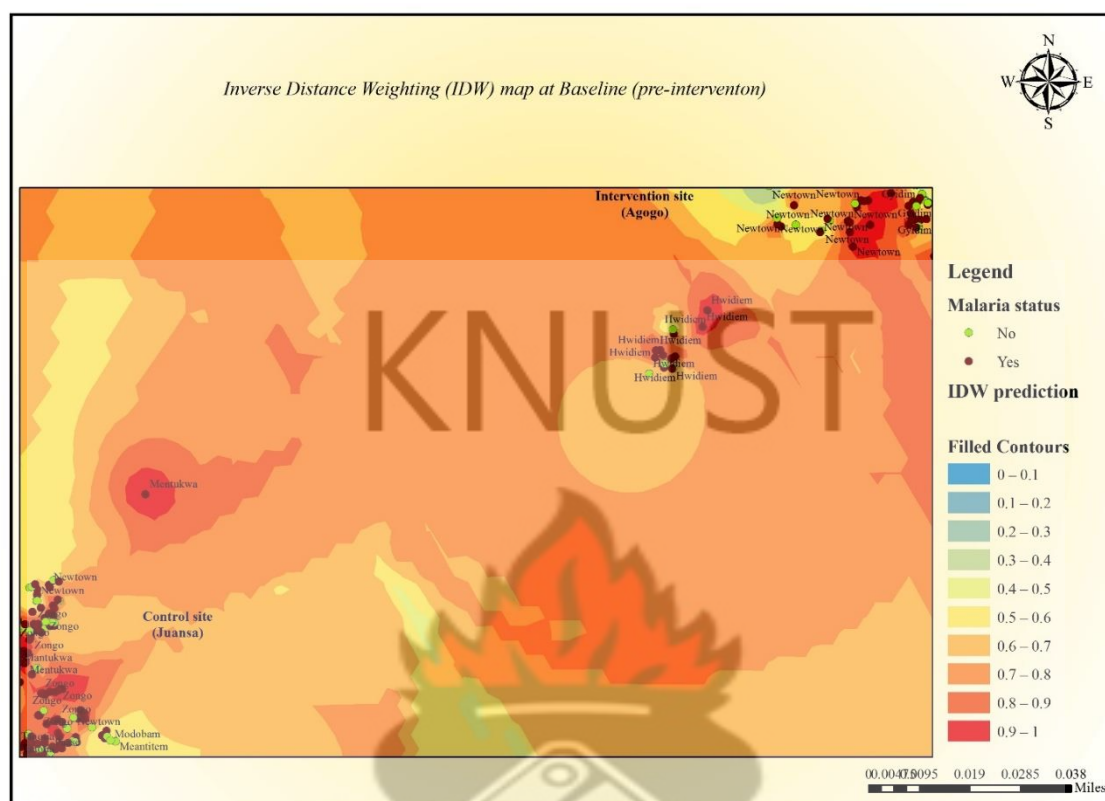


Figure 4.1: Spatial interpolation of malaria prevalence at baseline

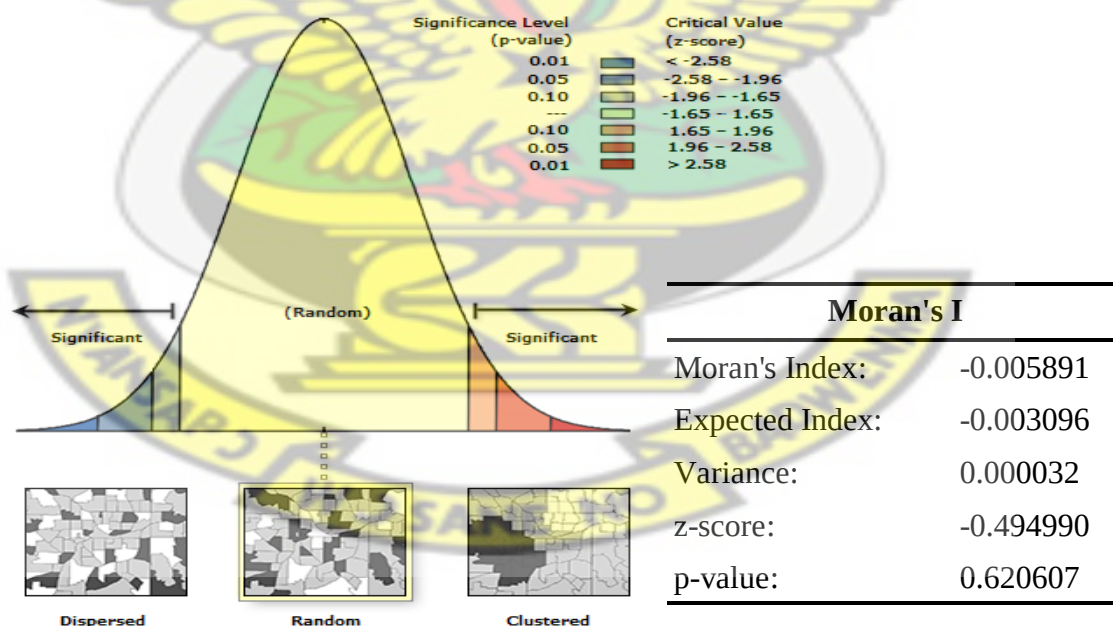
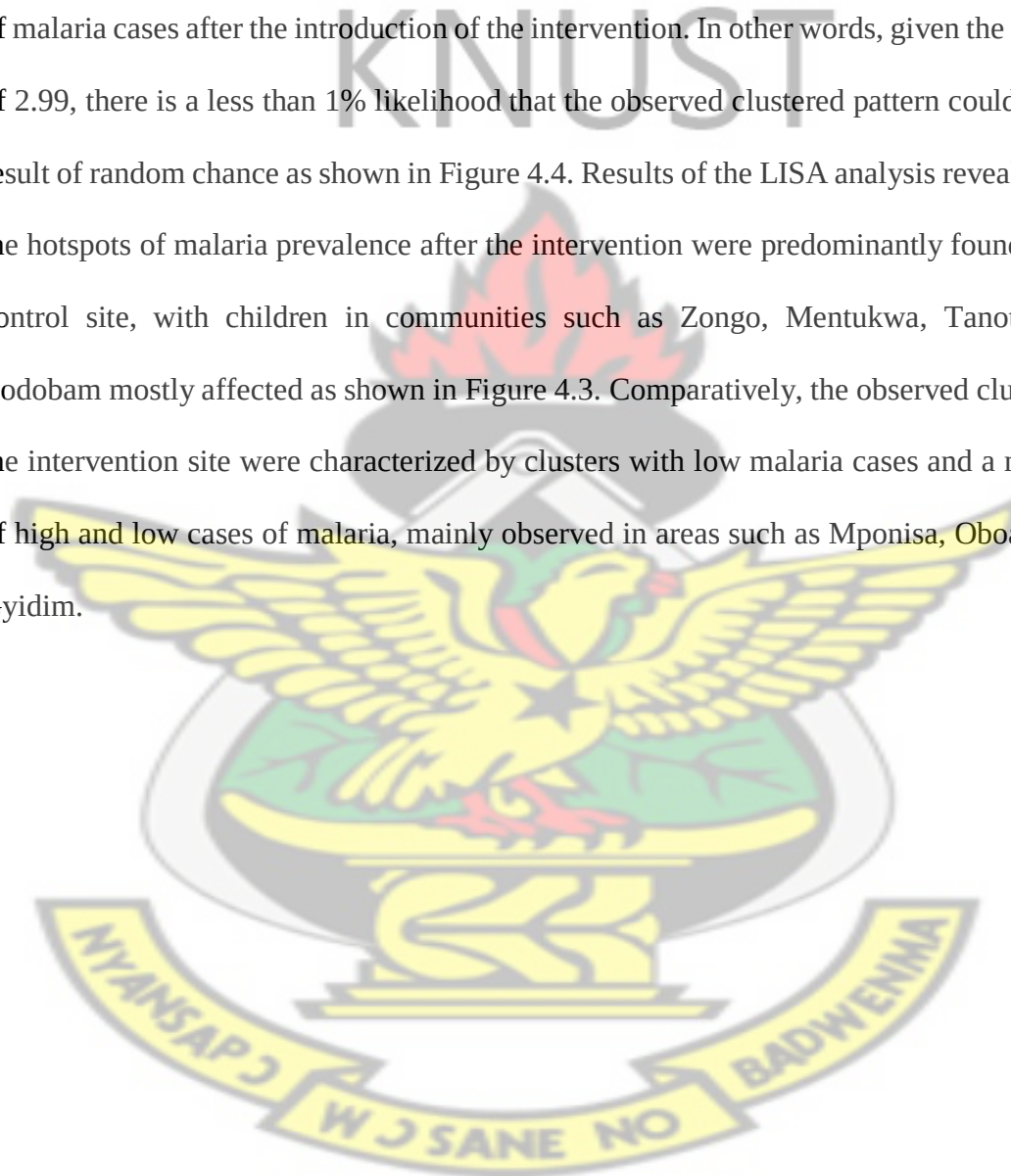


Figure 4.2: Global spatial autocorrelation at baseline

Source: Field Data, 2016

4.3.2.2 Post-intervention

On the contrary, at endline, the result of the IDW interpolation and spatial autocorrelation showed a noticeable variation in both sites. The IDW interpolation revealed low malaria risk areas at the intervention site compared with the control site [Figure 4.3]. The Global Moran's I , 0.013843 ($p=0.003$), revealed the existence of statistically significant clusters of malaria cases after the introduction of the intervention. In other words, given the z-score of 2.99, there is a less than 1% likelihood that the observed clustered pattern could be the result of random chance as shown in Figure 4.4. Results of the LISA analysis revealed that the hotspots of malaria prevalence after the intervention were predominantly found at the control site, with children in communities such as Zongo, Mentukwa, Tanotia and Bodobam mostly affected as shown in Figure 4.3. Comparatively, the observed clusters at the intervention site were characterized by clusters with low malaria cases and a mixture of high and low cases of malaria, mainly observed in areas such as Mponisa, Oboase and Gyidim.



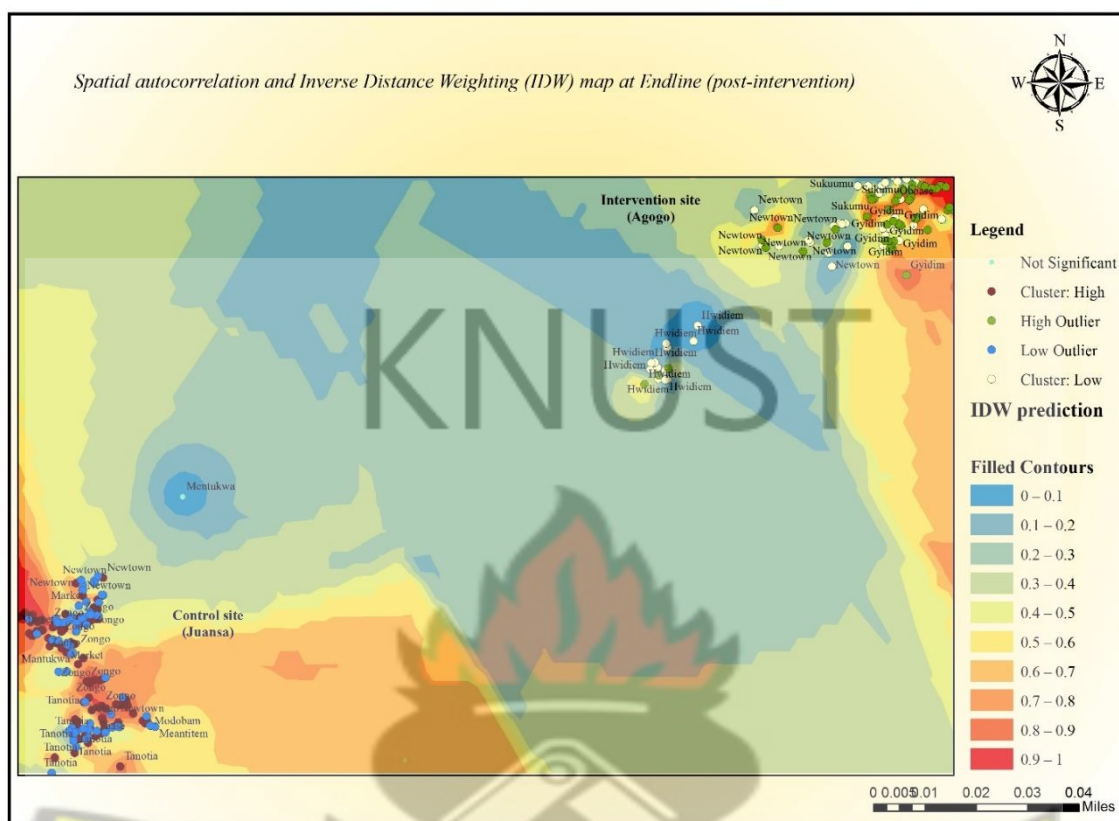


Figure 4.3: Spatial autocorrelation and interpolation of malaria prevalence at endline

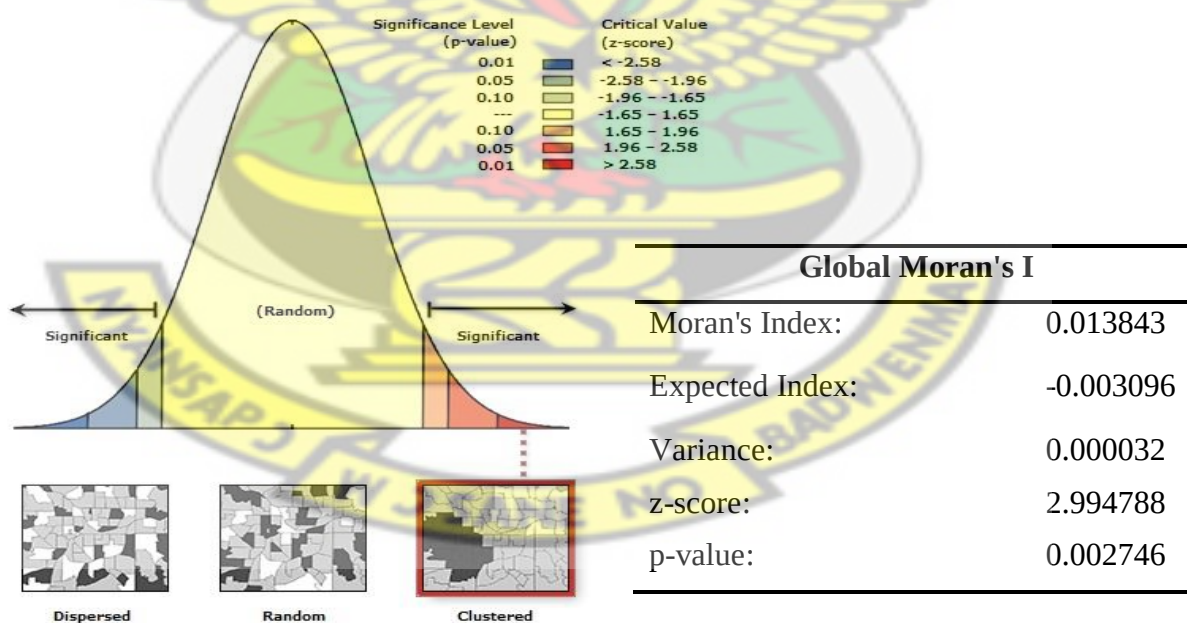


Figure 4.4: Global spatial autocorrelation at endline

Source: Field Data, 2016

4.4 EFFECT OF INTERVENTION (BCC MESSAGES) ON MALARIA PREVALENCE

4.4.1 Comparison of malaria prevalence between intervention and control group before and after PSM

In order to account for the pre-existing differences between the intervention and the control group, and estimate the counterfactual outcome (average treatment effect on the treated (ATET) if they were not treated), the nearest neighbor PSM analysis was employed. Based on the propensity scores generated after matching the intervention and the control group [Figure 4.5], the two groups did not significantly differ with regards to key demographic variables such as age of caregiver, marital status and the wealth index [Appendix E]. The average treatment effect after matching revealed the existence of a statistically significant effect only at the endline ($t_{nn} = -3.07$), with the baseline estimate showing a non-significant effect ($t_{nn} = -0.26$). With 161 caregivers in the intervention group matched with 162 caregivers in the control group (SD error = 0.052), the likelihood of a child whose caregiver received the intervention experiencing malaria was significantly less ($ATET_{nn} = -0.170$, $t_{nn} = -3.07$, 95% CI = -0.28, -0.03). In other words, among the intervention group, receiving the intervention likely reduced the prevalence of malaria by 17.0%, which would not have been the situation if the caregivers had not received the BCC intervention [Table 4.5.1].

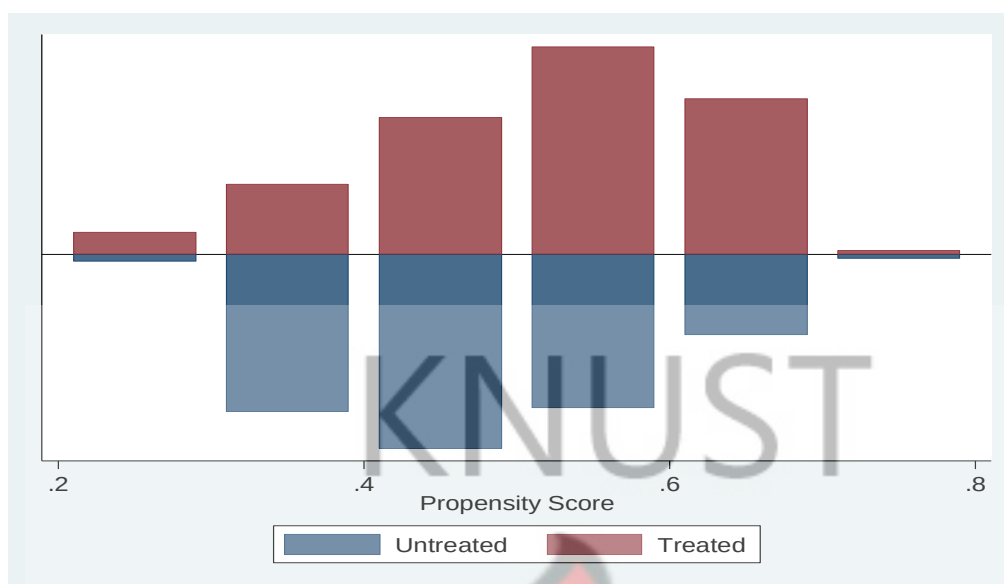


Figure 4.5: Distribution of propensity scores among treatment and control group

Table 4.5.1: Average treatment effect on the treated estimation with Nearest Neighbour (ATET_{nn}) Matching method

Time-point	Intervention (n)	Control (n)	†ATET _{nn}	SE	t _{nn}	95% CI
Baseline	160	158	-0.013	0.049	-0.26	-0.14, 0.09
Endline	160	158	-0.170**	0.056	-3.07	-0.28, -0.03

*indicates $p < 0.05$, ** significant at $p < 0.01$, SE=Standard errors *** significant at $p < 0.001$; †adjusted for age of caregiver, marital status and household wealth; ATET_{nn} = treatment effect with Nearest Neighbour Matching
Source: Field Data, 2016

4.42 Treatment effect estimation with Inverse-probability weights (ATET_{ipw})

The reliability of the ATET_{nn} was confirmed using the inverse-probability weights method, which basically uses the estimated probability weights to correct for missing data on the potential outcomes. The results of this method [Table 4.5.2] shows a great congruence with the nearest neighbour PSM estimate of the ATET_{nn}; baseline (ATET_{ipw} = -0.024 vs. ATET_{nn} = -0.013) and endline (ATET_{ipw} = -0.162 vs. ATET_{nn} = -0.170).

Table 4.5.2: Average treatment effect on the treated estimation with Inverse-probability weights (ATET_{ipw})

Time-point	†ATET _{ipw}	SE	Z _{ipw}	95% CI
Baseline	-0.024	0.05	-0.48	-0.12, 0.07
Endline	-0.162**	0.042	-2.82	-0.27, -0.05

*indicates $p < 0.05$, ** significant at $p < 0.01$, SE=Standard errors *** significant at $p < 0.001$; †adjusted for age of caregiver, marital status and household wealth; ATET_{ipw} = inverse-probability weights

Source: Field Data, 2016

4.4.3 Sensitivity analysis of PSM estimate

To test for the robustness of the PSM analysis and account for possible unmeasured confounders, sensitivity analysis using the *sensatt* command in Stata was employed. The re-estimated effect (using read_write as the simulated confounder) both at baseline and endline suggests that the effect of the BCC message on malaria prevalence was insensitive to the omission of plausible unobserved confounders (Nannicini et al., 2007) as shown in Table 4.6. In other words, the simulated ATET estimate [Table 4.6] is close to the original ATET_{nn} estimate [Table 4.5].

Table 4.6: ATET estimation with simulated confounder

Time-point	ATET	SE	Outcome effect† (OR)	Selection effect† (OR)
Baseline	-0.005	0.059	1.265	0.719
Endline	-0.150	0.068	0.854	0.726

†Effects are odds ratios from logit estimations; SE=Standard errors

Source: Field Data, 2016

4.4.2 Difference-In-Differences (DiD) Model

In order to estimate the overall impact of the intervention, the difference-in-difference model was used to account for the non-parallel modification before and after introducing the intervention between the intervention and control group as shown in Table 4.7. The

baseline estimate revealed a non-significant difference (Diff=-0.022; $t = -0.60$; $p=0.551$) in the prevalence of malaria. The endline difference in malaria prevalence was however, statistically significant (Diff=-0.154, $t = 2.97$, $p=0.003$). The overall impact of the intervention revealed a statistically significant reduction of malaria prevalence by 13.3% (Diff=-0.133, $t = 2.14$, $p=0.032$).

Table 4.7: Effect of intervention with DiD using Kernel Propensity Score

Outcome variable	†Prevalence of malaria	SE	t	p-value
Baseline				
Intervention	0.739			
Control	0.761			
Diff (I – C) ^b	-0.022	0.036	-0.60	0.551
Endline				
Intervention	0.435			
Control	0.589			
Diff (I – C) ^e	-0.154	0.052	2.97	0.003**
Diff-in-Diff [(I – C) ^e – (I – C) ^b]	-0.13.3	0.062	2.14	0.032*

*indicates $p < 0.05$, ** significant at $p < 0.01$, *** significant at $p < 0.001$; I=Intervention and C=Control; †Model adjusted for age, marital status and wealth and, bootstrapped with 50 reps
Source: Field Data, 2016

4.5 KNOWLEDGE ON MALARIA AMONG CAREGIVERS

4.4.1 Awareness of malaria

As a proximate determinant of behaviour change and programme effect, the knowledge of caregivers with regard to malaria was assessed before and after the intervention. Generally, the awareness of malaria among the caregivers was high, with 90.4% having heard about malaria 12 months prior to introducing the intervention – 87.6% and 93.3% for intervention and control group, respectively as shown in Figure 4.6. The difference was not statistically significant ($p=0.083$). On the other hand, the proportion of caregivers who had heard about malaria 12 months after the intervention had reduced to 87.6%. Caregivers

who had heard about malaria 12 months after the intervention was found to be higher for the intervention group (98.8%) compared with the control group (76.5%). Chi-square estimate of the difference was found to be statistically significant ($p < 0.001$) as shown in Figure 4.7.

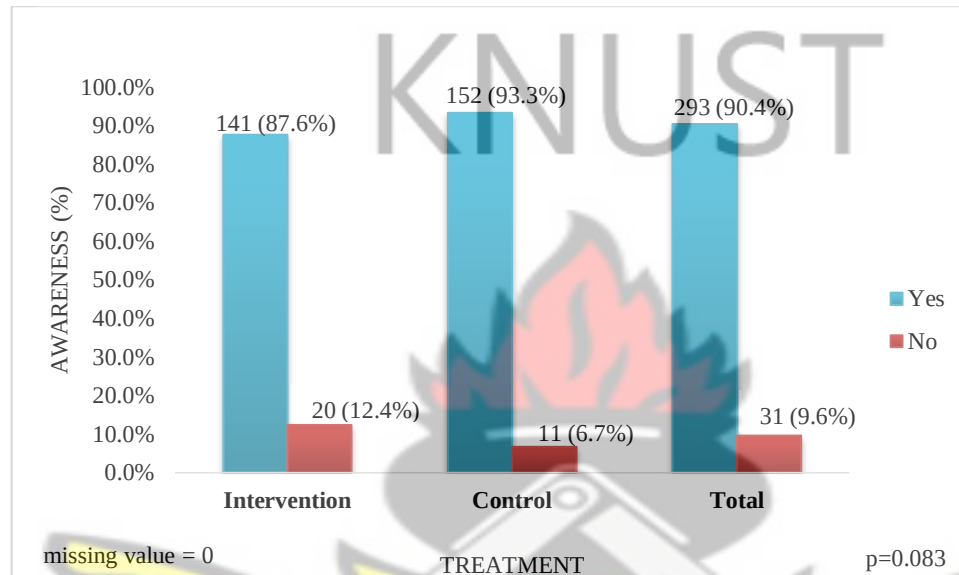


Figure 4.6: Malaria awareness at *baseline*

Source: Field Data, 2016

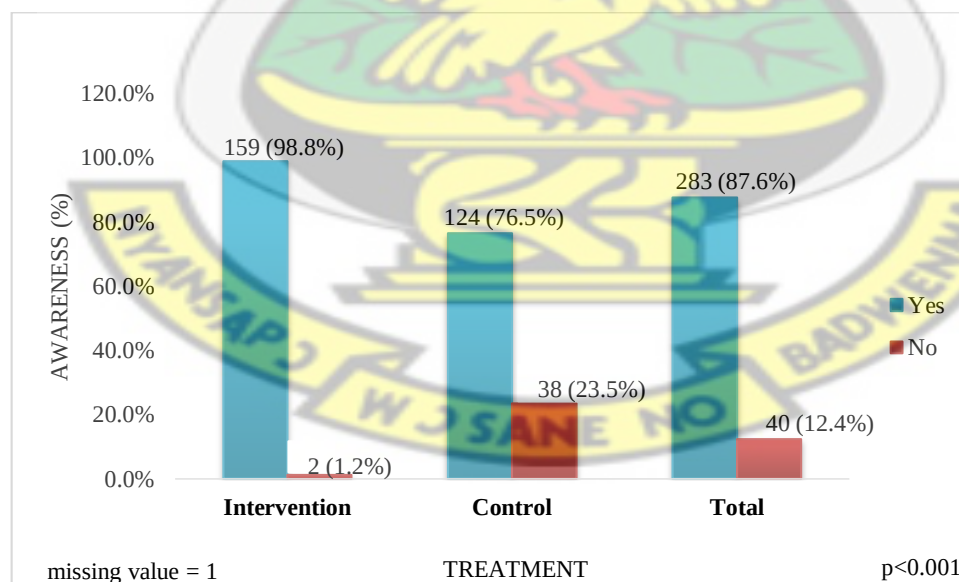


Figure 4.7: Malaria awareness at *endline*

Source: Field Data, 2016

4.4.2 Sources of malaria information

Caregivers were asked to indicate their sources of information regarding malaria, with an option of indicating more than one source. The major sources of information on malaria at pre-intervention were predominantly radio (25.0%) and health facility (23.0%), followed by television (16.6%), CHW (13.0%), and friends/family (7.5%) as shown in Table 4.8. The least source was Newspaper (0.7%). Compared with caregivers in the control group (24.0%), the major source of information at baseline for caregivers in the intervention group was also radio (26.0%). On the other hand, the post-intervention assessment revealed that television (21.4%) and radio (21.3%) were the predominant source of information, followed by health facility (18.9%) and mobile phone (15.9%). Compared with the control group (0.3%), all except one of the caregivers in the intervention group received malaria information through their mobile phones (24.2%).

Table 4.8: Sources of information on malaria

Sources	Baseline			Endline		
	Intervention	Control	Total	Intervention	Control	Total
	n (%)	n (%)	n (%)	n (%)	n (%)	n (%)
Health facility	103 (23.5)	106 (23.1)	209 (23.3)	116 (17.7)	75 (21.3)	191 (18.9)
CHW	41 (9.4)	75 (16.4)	116 (13.0)	36 (5.5)	23 (6.5)	59 (5.9)
Friends/Family	35 (8.0)	32 (7.0)	67 (7.5)	38 (5.8)	21 (6.0)	59 (5.9)
Workplace	15 (3.4)	10 (2.2)	25 (2.8)	13 (2.0)	1 (0.3)	14 (1.4)
Peer educators	11 (2.5)	7 (1.5)	18 (2.0)	3 (0.5)	3 (0.9)	6 (0.59)
Poster/Billboards	1 (0.2)	8 (1.8)	9 (1.0)	0 (0.0)	0 (0.0)	0 (0.0)
Television	80 (18.3)	69 (15.1)	149 (16.6)	133 (20.2)	83 (23.6)	216 (21.4)
Radio	114 (26.0)	110 (24.0)	224 (25.0)	116 (17.7)	99 (28.1)	215 (21.3)
Mobile phone	0 (0.0)	0 (0.0)	0 (0.0)	159 (24.2)	1 (0.3)	160 (15.9)
Newspaper	4 (0.9)	2 (0.4)	6 (0.7)	6 (0.9)	4 (1.1)	10 (1.0)
Other	34 (7.8)	39 (8.5)	73 (8.2)	37 (5.6)	42 (11.9)	79 (7.8)
Total	438 (100.0)	458 (100.0)	896 (100.0)	657 (100.0)	352 (100.0)	1009 (100.0)

Source: Field Data, 2016

4.4.3 Causes and prevention of malaria

The pre-and post-descriptive assessment of knowledge about the causes and prevention of malaria among the caregivers is shown in Table 4.9. Caregivers were asked to indicate the causes and prevention of malaria before and after the intervention. The pre-intervention assessment revealed a statistically non-significant difference in all the responses provided ($p>0.05$) for both knowledge on causes and prevention of malaria between the two groups. Of the 865 responses regarding the causes of malaria, 92.3% of the caregivers indicated mosquito bites to be the cause of malaria. This however, differed non-significantly between the intervention (91.9%) and the control group (93.8%). On the other hand, 21.5% and 26.5% indicated standing or working in the sun and eating contaminated food to be the cause of malaria, respectively. The responses did not vary significantly between the two groups – 20.0% and 23.1% for intervention group; and 23.0% and 29.8% for control group. With respect to the ways of preventing malaria, 92.6% of them indicated sleeping under a mosquito net. This however did not vary significantly between the intervention (90.7%) and control group (94.4%). Some of the caregivers also indicated not drinking dirty water (23.0%), not eating bad food (31.7%) and not getting soaked in rain (12.4%) as a means of preventing malaria.

Approximately, one-third (32.1%) of the caregivers in the control group compared with 5.7% of the caregivers in the intervention indicated standing or working in the sun as a cause of malaria. In the same vein, a larger proportion of the caregivers in the intervention group indicated the use of mosquito repellent and coils as a means of preventing malaria compared with caregivers in the control group.

Table 4.9: Percentage distribution of knowledge on causes and prevention of malaria

Variable	Baseline			Endline		
	Intervention	Control	Total (%)	Intervention	Control	Total (%)
	n (%)	n (%)		n (%)	n (%)	
<i>Causes of malaria</i>						
Eating sweet foods	3 (1.9)	1 (0.6)	4 (1.3)	1 (0.6)	3 (1.9)	4 (1.3)
Standing/working in the sun	32 (20.0)	37 (23.0)	69 (21.5)	9 (5.7)	52 (32.1)	61 (19.0)
Eating contaminated food	37 (23.1)	48 (29.8)	85 (26.5)	14 (8.8)	30 (18.5)	44 (13.7)
Mosquito bites	147 (91.9)	151 (93.8)	298 (92.8)	152 (95.6)	144 (88.9)	296 (92.2)
Malaria parasite	4 (2.5)	1 (0.6)	5 (1.6)	14 (8.8)	3 (1.9)	17 (5.3)
Hereditary	2 (1.3)	1 (0.6)	3 (0.9)	2 (1.3)	1 (0.6)	3 (0.9)
Dirty surroundings	73 (45.6)	82 (50.9)	155 (48.3)	98 (61.6)	90 (55.6)	188 (58.6)
Weedy surroundings and stagnant water	56 (35.0)	69 (42.9)	125 (38.9)	78 (49.1)	86 (53.1)	164 (51.1)
Cold or changing weather	3 (1.9)	4 (2.5)	7 (2.2)	8 (5.0)	2 (1.2)	10 (3.1)
Other	53 (33.1)	61 (37.9)	114 (35.5)	38 (23.9)	38 (23.5)	76 (23.7)
Total	410 (160)	455 (161)	865 (321)	414 (159)	449 (162)	863 (321)
<i>Prevention of malaria</i>						
Sleep under a mosquito net	146 (90.7)	152 (94.4)	298 (92.6)	142 (88.2)	140 (87.5)	282 (87.9)
Sleep under an insecticide treated mosquito net	20 (12.4)	18 (11.2)	38 (11.8)	52 (32.3)	64 (40.0)	116 (36.1)
Use mosquito repellant	6 (3.7)	6 (3.7)	12 (3.7)	65 (40.4)	28 (17.5)	93 (29.0)
Avoid mosquito bites	55 (34.2)	71 (44.1)	126 (39.1)	106 (65.8)	81 (50.6)	187 (58.3)
Take preventive medication	2 (1.2)	2 (1.2)	4 (1.2)	16 (9.9)	13 (8.1)	29 (9.0)
Spray house with insecticide	25 (15.5)	35 (21.7)	60 (18.6)	49 (30.4)	34 (21.3)	83 (25.9)
Use mosquito coils	48 (29.8)	46 (24.6)	94 (29.2)	102 (63.4)	68 (42.5)	170 (53.0)
Clear Weeds around the house	33 (20.5)	18 (11.2)	51 (15.8)	23 (14.3)	19 (11.9)	42 (13.1)
Fill in Stagnant waters (puddles)	29 (18.0)	36 (22.4)	65 (20.2)	52 (32.3)	57 (35.6)	109 (34.0)
Keep house surroundings clean	68 (42.2)	74 (46.0)	142 (44.1)	66 (41.0)	70 (43.8)	136 (42.4)
Burn leaves	23 (14.3)	10 (6.2)	33 (10.3)	17 (10.6)	5 (3.1)	22 (6.9)
Don't drink dirty water	45 (27.9)	29 (18.0)	74 (23.0)	4 (2.5)	35 (21.9)	39 (12.2)
Don't eat bad food	49 (30.4)	53 (32.9)	102 (31.7)	7 (4.4)	18 (11.3)	25 (7.8)
Don't get soaked with rain	14 (8.7)	26 (16.2)	40 (12.4)	29 (18.0)	37 (23.1)	66 (20.6)
Other	48 (29.8)	64 (39.8)	112 (34.8)	37 (23.0)	42 (26.3)	79 (24.6)
Total	640 (161)	611 (161)	1251 (322)	767 (161)	711 (160)	1478 (321)

Source: Field Data, 2016

4.4.4 Difference in level of knowledge about malaria

Based on test scores, the adequacy of knowledge about malaria was examined using chi-square. The pre-intervention assessment revealed a statistically significant difference ($p < 0.001$) between the intervention and control group with respect to knowledge on the ways of preventing malaria as shown in Table 4.10. The two groups however, did not vary significantly with respect to the overall knowledge score ($p = 0.585$). A higher proportion (81.0%) of caregivers in the control group had adequate knowledge on ways to prevent malaria compared with caregivers in the intervention group (58.4%). The post-intervention assessment revealed a statistically significant difference ($p = 0.002$) between the intervention and control group with respect to the overall score. Higher proportion (76.4%) of caregivers in the intervention group had adequate knowledge compared with caregivers in the control group (60.7%).



Table 4.10: Difference in knowledge on causes and prevention of malaria at baseline and endline

Variable	Baseline			χ^2 (p-value) ^a	Endline			χ^2 (p-value) ^a
	Intervention n (%)	Control n (%)	Total n (%)		Intervention n (%)	Control n (%)	Total n (%)	
Causes				0.678				0.131
Adequate	115 (71.4)	113 (69.3)	228 (70.4)		136 (84.5)	127 (77.9)	263 (81.2)	
Inadequate	46 (28.6)	50 (30.7)	96 (29.6)		25 (15.5)	36 (22.1)	61 (18.8)	
Total	161 (100.0)	163 (100.0)	324 (100.0)		161 (100.0)	163 (100.0)	324 (100.0)	
Prevention				<0.001				0.077
Adequate	94 (58.4)	132 (81.0)	226 (69.8)		111 (68.9)	97 (59.5)	208 (64.2)	
Inadequate	67 (41.6)	31 (19.0)	98 (30.2)		50 (31.1)	66 (40.5)	116 (35.8)	
Total	161 (100.0)	163 (100.0)	324 (100.0)		161 (100.0)	163 (100.0)	324 (100.0)	
Overall score				0.585				0.002
Adequate	62 (38.5)	58 (35.6)	120 (37.0)		123 (76.4)	99 (60.7)	222 (68.5)	
Inadequate	99 (61.5)	105 (64.4)	204 (63.0)		38 (23.6)	64 (39.3)	102 (31.5)	
Total	161 (100.0)	163 (100.0)	324 (100.0)		161 (100.0)	163 (100.0)	324 (100.0)	

Source: Field Data, 2016

4.4.5 Predictive effect of intervention on knowledge about malaria among caregivers

Adjusted for covariates including age of caregiver, marital status, education level and household wealth, the predictive effect of the BCC intervention on knowledge about the causes and prevention of malaria was assessed at baseline and endline using logistic regression as shown in Table 4.11. At baseline, treatment assignment did not significantly affect caregivers' knowledge about malaria (AOR=1.1, 95% CI=0.69, 1.79). However, the post-intervention estimate revealed that receiving the intervention significantly increased the odds (AOR=1.81, 95% CI=1.09, 2.99) of having adequate knowledge about malaria. Likewise, the odds of having adequate knowledge was significantly less (AOR=0.48, 95% CI=0.29, 0.78) for caregivers whose children had malaria at endline. Although the predictive effect of age of caregiver, marital status, education level and household wealth was not statistically significant ($p < 0.05$), their presence in the model modified the effect of the treatment on knowledge, both at baseline and endline. Assessment of the goodness-of-fit of the multivariate model suggests that the predicted probabilities of the expected counts does not deviate significantly from the predicted probabilities of the observed counts for the baseline ($p=0.24$) and endline ($p=0.17$) estimates.

Table 4.11: Bivariate and Multivariate logistic regression of intervention effect on knowledge about malaria

Covariate	Baseline				Endline			
	OR		AOR	95% CI	OR	95% CI	AOR	95% CI
†Treatment	1.13	0.72, 1.78	1.11	0.69, 1.78	2.09**	1.29, 3.38	1.81*	1.09, 2.99
‡Malaria status of child	0.81	0.48, 1.36	0.86	0.51, 1.45	0.45***	0.28, 0.73	0.48**	0.29, 0.78
Age of caregiver	0.98	0.96, 1.00	0.99	0.96, 1.02	0.99	0.96, 1.01	0.98	0.95, 1.01
Marital status	1.24	0.97, 1.60	1.20	0.90, 1.60	0.98	0.75, 1.27	0.90	0.67, 1.21
Education level	1.16	0.88, 1.53	1.09	0.81, 1.47	1.07	0.80, 1.43	1.01	0.74, 1.38
Household Wealth Index	1.13	0.96, 1.33	1.11	0.93, 1.32	1.13	0.96, 1.34	1.08	0.90, 1.29
LR			6.49				20.32**	
H-L p-value			0.24				0.17	

*indicates $p < 0.05$, ** significant at $p < 0.01$, *** significant at $p < 0.001$, †Control group and ‡had malaria as reference categories; Likelihood ratio test (LR); Hosmer-Lemeshow (H-L) test of goodness of-fit.

Source: Field Data, 2016

4.4.6 Treatment effect of intervention on knowledge about malaria among caregivers

Using nearest neighbour PSM, the logit model used to model the effect of the intervention on knowledge revealed statistically significant estimate of the effect at endline ($t_{nn}=3.87$) compared with the baseline ($t_{nn}=0.41$) estimate as shown in Table 4.12. The effect of the intervention at endline revealed a significantly higher increase in knowledge (ATET_{nn}=0.137, 95% CI=0.06, 0.22). In other words, among the intervention group, receiving the intervention likely increased the knowledge about malaria among the caregivers by 13.7%, which would have not been the situation if the caregivers had not received the BCC intervention.

Table 4.12: Average treatment effect (ATET) of intervention on knowledge about malaria

Time-point	Intervention (n)	Control (n)	ATET _{nn}	SE	t _{nn}	95% CI
Baseline	160	162	0.014	0.034	0.41	-0.06, 0.09
Endline	160	162	0.137	0.036	3.87	0.06, 0.22

Effect estimate bootstrapped with 10 reps

Source: Field Data, 2016

4.5 BEHAVIOUR CHANGE

4.5.1 Effect of BCC message (fear appeal) on health behaviours of caregivers

Based on the EPPM which suggests that exposure to fear appeal messages cause a person to engage in either danger control (message acceptance), fear control (message rejection) or no action, three of the propositions relevant to the study were re-examined for only the intervention group using Pearson correlation and Hayes (2013) mediation analysis, in order to establish the effectiveness of the theory-driven BCC intervention.

Proposition 2: When perceived efficacy is high, threat corresponds to danger control.

The EPPM posits that when efficacy is high, threat corresponds to danger control outcomes. The results of the correlation analysis showed that the perceived efficacy of the caregivers was moderately high (response efficacy: M=3.93 SD=0.97; self-efficacy: M=3.99, p<0.001). Hence, threat (severity: M=3.88, SD=0.76; susceptibility: M=4.39, p<0.001) positively correlated significantly with all danger control outcomes – attitude: $r(158)=0.29$, p<0.001; intention: $r(158)=0.37$, p<0.001) and behaviour change: $r(158)=0.36$, p<0.001 at endline [Table 4.13]. Similarly, perceived efficacy was positively related to danger control outcomes (attitude: $r(157)=0.18$, p<0.05; intention: $r(157)=0.55$, p<0.001; and behaviour change: $r(157)=0.41$, p<0.001) but negative related to fear control outcomes (defensive avoidance: $r(157)=-0.14$, p<0.05; message minimization: $r(157)=-$

0.41, $p < 0.001$; and behaviour change: $r(157) = -0.37$, $p < 0.001$). The inverse relation between danger control and fear control responses further suggests that the more the caregivers perceived the message as exaggerating or manipulative, the less they believe the recommended action would prevent their children from getting malaria.

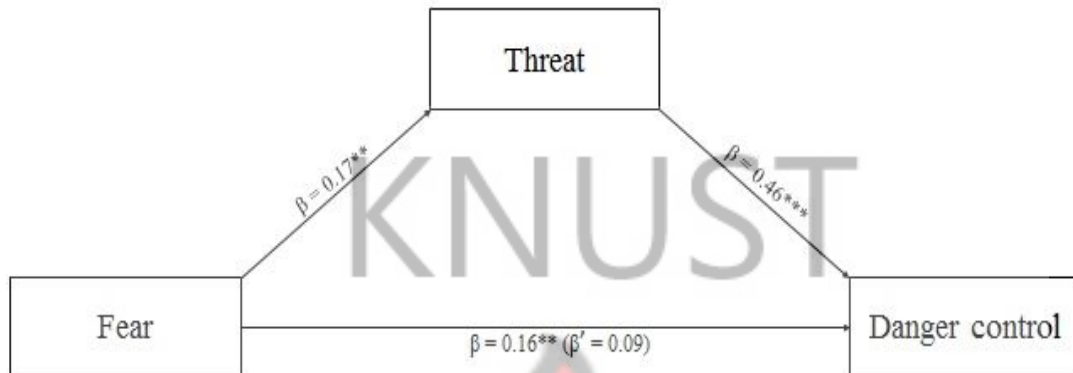
Proposition 6: *Fear causes fear control responses.*

The EPPM posits that fear causes fear control responses. Fear was found to have a significant and negative relationship with fear control outcomes - defensive avoidance: $r(159) = -0.48$, $p < 0.05$; message minimization: $r(159) = -0.37$, $p < 0.001$; and manipulation: $r(159) = -0.34$, $p < 0.001$ as shown in Table 4.13.

Proposition 7: *Fear indirectly influences danger control outcomes, as mediated by perceived threat, when perceived efficacy is high.*

The EPPM assumes that when perceived efficacy is high, threat mediates the indirect influence of fear on danger control outcomes. As observed in this study, efficacy was moderately high ($M = 3.96$, $SD = 0.85$). It was found that fear significantly predicted danger control ($\beta = 0.16$, $t(156) = 2.73$, $p = 0.007$). It was also found that fear significantly predicted perceived threat ($\beta = 0.17$, $t(156) = 2.96$, $p = 0.004$). The result also indicated that the mediator, cognitive threat, significantly predicted danger control ($\beta = 0.46$, $t(155) = 5.92$, $p < 0.001$). With bias-corrected confidence estimates (MacKinnon et al., 2004; Preacher and Hayes, 2004), the 95% confidence interval of the indirect effect, obtained with 5000 bootstrap resamples (Hayes, 2009) indicated that cognitive threat about malaria significantly mediate the relationship between fear and danger control ($\beta = 0.08$, $SE = 0.03$, $CI = 0.24$ to 0.14) as proposed by the EPPM [Figure 4.8]. Additionally, using the

normal theory test (Sobel test), it was revealed that the direct and the indirect effect varied, and statistically different from zero ($Z=2.62$, $p=0.009$, $k^2=0.03$).



indicates $p < 0.05$, ** significant at $p < 0.01$, * significant at $p < 0.001$*

Figure 4.8: Indirect effect of fear on danger control

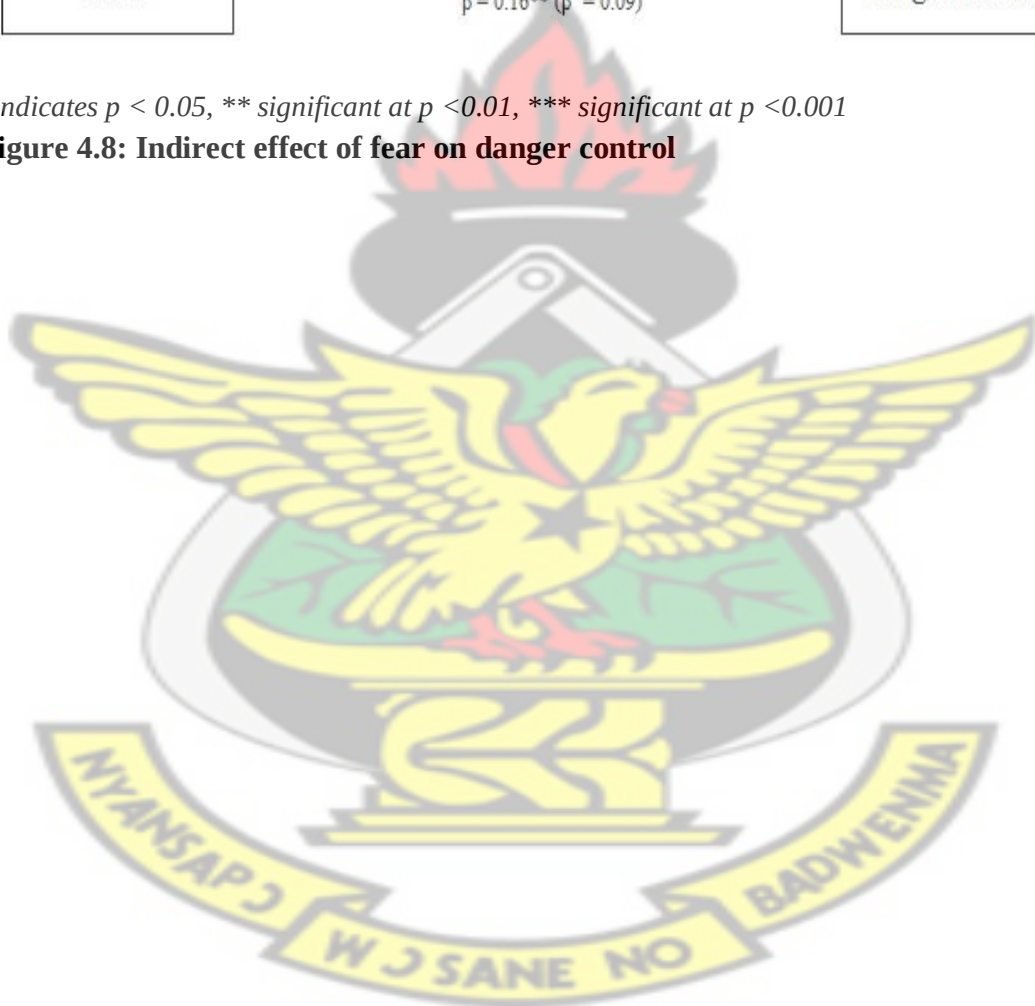


Table 4.13: Correlations and descriptive statistics for all EPPM construct

	Fear	Threat	Severity	Susceptibility	Efficacy	Resp. efficacy	Self-efficacy	Danger Control	Attitude	Intention	Beh. changes	Fear Control	Def. avoid.	Mess. mini.	Perceived manip.
<i>Fear</i>	-														
<i>Threat</i>	0.23**	-													
<i>Severity</i>	0.18*	0.88***	-												
<i>Susceptibility</i>	0.22**	0.82***	0.47***	-											
<i>Efficacy</i>	0.08	0.65***	0.62***	0.50***	-										
<i>Response efficacy</i>	0.21**	0.61***	0.60***	0.44***	0.85***	-									
<i>Self-efficacy</i>	-0.07	0.50***	0.45***	0.40***	0.86***	0.46***	-								
<i>Danger Control</i>	0.21**	0.05***	0.40***	0.38***	0.53***	0.36***	0.53***	-							
<i>Attitude</i>	0.63***	0.29***	0.30***	0.20*	0.18*	0.30***	-0.002	0.50**	-						
<i>Intention</i>	-0.12	0.37***	0.30***	0.34***	0.55***	0.25**	0.66***	0.83**	0.04	-					
<i>Behaviours changes</i>	0.10	0.36***	0.32***	0.29***	0.41***	0.27***	0.42***	0.88**	0.25**	0.67***	-				
<i>Fear Control</i>	-0.46***	-0.48***	-0.44***	-0.37***	-0.33***	-0.47***	-0.10	-0.36**	-0.58***	-0.09	-0.23**	-			
<i>Defensive avoidance</i>	-0.48***	-0.30***	-0.28***	-0.23**	-0.14*	-0.28***	0.0043	-0.28**	-0.48***	-0.05	-0.17*	0.83***	-		
<i>Message minimization</i>	-0.37***	-0.51***	-0.47***	-0.40***	-0.41***	-0.50***	-0.21**	-0.37**	-0.50***	-0.13	-0.25**	0.90***	0.55***	-	
<i>Perceived manipulation</i>	-0.34***	-0.50***	-0.47***	-0.38***	-0.37***	-0.50***	-0.14	-0.30**	-0.53***	-0.05*	-0.19*	0.87***	0.45***	0.90***	-
Mean	4.14	4.13	3.88	4.39	3.96	3.93	3.99	3.55	4.23	3.11	3.32	1.59	1.70	1.57	1.50
SD	0.83	0.60	0.76	0.63	0.85	0.97	1.01	0.64	0.70	0.99	0.83	0.74	1.09	0.75	0.72
Total	161	160	161	160	159	159	161	159	160	161	160	161	161	161	161

*indicates $p < 0.05$, ** significant at $p < 0.01$, *** significant at $p < 0.001$

Source: Field Data, 2016

4.5.2 Change in threat and efficacy indicators among intervention and control group

Threat (severity and susceptibility) and efficacy (self-efficacy and response efficacy) indicators were compared within the intervention and control group in order to assess whether there was a change after introducing the intervention as shown in Table 4.14. Chi-square and paired Student's t-test were used to examine the association and mean difference of the indicators, respectively. Grouped into either having high or low perceived threat or efficacy, logistic regression was used to assess the extent of the association. For the intervention group, the results revealed that there was a statistically significant association with respect to perceived threat ($p=0.025$), susceptibility ($p=0.036$), self-efficacy ($p=0.014$) and response efficacy ($p=0.049$) after the intervention. The results of the t-test also revealed that, with the exception of response efficacy ($p=0.41$), there was an observed statistical significance in the means of perceived threat ($p<0.001$), susceptibility ($p=0.011$) and self-efficacy ($p<0.001$) after the intervention. The odds of a caregiver who received the intervention perceiving malaria to be severe (OR=1.68, 95% CI=1.06, 2.64), perceiving their children to be susceptible to the disease (OR=1.61, 95% CI=1.03, 2.52), having high self-efficacy (OR=1.7, 95% CI=1.11, 2.70) and high response efficacy (OR=1.56, 95% CI=1.00, 2.44) was significantly higher compared with caregivers whose perceptions were low. On the other hand, for caregivers who did not receive the intervention, there was statistically significant difference with respect to how perceptible their children are to malaria ($p=0.029$). Their perceived susceptibility ($p<0.001$), self-efficacy ($p<0.001$) and response efficacy ($p<0.001$) showed a statistically significant reduction after the period of the intervention.

Table 4.14: Change in perceived threat and efficacy before and after intervention

EPPM indicator	Intervention group				Control group				
	Baseline n (%)	Endline n (%)	Total Mean diff. (SD)	χ^2 (p-value) ^a	OR [95% CI]	Baseline n (%)	Endline n (%)	Total Mean diff. (SD)	χ^2 (p-value) ^a
THREAT									
Perceived severity				0.025					0.082
Low (ref)	108 (67.5)	89 (55.3)	197 (61.4)		1.00	77 (47.5)	91 (57.2)	168 (52.3)	1.00
High	52 (32.5)	72 (44.7)	124 (38.6)		1.68*[1.06, 2.64]	85 (52.5)	68 (42.8)	153 (47.7)	0.71[0.46, 1.11]
Total	160 (100.0)	161 (100.0)	321 (100.0)			162 (100.0)	159 (100.0)	321 (100.0)	
Mean† (SD)	3.53 (1.12)	3.89 (0.76)	0.355 (1.14)	<0.001		4.09 (1.01)	3.59 (1.03)	-0.49 (1.33)	<0.001
Perceived susceptibility				0.036					0.029
Low (ref)	100 (62.9)	82 (51.2)	182 (57.1)		1.0	75 (46.0)	93 (58.1)	168 (52.0)	1.00
High	59 (37.1)	78 (48.8)	137 (42.9)		1.61*[1.03, 2.52]	88 (54.0)	67 (41.9)	155 (48.0)	0.64[0.42, 1.00]
Total	159 (100.0)	160 (100.0)	319 (100.0)			163 (100.0)	160 (100.0)	323 (100.0)	
Mean† (SD)	4.20 (0.94)	4.39 (0.64)	0.19 (0.92)	0.011		4.4 (0.83)	3.84 (1.05)	-0.55 (1.17)	<0.001
EFFICACY									
Self-efficacy				0.014					0.07
Low (ref)	91 (57.2)	70 (43.5)	161 (50.3)		1.00	77 (47.8)	91 (58.0)	168 (52.8)	1.00
High	68 (42.8)	91 (56.5)	159 (49.7)		1.74*[1.11, 2.70]	84 (52.2)	66 (42.0)	150 (47.2)	0.70[0.45, 1.09]
Total	159 (100.0)	161 (100.0)	320 (100.0)			161 (100.0)	318 (100.0)	318 (100.0)	
Mean† (SD)	4.38 (0.66)	4.0 (1.01)	-0.38 (1.12)	<0.001		4.50 (0.50)	3.95 (0.80)	-0.55 (0.82)	<0.001
Response efficacy				0.049					0.67
Low (ref)	99 (61.9)	81 (50.9)	180 (56.4)		1.0	90 (55.6)	91 (58.0)	181 (56.7)	1.00
High	61 (38.1)	78 (49.1)	139 (43.6)		1.56*[1.00, 2.44]	72 (44.4)	66 (42.0)	138 (43.3)	0.91[0.59, 1.42]
Total	160 (100.0)	159 (100.0)	319 (100.0)			162 (100.0)	157 (100.0)	319 (100.0)	
Mean† (SD)	4.01 (1.21)	3.93 (0.97)	-0.08 (1.21)	0.410		4.03 (1.22)	3.94 (0.80)	-0.09 (1.23)	0.33

*indicates $p < 0.05$, ** significant at $p < 0.01$, *** significant at $p < 0.001$; † Estimated using paired t-test

Source: Field Data, 2016

4.5.3 Predictive effect of intervention on behaviour change indicators

The predictive effect of receiving the intervention on behaviour change outcomes was assessed using multivariate logistic regression, adjusted for malaria status of the child, age of caregiver, marital status, education and household wealth. Caregivers who received the intervention were significantly more likely to have positive attitude (AOR=2.58, 95% CI=1.61, 4.15) and behaviour change (AOR=2.03, AOR=1.29, 3.19) compared with those who did not receive the intervention as shown in Table 4.15. Also, the results revealed that caregivers who received the intervention were significantly less likely to engage in defensive avoidance (AOR=0.39, 95% CI=0.25, 0.61), message minimization (AOR=0.32, 95% CI=0.20, 0.50) and message manipulation (AOR=0.23, 95% CI=0.14, 0.38). The post-intervention assessment further revealed that caregivers whose children had malaria exhibited higher odds of positive intention (AOR= 3.34, 95% CI=2.13, 5.23) and behaviour change (AOR=2.05, 95% CI=1.32, 3.17), but lower odds of defensive avoidance (AOR=0.44, 95% CI=0.29, 0.68) and message minimization (AOR=0.51, 95% CI=0.33, 0.78) compared with caregivers whose children did not experience malaria. An increase in age significantly also increased the odds of a caregiver having positive intention (AOR=1.05, 95% CI=1.02, 1.08) and behaviour change (AOR=1.03, 95% CI=1.00, 1.06), but lower odds of defensive avoidance (AOR=0.96, 95% CI=0.93, 0.98) and message minimization (AOR=0.96, 95% CI=0.94, 0.99). Household wealth was however found to significantly decrease the odds of having positive attitude (AOR=0.81, 95% CI=0.68, 0.96) and behaviour change (AOR=0.85, 95% CI=0.72, 0.99), but rather increase the odds of defensive avoidance (AOR=1.24, 95% CI=1.06, 1.45) among the caregivers irrespective of the treatment status.

Table 4.15: Multivariate Analysis of Predictors of behaviour change

Variable	Danger Control						Fear Control					
	Attitude		Intention		Behaviour change		Defensive avoidance		Message minimize		Message manipulate	
	AOR	95% CI	AOR	95% CI	AOR	95% CI	AOR	95% CI	AOR	95% CI	AOR	95% CI
Treatment	2.58***	1.61, 4.15	0.77	0.49, 1.21	2.03**	1.29, 3.19	0.39***	0.25, 0.61	0.32***	0.20, 0.50	0.23***	0.14, 0.38
Malaria status of child	1.14	0.73, 1.78	3.34***	2.13, 5.23	2.05***	1.32, 3.17	0.44***	0.29, 0.68	0.51**	0.33, 0.78	0.65	0.41, 1.01
Age of caregiver	1.01	0.98, 1.03	1.05**	1.02, 1.08	1.03*	1.00, 1.06	0.96**	0.93, 0.98	0.96*	0.94, 0.99	0.97	0.94, 1.00
Marital status	0.91	0.70, 1.19	1.21	0.92, 1.60	1.13	0.86, 1.49	0.93	0.71, 1.21	0.83	0.64, 1.09	0.85	0.65, 1.13
Education level	0.85	0.64, 1.14	1.14	0.85, 1.51	0.89	0.67, 1.19	0.87	0.67, 1.14	1.00	0.76, 1.32	1.03	0.77, 1.38
Household Wealth Index	0.81*	0.68, 0.96	0.95	0.80, 1.12	0.85*	0.72, 0.99	1.24**	1.06, 1.45	1.05	0.90, 1.23	1.00	0.85, 1.19
LR	25.42***		41.50***		27.32***		39.45***		36.02***		43.03***	

*indicates $p < 0.05$, ** significant at $p < 0.01$, *** significant at $p < 0.001$, †Control group and ‡had malaria as reference categories; Likelihood ratio test (LR).

Source: Field Data, 2016

4.6 Feasibility of the mobile phone-based system for monitoring childhood diseases symptoms

4.6.1 mHISS statistics

A total of 166 caregivers were recruited and registered to call the mHISS designed to provide health advice, while at the same time collecting data on disease symptoms experienced by children under-five, as reported by caregivers. The system summary statistics at the end of the 12-month period of introducing the system revealed that majority (86.4%) of the caregivers opted for Twi as their preferred language for reporting symptoms experienced by their children. More than half (42.3%) of the calls received were incomplete – not all symptoms were indicated during the call. The average time spent by the caregivers reporting disease symptoms was 4 minutes (SD=1.60), with a little more than one-third (34.6) of the calls captured by the system between the hours of 4 - 7pm as shown in Table 4.16.

Table 4.16: Summary of surveillance system output

Indicator	Frequency (n)	Percentage (%)
Language opted		
English	7	13.5
Twi	45	86.4
Total	52	100.0
Call status		
Complete	22	42.3
Incomplete	30	57.7
Total	52	100.0
Call duration		
(minutes)		
Mean (SD)	4	1.60
Time of call		
5 – 7am	7	13.5
8 – 11am	4	7.7
12 – 3pm	12	23.1
4 – 7pm	18	34.6
8 – 10pm	11	21.2
Total	52	100.0

Source: IVR System Data, 2016

4.6.2 Disease symptoms recorded by the system

Provided to only the intervention group, a total of 126 calls were recorded by the system throughout the 12 months period of the intervention as shown in Figure 4.9. Of these, 58.7% were excluded due to incompleteness and multiple calls from one individual. A total of 52 (41.3%) of the 126 calls were valid, out of which data on diseases symptoms for 38 (73.1%) of the children were obtained from hospital/CHPS records. Majority (67.3%) of the calls came from phone numbers with known details – caregiver name, age and location. Throughout the study period the predominant common symptoms recorded by the system included fever (46.0%, n=24), cough (52.1%, n=25), diarrhoea (40.0%, n=18) and vomiting (39.2%, n=20). As indicated by the caregivers, the system also revealed that 34.1% (n=15) and 12.0% (n=6) of the children were unable to breastfeed and experienced either convulsions or were unconscious at some point, respectively. Of the 24 children who experienced fever, majority (87.5%) had it for less than 7 days, with 66.7% reported to have had stiff neck. Of the 25 children who reported to have coughed at some point, 58.3% breathed faster than normal, with none of them having difficulty breathing. One-half (50.0%) of the 18 children who had diarrhoea, had bloody or mucoid stool. Less than one-fifth (16.7%) were reported to have sunken eyes.

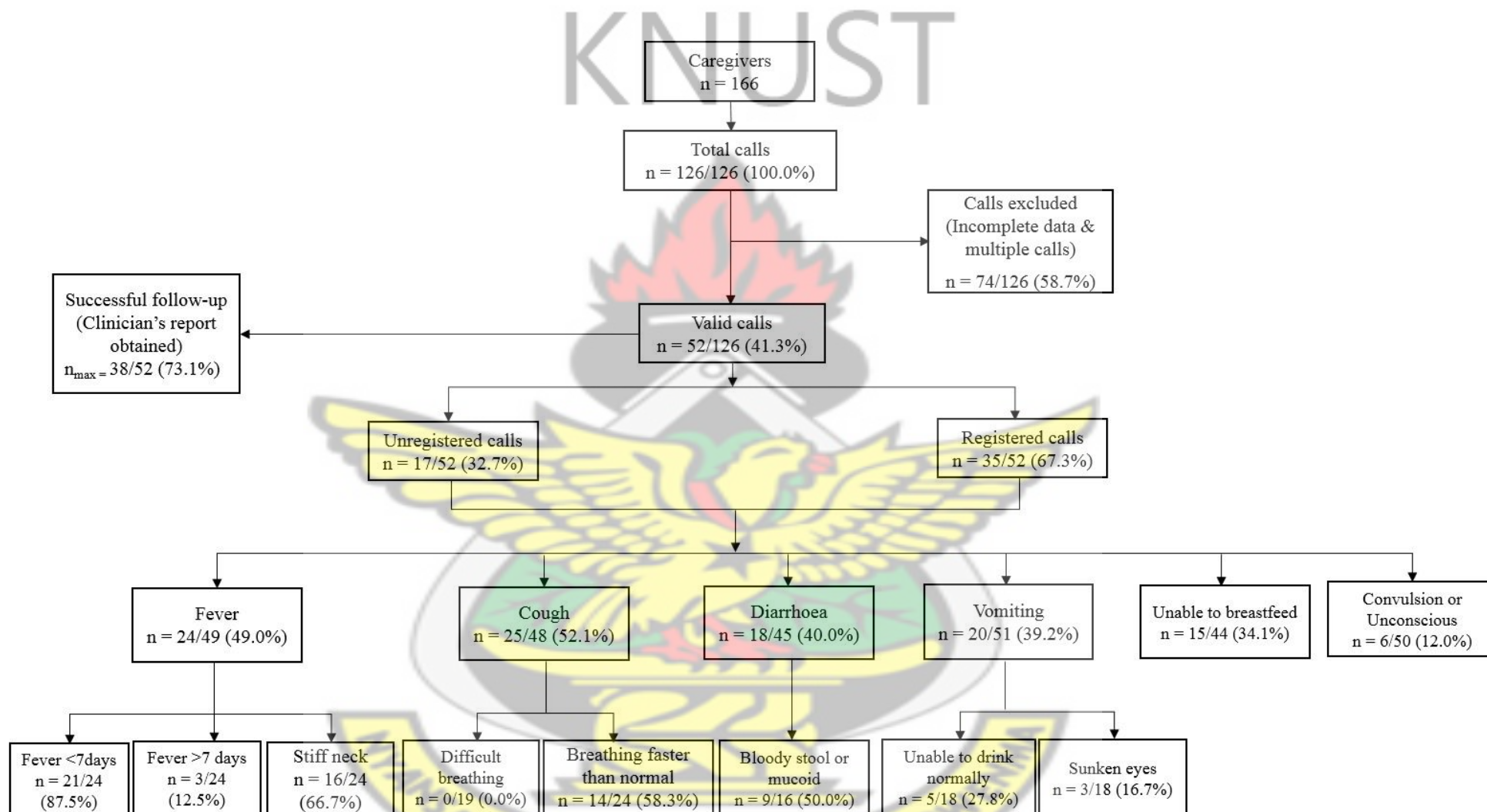


Figure 4.9: Flowchart of disease symptoms reported

Source: Field & IVR System Data, 2016

4.6.3 Common symptoms reported by age of child

Children aged less than a year old and between 1 – 2 years old were the two most common age groups caregivers reported symptoms on behalf, followed by 1 – 4 years and children older than 4 years but less than 5 years as shown in Figure 4.10. The two most common symptoms reported for the children less than one year were fever and vomiting (10 each), followed by cough (n=8) and diarrhoea (n=7). Cough was the most common symptoms experienced by children with age group of 1 – 2 years (n=11) and less than 3 – 4 years (n=5).

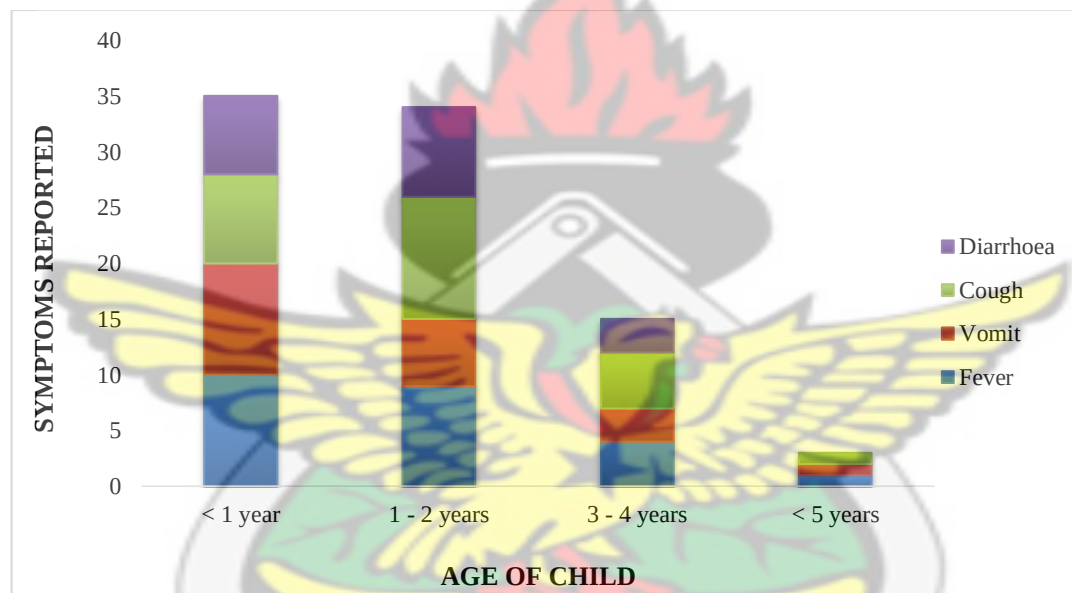


Figure 4.10: Symptoms reported by age of child

Source: IVR System Data, 2016

4.6.4 Temporal pattern of common childhood disease symptoms

The monthly distribution of common disease symptoms experienced by children in this study are shown in Figure 4.11. Throughout the 12-month period of the intervention, the most common symptom experienced by children was cough, with the highest numbers observed in the months of July (n=6) and October (n=5). For fever and diarrhoea, high numbers of reports were observed in the month of October – n=5 and n=4, respectively. The highest number of children who vomited (n=5) was however recorded in the month of July.

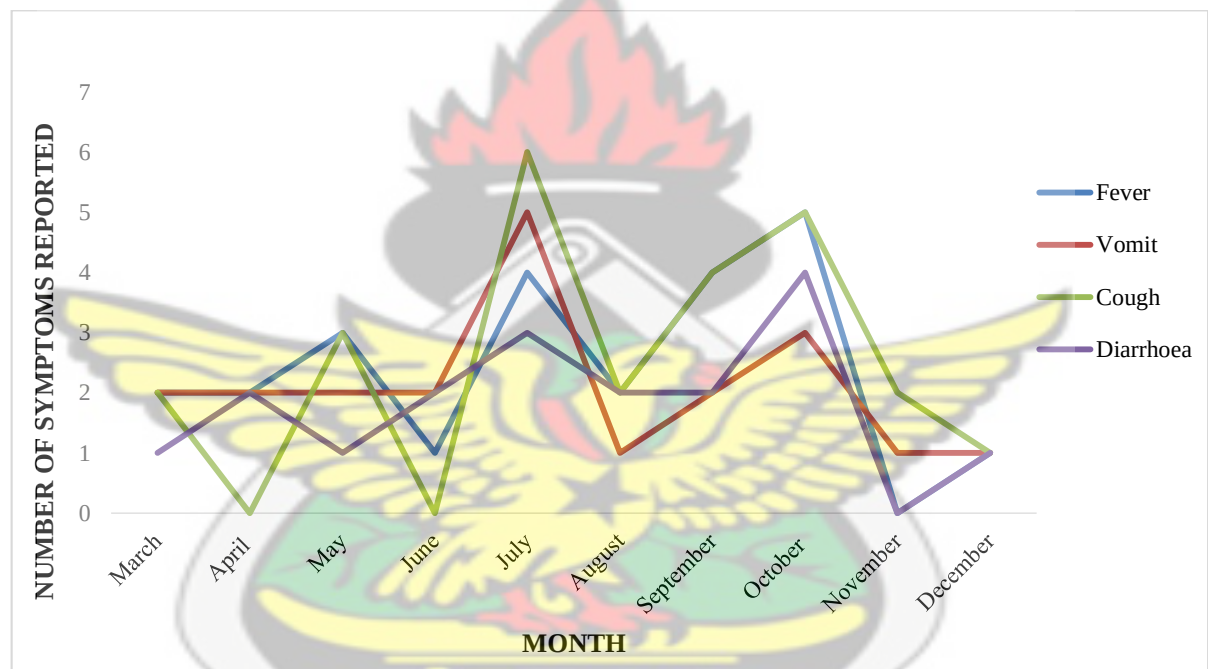


Figure 4.11: Temporal patterns of symptoms

Source: IVR System Data, 2016

4.6.5 Validity of disease symptom reported

The validity of the symptoms reported by the caregivers for 38 complete data obtained from the hospital/health Centre records were examined. The highest agreement between the findings of the system and the clinicians report was observed for fever (percentage agreement, 84.9%, kappa=0.70, $p < 0.001$, sensitivity=86.7%, NPV=88.2%). Good agreement was also seen for diarrhoea (percentage agreement, 74.2%, kappa=0.44,

p<0.007, sensitivity=70.0%, NPV=84.2%) and vomiting (percentage agreement, 73.7%, kappa=0.46, p<0.002, sensitivity=68.8%, NPV=77.3%), with cough showing a fair agreement (percentage agreement, 67.7%, kappa=0.37, p<0.0129, sensitivity=80.0%, NPV=78.6%) as shown in Table 4.17.

Table 4.17: Concordance of symptoms between IVR system and clinician's report

Symptom	Agreement (%)	Cohen's kappa	p-value	Sensitivity (%)	Specificity (%)	PPV	NPV	Prevalence (%)
Fever	84.9	0.70	<0.0001	86.7	83.3	81.3	88.2	45.0
Vomiting	73.7	0.46	0.0023	68.8	77.3	68.8	77.3	42.0
Cough	67.7	0.37	0.0129	80.0	57.9	60.0	78.6	44.0
Diarrhoea	74.2	0.44	0.0068	70.0	76.2	58.3	84.2	32.0

PPV = Positive predictive value; NPV = Negative predictive value

Source: Field Data, 2016

4.5.6 Recommendation based on symptom reported

Caregivers were advised by the system on what to do based on the symptom reported, determined by the combinations of different symptoms. Majority (59.6%, n=31) of the symptoms indicated by the caregivers which required emergency treatment were of category 'A', while 40.4% (n=21) which required causal treatment were of category 'B' as shown in Table 4.18. None of the calls fell within category 'C' or 'O'. Of the calls that fell within category 'A', majority were predicted by the system to be children who were unable to breastfeed (28.9%, n=15), severe RTI (26.9%, n=14) and severe dehydration (19.2%, n=10). On the other hand, majority that fell in the 'B' category, were predicted by the system to be children who had moderate RTI (37.8%, n=14), GI-infection (27.0%, n=10) and dysentery (24.3%, n=9).

Table 4.18: Treatment recommendation based on the level of severity

System recommendation		Symptom category	
	n (%)		n (%)
A'	31 (59.6)	Unable to breastfeed	15 (28.9)
		Unable to drink	5 (9.6)
		Unconscious or Convulsions	6 (11.5)
		Severe febrile disease	2 (3.9)
		Severe RTI	14 (26.9)
		Severe dehydration	10 (19.2)
		Total	52 (100.0)
B'	21 (40.4)	Febrile disease	4 (10.8)
		Moderate RTI	14 (37.8)
		Dysentery	9 (24.3)
		GI – Infection	10 (27.0)
		Total	37 (100.0)
C'	0 (0.0)	Mild RTI	0 (0.0)
		GI – Infection with no dehydration	0 (0.0)
		Total	0 (0.0)
O'	0 (0.0)	No positive symptom indicated	0 (0.0)
Total	52 (100.0)		89 (100.0)

A = requiring emergency treatment; B = requiring causal treatment; C = requiring home care

Source: IVR System Data, 2016

CHAPTER FIVE

5.0 DISCUSSION

5.1 INTRODUCTION

This chapter discusses the results in more detail, and in relation to the objectives and key variables of the study. The results are also compared with results from other studies, and their implications on healthcare provision and policy are extensively discussed. As an intervention study, this research was conducted to provide evidence to support mHealth approaches by examining the effect of using a mobile phone-based health information system on health behaviours of caregivers of children under-five. The system was also designed to monitor common childhood disease symptoms, with a secondary expected outcome of improving knowledge on malaria and health behaviours of caregivers with children under-five. An overall outcome of reducing the prevalence of malaria in children under-five was expected after the mHealth intervention.

Mobile technology has been used extensively to support healthcare services over the years (Gurol-Urganci et al., 2013; Prue et al., 2013; Uddin et al., 2016). For malaria specifically, mHealth has been suggested to have the potential to complement malaria prevention and control efforts by improving quality of and access to malaria healthcare services (Asiimwe et al., 2011; Higgs et al., 2014). It also has the potential to alter behaviours through patient/healthcare worker education to strengthen prevention and demand for malaria related services. Based on a well-established behaviour change model, this study examined how the knowledge and health behaviours of caregivers could be affected by strategically delivering tailored-health messages to them via their mobile phones. An important component of this study was therefore to assess how the provision of malaria health

information via mobile phones could influence the health behaviours of primary caregivers who are known to exert the strongest influence on a young child's life.

5.2 PREVALENCE AND SPATIAL EPIDEMIOLOGY OF MALARIA

5.2.1 Prevalence of Malaria

In this study, the prevalence of malaria in children under-five was assessed before and after introducing a mobile phone-based health intervention. Findings from this study suggests that the use of mobile technology as a communication channel for delivering health information to caregivers of children under-five has a significant influence on malaria prevalence in children under-five.

Mobile technology has the potential to accelerate the elimination of malaria by improving its diagnosis and treatment (Chihanga et al., 2012). In an attempt to prevent and control the incidence of the disease, a number of mHealth interventions were initiated (Asiimwe et al., 2011; Barrington et al., 2010; Kabanywany et al., 2010). However, majority of these interventions conducted in Africa focused on surveillance and commodity monitoring (Davis et al., 2011; Randrianasolo et al., 2010; Zurovac et al., 2011). The current study, however, considered mobile phones as a health communication tool for preventing malaria in children less than five. Data obtained from the study revealed a general reduction in malaria prevalence from 75% at baseline to 51% at endline. Comparatively, these were higher than the national figure of 36% and 48% as indicated in the 2014 GDHS and 2011 MICS, reports respectively (GSS et al., 2015). Although the current study observed a higher prevalence as confirmed by both RDT and microscopy, a number of factors could have accounted for this. A plausible explanation for the higher prevalence could be as a result of the differences in the ecological topographies, and other unobserved characteristics of the study areas including drainage system, temperature variation, precipitation, etc, a point well established and documented (Appawu et al., 2004; Chinery, 1984; Dery et al.,

2010; Tchouassi et al., 2012). Nonetheless, the high prevalence observed in the current study is similar to previous studies conducted in other parts of the country and other neighboring countries. In Hohoe, Volta region of Ghana, the prevalence of malaria in children less than five years as measured by RDT was found to be significantly higher in rural areas than in the urban areas (42.5% vs. 25.2%; $p < 0.001$) (Kwaku et al., 2017). Studies conducted in Nigeria (Olasehinde et al., 2015), and Gabon (Dzeing-Ella et al., 2005) also documented under-five malaria prevalence of 70.6% and 40.0%, respectively, with *Plasmodium falciparum* accounting for the high prevalence. On the contrary, other studies reported a relatively lower prevalence of malaria – 0.7% in Zambia (Chanda et al., 2009) and 12.0% in Tanzania (Mazigo et al., 2011). The disparities in the reported malaria prevalence could be attributed partly to the difference in the transmission patterns of malaria, use of varying preventive measures and the period of study implementation. Nonetheless, in the current study a statistically significant reduction in malaria prevalence was observed at post-intervention. The baseline and endline comparison of malaria prevalence revealed a statistically significant reduction of 30% among the intervention group compared with 17% observed for the control group. The difference could be as a result of the frequency of exposure of caregivers in the intervention to the malaria health messages via mobile phones. Children whose caregivers received the intervention were significantly less likely to experience an episode of malaria, after adjusting for age and education level of the caregiver. The findings of this study reiterates the vital role of health education programmes in the control and management of malaria, as evidenced in other studies which documented a reduction in malaria prevalence among school going children (Ayi et al., 2010; Elsheikh, 2007; Kouyaté et al., 2008). A study conducted in Ghana by Ayi and colleagues (2010) reported a statistically significant reduction in malaria prevalence from 31% at baseline to 10% at endline, by disseminating malaria related

messages to communities with the help of school going children. Few studies conducted in other African countries using a similar approach observed a comparable result (Nonaka et al., 2008; Okabayashi et al., 2006). This therefore calls for further discussions on the most cost-effective means of disseminating health information for better malaria outcome in children especially those in the most remote settings with limited health resources; although the use of mobile phone technology has been suggested to be a cost-effective way of improving health literacy (Zhuang et al., 2016). Comparatively, the prevalence reported in these studies are lower than that observed in the current study. Factors including the content of the message, channel of communication, ages of both the caregiver and child as well as the type of malaria outcome measured could have accounted for the difference. These studies also considered microscopy as their preferred method of detecting malaria parasite, although RDT, as considered in the current study is likely to detect antigens which may still be present in the child's blood even after the parasites have disappeared. Nonetheless, as initially hypothesized, the use of mobile technology as the conduit for delivering tailored malaria health education messages based on a behaviour change theory likely contributed to the observed significant difference in malaria prevalence among children whose carers received the intervention compared with caregivers who did not receive the intervention. The observed outcome could be attributed to the improved health knowledge and behaviours of the caregivers, likely triggering their internal emotional reaction which is known to be associated with the adoption of healthy behaviours (Jepson et al., 2010).

5.2.2 Spatial epidemiology of Malaria

Malaria risk maps are critical for identifying high-risk areas (Dalrymple et al., 2015; Hardy et al., 2015). Such maps can help malaria control programmes understand the epidemiology of the disease and strategically deploy vector control measures to high-risk

areas in order to identify and treat the parasite reservoirs (Tatem et al., 2014). Unfortunately, the use of malaria risk maps have not been explored extensively in the control of malaria at the community level in Ghana. Findings of the current study revealed a homogenous spatial distribution of malaria cases at baseline; a depiction of statistically non-significant spatial distribution of the disease between the intervention and control sites. On the other hand, statistically significant heterogeneous distribution of malaria cases in the children was observed at endline, with high clustering of the disease limited to four communities in the control site. Comparatively, three communities in the intervention site were characterized by low clusters of the disease. A closer examination of the observed geographical clusters of the malaria cases in these areas revealed common characteristics including open refuse dumping sites and stagnant waters which are likely to be the breeding sites of mosquitoes. Similar to the disease pattern observed in the current study at endline, Appiah and colleagues (2011) also observed a non-random spatial distribution of monthly morbidity cases of malaria obtained from records of public health facilities, with the highest burden noted in the northern and central part of Ghana. The findings of the current study also replicates the findings of an earlier study which employed a maximum spatial clustering of $\leq 20\%$ of the total population to identify areas with high risk of malaria incidence (Hui et al., 2009). Hence, the introduction of the mobile technology as an intervention tool, possibly accounted for the variation in the spatial distribution of malaria observed between the intervention and control sites.

5.3 EFFECT OF mHEALTH INTERVENTION ON MALARIA PREVALENCE

Given the nascent state of mHealth, evidence to support the role of mobile technologies in improving child health outcomes especially in sub-saharan African countries like Ghana is limited, with most studies focused on improving the health system by promoting equity of service delivery, surveillance and referral system (Higgs et al., 2014). Nonetheless, some

studies attributed the observed health outcomes to the use of mobile technologies (Lester et al., 2010; Musoke, 2002). Evidence gathered from this study reiterates the potential of mobile technologies for reducing malaria morbidities in children under-five. In line with the hypothesis of the study, the observed treatment effect documented after matching key covariates suggests that receiving a theory-driven health messages via mobile phones could significantly reduce the likelihood of a child to be infected with malaria. The observed counterfactual outcome further suggests that receiving malaria health messages likely reduced the prevalence of malaria in children under-five, a situation which would not have been observed if the caregivers in the intervention group had not received the intervention, having adjusted for pre-existing baseline characteristics such as age, marital status and household wealth. The reduction could be accounted for by the behaviour change theory adopted to influence the perception of the caregivers regarding malaria. Also, the twelve (12) months duration of the intervention and the content of the message, designed to emphasize on the negative health implications of malaria and provide preventive advice, may have influenced the health practice of the caregivers. In line with this assertion, studies that employed this fear appeal tactic have reported a similar improvement in health outcomes (Terblanche-Smit and Terblanche, 2010; Wong and Cappella, 2009a). The observed improvements in these studies were attributed to an increase in the perceived threat and efficacy among the participants as posited by the behaviour change theory (Witte, 1994, 1992a). Although limited evidence exist on the use of mHealth as a malaria control tool, the findings of a randomized control trial study by Lester and colleagues (2010) revealed that receiving SMS messages significantly suppresses viral loads of HIV patients. Another study by Sharma and colleagues (2011) comparing text messaging and pamphlets found that delivering health messages via mobile phones significantly reduced visible plaque scores in preschool children (Sharma et al., 2011). On

the contrary, Jareethum and colleagues (2008) reported that receiving SMS messages did not have any effect on pregnancy outcome, a result attributed to small sample used (Jareethum et al., 2008). Nonetheless, these findings suggests that mobile technologies could have a significant impact on health outcomes especially if the SMS messages of these interventions are theoretically constructed to influence the cognitive, normative and behavioural dimensions of the target population (Higgs et al., 2014).

Recognizing the effect, as much as possible, the Hawthorne effect (Cook, 1962), which usually occurs when subjects under study change an aspect of their behaviour due to their awareness of them being observe, was minimized after matching the intervention and control group. This effect is known to increase the magnitude of the estimated effect as study participants may over-estimate responses (McCarney et al., 2007). All participants of the current study were however aware of them been observed. Hence, the effect estimate after matching based on their pre-existing differences is unlikely to be affected as observed in the sensitivity analysis, which showed that the observed outcome could be insensitive to the omission of plausible unobserved confounders.

5.4 EFFECT OF mHEALTH INTERVENTION ON KNOWLEDGE ABOUT MALARIA

Knowledge assessment is of vital importance for the adoption of good practices for health improvement and disease prevention. The use of mobile technology as a health communication tool have been reported to improve health knowledge (Lee et al., 2011) and outcomes (Finitsis et al., 2014; Lester et al., 2010), although limited studies exist on its effect on caregiver knowledge about malaria. In the current study, the relatively higher reduction in malaria prevalence among caregivers in the intervention group may be attributed to the improved knowledge about the causes and prevention of malaria as

observed at post-intervention. Findings from previous studies suggest that knowledge about malaria could influence malaria parasitaemia (Nasir et al., 2016) and its control measures (Iriemenam et al., 2011). In the current study, knowledge about the causes and prevention of malaria were assessed before and after the intervention. Remarkably, more than 90% of the caregivers identified mosquito bite as the cause of malaria. This finding is similar to that reported in other studies (Iwuafor et al., 2016; Yewhalaw et al., 2010), although higher than another study conducted in Nepal (Joshi and Banjara, 2008) and Ethiopia (Kaliyaperumal and Yesuf, 2009) as well as that reported in the Ghana MICS (Ghana Statistical Service, 2011). Interestingly, although there was no significant difference in knowledge about the causes of malaria between the intervention and control group at baseline, the endline data suggested otherwise. A relatively higher proportion of caregivers in the control group indicated standing or working in the sun as a cause of malaria. This finding is similar to a study in Nigeria where 65% of the caregivers cited exposure to the sun as a cause of malaria (Ovadge and Nriagu, 2016). Compared with the MICS report, more than half of the caregivers also indicated dirty surrounding as a cause of malaria. Although filth in the environment does not promote *Anopheles* breeding, four-in-ten of the caregivers indicated “keeping surroundings clean” as a way of preventing malaria, a finding lower than that documented in the MICS report. A relatively higher proportion of caregivers in the intervention group indicated the use of mosquito repellants and mosquito coils as effective methods for safeguarding their children against malaria compared with the control group at endline. Similarly, fewer caregivers in the intervention group also cited drinking dirty water or eating bad food as a cause of malaria. This improvement in knowledge is not surprising considering the content of the messages were designed to demystify the long held misconceptions about the causes and ways of preventing malaria.

The findings of the current study suggests that caregivers who received the mHealth intervention were significantly more likely to have higher post-knowledge score about malaria compared with caregivers who did not receive the intervention. Although both groups were assumed to be exposed to other malaria campaigns via other sources as observed in the study, the improved knowledge among caregivers in the intervention group could be due to the additional health information they received via their mobile phones. This finding is in line with other studies from other settings which have shown the advantage of using mobile technology as a tool for improving health knowledge (McLeod et al., 2009; Tempelhof et al., 2009). Comparing the effectiveness of mobile phone text messaging and pamphlets for improving health knowledge, Sharma and colleagues (2011) also found that the knowledge, attitudes and practices of mothers who received health messages via mobile phones had significantly increased at endline. Although this study used text messages, an approach likely to pose some challenges for non-literates, the current study considering the target population opted for voice SMS recorded in the native language in order to maximize message recall and acceptability, an approach which paid dividends considering the knowledge outcome. Another likely reason for the relatively higher upshot of knowledge observed among the caregivers in the intervention group could be explained by the way these messages were tailored to the health knowledge needs of the target population. Hence, considering its wide use and low cost, this suggest that the use of mobile technology, which usually require fewer staff with little technical skills could be a useful tool for disseminating tailored health messages to a large audience in a bid to promote good health and prevent diseases (Kaplan, 2006; Leach-Lemens, 2009).

5.5 EFFECT OF mHEALTH INTERVENTION ON BEHAVIOUR CHANGE

Previous studies suggests that healthy behaviours on the part of families, communities, and health systems could dramatically accelerate reductions in under-five mortality (Black

et al., 2003; Lozano et al., 2011; Rajaratnam et al., 2010). However, to achieve this, a comprehensive behaviour change and communication is required to improve the knowledge of disease transmission and preventive measures (Legesse et al., 2007) of caregivers, particularly of malaria which continue to pose public health threat to children under-five in most African countries. Nevertheless, knowledge about preventive measures does not necessarily translate into improvement in practices (Singh et al., 2014). On the other hand, change in health behaviours could lead to improved health outcomes (Jepson et al., 2010; Kilian et al., 2016).

The behaviour change model, EPPM (Witte, 1992b), employed in the current study have been extensively tested and has covered multitude of topics, although with mixed results (Popova, 2012). This theory-driven approach adopted in the current study primarily focused on how the use of mobile technology as a BCC tool could trigger cognitive dimensions and decision making processes, an area with limited evidence (Higgs et al., 2014; Jones et al., 2012). The mechanisms of change according to this theory are well documented in earlier studies (McKay et al., 2004; Muthusamy et al., 2009; Roberto and Goodall, 2009). In the current study, three basic assumptions of the behaviour change theory were re-examined to confirm its usefulness for supporting the mHealth intervention employed. Consistent with previous studies, the three essential tenets of the model assessed in the current study suggest that the health behaviours of the caregivers were affected by the messages disseminated to them via their mobile phones. Data obtained from the study indicates that the use of fear appeal messages resulted in an increase in levels of caregivers' perceived threat but not their perceived efficacy about malaria at post-intervention. Consistent with the philosophy of the model, the study finds that when perceived efficacy was high, perceived threat was associated with danger control outcomes such as attitudes, intentions and behaviour change. This finding is in line with earlier

studies (Kleinot and Rogers, 1982; McMahan et al., 1998; Smalec and Klinge, 2000) and a more recent study by Roberto and Goodall (2009). The proposition that fear causes fear control responses have generally received mixed support (Tay and Watson, 2002; Witte and Allen, 2000). However, data obtained from the current study suggests that the likely fear observed among the caregivers was inversely related to all the fear control responses such as defensive avoidance, message minimization, and manipulation, a finding consistent with other studies (Lewis et al., 2010; Witte, 1994), although contrary to a study by (Ooms et al., 2016). This implies that an increase in fear of malaria as a result of a health message would likely result in the possibility of caregivers engaging in maladaptive behaviours. The observed inverse relationship could be due to the high perceived efficacy, the believe in their ability and the recommendation of the message to avert the threat by practicing the recommended response, a relationship reported to be mediated by response efficacy (Lewis et al., 2010). Additionally, data obtained in the current study agrees with the proposition of the EPPM that fear indirectly influences danger control outcomes, as mediated by perceived threat when perceived efficacy is high. Support for this proposition have also been mixed, with Witte (1994) reporting that although fear was not related to attitudinal changes, it indirectly affects both intention and behaviour. Lewis and colleagues (2010) however in their study found a direct relationship between fear and message acceptance (danger control). This implies that under high efficacy condition, fear of malaria would likely result in the adoption of positive health behaviours by caregivers if the messages disseminated to them cognitively affects their perception of threat about the disease. Hence, an increase or decrease in the level of the perceived threat of malaria due to the message conveyed to the caregivers could determine the level of their fear. Their level of fear of malaria, as elicited by the fear appeal message, could either motivate them

to control malaria by adapting preventive behaviours or control their fears, in which case deny the existence of the threat of malaria that put their children at risk.

Generally, the use of fear appeal tactic adopted in the current study for improving health behaviours of caregivers by disseminating voice SMS via their mobile phones yielded an appreciable level of change, as observed in the pre- and post-intervention data. As suggested by the EPPM, threat motivates action but perceived efficacy determines the nature of that action (McMahan et al., 1998). Thus, high perceptions of threat and efficacy results in an increase in adoption of positive behaviours (Witte, 1994, 1992b). Previous studies supports this assertion (Roberto and Goodall, 2009; Wong and Cappella, 2009a). Consistent with these studies, the findings of the current study suggest a significant improvement in the perceived threat and efficacy of caregivers who received the intervention as opposed to caregivers who did not. Additionally, caregivers who received the intervention were more likely to report positive attitudes and behaviours, and less likely to be in a state of denial of the threat which is associated with defensive avoidance, message minimization and message manipulation. The positive impact of health behaviours have been documented in other studies that employed mobile technology (Huang et al., 2013; Lund et al., 2014; Rotheram-Borus et al., 2012). These studies, however, lacked the theoretical basis to account for the observed changes in the health related outcomes. Consistent with the current study, the findings of a study by Evans and colleagues (2012) using the HBM behaviour change theory suggested an improvement in the belief about birth preparedness among the intervention group, with the intervention effect found to be greater among individuals with higher education level. This clearly suggests the critical role literacy plays in behaviour change and mHealth interventions (Evans et al., 2012). Notwithstanding this evidence, the current study anticipated, although observed at baseline, the existence of an inherent fear of malaria among the caregivers due

to previous experience or prior knowledge of the disease, a factor documented to affect the effectiveness of the messages delivered to the audience (McKay et al., 2004; Muthusamy et al., 2009). In effect, in order to maximize the effectiveness of health messages on cognitions about a health threat, prior information of the stage of change is paramount.

The frequency and time of message dissemination may have influenced assimilation of the messages by the caregivers which might have resulted in high cognitive development leading to the improved health behaviours. This could also be explained by the persuasive approach adopted in the current study and considering that some caregivers were also exposed to the mass media. This may have positively influenced their self-efficacy, a situation known to improve people's ability to act on the message received (Morton and Duck, 2001).

5.6 FEASIBILITY OF mHISS FOR MONITORING CHILDHOOD DISEASES SYMPTOMS

The findings of this study illustrate that mobile phone technology has the capacity to aid in identifying sick children who may require urgent attention based on direct symptomatic reports from caregivers. The feasibility of the mHealth system with regard to its reliability and potential as an early warning and referral system was evaluated.

Although a plethora of literature exist on the use of mobile technology for surveillance (Asiimwe et al., 2011; Fu et al., 2017; Yang et al., 2009), to the best of our knowledge, no study has examined its potential for gathering symptomatic data based on direct reports from caregivers in rural settings. The findings from the current study reiterates the potential of using mHealth as a surveillance tool for monitoring the development of common childhood illnesses based on symptom reports from caregivers, with an ultimate

goal of guiding them to appropriate prevention, treatment measures and encouraging positive healthcare-seeking behaviours.

Previous studies have also used mobile technology to identify individuals with diseases, although in majority of these cases, trained personnel were employed to use text messages as a means of disease identification (Meankaew et al., 2010; Prue et al., 2013). On the contrary, the current study identified 52 sick children based on symptom reports directly gathered from caregivers using the mHealth system, an approach generally described to be effective for reporting health data (Patnaik et al., 2009). The prominent symptoms contributing to the pool of cases identified included: fever, cough, diarrhoea and vomiting; the children <1 and those aged 1 – 2 years were affected most.

Based on the level of severity of the symptoms reported, a large proportion of the children were considered by the system to require emergency care. Data obtained from the study suggests that caregivers of these children were advised by the system to take their children immediately or within 24 hours to the nearest health facility. Although not all caregivers who used the system were successfully followed up, data obtained from the system suggests that all caregivers who accessed the system were given tailored health advice based on reported symptoms of the sick child. Data obtained during the follow up also suggest that majority of these caregivers acted on the advice given by the system. Previous studies have reported the usefulness of Short Message Service (SMS) to significantly improve healthcare-seeking behaviours through increased utility of healthcare services (Lund et al., 2014) and adherence to antiretroviral treatment (da Costa et al., 2012; Lester et al., 2010). The implication is a likely reduction in self-treatment and over-reliance on unqualified drug vendors mostly common in sub-Saharan Africa (Wafula et al., 2012). Remarkably, a closer look at the temporal pattern of the common symptoms reported by the caregivers suggests a likely malaria transmission period in the months of July and October. Coincidentally, these common symptoms conform to the seasonal variation of

malaria transmission in Ghana (Donovan et al., 2012; Owusu-Agyei et al., 2009), although the observed pattern could have been influenced by other factors including the malaria prevention reminders delivered to the caregivers via their mobile phones. Nonetheless, data obtained from the system revealed a fluctuating pattern of common disease symptoms of sick children based on direct symptom reports from caregivers.

The mobile phone-based system heavily relied on the ability of the caregivers to recognize and report disease symptoms. Hence, a major interest was the reliability of the reports directly gathered from the caregivers. In a hospital-based study conducted by Franke and others (Franke et al., 2018), their findings showed an appreciable level of reliability for common childhood disease symptom capturing using an IVR-based mHealth system. The clinician's report served as the standard for measuring the reliability of responses provided by caregivers using the mHealth system. Using Cohen's Kappa statistics, the level of agreement for fever, cough, diarrhoea and vomiting were 0.59, 0.64, 0.57 and 0.42, respectively. In comparison, the reliability of these symptoms observed in our study varied marginally – 0.70, 0.37, 0.44 and 0.46, for fever, cough, diarrhoea and vomiting respectively.

Contrary to a systematic review (Geldsetzer et al., 2014) which suggests poor recognition of common symptoms of childhood illnesses including diarrhoea, malaria and pneumonia by caregivers of children under-five, data from the current study suggests otherwise. The level of agreement of symptoms reported using the mHealth system and the clinician's report were relatively higher, with observed sensitivity levels ranging from 70 – 87%, although the interobserver agreement for cough suggests fair reliability. The results of the study reiterates the feasibility of using mobile technology as the first line for depicting a potential outbreak of diseases based on symptom reports in poorly resourced areas. In line with this assertion, findings from a study (Andersson et al., 2014) suggest that telephone

triage data could provide outbreak signals, weeks and months in advance, with the possibility of aiding early detection of disease occurrence. Subsequently, although the introduction of a new surveillance system is usually associated with early misunderstanding of some features (Paterson et al., 2012), the obstacles experienced in the current study were minimal and mostly limited to communities in the most rural parts of the district; usually with unstable communication networks. Nonetheless, the use of two languages, including the most spoken local language as an option to be selected when reporting symptoms was possibly favourable to the caregivers. Evidence from a qualitative study conducted by Brinkel and colleagues using a sample (3 groups of 8 – 10) of caregivers recruited from the same study site reaffirms the cultural acceptability of the mHealth system even among the marginalized and non-literates (Brinkel et al., 2017).

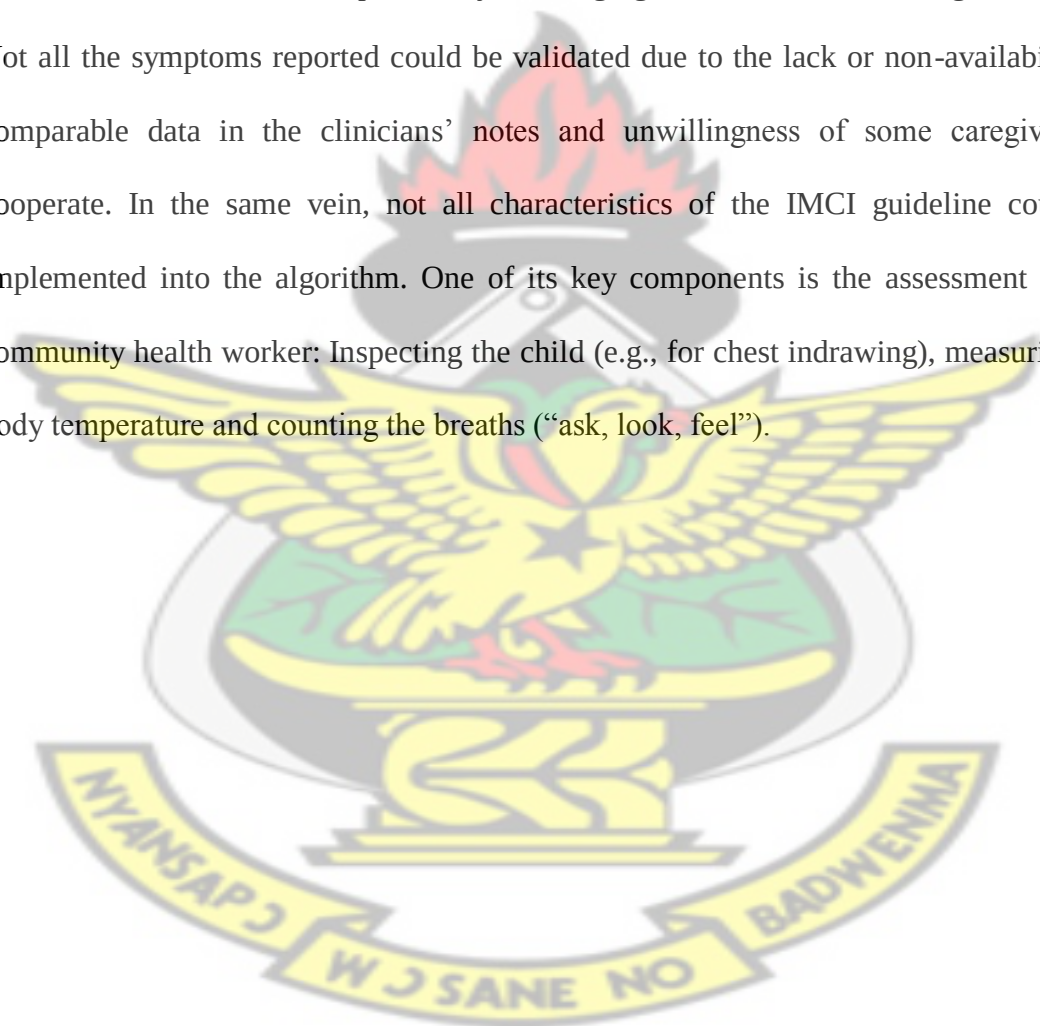
5.7 LIMITATIONS OF THE STUDY

This study had some limitations:

First, in order to demonstrate causality between the intervention and outcome, the quasi experimental study was chosen. However, lack of random assignment of participants was considered as one of the major weakness of this study design. Unlike randomized control trial, a number of frailties in the methodological makeup of this approach could have undermined its value. Therefore, observed statistical association does not necessarily imply causal association because of the difficulty in controlling all confounding variables. Second, maturation effect could have also affected the validity of concluding that introducing the mHealth intervention could have accounted for the change in behaviours and reduction in malaria prevalence. Thus, unaccounted environmental factors including poor sanitation could have affected the validity of attributing the change and reduction to the use of the mobile technology. Also, recall bias and loss to follow up are some of the problems associated with surveys of this nature. A number of respondents could not

remember events that occurred months ago while others could not be followed up at endline.

Furthermore, with regards to the symptom assessment of the system, some of the cases identified could have been reports from the same caregivers who used different numbers or caregivers from other areas outside the study area, adding to the numerator. Also, the inability of the system to automatically generate GPS data and unstable mobile networks in some communities made it practically challenging to authenticate the unregistered calls. Not all the symptoms reported could be validated due to the lack or non-availability of comparable data in the clinicians' notes and unwillingness of some caregivers to cooperate. In the same vein, not all characteristics of the IMCI guideline could be implemented into the algorithm. One of its key components is the assessment by the community health worker: Inspecting the child (e.g., for chest indrawing), measuring the body temperature and counting the breaths ("ask, look, feel").



CHAPTER SIX

6.0 CONCLUSIONS AND RECOMMENDATIONS

6.1 INTRODUCTION

This chapter presents the conclusions of the study based on the results and the discussion of pertinent findings with major implications on theory and practice. The conclusions are written to reflect the specific objectives of the study. The recommendations of the study are based on key issues that require attention which could help successfully harness the multi-purpose functions of mobile technology for improving health outcomes especially among children under-five in rural settings.

6.2 CONCLUSIONS

The theory-driven mHealth intervention employed in this study further projects the usefulness of mobile technology as a tool for strengthening the healthcare system by improving health literacy and behaviours of caregivers, and malaria outcomes in children under-five. Overall, the novel evidence gathered from this study reaffirms the significance of using mobile technology for augmenting BCC and surveillance activities. Consequently, regardless of the literacy level, the use of mobile technology by caregivers of children under-five at the Asante Akyim North district could positively influence their health decision making and improve the management of febrile illnesses. Subsequently, this intervention as part of public health interventions such as BCC and malaria control programmes implemented by the National Malaria Control Programme could be adopted to improve usage of preventive measures and encourage early treatment of the disease.

6.2.1 Prevalence and spatial distribution of malaria in children before and after mHealth intervention

The prevalence of malaria among the children under-five significantly differed between the caregivers who received the intervention and caregivers who did not at post-intervention – reducing from 73.9% at baseline to 43.5% at endline for intervention group; and 76.1% at baseline to 58.9% for control group. Children whose caregivers received the intervention were significantly less likely to have malaria compared with children whose caregivers did not receive the intervention.

The spatial distribution of malaria revealed a significantly high-cluster areas in the control site and low-cluster areas in the intervention site at post-intervention, with the pre-intervention showing a homogeneous distribution of the disease compared with the heterogeneous distribution observed at post-intervention.

6.2.2 Effect of mHealth intervention on malaria prevalence in children under-five

The counterfactual outcome, estimated as the treatment effect on the treated (ATET) if had not received the treatment, suggests that receiving the intervention likely reduced the prevalence of malaria in the children by 17.0%, a prevalence which would not have been observed if the caregivers had not received the theory-driven mHealth intervention.

The overall impact of the intervention estimated with the difference-in-difference model also suggests a statistically significant reduction in under-five malaria prevalence by 13.3%.

6.2.3 Effect of mHealth intervention on knowledge about malaria among caregivers

The overall knowledge about malaria was significantly higher among caregivers who received the intervention compared with those who did not receive the intervention at post-intervention, as opposed to the pre-intervention difference which was not statistically significant. Caregivers who received the intervention were twice more likely (AOR = 1.8,

95% CI = 1.09, 2.99) to have an improved knowledge about malaria compared with caregivers who did not receive the intervention. Thus, receiving the intervention likely increased the knowledge about malaria among the caregivers by 13.7%, an increase which would have not been observed if the caregivers had not received the intervention.

6.2.4 Effect of mHealth intervention on health behaviours of caregivers of children under-five

There was a statistically significant improvement in the cognition of malaria in terms of the perception about the disease severity, vulnerability of children to it, and the ability to recommend actions to avert the disease from affecting children among caregivers who received the intervention compared with caregivers who did not receive the intervention during the 12-month study period. Thus, the odds of positive behaviour change outcomes such as attitude (AOR = 2.58, 95% CI = 1.61, 4.15) and behaviours (AOR = 2.03, 95% CI = 1.29, 3.19) were relatively higher among caregivers who received the intervention compared with those who did not.

6.2.5 Feasibility of mobile technology as surveillance tool for monitoring common childhood febrile illnesses

Findings of this study suggest that the mobile phone-based system could serve as a first line surveillance tool for monitoring potential disease outbreaks based on the recorded symptom reports directly obtained from caregivers. The reliability of these reports were feasible and generally comparable to the clinician's assessment, with common symptoms including fever, diarrhoea and vomiting recording a relatively higher interobserver agreement than cough. The temporal pattern of these symptoms, characteristic of malaria, were highest in the month of July and October.

6.2.6 Further research

Despite the continuous improvement and use of mobile phone technology for health interventions, further research is required to fully understand its potential on health outcomes applied in different diseases, settings and target populations. As an important component for establishing the scalability and sustainability of an intervention, the current study did not evaluate the cost-effectiveness of implementing the mobile phone-based system which is vital for adoption and sustainability. Limited evidence exists on the cost-effectiveness of mHealth interventions which is a major component used in assessing the net cost of a project relative to the outcomes generated, while demonstrating how to attain maximum health benefits. Thus, future studies could examine the cost-effectiveness of utilizing this system for improving knowledge, health behaviours and monitoring disease symptoms. Further studies are also required to strengthen and support the evidence by examining the reliability of the IMCI-based system.

6.2.7 Implications for policy and practice

Overall, this study has implications for policy makers and global funders of mHealth programmes. This is one of the first mHealth interventions to apply a theory-driven mHealth approach for malaria BCC campaign and monitoring symptoms of childhood illnesses based on self-reported symptoms from caregivers. Global evidence to support theory-based mHealth approach is currently unavailable (Higgs et al., 2014). In line with the current eHealth policy of Ghana, ICT4AD, which seeks to promote the use of ICT for the delivery of health services by supporting the collection, analysis and dissemination of health information to support health education and awareness creation, the compelling evidence of the current study confirms the usefulness of mHealth interventions for healthcare delivery. In contrast to the existing District Health Information and Management System (DHIMS) which provides passive aggregated surveillance data, the

mHISS deployed in the current study is individual centred, with a multi-purpose functionality of serving as a health information dissemination and syndromic surveillance system. The observed improvement in the primary (malaria prevalence in children under-five) and secondary endpoints (health knowledge and behaviours among caregivers) reaffirms its usefulness for healthcare support. However, a projection of its feasibility in terms of cost-effectiveness is necessary for potential scale-up at the district level. Nonetheless, this study provides a wealth of knowledge to the current literature. Hence, whether or not the government or policy makers will harness mobile technology to improve the health systems should not only depend on mobile phone access, but instead on demonstrated impact and cost-effectiveness, at large scale (Mehl and Labrique, 2014). This study provides the empirical evidence to support the systematic integration of mobile phone use for the delivery of health service especially for health promotion and as a first line surveillance of disease symptoms common childhood diseases including malaria, cholera and pneumonia.

6.3 RECOMMENDATIONS

6.3.1 mHealth for literacy improvement

In light of the compelling evidence revealed in this study, it is recommended that health campaigns organized by the DHA that seek to improve the knowledge of caregivers on pertinent health issues especially on malaria could disseminate the messages via their mobile phones. Designed as voice SMS and in the most spoken language of the target population, these messages could be delivered to them once every week. For malaria specifically, these messages should contain both causes and preventive measures as well as symptoms of the disease. The messages should also focus on demystifying the misconceptions about the causes of malaria including “standing in the sun.” These

messages should be slightly modified every month to maintain interest and continuous participation among the target population.

6.3.2 mHealth for BCC interventions

The finding suggests that the use of fear appeals as part of BCC campaigns could have important implications for malaria control programmes in the country. BCC campaigns which primarily seek to change the health behaviours of its target group should be based on a behaviour change theory. Therefore, the DHA as part of its malaria control measures could educate caregivers on how to prevent malaria in their children by providing them with more information on the devastating effect of malaria on the health of their children. The information should also be designed to influence the efficacy beliefs of the caregivers including perception about their ability to prevent malaria in their children and their belief that the recommendation given to them will prevent their child from malaria. Hence, high threat and efficacy messages could lead to message acceptance which is associated with positive attitude, intention and behaviour change outcomes. However, maximum benefit could be achieved if supplemented with mobile technology. Theory-driven health messages delivered via mobile phones have been found to improve health behaviours of caregivers, which could influence malaria outcomes in children under-five.

6.3.3 Advocacy for the establishment of a mobile phone-based health information and surveillance system by MoH/GHS

In parallel, it is incumbent upon the health authority particularly the MoH and GHS to advance the wealth-related evidence gathered in the study to establish for all its DHAs known to implement community-level interventions, a mobile phone-based health information and surveillance system for supporting BCC campaigns and monitoring childhood diseases. Community health nurses, health information officers and disease

control officers could be trained to use the system to identify and manage common childhood febrile diseases including malaria, pneumonia and diarrhoeal diseases. This could lead to an important improvement in child survival especially those in the remote areas with limited access to health care services, and ultimately contribute to the achievement of the overall goal of reducing preventable deaths in children under the age of five years and promoting their healthy development.



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APPENDICES

APPENDIX A: Study Questionnaire

BASELINE/ENDLINE QUESTIONNAIRE

**KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY,
KUMASI
SCHOOL OF PUBLIC HEALTH, KNUST**

Project title: The use of mobile phone technology as a health information and surveillance tool for childhood fevers among children under-five at the Asante Akyim North District of Ghana

Identity No..... Date.....
Sub-district..... Community.....
Mobile phone #..... Interviewer.....
GPS (Garmin)..... SnooCode:
Name of caregiver: Address.....

SECTION I: SOCIO-DEMOGRAPHIC CHARACTERISTICS OF CAREGIVER AND CHILD(REN)			
No.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKI P
Q1	What is your age (mother/caregiver)?	[_ _] years	
Q2	Are you the head of this household?	Yes.....01 NO.....02 DK.....88	
Q3	What is your marital status?	Married.....01 Widowed.....02 Divorced.....03 Separated.....04 Never married.....05	
Q4	What is your highest level of school attended?	Please enter level of education code [_ _]	
Q6	Can you read and write?	Yes.....01 NO.....02 DK.....88	

Q7	What is your religion?	<i>Please enter religion code</i> [_ _]	
Q8	What is your employment status?	<i>Please enter employment status code</i> [_ _]	
Q9	Number of dependants	[_ _]	
Q10	Which ethnic group do you belong to?	<i>Please enter ethnic group code</i> [_ _]	
Now I would like to ask about all the births you have had during your life (Children under-five only)			
Q11	Have you ever given birth?	Yes.....01 NO.....02	
Q12	Do you have any sons or daughters who are now living with you?	Yes.....01 NO.....02	
Note: This includes biological and non-biological children under-five			
Q13	How many sons & daughters do you have?		
	a. Sons	[_ _]	
	b. Daughters	[_ _]	
For all children under-five under the care of caregiver, list starting with the youngest one.			
Q14	Name (first name only)	Age (months)	Sex (Male/Female)
Household Head (HH)			
Q15	Age of HH?	[_ _] years	
Q16	Household Head highest level of school attended?	<i>Please enter level of education code</i> [_ _]	

Q17	Can you read and write?	Yes.....01 NO.....02 DK.....88	
Q18	Employment status of HH?	Please employment status code [_ _]	
EDUCATION, RELIGION & ETHNIC GROUP CODING			
	Education level No education.....01 Primary.....0 2 Middle/JSS.....03 Secondary.....04 University/Polytechnic+..0 5	Ethnic group Akan.....01 Ga/Dangme.....02 Ewe.....03 Guan.....04 Mole-Dagbani.....05 Grussi.....06 Gruma.....07 Mande.....08 Other.....09	Religion Catholic.....01 Anglican.....02 Methodist.....03 Presbyterian.....04 Pentecostal.....05 Other Christian.....06 Muslim.....07 Traditional.....08
	Employment status Unemployed.....01 Employed.....02 Self-employed.....03 Student/Apprentice.....04 Retired/Disabled.....05 Other (specify).....06		

SECTION II: HOUSEHOLD CHARACTERISTICS (Socio-economic indicators)			
No	QUESTIONS AND FILTERS	CODING CATEGORIES	SK IP
	Now I would like to ask you a few questions about the characteristics of your household. Please tell me about items that your household owns.		
Q19	Does your household have: <i>Multiple select question</i> <i>(Select all that apply)</i>	Electricity.....01 Wall clock.....02 Radio.....03 Black/white television.....04 Colour television.....05 Mobile phone.....06 Landline telephone.....07 Refrigerator.....08 Freezer.....09 Electric generator.....10 Washing machine.....11 Computer.....12 Digital photo camera.....13 Car.....14 Motorcycle.....15 Table.....16 Bed.....17 None of the above.....20	
Q20	<i>Mobile phone use</i> Who owns the mobile phone?	Partner.....01 Self.....02 Relative.....03	
Q21	What do you use it for?		
	a. Calls	Yes.....01 NO.....02	
	b. Messaging (SMS)	Yes.....01 NO.....02	
	Water & Sanitation		
Q22	What is the main drinking water supply of your household?	Bottled.....01 Sachet water.....02 Inside tap.....03	

		Well.....04 Borehole.....05 Surface water.....06 Stand pipe.....07 Other (<i>specify</i>).....08	
Q23	Which kind of toilet facility does your household typically use?	Inside flush toilet.....01 Pit latrine.....02 Public toilet.....03 Open field.....04 Other (<i>specify</i>).....05	

SECTION III: PREVALENCE OF CHILDHOOD FEVERS			
<i>Please ask of only children under-five who have experienced fever during the past 1 years</i>			
No.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
Q24	Have ANY of your children experienced fever at any time in the last:		
a	2 weeks	Yes.....01 NO.....02 DK.....88	
b	6 months	Yes.....01 NO.....02 DK.....88	
c	12 months	Yes.....01 NO.....02 DK.....88	
Q25	What was the underlying cause?	Cough or difficult breathing.....01	

		Diarrhoea.....02 Malaria.....03 Ear problem.....04 Other (<i>specify</i>).....05 Don't know.....88	
Q26	In your opinion was (Name)'s fever mild, moderate or severe?	Mild.....01 Moderate.....02 Severe.....03 Don't know.....88	
Q27	In the last 12 months, how many of your children have experienced fever?	[_ _] Don't know.....88	
Q28	How many times in the last 12 months have your children experienced fever?	[_ _] Don't know.....88	
Q29	In which month did the child (most recent) experience fever?	[_ _ _] Don't know.....88	
SECTION IV: HEALTH SERVICE UTILISATION/HEALTH SEEKING BEHAVIOUR			
No.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
Q30	Did you seek any advice or treatment for the fever from any source?	Yes.....01 NO.....02 DK.....88	

Q31	Where did you first seek advice or treatment when (NAME) experienced fever? Anywhere else? PROBE TO IDENTIFY EACH TYPE OF SOURCE IF UNABLE TO DETERMINE IF PUBLIC OR PRIVATE SECTOR, WRITE THE NAME OF THE PLACE	Govt Hospital/ Polyclinic.....01 Govt Health Centre.....02 Govt Health Post/CHP.....03 Private clinic.....04 Pharmacy/Chemical shop.....05 Friends/Relative/Elder.....06 Traditional practitioner.....07 Community Health Volunteer.....08 Other Public (<i>specify</i>).....09	
Q32	How long after the fever began did you first seek advice or treatment for (NAME)?	Same day.....01 Next day.....02 2 days after the fever.....03 3 days after the fever.....04 4 or more days after the fever.....05 DK.....88	
Q33	If didn't get advice or treatment: Why didn't you get advice or treatment for the child?	Health centre too far.....01 Do not trust the malaria test.....02 No malaria tests at the health centre.....03 Do not like the health centre staff.....04 No money for test.....05 No reason.....06 Other (<i>specify</i>):.....07 DK.....88	
Q34	How do you perceive the distance from your house to a health facility?	Short distance.....01 Not so far.....02 Far.....03 Very far.....04 DK.....88	
Q35	What do you normally do when your child has fever?	Treat child at home using traditional medicine.....01 Treat child at home with medicine obtained from pharmacy shop.....02	

		Treat child at home with medicine obtained previously from hospital.....03 Take child to Hospital/CHPS after providing first aid.....04 Take child to Hospital/CHPS without providing first aid.....05 Nothing.....06 DK.....88 Other (specify).....99	
Q36	What did you do the last you're your child experienced fever?	Treat child at home using traditional medicine.....01 Treat child at home with medicine obtained from pharmacy shop.....02 Treat child at home with medicine obtained previously from hospital.....03 Take child to Hospital/CHPS after providing first aid.....04 Take child to Hospital/CHPS without providing first aid.....05 Nothing.....06 DK.....88 Other (specify).....99	

SECTION V: KNOWLEDGE ABOUT DANGER SIGNS

The next set of questions will assess your knowledge about danger signs.

No.	QUESTIONS AND FILTERS	CODING CATEGORIES	SKIP
	Sometimes children have severe illnesses and should be taken immediately to a health facility		
Q37	Are you aware of the general danger signs that would require you to take the child immediately to the hospital?	Yes.....01 NO.....02	

Q38	Can you tell me the general danger signs you know of?	Inability to drink or breastfeed.....01 Vomits everything.....02 Convulsions.....03 Unconsciousness.....04 DK.....88	
Q39	What types of symptoms would cause you to take your child to a health facility right away?	Child not able to drink or breastfeed..... 01 Child becomes sicker.....02 Child develops a fever.....03 Child has fast breathing.....04 Child has difficulty breathing.....05 Child has blood in stool.....06 Child is drinking poorly.....07 Child has diarrhoea.....08 Child incessant crying for no reason.....09 Child not eating well.....10 Other (<i>specify</i>).....99	
KNOWLEDGE ABOUT CAUSES AND PREVENTION OF MALARIA The next set of questions will assess your knowledge about the causes and prevention of malaria.			
Q40	In the past 12 months, have you seen or heard any messages about malaria?	Yes.....01 NO.....02	
Q41	Where did you hear or see the messages or information? Anywhere else?	Gov.t clinic/hospital.....01 Community health worker.....02 Friends/family.....03 Workplace.....04 Drama groups.....05 Peer educators.....06	

		Poster/billboards.....07 Television.....08 Radio.....09 Newspaper.....10 Other (specify):.....11 Don't know.....88	
Q42	What messages about malaria did you hear or see? Is there anything else?	Malaria is dangerous.....01 Malaria can kill.....02 Mosquitoes spread malaria.....03 Sleeping under a mosquito net is important.....04 Who should sleep under mosquito net.....05 Seek treatment for fever.....06 Seek treatment for fever promptly (within 24 hours).....07 Importance of house spraying.....08 Not plastering walls after spraying.....09 Environmental sanitation activities.....10 Other (specify):.....11 Don't know.....88	
Q43	In your opinion, what causes malaria? Probe: What else?	Eating sweet foods.....01 Standing/ working in the sun.....02 Eating contaminated food.....03 Mosquito bites.....04 Malaria parasite (p. falciparum).....05 Hereditary.....06 Dirty surroundings.....07 Weedy surroundings and stagnant water..08 Cold or changing weather.....09 Other (specify).....10	

		DK.....88	
Q44	How would you know that someone has malaria? Probe: What else?	Hot body fever.....01 Vomiting.....02 Diarrhoea.....03 Strong headaches.....04 Dizziness.....05 Loss of appetite.....06 Weakness of the body.....07 Cough.....08 Chills.....09 Bitterness in the mouth.....10 Pale eyes.....11 Other (specify).....12 DK.....88	
Q45	How can one protect him/herself against malaria?	Sleep under a mosquito net.....01 Sleep under an insecticide treated mosquito net.....02 Use Mosquito repellent.....03 Avoid mosquito bites.....04 Clear Weeds around the house.....05 Fill in Stagnant waters (puddles).....06 Keep surrounding clean.....07 Put mosquito screen window.....08 Spray house with insecticide.....09 Use mosquito coils.....10 Don't drink dirty water.....11 Don't eat bad food12 Don't get soaked with rain13	

		Other (specify).....14	
		DK.....88	
Q46	Can malaria be treated?	Yes.....01	
		NO.....02	
		DK.....88	
Q47	What is the most effective medication used to treat malaria?	Sp/fansidar.....01	
		Chloroquine.....02	
	Anything else?	Quinine.....03	
	RECORD ALL MENTIONED	New malaria drug/ act.....04	
		Aspirin, panadol, p'mol.....05	
		Other (specify):.....99	
		Don't know.....88	

SECTION VI: BEHAVIOUR CHANGE

NOTE: I am going to ask you about a series of actions you could take, and I would like you to tell me how confident you are that you could actually do that action successfully. For each action, please tell me if you think you definitely could, probably could, probably could not or definitely could not do each action successfully. **INTERVIEWER: DO NOT READ “DON’T KNOW” / “UNCERTAIN” RESPONSE AND ONLY USE IF RESPONDENT IS NOT ABLE TO PROVIDE ANOTHER ANSWER.**

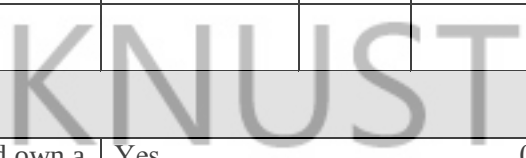
Q49. SUSCEPTIBILITY INDICATOR

		Strongly Disagree	Somewhat Disagree	Don't Know/ Uncertain	Somewhat Agree	Strongly Agree
a	I don't worry about malaria because it can be easily treated	1	2	3	4	5
b	My children are so healthy that they would be able to recover from a case of malaria	1	2	3	4	5

c	People in this community only get malaria during rainy season	1	2	3	4	5
d	People only get malaria when there are lots of mosquitoes	1	2	3	4	5
e	Only weak children can die from malaria	1	2	3	4	5
Q50. SEVERITY INDICATOR						
a	Every case of malaria can potentially lead to death	1	2	3	4	5
b	When my child has a fever, I almost always worry that it might be malaria	1	2	3	4	5
c	When someone I know gets malaria, I usually expect them to completely recover in a few days	1	2	3	4	5
d	When my child has a fever, I usually wait a couple of days before going to a health provider	1	2	3	4	5
Q51. Bed net use/insecticide spray/mosquito coil						
		Strongly Disagree	Somewhat Disagree	Don't Know/ Uncertain	Somewhat Agree	Strongly Agree
a	My chances of getting malaria are the same whether or not I sleep under a bed net	1	2	3	4	5
b	Many people who sleep under a bed net still get malaria	1	2	3	4	5

c	I have noticed my family gets sick less often since we began sleeping under nets	1	2	3	4	5
d	My chances of getting malaria are the same whether I spray with insecticide or not	1	2	3	4	5
e	My chances of getting malaria are the same whether I use mosquito coil or not	1	2	3	4	5
f	ACTs* work quickly to treat malaria	1	2	3	4	5
G	All the malaria medicines work equally well at treating malaria	1	2	3	4	5

Q52. SELF-EFFICACY						
Bed net use/malaria detection/seek diagnosis & treatment						
		Strongly Disagree	Somewhat Disagree	Don't Know/Uncertain	Somewhat Agree	Strongly Agree
a	Easily protect your children from getting malaria	1	2	3	4	5
b	Obtain enough bed nets to cover all of the sleeping spaces in your household	1	2	3	4	5
c	Sleep under a bed net for the entire night when there are mosquitoes	1	2	3	4	5
d	Know if a fever is a sign of malaria or something else	1	2	3	4	5

e	Find someone I trust to tell me whether my child has malaria	1	2	3	4	5
f	Find resources to travel with my child to the clinic within 24 hours when he/she is very sick	1	2	3	4	5
						
BED NET USE						
Q53	Does your household own a mosquito net?	Yes.....01 No.....02				
Q54	Did any of the children sleep under mosquito net last night?	Yes.....01 No.....02 Not sure.....03				
Q55	How many of the children slept under mosquito net?	[.....]				
Q56	For those children who did not sleep under the bed net last night, what were the reasons for not sleeping under the bed net?	Too hot.....01 Too cold.....02 Child cries.....03 Child afraid.....04 Not enough nets.....05 Net not hung up.....06 Used by adults.....07 Net not used when travelling.....08 Net not in good condition.....09 Net bad for children's health.....10 Net has too many holes.....11 Other (specify).....99				
Behaviour Change Questions introduced at Endline						
Q57. FEAR						

a	After listening to the message about malaria, how did you feel?	Not scared (1)	2	3	4	Very scared (5)
b	After listening to the message about malaria, how did you feel?	Not anxious (1)	2	3	4	Very anxious (5)
c	After listening to the message about malaria, how did you feel?	Not frightened (1)	2	3	4	Very frightened (5)

DANGER CONTROL REPONSES

Q58. ATTITUDE

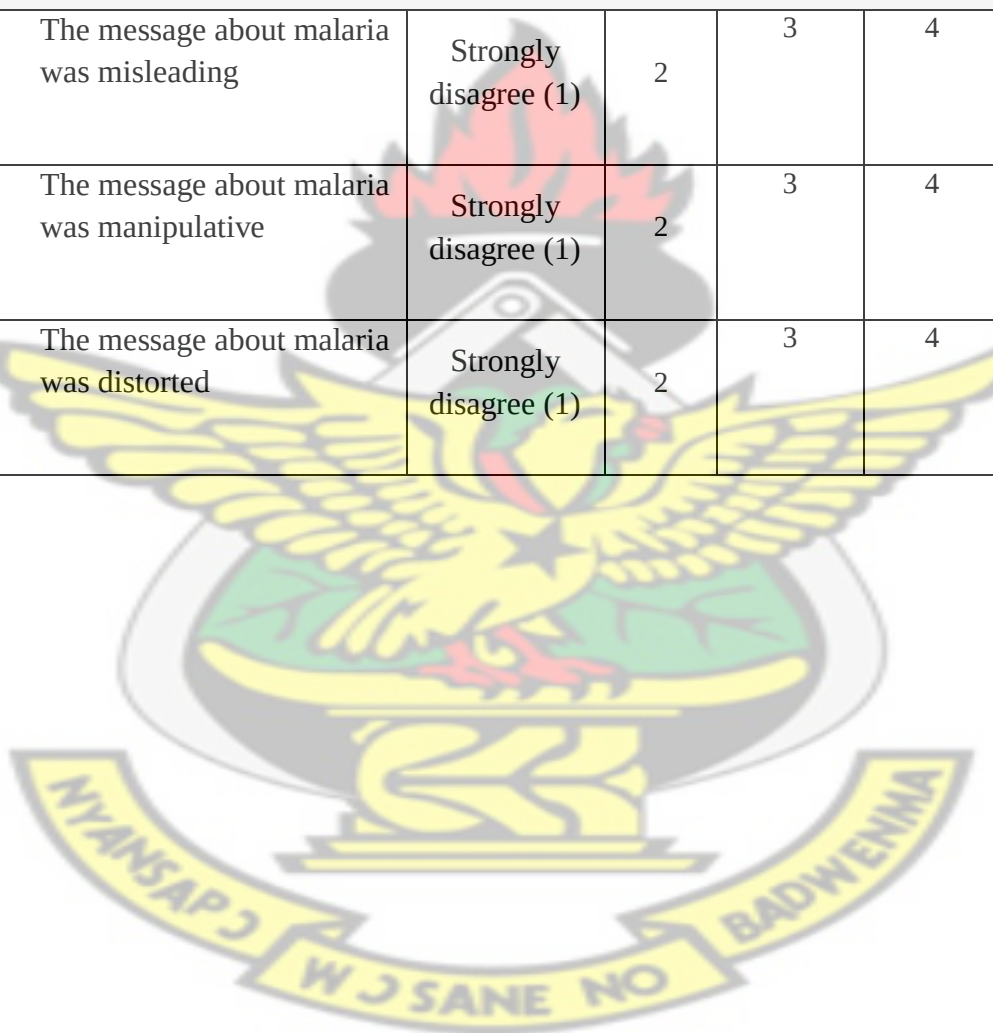
a	Reducing exposure to mosquitos by using mosquito net or coil will be	Very bad (1)	2	3	4	Very good (5)
b	Reducing exposure to mosquitos by using mosquito net or coil will be	Very undesirable (1)	2	3	4	Very desirable (5)
c	Reducing exposure to mosquitos by using mosquito net or coil will be	Very unfavourable (1)	2	3	4	Very favourable (5)

Q59. INTENTION

a	I plan to use recommended control measures every time to prevent malaria	Strongly disagree (1)	2	3	4	Strongly disagree (5)
b	I plan to always use recommended control measures every time to prevent malaria	Strongly disagree (1)	2	3	4	Strongly disagree (5)

Q60. BEHAVIOUR CHANGE						
a	I currently use recommended control measures to prevent malaria	Strongly disagree (1)	2	3	4	Strongly disagree (5)
b	I consistently use recommended control measures to prevent malaria	Strongly disagree (1)	2	3	4	Strongly disagree (5)
c	I regularly use recommended control measures to prevent malaria	Strongly disagree (1)	2	3	4	Strongly disagree (5)
FEAR CONTROL RESPONSES						
Q61. DEFENSIVE AVOIDANCE						
a	When I heard about the effect or consequence of malaria, my first instinct was to (Want to (1) – Not want to (5)) think about it	Want to (1)	2	3	4	Not want to (5)
b	When I heard about malaria, my first instinct was to (Want to (1) – Not want to (5)) do something to keep myself and children from getting malaria	Want to (1)	2	3	4	Not want to (5)
Q62. MESSAGE MINIMIZATION/REACTANCE/DEROGATION						
a	The message about malaria was exaggerated	Strongly disagree (1)	2	3	4	Strongly disagree (5)

b	The message about malaria was overblown	Strongly disagree (1)	2	3	4	Strongly disagree (5)
c	The message about malaria was overstated	Strongly disagree (1)	2	3	4	Strongly disagree (5)
Q63. PERCEIVED MANIPULATION						
a	The message about malaria was misleading	Strongly disagree (1)	2	3	4	Strongly disagree (5)
b	The message about malaria was manipulative	Strongly disagree (1)	2	3	4	Strongly disagree (5)
c	The message about malaria was distorted	Strongly disagree (1)	2	3	4	Strongly disagree (5)



Appendix B: List of Study Communities

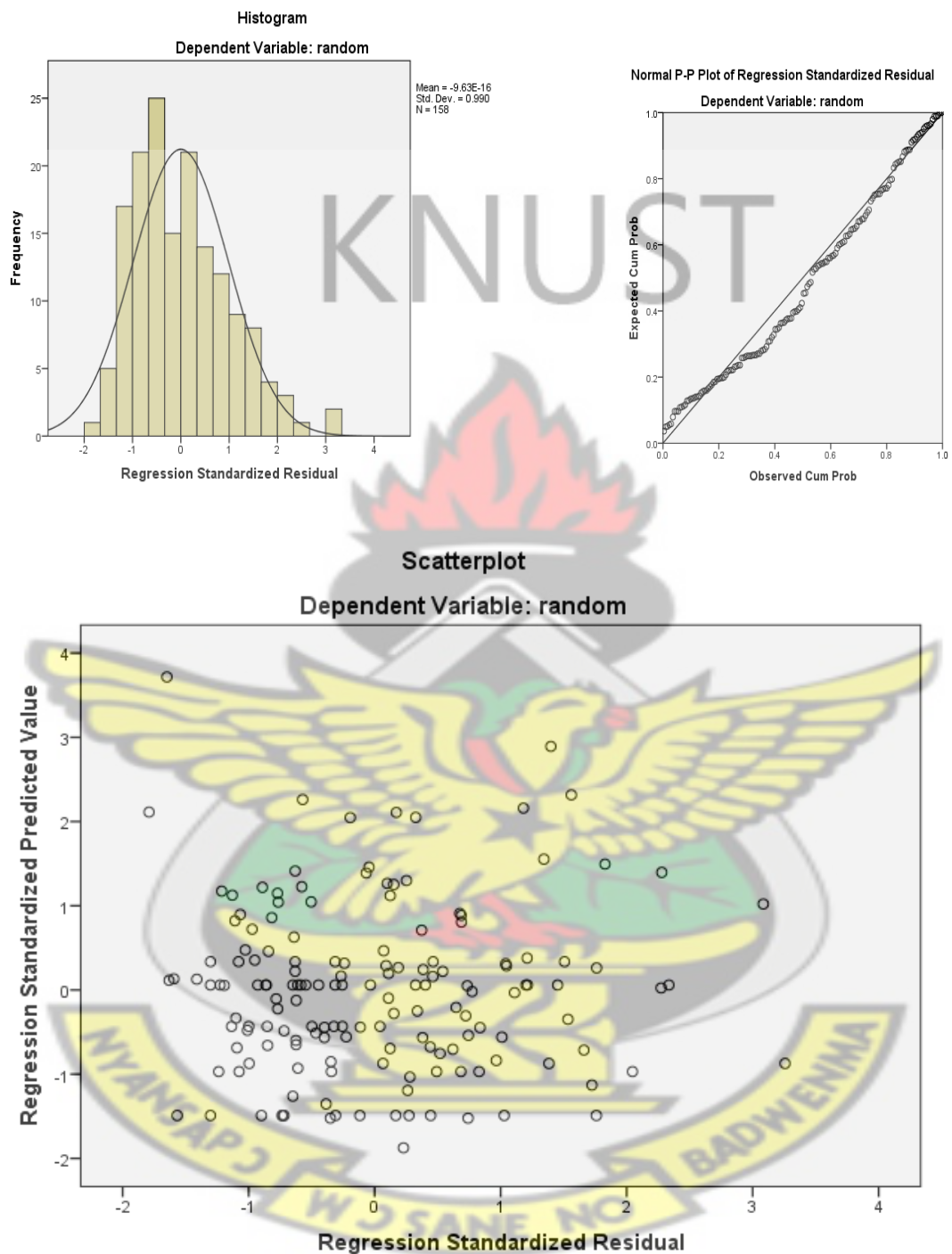
Agogo Sub-district (Intervention site)

No.	Community	Population of children under-five	n/ Total population of under-five (N)	Percentage contributed	Sample size allocated
		(n)	n/N	(%)	(n/N × 167)
1	Newtown	270	0.14	13.53	20
2	Hwidiem	125	0.06	6.26	15
3	Sukumu	191	0.10	9.57	10
4	Gyidim	336	0.17	16.83	25
5	Oboasi/Mponisa	216	0.11	10.82	26
6	Zongo/LA6	321	0.16	16.08	20
7	Bontodiase	173	0.09	8.67	16
8	Ahenbrorum	109	0.05	5.46	12
9	Market	133	0.07	6.66	9
10	Etia	122	0.06	6.11	14
		1996	1	100	167

Juansa (Control site)

No.	Community	Population of children under-five	n/ Total population of under-five (N)	Percentage contributed	Sample size allocated
		(n)	n/N	(%)	(n/N × 167)
1	Modubam	241	0.15	14.64	21
2	Paase	161	0.10	9.78	13
3	Adiembra	152	0.09	9.23	19
4	Otikrom	98	0.06	5.95	16
5	Zongo	307	0.19	18.65	11
6	Mentukwa	171	0.10	10.39	12
7	Tanotia	210	0.13	12.76	23
8	Newtown	194	0.12	11.79	34
Total		1646	1	100	167

APPENDIX C: Diagnostics of Mediation Analysis



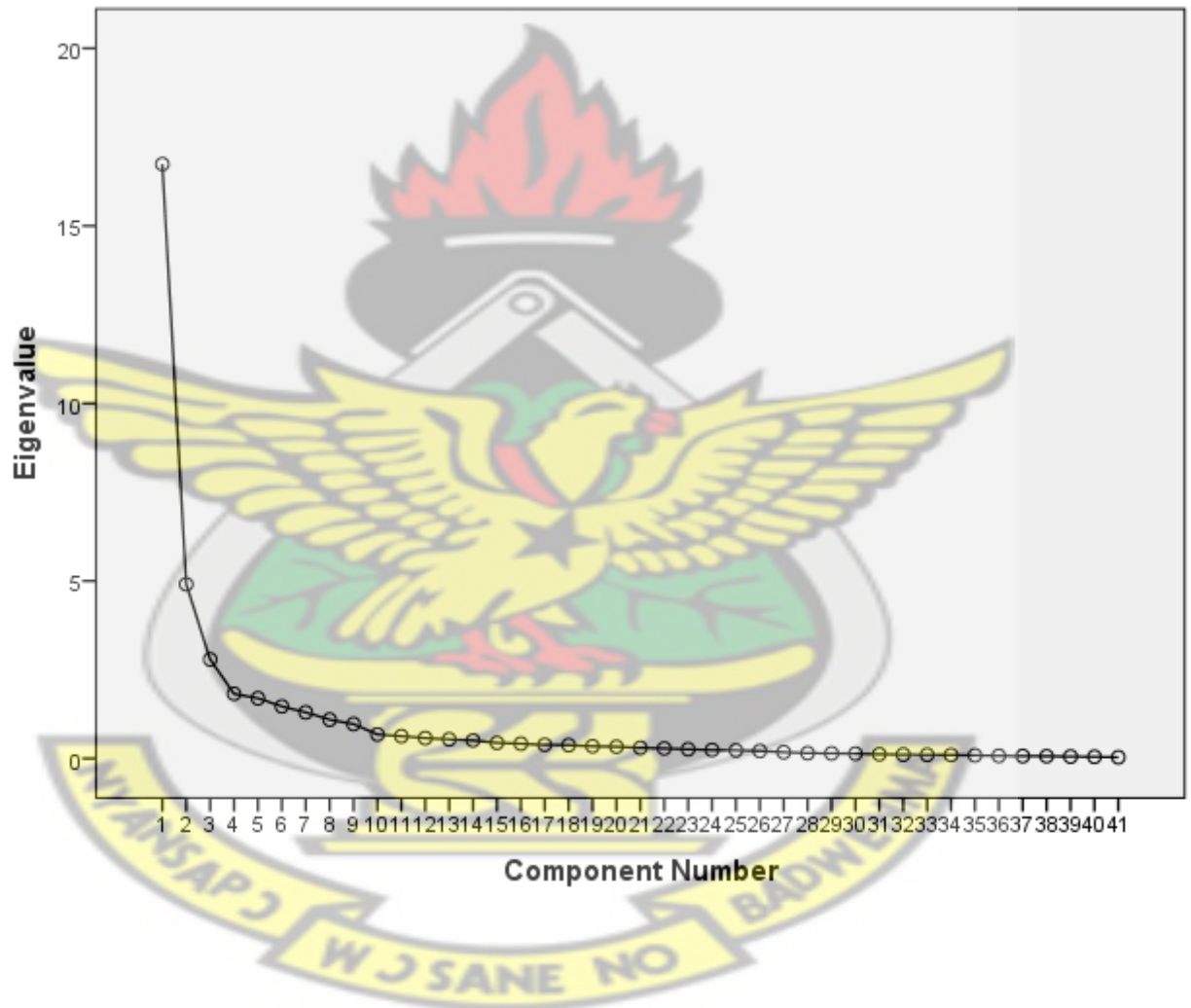
APPENDIX D: Factor Analysis

Measurement of dimensionality of the EPPM constructs

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.912
Approx. Chi-Square		13018.144
Bartlett's Test of Sphericity	Df	820
	Sig.	.000

Scree Plot



Appendix E: PSM Matching Diagnostic

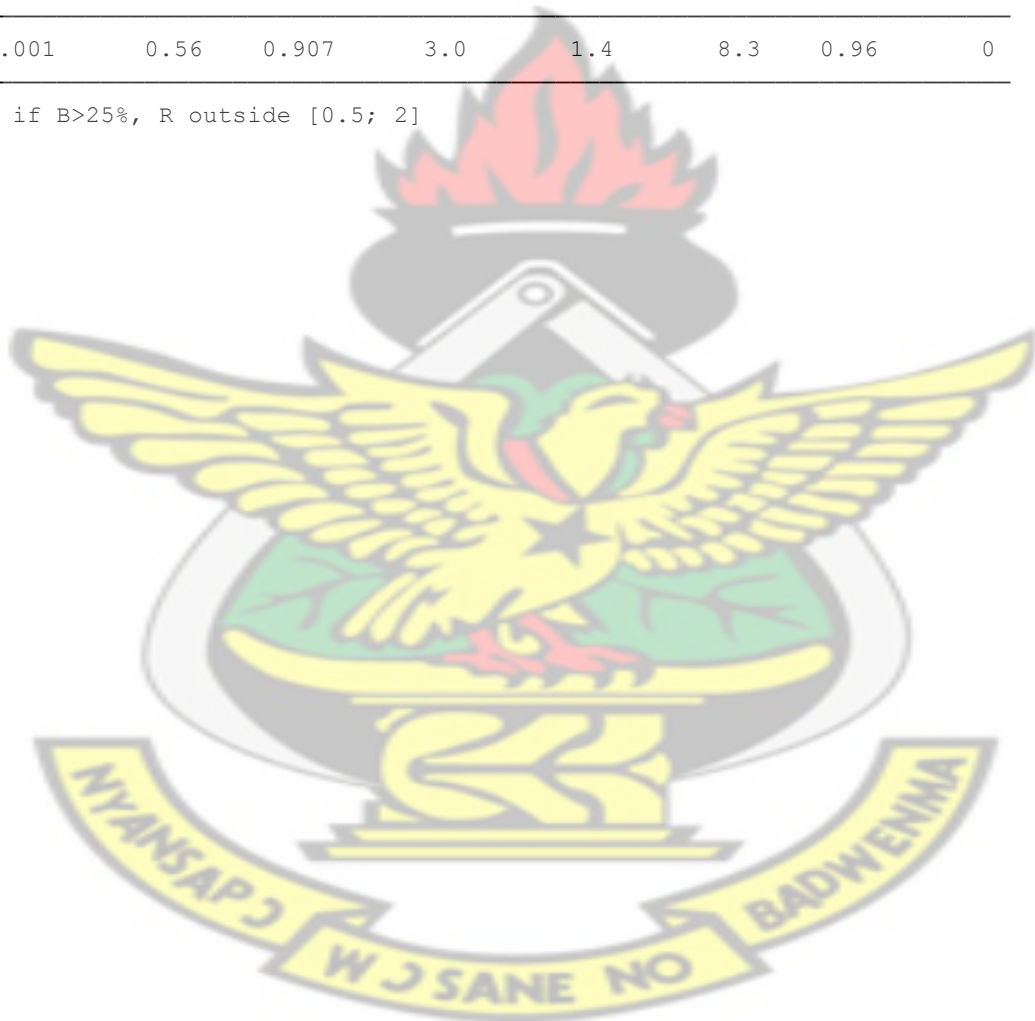
Matching success for the exogenous demographic and household variables

Variable	Mean		%bias	t-test		V(T) / V(C)
	Treated	Control		t	p> t	
age_cat	2.5093	2.4472	7.7	0.73	0.465	0.94
marital	4.087	4.0994	-1.4	-0.13	0.896	1.09
wealth	3.2547	3.2547	0.0	0.00	1.000	0.94

* if variance ratio outside [0.73; 1.36]

Ps	R2	LR	chi2	p>chi2	MeanBias	MedBias	B	R	%Var
0.001		0.56	0.907	3.0	1.4	8.3	0.96	0	

* if B>25%, R outside [0.5; 2]



APPENDIX F: Knowledge and Fear Appeal Messages

Message Modules	Content	Schedule
<i>Knowledge about malaria</i>	• Malaria is a life-threatening disease caused by parasites that are transmitted to people through the bites of infected mosquitoes. • Most deaths occur among children living in Africa where a child dies every minute from malaria. • The parasites are spread to people through the bites of infected Anopheles mosquitoes. • Malaria is an acute febrile illness. Symptoms include: fever, headache, chills and vomiting. • Children with severe malaria frequently develop one or more of the following symptoms: severe anaemia, respiratory distress in relation to metabolic acidosis, or cerebral malaria. • Early diagnosis and treatment of malaria reduces disease and prevents deaths. Protect your family from malaria.	<i>Variable</i>
<i>Threat</i>	• In 2013, malaria caused an estimated 584,000 deaths (with an uncertainty range of 367,000 to 755,000), mostly among African children. • If not treated within 24 hours, it can progress to severe illness often leading to death. • Malaria can result in miscarriage and low birth weight, especially during first and second pregnancies.	<i>Variable</i>
<i>Efficacy</i>	• Malaria is preventable and curable. Increased malaria prevention and control measures are dramatically reducing the malaria burden in many places. • The best available treatment, particularly for <i>P. falciparum</i> malaria, is artemisinin-based combination therapy (ACT). • Some common forms of vector control include: 1. Use of ITNs 2. Indoor spraying with residual insecticides 3. Mosquito coils & repellent 4. Rid environment of stagnant waters	<i>Variable</i>

APPENDIX G: 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/405/16 31st August, 2016.

Mr. Aliyu Mohammed
Kumasi Centre for Collaborative
Research in Tropical Medicine
KNUST-KUMASI

Dear Sir,

LETTER OF APPROVAL

Protocol Title: *“Assessing the Use of Mobile Phone Technology as a Behaviour Change Communication and Surveillance Tool for Childhood Fevers among Children Under- Five at the Asante Akyim North District of Ghana.”*

Proposed Sites: *Asante Akyim North District, Agogo Presbyterian Hospital, Juansa Health Centre.*

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:

- Notification letters from the three selected study sites indicating approval for the conduct of the study in the Hospitals.
- A Completed CHRPE Application Form.
- Participant Information Leaflet and Consent form.
- Research Protocol.
- Questionnaire.

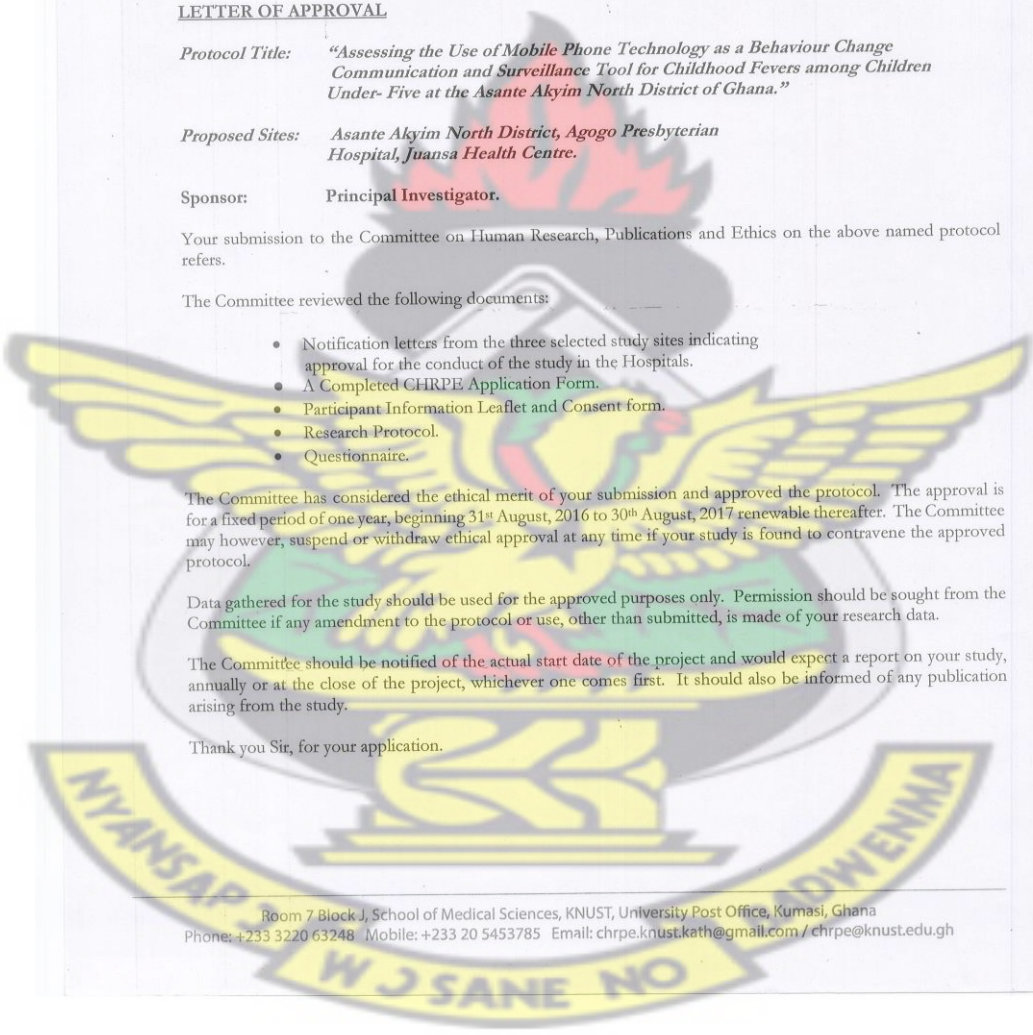
The Committee has considered the ethical merit of your submission and approved the protocol. The approval is for a fixed period of one year, beginning 31st August, 2016 to 30th August, 2017 renewable thereafter. The Committee may however, suspend or withdraw ethical approval at any time if your study 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.

Room 7 Block J, School of Medical Sciences, KNUST, University Post Office, Kumasi, Ghana
Phone: +233 3220 63248 Mobile: +233 20 5453785 Email: chrpe.knust.kath@gmail.com / chrpe@knust.edu.gh



APPENDIX H: PUBLICATIONS

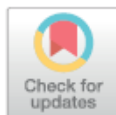
RESEARCH ARTICLE

Feasibility of Electronic Health Information and Surveillance System (eHISS) for disease symptom monitoring: A case of rural Ghana

Aliyu Mohammed¹, Konstantin Franke², Portia Boakye Okyere¹, Johanna Brinkel³, Axel Bonačić Marinović⁴, Benno Kreuels^{2,5}, Ralf Krumkamp⁵, Julius Fobil³, Jürgen May⁵, Ellis Owusu-Dabo^{1*}

1 Kumasi Centre for Collaborative Research in Tropical Medicine (KCCR), Kumasi, Ghana, **2** University Medical Centre Hamburg-Eppendorf (UKE), Hamburg, Germany, **3** School of Public Health (GSPH), Accra, Ghana, **4** National Institute for Public Health and the Environment (RIVM), Bilthoven, Netherlands, **5** Bernhard Nocht Institute for Tropical Medicine (BNITM), Hamburg, Germany

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<https://doi.org/10.1186/s12911-018-0600-3>

BMC Medical Informatics and
Decision Making

RESEARCH ARTICLE

Open Access



A mobile phone based tool to identify symptoms of common childhood diseases in Ghana: development and evaluation of the integrated clinical algorithm in a cross-sectional study

Konstantin H. Franke^{1,2}, Ralf Krumkamp², Aliyu Mohammed³, Nimako Sarpong³, Ellis Owusu-Dabo³, Johanna Brinkel⁴, Julius N. Fobil⁵, Axel Bonačić Marinović⁶, Philip Asihene⁷, Mark Boots⁷, Jürgen May² and Benno Kreuels^{1,2*}