Mobile phone-based health interventions for improved management of non-communicable diseases in Sub-Saharan Africa: challenges and opportunities for Ghana

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MOBILE PHONE-BASED HEALTH INTERVENTIONS FOR IMPROVED MANAGEMENT OF NON-COMMUNICABLE DISEASES IN SUB-SAHARAN AFRICA: CHALLENGES AND OPPORTUNITIES FOR GHANA

To God be the Glory

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Abbreviations

NCDs	Non-communicable diseases
SSA	Sub-Saharan Africa
WHO	World Health Organization
ICT	Information and communication technologies
eHealth	electronic health
mHealth	Mobile health or Mobile phone-based health technologies
SMS	Short message service
UHC	Universal Health Coverage
MDGs	Millennium Development Goals
UN	United Nations
SDGs	Sustainable Development Goals
LMICs/LaMICs/LAMICs	Low- and middle-income countries
RCTs	Randomized controlled trials
DALYs	Disability Adjusted Life Years
HIV	Human Immunodeficiency Virus
UNICs	Upper middle income countries
PEFR	Peak Expiratory Flow Rate
CHWs	Community health workers
QoL	Quality of life
ADA	American Diabetes Association
DSME	Diabetes Self-Management Education
OHA	Oral hypoglycemic agents
MMAS	Morisky Medication Adherence Scale
C-M-O	Context-Mechanism-Outcome

CAM	Complementary and alternative medicine
CHPS	Community-based Health Planning and Services
CBRs	Community-based rehabilitation
CMHOs	Community mental health workers
CPNs	Community psychiatric nurses
CPOs	Clinical psychiatric officers
GPs	General practitioner
CVD	Cardiovascular disease
NHIS	National Health Insurance Scheme
KATH	Komfo Anokye Teaching Hospital
PNE	Predisposing characteristics, need, enabling resources
QCA	Qualitative content analysis

Zusammenfassung

Hintergrund

Nichtübertragbare Krankheiten (NCDs) sind allgemein als globale Krankheitslast bekannt, die die Gesundheitssysteme auf der ganzen Welt bedrohen. Die mit NCDs verbundenen Sterberaten steigen und werden auch in Subsahara-Afrika (SSA) beobachtet. Um dieses große Problem der öffentlichen Gesundheit zu bekämpfen, wird der Einsatz von Informations- und Kommunikationstechnologien im Gesundheitswesen als Teil der Bemühungen untersucht, die erforderlich sind, um den Anstieg der NCDs umzukehren und auch die Gesundheitssysteme zu stärken, um den gesundheitlichen Bedürfnissen und Wünschen der von diesen Krankheiten betroffenen Personen gerecht werden zu können. In SSA haben die Fortschritte bei technologischen Innovationen für die Gesundheit zunehmend an Bedeutung gewonnen, vor allem für den potenziellen Nutzen einer hohen Verbreitung von Mobiltelefonen, um zur Weiterentwicklung von Strategien für Gesundheitsmaßnahmen (mHealth) beizutragen.

Hauptziele und Methodik

Diese Studie hatte zwei Hauptziele: erstens, die Beiträge von mHealth in SSA zu bewerten und festzustellen, wie mHealth-Interventionen zur Verbesserung des NCD-Managements beitragen könnten, und zweitens, neue Forschungsmethoden beizutragen, um den Bereich der digitalen Gesundheitsforschung voranzubringen. Zwei systematic reviews der verfügbaren Literatur wurden durchgeführt, um die Beiträge von mHealth für das NCD-Management zu ermitteln. Um spezifische Fragen zu kausalen Mechanismen zu beantworten wurde eine realistische Überprüfung durchgeführt, welche den Erfolg oder Misserfolg von mHealth-Interventionen für das NCD-Management stützen sollen. Dieser Ansatz war neuartig und trug hauptsächlich zur Erreichung von Ziel zwei der Studie bei. Außerdem wurde ein Mixed-Methods-Studiendesign verwendet, um den Ansatz der Gesundheitssysteme für das NCD-Management zu untersuchen. Sowohl quantitative Erhebungen als auch qualitative Interviews wurden durchgeführt, um mit einer neuen Methodik zu experimentieren, die für die Implementierung und Erforschung der mHealth-Nachhaltigkeit und des Scale-Up entwickelt wurde.

Ergebnisse

Die Studie ergab, dass sechs große Forschungsthemen untersucht wurden, welche jeweils einen spezifischen Aspekt des breiten Themas der mobiltelefonbasierten Gesundheitsmaßnahmen zur besseren Verwaltung von NCDs behandeln.

Das erste Forschungsthema beschäftigt sich mit randomisierten Kontrollstudien von mHealth-Interventionen gegen NCDs in Entwicklungsländern. Es wurde insbesondere die Wirksamkeit von mHealth-Interventionen untersucht, um NCD-bezogene Ergebnisse zu beeinflussen. Insgesamt acht randomisiert kontrollierte Studien mit mHealth NCD-Interventionen hatten 15 klinische Ergebnisse, neun Compliance-Maßnahmen und zwei Lebensqualitätsmaßnahmen signifikant und positiv beeinflusst. Aufgrund der geringen Anzahl der enthaltenen RCTs wurden die Ergebnisse eher als Hinweise denn als Bestätigungen für die Wirksamkeit von mHealth NCD-Interventionen angesehen.

Das nächste Forschungsthema dieser Studie war das Selbstmanagement von Diabetes. Selbstmanagement wurde als wichtiger Ansatz des NCD-Managements identifiziert. Die Einstellung der Typ-2-Diabetiker bei SSA war jedoch schlecht gegenüber Selbstmanagementaktivitäten wie der Selbstkontrolle des Blutzuckerspiegels, körperlichen Aktivitäten und Verhalten bei der Risikominderung.

Frühere Bewertungen in dieser Studie kamen zu dem Schluss, dass mHealth-Interventionen zur Verbesserung der NCDs beigetragen haben und dass die Nutzung von mHealth-Interventionen hauptsächlich auf den (Fern-)Zugang zu (spezialisierten) Dienstleistungen ausgerichtet war. Diese Studie untersuchte weiter die Fragen, wie, warum, für wen und unter welchen Umständen mHealth-Interventionen die Pflege und Behandlung von NCDs verbessern. Vor allem drei kontextabhängige Faktoren spielen eine entscheidende Rolle bei der Umsetzung der mHealth-Intervention. Sie sind die prädisponierenden Eigenschaften und Bedürfnisse von Patient*innen und Leistungserbringern sowie die für die Durchführung der Maßnahmen verfügbaren Ressourcen. Diese Ergebnisse führten zur Entwicklung eines theoretischen Frameworks für das Verständnis der Beiträge von mHealth.

Basierend auf dem theoretischen Framework wurden eine quantitative Umfrage und qualitative Interviews durchgeführt, um die verschiedenen Komponenten des Frameworks zu testen. Als Proof of Concept trugen beide Studien dazu bei, das Framework zu verfeinern, aber weitgehend hat sich das Framework als nützlich erwiesen.

Schlussfolgerungen

Diese Studie hat hauptsächlich zur Entwicklung eines innovativen Frameworks für das Verständnis der Beiträge von mHealth-Interventionen geführt. Dies ist ein großer Fortschritt in diesem Bereich der digitalen Gesundheitsforschung. Das Framework hat sich als nützliches quantitatives Forschungsinstrument zur Gestaltung von Umfragen erwiesen und kann auch als

Modell für die quantitative Datenanalyse verwendet werden. Es hat sich ebenfalls als nützliches qualitatives Forschungsinstrument zur Analyse von explorativen Interviews erwiesen. Darüber hinaus bot das Framework die Möglichkeit, politische Entscheidungsträger zu einer umfassenderen und systematischeren Bewertung der kritischen Faktoren zu führen, die mHealth-Interventionen in verschiedenen Phasen der Umsetzung, Nachhaltigkeit und Skalierung unterstützen.

Abstract

Background

Non-communicable diseases (NCDs) are widely known as a global disease burden threatening health systems across the world. The death rates associated with NCDs have been increasing and observed also in Sub-Saharan Africa (SSA). To combat this major public health problem, use of information and communication technologies in health are being explored as part of the efforts needed to help reverse the upsurge of NCDs and to also strengthen health systems in order to be able to meet the health needs and desires of persons affected by these diseases. In SSA, the advancements in technological innovations for health have gained increasing relevance basically for the potential benefits of high penetration of mobile phones to contribute to advancing strategies for health actions (mHealth).

Main objectives and methodology

This study had two main objectives; first, to assess the contributions of mHealth in SSA and to determine how mHealth interventions could help improve NCD management, and second, to contribute new research methodologies to help advance the field of digital health research. Two systematic reviews of the available literature were conducted in attempt to ascertain the contributions of mHealth for NCD management. To answer specific question on causal mechanisms underpinning the success or failure of mHealth interventions for NCD management, a realist review was conducted. This approach was novel and mainly contributed to achieving objective 2 of the study. Also, a mixed-methods study design was employed to investigate the approach of health systems toward NCD management. Both quantitative survey and qualitative interviews were also conducted to experiment with a new methodology that was developed for implementing and researching mHealth sustainability and scale-up.

Results

The study resulted in exploring 6 major research topics, each addressing a specific aspect of the broad theme of mobile phone-based health interventions for improved management of NCDs.

The first research topic was about randomized control trials of mHealth interventions against NCDs in developing countries. It specifically examined the effectiveness of mHealth interventions to influence NCD-related outcomes. A total of 8 randomized controlled trials of

mHealth NCD interventions had significantly and positively influenced 15 clinical outcomes, 9 compliance measures and 2 quality of life measures. Due to the small number of RCTs included, the results were found to be indications rather than confirmations of the effectiveness of mHealth NCD interventions.

The next research topic addressed in this study was diabetes self-management. Self-management was identified as an important approach of NCD management. However, the attitude of type 2 diabetic patients in SSA was poor towards self-management activities such as self-monitoring of blood glucose level, physical activities and risk reduction behaviours.

Previous assessments in this study have concluded that, mHealth interventions have contributed to improving NCDs and that the use of mHealth interventions has mainly been to facility (remote) access to (specialized) services. This study explored further the questions regarding how, why, for whom and in what circumstances mHealth interventions improve NCD care and treatment. Mainly, three contextual factors play crucial role in the implementation of mHealth intervention. They are the predisposing characteristics and need of both patients and healthcare providers, as well as the enabling resources available for the implementation of the interventions. These finding resulted in the development of a theoretical framework for understanding the contributions of mHealth.

Based on the theoretical framework, a quantitative survey and qualitative interviews were conducted to test the various components of the framework. As a proof of concept, both studies helped to refine the framework, but largely, the framework has been proven to be useful.

Conclusions

This study has mainly resulted in the development of an innovative framework for understanding the contributions of mHealth interventions. This is a major advancement in this digital health field of research. The framework has proven to be a useful quantitative research instrument for designing surveys and can as well be used as a model for quantitative data analysis. The framework has also proven to be a useful qualitative research tool for analyzing exploratory interviews. Also, the framework has provided the opportunity to guide policy makers toward a more comprehensive and systematic assessments of the critical factors that support mHealth interventions at various stages of implementation, sustainability and scale-up.

Confirmation of author's contribution [Daniel Opoku]

Chapter 2: A systematic review of randomized controlled trials of mHealth interventions against non-communicable diseases in developing countries

Victor Stephani, Daniel Opoku and Wilm Quentin

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Victor Stephani conceived the idea, collected data, participated in analysis and drafting of manuscript. Wilm Quentin participated in analysis and drafting of manuscript. Daniel Opoku collected data, participated in analysis and drafting of manuscript. All authors read and approved the final manuscript.

Chapter 3: Self-management of diabetes in Sub-Saharan Africa: a systematic review

Victor Stephani, Daniel Opoku and David Beran

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Daniel Opoku and Wilm Quentin conceived and designed the study. Daniel Opoku and Victor Stephani collected data. Daniel Opoku prepared an initial draft of the manuscript, which was subsequently revised by Victor Stephani and Wilm Quentin. All authors participated in data synthesis and analysis, and all read and approved the final manuscript

Chapter 5: A review of NCD management in Ghana using the WHO health system building blocks: A mixed methods approach

Daniel Opoku, Victor Stephani, Reinhard Busse, Wilm Quentin

African Health Sciences [in review]

Daniel Opoku conceived the idea, designed the study and conducted the qualitative interviews. Daniel Opoku and Victor Stephani screened and collected the included study data for the systematic review. Daniel Opoku prepared an initial draft of the manuscript, which was subsequently revised by Victor Stephani and Wilm Quentin. Victor Stephani, Reinhard Busse

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Chapter 6: Determining the potential of mobile phone-based health interventions in sub-Saharan Africa: a study from Kumasi, Ghana

Victor Stephani, Daniel Opoku, Easmon Otupiri

Ghana Medical Journal [in review]

Victor Stephani conceived the idea. All authors reviewed the questionnaire. Easmon Otupiri gave guidance for getting the ethics approval. Victor Stephani and Daniel Opoku conducted the survey at the diabetes clinic. All authors reviewed and approved the final manuscript.

Chapter 7: Achieving sustainability and scale-up of mHealth interventions in sub-Saharan Africa: The views of policy-makers in Ghana

Daniel Opoku, Reinhard Busse, Wilm Quentin

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Daniel Opoku conceived the idea, designed the study and collected the data Wilm Quentin reviewed the interview guide. Daniel Opoku prepared a draft of the manuscript, which was first reviewed by Wilm Quentin. Daniel Opoku revised the manuscript, which was subsequently reviewed by Reinhard Busse and Wilm Quentin. All authors participated in analysis and approved the final manuscript

Chapter 1: Introduction

Daniel Opoku

1.1 Trends in non-communicable diseases growth in sub-Saharan Africa

Non-communicable diseases (NCDs) – also known as non-infectious chronic diseases and conditions – used to be widely perceived as a public health problem exclusive to wealthy countries. However, NCDs have become a global burden of disease for both developed and developing countries alike. The World Health Organization (WHO) estimates that, 41 million people out of the world's population now die from NCDs annually [1]. Most of these NCD deaths are considered as premature or preventable and that, a combination of cardiovascular diseases, cancers, chronic respiratory diseases and diabetes alone is causing about 80% of all the premature NCD deaths [1], out of which 48% occurred in low- and middle- income countries as at 2015 [2].

This growing trend of NCDs has mainly been observed in Africa recently. Between 2000 and 2016, some African countries – particularly those in the sub of the Sahara – had the highest record of NCD associated death rates among all the six WHO regions. In particular, NCD death rates (per 100 000 population of both sexes) in Sierra Leone was 985.7 and this was far more higher than what was observed in the country with the highest NCD death rate in Europe – 823.4 in Turkmenistan, in the Americas – 831.6 in Guyana, in Eastern Mediterranean – 880.6 in Yemen, in South-East Asia – 764 in Indonesia, and in the Western Pacific – 825.7 in Mongolia [2].

Based on this evidence, it suffices to conclude that NCDs have become a major threat to health systems of both wealthy and developing countries alike. This gives a clear indication that, it has become far more incumbent on the managers of health systems, particularly in Sub-Saharan Africa (SSA), to ensure that not only should this upsurge of NCDs be reversed, but also that the health needs and desires of persons living with any of these chronic diseases are met. To achieve this, health care systems need to be strengthened in ways that would help improve healthcare services delivery systems, health workforce, health information systems, essential medical products, vaccines and technologies, not excluding health financing systems, as well as developing strategic policy frameworks to ensure that health systems are more responsive towards the needs of people [3–5]. And to be able to do this, available opportunities may include the continuous advancements in technological innovations in health, which has given rise to the use of information and communication technologies (ICT) for health also.

1.2 Use of information and communication technologies (ICT) for health

Medical history has it that, the use of ICT for health goes as far back as the 19th century when Alexander Graham Bell had invented the telephone [6]. As reported by Mackenzie [7] and Aronson [6], the first time anyone ever talked over telephone or a wire was when Bell on 10th March 1876 had, in addition to successfully transmitting speech electrically, requested for medical assistance from his assistant. Since that time, the idea to use ICT for health has evolved through several concepts to what is now known in popularly parlance as *digital health*. Examples of these concepts/definitions are: *telemetry in medicine* – "transmission by telephone of information taken from the examination of a patient" ([6] p. 69), *telemedicine* – "the provision of healthcare services, through the use of ICT, in situations where the health professional and the patient (or two health professionals) are not in the same location. It involves secure transmission of medical data and information, through text, sound, images or

other forms needed for the prevention, diagnosis, treatment and follow-up of patients" ([8] p. 2), and *eHealth* – "the cost-effective and secure use of information and communication technologies in support of health and health-related fields, including health-care services, health surveillance, health literature, and health education, knowledge and research" ([9] p. 121).

These concepts and the various forms of the use of ICT for health (digital health) constitute a historical expansion of the role of ICTs in the field of health – i.e. covering from disease prevention to life improvement. They also reveal for which different purposes the various types of ICTs are being utilized in health. Recently, the rapid advancements and exponential increase in mobile technologies have resulted in what is also referred to as mobile health or *mHealth* – "which covers medical health and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants, and other wireless devices" ([4] p. 6). Also, this may include "applications such as lifestyle and wellbeing apps as well as personal guidance systems, health information and medication reminders provided by short message service (SMS) and telemedicine provided wirelessly" ([10] p. 3).

1.3 Why the increasing relevance of digital health in sub-Saharan Africa?

There is a wide spectrum of potential benefits of digital health which may have accounted for its increasing relevance in SSA. These benefits may include the ability of digital health technologies and interventions to: reduce long distance travels to access healthcare, facilitate healthcare services delivery, improve self-care and disease management, provide quality and efficient healthcare services, prevent or minimize the number of unnecessary referrals of patients to higher levels of usually expensive (specialized) care, enhance disease surveillance, facilitate support for healthcare workers, and improve health professional education. In addition, digital health nowadays has become both visible and invisible imperatives in order to advance health strategy actions [4, 11–13], which strategies for health actions include the following:

1.3.1 Primary Health Care (Alma-Ata Declaration, 1978)

In September 1978, most countries of the world gathered in Alma-Ata, Kazakhstan and declared a strong commitment to provide comprehensive and continuous essential health care services to all the world's people by the year 2000 based upon the concept of Primary Health Care [14]. The principles underlying this concept mainly include the provision of integrated, quality, and cost-effective health care services, especially in remote communities, focusing on the individual (patient) and the family at the community level through building long-term relationship with the health workers [14, 15]. The primary health care concept has been given impetus forty years after its implementation by the increasing demands for it from health professionals as well as policy-makers and other major stakeholders [15]. Especially in SSA, most countries – Ghana included – have modelled their national health systems toward primary health care and have since been exploring novel initiatives, including the use of technological innovations, to train and distribute (community) health workers purposely to live in and/or engage the communities to deliver primary health care services (e.g. curative and preventive care, immunization, reproductive health and family planning services) [16–

19]. Therefore, according to the WHO's vision for primary health care in the 21st century [20], digital health technologies have been considered as a critical operational primary health care lever for improving effective and efficient integrated health services, multisectoral policy and action, as well as for empowering people and communities.

1.3.2 Universal Health Coverage (UHC, 2000)

Universal Health Coverage (UHC) is a powerful concept in public health and one of the strategic actions of progress in health in the African region [21]. It involves: equity in access – everyone who needs health service should get them, and not simply those who can pay for them; quality of health services – to ensure that health care services are good enough to improve the health of those receiving the services health; financial-risk protection – to ensure that the cost of health care does not put people at risk of financial hardship or catastrophic expenditures [22]. At the heart of UHC are the actual operational actions and strategies to devise appropriate health care financing mechanisms and essential interventions in order to ensure that on the one hand, health care providers incentivized enough, and on the other hand, patients can access needed services without incurring any form of financial impoverishment [5, 21, 22]. Interestingly, majority of countries having developed digital health strategies have done so with clear conviction that UHC and its key elements would be difficult to achieve without the support of digital health technologies and interventions [23].

1.3.3 Sustainable Development Goals (SDGs, post 2015)

The year 2015 marked the end of the eight international development goals – referred to as the Millennium Development Goals (MDGs) – set by the United Nations (UN) member states in 2000 to reduce extreme poverty [24, 25]. The MDGs were largely successful, beating down the trends in under-five mortality and maternal mortality, among others [24]. Post 2015, seventeen new set of goals known as the Sustainable Development Goals (SDGs) have also been developed. Particularly, Goal 3 is set to ensure healthy lives and promote well-being for all persons at all ages [25]. Aiming to be achieved by the year 2030, the SDGs serve as commitments of both developed and developing countries alike to explore innovative strategies to tackle climate change and preserve the oceans and forests, reduce inequality and stimulate economic growth, as well as improve health and education across the world [25]. Here too, current research and ongoing discussions have underscored that digital health technologies, such as cloud-based solution and the use of cellular technology, may help to overcome physical barriers to healthcare access in war-torn areas, improve the efficacy of the training of health workers, among others, all gearing towards the realization of SDG 3 [26, 27].

All these strategies for health actions provide compelling justifications to explore more the opportunities and challenges of implementing digital health interventions and to critically examine how to exploit their potentials in various contexts specified for adaption.

1.4 Main objectives and methodology

Considering the developments in digital health and their contributions in the wake of a growing burden of NCDs in SSA, it was rather more important for this study to focus on

mobile phone-based health technologies (mHealth) due to the high mobile phone penetration and increasing relevance to SSA [4, 23]. The aim was to assess the contributions of mHealth in SSA and to ascertain how mHealth interventions could help improve the management of NCDs. Another aim of this study was to contribute new research methodologies to help advance the field of digital health research.

First, the study adopted the Cochrane systematic review approaches to assess the available evidences on mHealth interventions and the health care behaviours of people living with NCDs in low- and middle-income countries (LMICs). One systematic review was conducted focusing on randomized controlled trials of mHealth interventions and to ascertain what specific intervention characteristics are associated with reported health outcomes. In the second systematic review, the study applied broader inclusion criteria to review published research studies of different designs in order to ascertain the extent to which the approaches for managing NCDs are followed in SSA. It focused on analyzing self-management behaviours among diabetes patients and identifying the potential areas for improvement using mHealth interventions.

Second, the study followed guidelines for realist reviews to answer specific questions as to what and how causal mechanisms underpin the successful implementation of mHealth interventions for NCD management, for whom and in what circumstances. This study was the first realist review of mHealth interventions for patients with NCDs in SSA countries and has resulted in the development of an innovative framework for understanding mHealth interventions.

Third, the study focused on Ghana (as a case study) to review the challenges associated with the available NCD management approaches. It utilized the mixed methods of systematic review and qualitative interviews of policy makers to identify and examine which specific areas of the health system could be improved based upon the opportunities offered by mHealth technologies.

Fourth, the study experimented with the innovative framework for understanding mHealth interventions that has been developed. As a proof of concept, it used the framework to design a questionnaire to conduct a survey among patients visiting a diabetes clinic in Ghana with the aim to determine whether a mHealth intervention has any potential contributions to improving diabetes management. It was also the first observational survey which has been designed using the mHealth framework developed as both a quantitative research instrument for data collection and a model for analysis.

Finally, the study followed qualitative methods and qualitative content analysis approach to design semi-structured interview-guide based on the framework developed to explore the view of policy makers on how to achieve sustainability and scale-up of mHealth NCD interventions in SSA. The views of the policy makers were coded and analyzed according to the categories of the framework. Again, this study was the first qualitative study in which the semi-structured interview-guide and the coding frame for analysis were all based on the innovative framework for understanding mHealth interventions.

1.5 Introduction to the main chapters

The main work focused on the contributions of mHealth interventions for NCD management in SSA, how to sustain and scale up the implementation of successful mHealth NCD interventions in a given context. It also presented contributions new research designs and methods as a contribution to the advancement of the digital health research field. The research studies conducted for this thesis are presented in chapters 2 – 7. Each chapter contains an original research article which explores a specific research objective of this thesis. It outlines in detail the methods applied to address the research questions therein, the findings, as well as the implications of the study results.

Chapter 2 presents the available evidence on mHealth interventions which have been reviewed using rigorous scientific methods. Such rigorous assessment helped to ascertain the effectiveness of mHealth technologies and to find plausible ways for their appropriate adaptions in developing countries context. In this chapter, the review of the evidence supporting mHealth interventions has helped to assess what specific characteristics or features of mHealth are associated with specific NCD-related health outcomes.

Chapter 3 focuses on exploring the key elements for the proper management of NCDs, particularly for the common ones including diabetes. It determines the extent to which the key elements for NCD management are being implemented in SSA. The review reveals the factors militating against the successful implementation of the approaches for managing NCDs, and to which the opportunities offered by mHealth technologies could be explored.

Chapter 4 provides insights into innovative approaches that unravel the critical factors underpinning the successful implementation of innovative technologies in health. It presents innovative research methods and designs in the attempt to answer critical research questions that traditional forms of research approaches would not be able to address appropriately, and thereby advances the research in the field of digital health.

Chapter 5 presents Ghana as a case study. It examines in great details the approaches of the health system of Ghana for NCD management in order to identify which specific areas could be improved using mHealth technologies.

Chapter 6 provides understanding into the adaptation of successful mHealth interventions into diabetes self-management by exploring the opportunities and challenges for implementing mHealth interventions among patients visiting a diabetes clinic in Ghana.

Chapter 7 draws attention to the tendency for most novel initiatives like that of digital health technologies to be limited to project or pilot level in SSA, and that even the ones that have proven to be successful may often not be scaled-up to higher levels of implementation. It explores the views of policy makers in order to establish the most important factors for successful implementation, sustainability and scale-up of mHealth NCD interventions in SSA.

Chapter 8 summarizes the main conclusions of the original research studies and the major implications. Recommendations from this thesis are also provided.

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Chapter 2: A systematic review of randomized controlled trials of mHealth interventions against non-communicable diseases in developing countries

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A systematic review of randomized controlled trials of mHealth interventions against non-communicable diseases in developing countries

Victor Stephani*, Daniel Opoku and Wilm Quentin

Abstract

Background: The reasons of deaths in developing countries are shifting from communicable diseases towards non-communicable diseases (NCDs). At the same time the number of health care interventions using mobile phones (mHealth interventions) is growing rapidly. We review studies assessing the health-related impacts of mHealth on NCDs in low- and middle-income countries (LAMICs).

Methods: A systematic literature search of three major databases was performed in order to identify randomized controlled trials (RCTs) of mHealth interventions. Identified studies were reviewed concerning key characteristics of the trial and the intervention; and the relationship between intervention characteristics and outcomes was qualitatively assessed.

Results: The search algorithms retrieved 994 titles. 8 RCTs were included in the review, including a total of 4375 participants. Trials took place mostly in urban areas, tested different interventions (ranging from health promotion over appointment reminders and medication adjustments to clinical decision support systems), and included patients with different diseases (diabetes, asthma, hypertension). Except for one study all showed rather positive effects of mHealth interventions on reported outcome measures.
Furthermore, our results suggest that particular types of mHealth interventions that were found to have positive effects on patients with communicable diseases and for improving maternal care are likely to be effective also for NCDs.

Conclusions: Despite rather positive results of included RCTs, a firm conclusion about the effectiveness of mHealth interventions against NCDs is not yet possible because of the limited number of studies, the heterogeneity of evaluated mHealth interventions and the wide variety of reported outcome measures. More research is needed to better understand the specific effects of different types of mHealth interventions on different types of patients with NCDs in LaMICs.

Background

As a result of increasing life-expectancy and growing welfare in low and middle income countries (LaMICs), there is a steady shift away from communicable to non-communicable diseases (NCDs) [1–3]. NCDs pose a major threat to public health in LaMICs. In 2010, NCDs already accounted for half of Disability Adjusted Life Years (DALYs) lost and for 58 % of all deaths in these countries [4]. It is predicted that this number will increase to 70 % of all deaths in 2020 [5]. The economic cost of the NCDs burden for LaMICs are estimated to reach US$21 trillion by 2030 [3].

The ability of LaMICs to provide treatment and care for the increasing number of patients with NCDs is limited by insufficient health care infrastructure, especially in rural areas [6]. At the same time there is a rapidly growing, hidden infrastructure: 90 % of the world's population now lives within reach of a mobile phone signal [7] and the developing world has the fastest-growing cellphone subscriber market in the world [8, 9]

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with a mobile-cellular subscription rate of almost 90 % in 2013 [10].

The number of health care interventions using mobile phones (short mHealth interventions) is growing rapidly [11]. In particular in LaMICs, mHealth is perceived to have great potential for improving health care provision for both communicable and non-communicable diseases [12]. Most of the available literature on mHealth interventions is focused on communicable diseases (such as HIV and Malaria) or on maternal care [13]. However, the number of studies focusing on mHealth for patients with NCDs has considerably increased over the last few years. In fact, two thirds of all articles on the topic have been published between 2012 and 2015 (based on a Web of Science search with the keywords TS = (mHealth OR "mobile Health" or tele*) AND TS = ("developing") AND TS = (NCD OR "non-communicable diseases"). Yet, evaluations of mheatlh interventions often do not follow rigorous scientific standards of randomized controlled trials (RCTs), and consequently, they carry a relatively high risk of bias [14].

Two reviews are available that have included studies analyzing certain aspects of mHealth interventions for NCDs in LaMICs: Beratarrechea et al. [15] evaluated text and automated voice interventions for chronic diseases in the developing world and Bloomfield et al. [16] performed a review of mHealth interventions against NCDs focusing only on Sub-Saharan African countries. However, as Beratarrechea et al. [15] did not focus specifically on NCDs and because Bloomfield et al. [16] focused exclusively on Sub-Saharan Africa, a comprehensive overview of the effectiveness of mHealth interventions for improved treatment and care of patients with NCDs living in LaMICs remains unavailable.

The aim of this study was 1) to systematically review the available evidence generated by randomized controlled trials (RCTs) of mHealth interventions for people with NCDs living in LaMICs, and 2) to assess the relationship between intervention characteristics and reported health-related outcomes. We focused on RCTs since they remain the gold standard for evidence of effectiveness of health interventions [17].

Method

Inclusion criteria

Studies were included for this review if they met the following inclusion criteria:

- The study reported results of an RCT, as defined by JN Matthews [18]
- The trial took place in at least one country that was classified as an LaMIC as defined by the World Bank classification of country income groups [19]
- The intervention involved the use of mHealth as defined by the Global Observatory for eHealth [11]
- Trial participants were patients suffering from NCDs as defined by the WHO [20]
- The study was published in English or German
- The study was published before August 2015 (no limit concerning the start date)

Literature search method

An initial systematic literature search was performed between December 2013 and February 2014 in MEDLINE (PubMed), CENTRAL and Business Source Complete. An update of the search was performed in August 2015.

After piloting appropriate search words, the terms were constructed around (1) "mHealth", (2) "Low and Middle Income Countries" and (3) "Non Communicable Disease". Search terms for the operationalization of NCDs were derived from WHO's Global Burden of Disease Report. In addition to the medical terms specified in the Global Burden of Disease Report (e.g., myocardial infarction or dermatological cancer), we added more common terms such as heart or skin (for including interventions against skin cancer) to the search algorithm.

The search conducted in CENTRAL is shown in the Additional file 1: Table S1. It was carried out using the free text search with Boolean operators and MeSH descriptors using the terms Telemedicine [MeSH] AND Developing Countries [MeSH] (with no filter for diseases and the enabled option of exploding all trees). The same search-approach was applied using MEDLINE. Due to a low number of results in the database Business Source Complete it was feasible to exclude the field of terms for NCDs and to include solely the location and intervention of interest.

In addition, reference lists of included studies and identified existing reviews were screened for relevant titles.

After removal of duplicates, the resulting list of titles (Medline 730, CENTRAL 116, Business Source Complete 125) was screened and studies whose titles/abstracts clearly indicated that they were not concerned with mHealth intervention trials for NCDs in LaMICs (e.g., if titles indicated that they focused on developed countries or HIV) were excluded from further consideration.

Full-text articles of 114 studies were retrieved and assessed, resulting in 8 articles included for this review. The screening process was conducted independently by two reviewers (VS and DO). Disagreements were discussed between authors and resolved by consensus.

Data collection and analysis

For each included study, information was collected on key characteristics of the RCTs concerning:

1) the study location (country, urban/rural);
2) the population (disease, inclusion and exclusion criteria for trial participants);
3) the intervention characteristics, including information on the type of mHealth intervention (e.g., text message, phone call), the data transmitted (e.g., appointment reminders, advice and medication reminders), interactivity of the intervention (i.e., whether it was possible for patients or providers to respond to information received), and personalization (i.e., whether timing or content of information were specific for the patient);
4) the comparator (control) group intervention (e.g., booklet with information on asthma instead of text message with information); and
5) outcomes reported by the studies, including clinical outcomes, compliance, quality of life, costs and other outcomes.

In order to assess the relationship between intervention characteristics and outcomes, studies were categorized into one of four types of mHealth interventions as suggested by Howitt et al. [21] (with slight modifications). We distinguished between interventions for 1) health promotion & awareness, 2) remote monitoring & care support, 3) disease surveillance & outbreak detection, and 4) decision support system.

Meta-analytic techniques were not employed because differences between studies concerning the type of intervention, the included study participants (different diseases), and the reported outcome measures (clinical outcomes, compliance, etc.) made a meaningful analysis of pooled data impossible.

Risk of bias

Risk of bias was assessed qualitatively concerning selection bias (sequence generation and allocation sequence concealment), performance bias (blinding of participants and personnel), detection bias (blinding of outcome assessment), extent of loss to follow-up, reporting bias (selective outcome reporting), and other bias (e.g., imbalance in baseline characteristics). We used the Cochrane Collaboration's tool for assessing risk of bias and information on assessment were derived from the text [22]. The full risk assessment of the included studies is available in the Additional file 2.

Results

Literature search results

Figure 1 illustrates the literature search and selection process, and presents reasons for exclusion of studies. We identified a total of 969 studies in the three databases and 23 studies were retrieved from references of other studies. Full texts of 114 studies were screened of which 106 were excluded, mostly because they did not deal with mHealth ($n = 43$), did not report results of an RCT ($n = 25$), did not take part in LaMICs ($n = 13$) or because of other reasons ($n = 25$). The final analysis included 8 studies, which met all inclusion criteria.

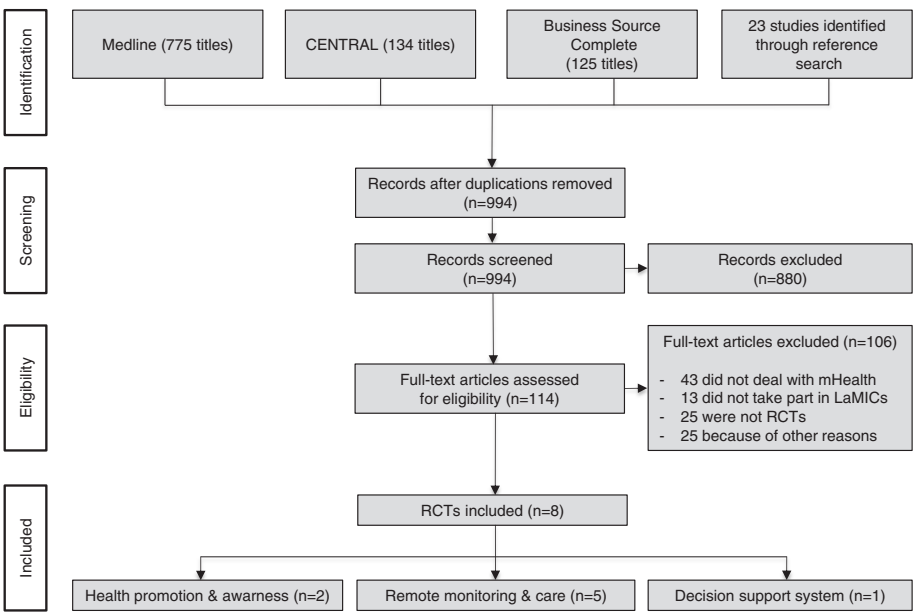

Fig. 1 Overview of the screening process

Characteristics of included studies

Trial characteristics

Table 1 summarizes the main characteristics of the eight included trials. Five studies were conducted in lower middle income countries (LMICs), three in upper middle income countries (UMICs). Two studies [23, 24] reported results of trials, which included patients in both a LMIC and a UMIC (Mexico and Honduras, and India and China, respectively). The participating patients came mostly from urban areas and were recruited mainly from primary care centers or urban hospitals. Three studies dealt with diabetes [25–27], two with asthma patients [28, 29], two with patients suffering from cardiovascular diseases, [23, 24] and one with patients having different NCDs [30], including hypertension, asthma and diabetes.

A total of 4375 participants were included in all eight studies, of whom 2095 received a mHealth intervention, 314 received an alternative landline-telephone based intervention, and 1966 were included in the control group. Trial size varied from 16 participants [29] to 2086 participants [24]. The mean age in the intervention group was 57.2 years and in the control group 57.8 years. Studies reported a wide range of outcomes, which were classified for the purposes of our review into disease specific clinical outcomes, compliance and others.

Intervention characteristics

Table 2 provides an overview about the main characteristics of the mHealth interventions that were evaluated in the eight RCTs. Two interventions informed patients with diabetes about the management of the disease and gave general advice on a healthy lifestyle (category health promotion & awareness): One informed the participants through an internet webpage and frequently sent text messages [25], while the other sent a text message once in three days to the study participants [26]. Both interventions were not personalized to the participants and not interactive.

The most basic intervention in the category of remote monitoring & care support was an appointment-reminder system, where text messages were sent 24–48 h before the patients' scheduled appointments [30].

Four interventions required the patients to record key parameters of their disease, e.g., the Peak Expiratory Flow Rate (PEFR) for patients with Asthma [28, 29], the blood glucose level for patients with Diabetes [27] or the blood pressure for patients with hypertension [23]. They did so by using additional devices (home blood pressure monitor, glucometer, peak expiratory flow meter) and the patients were then asked to send this data either via a text message to a physician [29], to type their records into an interactive phone software [28] or they were called by a specialist and transmitted the information via a phone-call [23, 27]. In all the four studies, patients received personalized disease-management advice.

Only one intervention fell into the category of clinical decision support systems [24]. Community health workers (CHWs) treating patients with cardiovascular diseases in rural areas received a smartphone with an application consisting of prompts regarding the patients' clinical values, adherence to treatment and other parameters. The application was tailored to the local customs.

Results of the RCTs

Table 3 provides an overview of all relevant outcomes reported by the eight included studies, illustrating significance of differences in outcomes between the intervention and control groups. The eight studies reported results for a total of 15 different measures of clinical outcome 9 measures of compliance, 2 measures of quality of life (QoL) and 13 other outcome measures.

The two *health promotion & awareness* interventions targeted diabetic patients but none of the reported outcome measures was available from both studies. In the study by Balsa and Gandelman [25], where diabetic patients received a text message that intended to motivate their use of a website, neither clinical outcomes nor other outcomes were improved. In the study by Shetty et al. [26], where patients received a text message with advice on nutrition, physical activity and drug intake, several clinical outcome measures showed significant improvements, although compliance measures did not improve significantly.

Out of the five studies evaluating tools for *remote monitoring and care support*, one study evaluated an interactive telephone-intervention for patients with diabetes [27]. Patients were advised to self-monitor their Blood Glucose level and received therapeutic advice over the phone twice a month. The study found that clinical and compliance outcomes improved significantly more strongly in the intervention group than in the control group.

Two studies evaluated interactive mHealth interventions for patients with asthma [28, 29], where patients transmitted information about their pulmonary function (as assessed by the peak expiratory flow rate, PEFR) to a physician and received personalized therapeutic advice (e.g., medication adjustments). Both studies found that individuals showed improved pulmonary function tests (FEV1% predicted and PEFR), although this finding was not significant in the study by Ostojic et al. [29], which included only a total of 16 participants. Liu et al. [28] also found significant improvements of quality of life, while Ostojic et al. [29] found significant improvements of PEFR variability and of some self-reported clinical outcome measures (e.g., coughing and night symptoms) although not of others, and no effect on compliance.

Table 1 Characteristics of the interventions

	Intervention					
Study name	Used channel	Received information	Control group	Timing	Interactivity	Personalization
Balsa and Gandelman [25]	Internet platform & text messages	New topics about type 2 Diabetes and healthy lifestyle	Brief educational brochure	Not reported	No	No
Shetty et al. [26]	Text messages	Medical nutrition therapy, physical activity and drug intake reminders	Oral advises on diet modification and physical activity	Once in three days	No	No
Liew et al. [30]	Text messages	Appointment reminder	No reminder	Once; 24–48 h before the scheduled appointment	No	Yes
Liu et al. [28]	Interactive software on cellphone	Adjustments of therapy	Booklet for written asthma diary and action plan	Immediately after the data has been uploaded	Yes	Yes
Ostojic et al. [29]	Text messages	Adjustments of therapy	No weekly therapeutic advise	Weekly	Yes	Yes
Piette et al. [23]	Mobile blood pressure monitor & phone calls	Advises and medication reminder	No weekly therapeutic advise	Weekly	Yes	Yes
Shahid et al. [27]	Glucometer & Phone calls	Adjustments of therapy	Self monitoring with Glucometer and regular follow up after 4 months	Every 15 days	Yes	Yes
Tian et al. [24]	Smartphone application	Advises on medication prescription and lifestyle changes	Usual cardiovascular management programs	Monthly	No	Yes

Table 2 Study design characteristics of included RCTs

Study	Location	Income group	Conditions	Place of recruitment	Inclusion criteria	Sample size	Mean Age (Intervention; control)	Planned Follow-up	Measured outcomes
Balsa and Gandel-man [25]	Uruguay (urban)	UMIC	Type 2 Diabetes	Waiting rooms of internists treating diabetic patients at three HMOs in Montevideo	Adult patients with Diabetes 2; Access to Internet (at least once a week)	195 (intervention) 193 (control)	n/d	6 months	Clinical, Others
Shetty et al. [26]	India (urban)	LMIC	Diabetes	Patients at a diabetes centre in Chennai	Type 2 Diabetes with a minimum duration of 5 years; Minimum of high school Education; HbA1c value ranging between 7 % to 10 %	110 (intervention) 105 (control)	50.1; 50.5	1 year	Clinical, Compliance
Liew et al. [30]	Malaysia (urban)	UMIC	Different chronic diseases (mainly NCDs)	Two primary care clinics in Kuala Lumpur	Registered with the clinics for at least 6 months; return appointment between 1 and 6 months; ownership of a mobile phone	314 (telephone) 398 (text mesages) 309 (control)	57.7; 58.1; 60.7	At least 6 months	Compliance
Liu et al. [28]	Taiwan (urban)	UMIC	Asthma	Outpatient clinics of Chang Gung Memorial Hospital, Linkou, northern Taiwan	Moderate to severe Asthma	43 (intervention) 46 (control)	54; 50	6 months	Clinical, Compliance, QoL
Ostojic et al. [29]	Croatia (urban)	UMIC	Asthma	General Hospital "SvetiDuh", Zagreb	Moderate Asthma for at least 6 months; consistent access to a cellphone, able to use text messages	8 (intervention) 8 (control)	24.5; 24.8	16 weeks	Clinical, Compliance, Costs
Piette et al. [23]	Honduras (rural), Mexico (urban)	UMIC, LMIC	Hypertension	Four private and two public clinics in Cortes, Honduras and one primary care center in Real de Monte	SBP > = 130 mm Hg if diabetic and SBP > = 140 mm Hg if non-diabetic; between 18 and 80 years; access to a cellphone and able to use it	89 (intervention) 92 (control)	58.0; 57.1	6 weeks	Clinical, Others
Shahid et al. [27]	Pakistan (rural)	LMIC	Diabetes	Department of Endocrinology, Liaquat National Hospital	Patients between 18–70 years, residing in rural areas of Pakistan, HbA1c ≥ 8.0 % and having personal functional mobile phone	220 (intervention) 220 (control)	48.95; 49.21	6 months	Clinical, Compliance
Tian et al. [24]	China (rural), India (rural)	UMIC, LMIC	Cardiovascular Diseases	CHWs at 27 villages from 15 townships in China and 20 villages in Haryana State, India	High cardiovascular risk individuals: above 40 years and a self-reported history of coronary disease	1095 (intervention); 991 (control)	59.7; 60.4	One year	Clinical, Compliance

Table 3 Overview of intervention-group outcomes compared to control-group outcomes

Study	Balsa and Gandelman [25]	Shetty et al. [26]	Shahid et al. [27]	Ostojic et al. [29]	Liu et al. [28]	Piette et al. [23]	Liew et al. [30]	Tian et al. [24]
Intervention	Health promotion & awareness		Remote monitoring & care support					Decision support system
Personalization	No		Yes					
Interactivity	No		Yes				No	
Disease	Diabetes			Asthma		Hyper-tension	Various NCDs	CVDs
Clinical outcomes								
SBP[a] (mm Hg), Mean	+/–		++			+ / ++[b]		++
Fasting blood glucose level	+/–							
BMI[c], kg/m^2		+/–[d]	+/–[e]					
PPG[f] < 180 mg		++						
HbA1c[g]		++[h]	++[i]					
TC[j] < 150 mg/dl		++						
HDL-C[k] > 40 mg/dl		+/–						
LDL-C[l] < 100 mg		++	++					
FEV1%[m], predicted				+	++			
PEFR[n], L/min				+	++			
PEFRvariability				++				
Coughing				++				
Night symptoms				++				
Wheezing				+/–				
Limitation of activities				+/–				
Compliance outcomes								
Attendance		+					++	
ICS[o] dosage				+/–	+			
Systemic steroids				+/–	+			
Antileukotrienes				+/–	+/–			
Long-acting beta2-agonist								
Anti-hypertensive medication use								++
Aspirin								++
Adherence to diet prescription		+/–	++					
Adherence to physical activity		+	++					
Quality of life related outcomes								
Physical component					++			
Mental component					++			
Cost								
Monetary				-				
Timely				-				
Other outcomes								
Knowledge	+/–							
Perception of health quality	+/–							
Health-related behaviors	+/–							
Physician-Patient relationship	+/–							

Table 3 Overview of intervention-group outcomes compared to control-group outcomes *(Continued)*

Number of visits to emergency department	++		
Depression scores		++	
Perceived overall health		++	
Overall satisfaction with care		++	
Medication problems		++	
Current smoker, %			+/−
Awareness of harms of high salt diet, %			+/−
Receiving monthly follow-up, %			++
Hospitalization during the past year, %			+

(+/−): no difference; (+): superior to control group without significance; (++): superior to control group with significance ($p < 0.05$); (−): inferior to control group. A more detailed summary of reported outcomes, specifying values for intervention and control groups is available in Stephani et al. [44]
[a]Systolic Blood Pressure
[b]Subgroup of low-literacy people/people with higher education needs
[c]Body Mass Index
[d]BMI < 26
[e]BMI < 25
[f]Postprandial Plasma Glucose Test
[g]Glycated hemoglobin
[h]HbA1c < 8 %
[i]mean HbA1c level
[j]Total Cholestorol
[k]High-Density Lipoprotein Cholesterol
[l]Low Density Lipoprotein
[m]Peak Expiratory Flow Rate
[n]Forced Expiratory Volume in 1 second
[o]Inhaled Corticosteroid

Piette et al. [23] found that their intervention providing personalized advice to hypertensive patients on the basis of their self-recorded blood pressure lowered systolic blood pressure in the intervention group, although this finding was significant only in a subgroup of 117 out of 181 participants with low literacy or high hypertension information needs.

Liew et al. [30] found that text messages and telephone appointment reminders lowered non-attendance of patients significantly when compared to controls.

The only study of a decision support system by Tian et al. [24] found that medication compliance of patients treated by CHWs, who were supported by smartphones, increased significantly, and they had significantly lower blood pressure when compared with controls.

The impact of mHealth on **costs** in terms of time and money for physicians and patients was observed by only one trial [29]. It was estimated that the intervention would lead to additional monetary costs per patient of €0.67 per week for text messages sent to physicians, and that physicians spent 2 min per patient per week at a cost of 1 Euro per patient.

Discussion

This is the first review focusing specifically on RCTs of mHealth interventions against NCDs in LaMICs. Despite much enthusiasm about the 'great potential' of mHealth for addressing NCD needs in LaMICs and despite a growing body of literature on the topic, we found only eight studies that reported results of RCTs performed in LaMICs. Except for one study [25], these showed generally positive effects of mHealth interventions on reported outcome measures. However, because trials tested different interventions (ranging from health promotion over appointment reminders and medication adjustments to clinical decision support systems), and included patients with different diseases (diabetes, asthma, hypertension), and – partially as a result of this – reported very different outcome measures, it is impossible to generalize these findings.

Nevertheless, our review provides a first glimpse of the slowly emerging evidence base on the effectiveness of mHealth interventions for NCDs and has important implications for policy-makers and researchers. First, it is remarkable that the evaluated mHealth interventions generally showed positive effects on reported outcome measures, including clinical outcomes, compliance, and quality of life. This finding is in line with findings from a much broader literature on communicable disease and maternal care, where many different kinds of mHealth interventions have been found to improve clinical outcomes and compliance of patients – although results have been shown to vary depending on the specific type of intervention [31–33].

Second, our results suggest that particular types of mHealth interventions that were found to have positive effects on patients with communicable diseases and for improving maternal care are likely to be effective also for NCDs. For example, text message appointment reminders have been found to lead to higher pre-natal visit rates of pregnant women [34–36], and two studies included in our review show that they are also effective at increasing attendance rates of patients with NCDs [26, 30]. Similarly, drug intake reminders have been found to improve treatment adherence of people with AIDS and Malaria [37–39], and one study in our review showed that drug intake reminders (combined with other information on medical nutrition and physical activity) improve clinical outcomes of patients with Diabetes [26].

Third, our results show that there is very limited evidence on the effects of mhealth in low income countries as all included studies reported results of trials conducted in middle income countries. Furthermore, when considering the 4 broad categories of mHealth interventions that we defined at the beginning, i.e., interventions of 1) health promotion & awareness, 2) remote monitoring & care support, 3) disease surveillance & outbreak detection, and 4) decision support system, it is evident that available RCTs have focused mostly on mHealth interventions falling into category 2. Also Bloomfield et al. [16] concluded that there is very limited evidence concerning a wide range of health systems challenges, which could potentially be addressed by the implementation of mHealth interventions. In our review, several studies evaluating *clinical decision support* systems were identified during full-text screening [40–43] but they had to be excluded because they were no RCTs. Information on cost-effectiveness of mHealth interventions is largely unavailable and only one study included in our review considered the effect of mHealth on costs of care [29].

An important limitation of our review is that we excluded all studies that did not report results of RCTs. Observational studies and non-randomized trials may provide important bits of information that are useful for understanding the effectiveness of mHealth. Nevertheless, we opted for excluding these studies as non-randomized trial designs carry a greater risk of being flawed as a result of multiple biases [22]. Another limitation of the review process could have been the restriction to the two languages German and English. Furthermore, given the limited number of studies, it was not possible to compare results of different studies. Effects of mHealth are likely to differ depending on the specific type of intervention, the specific disease, and the specific context. Consequently, it is impossible to draw firm conclusions on the effectiveness of mHealth interventions in general, e.g., by carrying out pooled analyses of outcome data. Finally, the specific effects of different kinds of mHealth interventions on different kinds of patients with NCDs living in LaMIC could not be investigated. For example, it is likely that the effectiveness of interventions depends on whether patients can interact with health professionals and whether information is personalized to the patients. Although our review includes studies with both interactive and non-interactive interventions as well as studies with both personalized and non-personalized information, the specific effects of these different interventions could not be compared because they were provided to different patients (in difference settings) and reported different outcome measures.

Conclusion

Our review shows that there are only eight studies reporting results of RCTs of mHealth interventions for patients with NCDs in LaMICs. These have generally found positive results. However, a more detailed analysis of the specific effects of different types of mHealth interventions on different types of patients and a firm conclusion about the effectiveness of mHealth against NCDs is impossible because of the small number of studies and the heterogeneity of reported outcome measures.

Nevertheless, our results indicate that some findings of the positive effects of mHealth interventions for patients with communicable diseases and for maternal care can be replicated by mhealth interventions for patients with NCDs. However, we can only repeat the conclusions of previous reviews [15, 16] that more research is needed to fill the many gaps in knowledge about mHealth interventions for NCDs in LaMICs.

Additional files

Additional file 1: Table S1. Search method conducted with the CENTRAL-database (DOC 30 kb)

Additional file 2: Table S2. Bias of the included studies (DOC 34 kb)

Abbreviations

CHWs, community health workers; DALYs, Disability Adjusted Life Years; FEV1%, Forced Expiratory Volume in 1 second; LaMICs, low and middle income countries; LMICs, lower middle income countries; mHealth, mobile health; NCDs, non-communicable diseases; PEFR, peak expiratory flow rate; RCTs, randomized controlled trials; UMICs, upper middle income countries

Authors' contributions

VS conceived the idea, collected data, participated in analysis and drafting of manuscript. WQ participated in analysis and drafting of manuscript. DO collected data, participated in analysis and drafting of manuscript. All authors read and approved the final manuscript.

Availability of data and materials

The datasets supporting the conclusions of this article are included within the article and its Additional files 1 and 2.

Competing interests

The authors declare that they have no competing interests.

Consent for publication

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Chapter 3: Self-management of diabetes in Sub-Saharan Africa: a systematic review

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Self-management of diabetes in Sub-Saharan Africa: a systematic review

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Abstract

Background: The prevalence of diabetes in sub-Saharan Africa has increased rapidly over the last years. Self-management is a key element for the proper management, but strategies are currently lacking in this context. This systematic review aims to describe the level of self-management among persons living with type 2 diabetes mellitus in sub-Saharan Africa.

Method: Relevant databases including PubMed, Web of Science and Google Scholar were searched up to September 2016. Studies reporting self-management behavior of people with type 2 diabetes mellitus and living in sub-Saharan Africa were included.

Results: A total of 550 abstracts and 109 full-text articles were assessed. Forty-three studies, mainly observational, met the inclusion criteria. The studies showed that patients rarely self-monitored their glucose levels, had low frequency/duration of physical activity, moderately adhered to recommended dietary and medication behavior, had poor level of knowledge regarding diabetes related complications and sought traditional or herbal medicines beside of their biomedical treatment. The analysis also revealed a lack of studies on psychosocial aspects.

Conclusion: Except for the psychosocial area, there is a good amount of recent studies on self-management behavior of type 2 diabetes mellitus sub-Saharan Africa. These studies indicate that self-management in sub-Saharan Africa is poor and therefore a serious threat to the health of individuals and the health systems capacity.

Background

Although the true burden of diabetes in sub-Saharan Africa (SSA) is unknown, it is recognized as a serious challenge to health systems [1, 2]. Current prevalence-estimates range between 2.1 and 6.0%, and the number of people suffering from the disease is likely to double within the next 25 years [3]. In order to reduce the burden posed to health systems and affected individuals, patients with diabetes need to adopt certain self-management behaviors. The American Diabetes Association (ADA) has therefore defined a list of essential self-care behaviors, which have been found to be positively correlated to good glycemic control and a reduction of complications [4, 5]. Diabetes Self-Management Education (DSME) is critical for informing patients about these essential self-care behaviors. Currently, DSME in most African countries is limited in scope, content and consistency and it is not clear how patients from SSA manage their diabetes [6–8]. Therefore, the aim of this systematic review is to assess the status of self-management of people with diabetes in SSA, and to analyze to what extent they follow the recommended self-management behavior.

Method

Search strategy and screening procedure

A preliminary search was performed in order to find appropriate terms. The final search strategy was discussed among the authors (VS and DO). Search term categories belonged to: "Diabetes", "Sub-Saharan Africa" and "Self-management". Databases included in the search were PubMed, Web of Science and Google Scholar. In addition, reference lists of screened studies were checked. An example of the performed search and the key words used is provided in Additional file 1.

The search-strategy yielded 741 publications (MEDLINE 436, Web of Science 232, Google Scholar 50). After removal of duplicates, 550 studies remained. VS and DO

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reviewed titles, keywords and abstracts independently and discussed the eligibility for full-text inclusion.

After discussing results and resolving disagreements, full texts of the remaining 109 publications were screened for eligibility. The overlapping rate of included and excluded studies was 87% between both authors. Disagreements were discussed and resolved by consensus, resulting in forty-three articles included in this review.

Inclusion criteria

Studies were included for this review if they met the following inclusion criteria:

- They took place in at least one country from sub-Saharan Africa, as defined by the World Bank [9]
- Participants were people living with type 2 diabetes mellitus (which accounts for 90% of all diabetes cases in SSA [10])
- The study analyzed self-management behavior of type 2 diabetes patients as defined by the American Diabetes Association (ADA) as described in Table 1. If a study analyzed both, type 1 and type 2 diabetes, it was only included if the outcome measures (or self-management behavior) for patients with type 2 diabetes were presented separately
- Published anytime before September 2016 (with no limit concerning the start date)
- The study was published in English or German

Table 1 presents all self-management related outcome categories and specifies them according to the recommendations given by the ADA [11].

Data extraction, analysis, and synthesis

Two data extraction templates (using Microsoft Excel) were developed to gather all data relevant for the analysis. One template was used for collecting characteristics of included studies (e.g. year of publication, country, number of participants, number of woman/man, age); study results and relevant information on self-management were collected in a second template. Qualitative and quantitative results were combined and summarized according to their specific area of self-management. Quantitative results were rounded to the nearest full percent and study-size-weighted arithmetic averages were calculated if eligible.

Risk of bias was assessed and information about the quality of the included studies were derived from the text using quality-assessment tools for cross-sectional studies [12], pre-post studies [13] and randomized controlled trials [14]. Additional file 2 contains the full details of a PRISMA checklist for this review and the full risk assessment of the included studies can be found in the Additional files 3, 4, 5.

Results

The final analysis included forty-three studies. Figure 1 illustrates the literature search and selection process. Common reasons for exclusion were: lack of results, reports from non-SSA countries, or focus on other diseases than type 2 diabetes mellitus. Publication dates were between 2002 and 2016. The majority of studies ($n = 33$) were published after 2010.

Description of included studies

Study characteristics such as the year of publication, sample size, study design and the measured outcome parameters of the forty-three included studies are summarized in Table 2. Most studies took place in Nigeria ($n = 13$) and South-Africa ($n = 11$), followed by Ghana ($n = 6$), Uganda ($n = 4$), Ethiopia (n = 3), Cameroon ($n = 2$), Tanzania, Kenya, Sudan, Zimbabwe (n = 1 each). Thirty-five studies were observational (mostly cross-sectional, only one longitudinal study [15]), while six studies were experimental (two studies described the same intervention [16, 17]).

Table 1 Specification of categories and included outcomes used for the analysis of self-management as given by the ADA [5]

Category	Specification	Included Outcomes
Healthy eating	General awareness of its importance, awareness of importance of measuring and portioning meals, adherence to an eating plan	Eating behavior, knowledge on diet recommendations, presence of and adherence to a diet plan
Being active	General awareness, existence of and adherence to an activity plan (with information on frequency, intensity, time and type of activity), glucose checking before and after sports	Knowledge on activity recommendations, presence of and adherence to an activity plan
Monitoring	General awareness, conducting SMBG (including information on frequency), keeping record of results, ability to analyze results	Awareness of SMBG, Availability of a glucose meter at home, frequency of SMBG
Taking Medication	Awareness of the kind of prescribed medicine, adherence to the medication plan	Prescribed medication, medication adherence, awareness that medication needs to be taken throughout the life-time
Reducing Risks	Awareness of possible complications, tobacco consumption, regular doctor appointments, taking care of feet	Awareness of consequences of uncontrolled Diabetes, consultations of specialists, self-care behavior, cigarette intake
Psychosocial Aspects	Environmental, social, emotional burden of diabetes	Support by relatives, emotional and environmental aspects

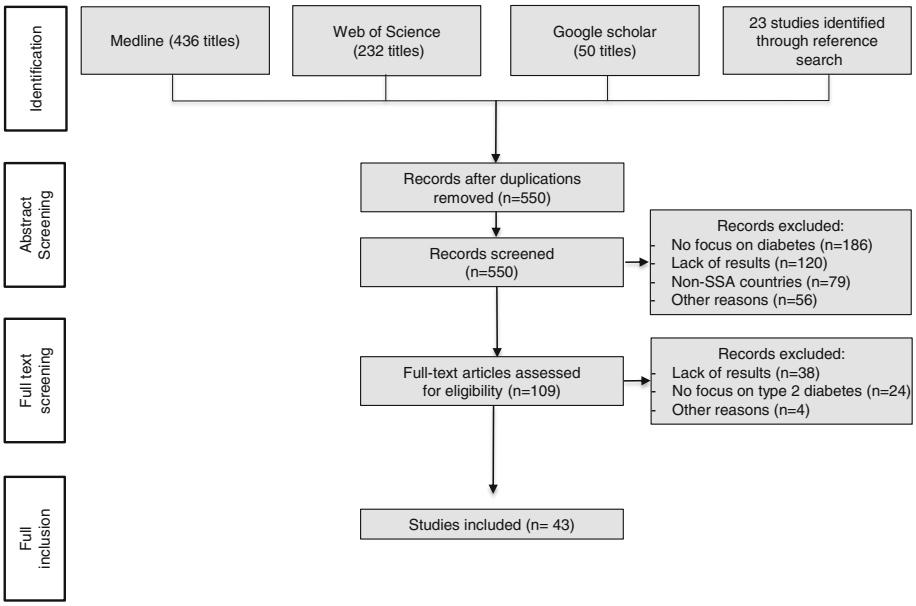


Fig. 1 Literature screening process

8281 participants with type 2 diabetes were included with an average age above 50 years, and out of which 4676 were women (3 studies did not indicate how many men or women were included). People had been living with their diabetes on average over 5 years. Most studies dealt with the self-management area of medication ($n = 26$), followed by the assessment of nutritional intake and the engagement in physical activity ($n = 21$ and $n = 20$). Fifteen studies were about risk reduction and self-monitoring of blood glucose, respectively. Only three studies considered psychosocial aspects of people with diabetes.

All experimental studies tested various forms of DSME programs, with either a pre-post design [18, 19], or a control group [16, 17, 20] study-design. One intervention was done by counselling and educating the patients on medication adherence at the beginning of the study [21]. In another study [18] patients attended a one-day education program. Two studies tested the impact of 4 one-hour group education sessions about the importance of nutrition, physical activity, adherence to medication and risk reduction [19, 20]. A more comprehensive intervention tested the outcome of weekly group education sessions on nutritional aspects, combined with monthly follow up sessions plus education in vegetable gardening [16, 17].

Study results on self-management

Healthy eating

Twenty-one studies included information on healthy eating self-care behaviors. Participants understood that unhealthy eating is a dominant cause of diabetes [16, 22, 23] and that it is important to take aspects such as the sugar-, salt- or fat-level of consumed food into consideration [19, 22, 24–26]. However, misconceptions and gaps of knowledge were present; particularly about the definition of high risk food [19], the sugar-level of food [24, 27] and the underlying diabetes related metabolic mechanisms [24]. As found in one study, respondents did not know the proportion of food they were allowed to eat [24]. And another study showed that mostly men talked about regular meals, while most women did not [28]. 'Positive dietary behavior changes' because of their diabetes were reported by 33% of Nigerian [29], 51% of Ghanaian [30] and most of South African [16] participants. Regarding the adherence to a certain diet plan, 60% [31], 70% [32] and 87% [33] stated that they 'followed an eating plan'.

Four experimental studies assessed the impact of counseling sessions on the adherence to diet plans. Two interventions assessed the impact of four one-hour group education sessions on nutritional aspects: One increased the level of adherence significantly from 4.8 to 5.9 days per week [19] and one decreased the adherence non-significantly from 4.8 to 4.6 days per week [20]. The third intervention, which combined weekly group educational sessions on nutritional aspects with monthly follow up sessions and education in vegetable gardening, significantly reduced the intake of energy and starchy food [17]. The fourth intervention, which consisted of weekly contacts among the patients over a period of four months, was found to improve the healthy eating habit of patients significantly from 11.5 points to 22.4 points (out of 25 total points on the 'Diabetes Self-Management Assessment and Reporting Tool') [18].

Table 2 Characteristics of included studies

	Author	Year	Country	Study Type	Sample characteristics				Reported outcomes					
					Sample size	Male	Female	Average age	Healthy eating	Being active	Monitoring	Medication	Risk Reduction	Psychosocial
Observational studies	Awah [57]	2008	Cameroon	cross-sectional	20	11	9	62.5				x		
	Awah [15]	2009	Cameroon	cross-sectional	65	30	35	–						
	Kassahun [43]	2016	Ethiopia	cross-sectional	309	189	120	50			x	x		
	Sorato [31]	2016	Ethiopia	cross-sectional	194	95	99	50.3	x	x	x	x		
	Wabe [42]	2011	Ethiopia	cross-sectional	384	186	161	48.3			x	x	x	
	Bruce [50]	2015	Ghana	cross-sectional	200	95	105	–				x	x	
	de-Graft Aikins [23]	2014	Ghana	cross-sectional	20	2	18	60	x		x	x	x	
	Doherty [27]	2014	Ghana	cross-sectional	30	10	20	48.7	x					
	Mogre [30]	2016	Ghana	cross-sectional	222	74	148	48.4	x	x				
	Obirikorang [54]	2016	Ghana	cross-sectional	630	243	387	55.2					x	
	Obirikorang [26]	2016	Ghana	cross-sectional	543	232	311	51.1	x	x			x	
	Matheka [44]	2013	Kenya	cross-sectional	187	–	–	–			x			
	Adibe [38]	2011	Nigeria	cross-sectional	314	136	178	43		x			x	
	Adisa [24]	2009	Nigeria	cross-sectional	121	60	61	–	x	x	x	x		
	Adisa [29]	2011	Nigeria	cross-sectional	114	51	63	61.3	x	x	x	x		
	Awotibede [37]	2016	Nigeria	cross-sectional	299	105	194	51.9		x				
	Ezuruike [48]	2016	Nigeria	cross-sectional	112	43	69	46				x		
	Iwuala [47]	2015	Nigeria	cross-sectional	100	38	62	59.9			x			
	Jackson [51]	2015	Nigeria	cross-sectional	303	171	132	54.5				x		
	Ogbera [40]	2011	Nigeria	cross-sectional	150	50	100	69.9		x	x	x		x
	Onakpoya [49]	2010	Nigeria	cross-sectional	83	32	51	57.5				x	x	
	Oyetunde [52]	2014	Nigeria	cross-sectional	102	35	67	59.6				x		
	Yusuff [46]	2008	Nigeria	cross-sectional	200	110	90	–				x	x	
	Jackson [36]	2014	Nigeria	cross-sectional	303	132	171	50		x	x	x	x	
	Adeniyi [22]	2015	South Africa	cross-sectional	17	6	11	58.5	x	x		x	x	x
	Haque [53]	2005	South Africa	cross-sectional	–	–	–	–				x		
	Matwa [55]	2003	South Africa	cross-sectional	15	5	10	61.4					x	
	Mendenhall [56]	2015	South Africa	cross-sectional	27	–	27	59				x		
	Nthangeni [33]	2001	South Africa	cross-sectional	288	133	155	62	x			x		
	Okonta [39]	2014	South Africa	cross-sectional	217	–	–	51	x	x				
	Steyl [35]	2014	South Africa	cross-sectional	26	11	15	58.9	x	x		x		

Table 2 Characteristics of included studies *(Continued)*

	Author	Year	Country	Study Type	Sample characteristics				Reported outcomes					
					Sample size	Male	Female	Average age	Healthy eating	Being active	Monitoring	Medication	Risk Reduction	Psychosocial
	Abdelgadir [45]	2006	Sudan	cross-sectional	193	95	98	50			x			
	Kamuhabwa [32]	2014	Tanzania	cross-sectional	469	171	298	54.9	x	x	x	x		
	Hijelm [34]	2008	Uganda	cross-sectional	25	10	15	–	x	x		x	x	
	Mayega [28]	2014	Uganda	cross-sectional	96	48	48	47.5	x	x				
	Nielsen [41]	2016	Uganda	cross-sectional	10	6	4	65.6	x	x	x			
	Hijelm [25]	2010	Zimbabwe	cross-sectional	21	10	11	48	x	x	x		x	
Experimental studies	Awodele [21]	2015	Nigeria	pre-post, quasi-experimental	152	47	105	65				x		
	Baumann [18]	2015	Uganda	pre-post, quasi-experimental	25	7	18	53	x	x		x		
	Mash [20]	2014	South Africa	RCTs	1570	411	1158	56.4	x	x		x	x	
	Muchiri [16]	2015	South Africa	RCTs	41	5	36	59.4	x					
	Muchiri [17]	2015							x					
	van der Does [19]	2013	South Africa	RCTs	84	68	16	51.6	x	x		x	x	x

Being active

Seventeen observational studies assessed physical activity behaviors and three interventional studies tested the impact of group educational programs.

The majority of participants in six studies were aware of the importance of being active and of doing regular aerobic exercises (such as brisk walking or climbing staircases) as part of their non-medical treatment [22, 25, 34–37]. However, respondents in three studies showed that a majority did not understand the relevance of physical activity as part of their glycemic control and therefore revealed gaps in knowledge on recommended type, frequency and duration of physical activity [24, 38, 39]. In addition, men and women were not always equally well-informed [34].

No study mentioned that participants had an activity plan or kept records of type, frequency, time and intensity of all exercises, or did glucose checking before and after doing sports.

Five observational studies indicated a low engagement in practicing exercises: 29% mentioned to 'practice exercise' [29], and only 25% [19], 27% [37], 33% [32] and 46% [40] said they were engaged in exercises on a regular basis. The most common type of exercise among participants was brisk walking [26, 37].

Less than half of the people who were engaged in regular exercises did their exercise daily [26] and only 39% at least in 30 min of duration [37]. In one study [31], 50.5% of respondents from Ethiopia reported to be engaged in at least 30 min of physical activity for total of ≥3 days per week.

Interventions with frequent group education sessions had mixed results based on the studies identified. One study found a significant increase in physical activity from 3 to 4.5 days per week [19], one found a non-significant increase from 4.1 to 4.5 [18], and one found a non-significant decrease from 4 to 3.9 days per week [20].

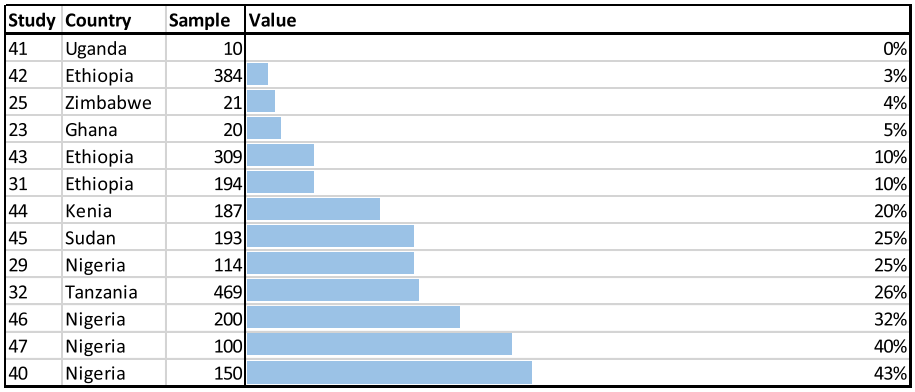
Monitoring

Fifteen observational studies reported on patients' behavior regarding monitoring of blood glucose. The vast majority of respondents from Nigeria [24] and Zimbabwe [25] reported to not be aware of SMBG. Thirteen studies observed how many of the study participants had the possibility to self-monitor their blood glucose level and had access to a glucometer at home (Fig. 2). The results indicate a very low degree of SMBG, ranging from a study from Uganda, where none of the patients had access to a glucose meter at home [41] to one study from Nigeria with 43% of all patients doing glucose testing at home [40]. On average only 15% of all patients were able to test his or her blood glucose level at home [23, 25, 29, 31, 32, 40–47].

Most patients, who had access to a glucometer at home, checked their glucose level only once a month or at no regular interval [21, 45, 47]. Only 1% [21] and 2% [45] of respondents measured their glucose level on a daily basis. One study mentioned that women did SMBG more regularly than men [47]. Another study reported that half of those people who performed SMBG, also kept records of their results [40]. Most importantly, no study reported patients' ability to analyze test results and whether they know what to do if their glucose numbers are off target.

Medication

Twenty-three observational and three experimental studies included information on peoples' awareness and adherence to prescribed medication. The most common type of medication prescribed were oral hypoglycemic agents (*OHA*): On average, 86% were on OHA alone, while 7% were on a combination of OHA and Insulin and the remaining 7% were on Insulin alone [29, 31–33, 40, 42, 46, 48, 49]. The fact that diabetes drugs need to be taken throughout the life-time was known by the majority of patients in Nigeria [24, 29, 36] and Uganda [34].



Study	Country	Sample	Value
41	Uganda	10	0%
42	Ethiopia	384	3%
25	Zimbabwe	21	4%
23	Ghana	20	5%
43	Ethiopia	309	10%
31	Ethiopia	194	10%
44	Kenia	187	20%
45	Sudan	193	25%
29	Nigeria	114	25%
32	Tanzania	469	26%
46	Nigeria	200	32%
47	Nigeria	100	40%
40	Nigeria	150	43%

Fig. 2 Percentage of people who are able to self-monitor their blood-glucose level at home

Six observational studies assessed patients' medication adherence by using the Morisky Medication Adherence Scale (MMAS). It entails (8 or 4, depending on the MMAS-version) questions about the self-reported medical adherence. A perfect medication adherence is having a full score on the MMAS (meaning 8 or 4 points). Setting a cut-off point at 75% of the MMAS (indicating a moderate level of adherence), the adherence rate is on average 64% (see Fig. 3) [29, 32, 43, 46, 50, 51].

Six other studies asked for the non-adherence (instead of adherence) without utilizing a standardized questionnaire. The results ranged from 20% of people who had a "lack of adherence" [52], to 21% who stated that they "missed the medication" [42], to 35% who were classified as having a "poor adherence" [22], to half of all participants who reported that they "forget sometimes" to take their medication [24] and who do not "take the drugs on time" [40].

One study [53] asked the responsible diabetes doctors about their perception on patients' adherence to prescribed medication. They concluded that the majority of all patients are non-compliant with the pharmacotherapy.

All three experimental studies improved medication adherence. A one-day education program in combination with weekly contacts among participants improved the frequency of 'missed medication' from 1.9 to 1.6 (1 never, 5 daily) [18], and the four one-hour group education programs about self-care behaviors improved the medication adherence from 6.3 to 6.5 days a week [19] and from 6.8 to 6.9 [20] days a week. However, all of these improvements resulted to be non-significant.

Risk reduction

Thirteen observational studies and two interventional studies dealt with risk reduction. Participants had various levels of knowledge about general consequences and complications of uncontrolled diabetes. All respondents from Ghana attributed complications to medical non-adherence [23] and most patients from a South African study [22] connected their already developed complications (e.g. foot problems, sexual dysfunction) to uncontrolled diabetes. However, only few participants were aware of the specific complications that could develop: the most frequently named complications were foot ulcers (on average named by 45%) and retinopathy (on average 36%) [42, 46, 50, 54, 55]. Other complications named were neuropathy (31%), sexual dysfunction (26%) [50, 54], or nephropathy (18%) [42, 50, 54]. The prevalence of cigarette smoking, which contributes to developing complications, appeared to be not very present and accounted on average for only 10% of all participants [18, 20, 31–33, 36, 43, 50, 54].

Having regular appointments at medical specialists (e.g. eye-doctor or dentist) is an important aspect of risk reduction. 77% of patients in one Nigerian study knew that they should go to the doctor when they have changes in their eyesight [38]. In another study 29% stated that they had previous dilated eye examinations [48]. On average, 80% [36, 38] of participants knew that they should take care of their teeth. No study assessed the frequency of visits at medical specialists.

Proper foot care is also critical for the reduction of risks. Most Nigerian diabetes patients knew that they have to take extra care of their feet [36]. In Zimbabwe only half of one group had been informed about foot care, and only with a limited content [25]. There was also a men-women discrepancy in one Ugandan study: women were better informed on how they should take care of their feet then men [34]. In one South African study all respondents reported that they adhered to the recommended foot care [55]. Two studies looking at group education programs about self-care behaviors, improved the foot care of participants non-significantly from 5.5 to 5.7 days per week [20] and significantly from 4.5 to 5.8 days per week [19].

Psychosocial aspects

Only three observational studies reported about the psychosocial aspects of having diabetes.

One study mentioned that the majority of patients received support from their family [22]. Stress and insufficient sleep due to the diabetes appeared to be below 1% among South African patients [19] and another study revealed a moderate level of emotional distress [40]. However, no study on environmental or other social aspects of living with diabetes was identified.

Alternative medicine

Although not included in the ADA framework (Table 1), alternative medicine was seen as an important component in

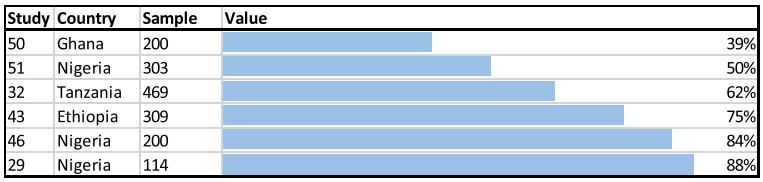


Fig. 3 'Morisky Medication Adherence Scale' results showing the percentage of people with a moderate medication adherence (> 75% of adherence)

SSA for self-management: Eleven studies addressed the utilization of alternative medicine by study participants. This shows that the western based model of self-management fails to describe the entire self-management behavior of diabetes patients in SSA. 11% of South African patients sought traditional healers [56] and many respondents from Cameroon stated that they used traditional diagnostic tools, such as tasting their urine for glucose [15]. Herbal medicine was equally valued with biomedical therapy [57] and frequently used [25]. The use of herbal medicines as part of the diabetes treatment was on average 32% [21, 34, 46, 48]. For some participants, it was grounded on their negative feelings and dissatisfaction towards biomedicine [15] or the belief that diabetes is a supernatural problem caused by witchcraft or fate [23, 25, 55]. To others, the willingness to treat diabetes took them to a 'modern' health facility but the willingness to cure diabetes took them to a traditional healer [15, 33, 56].

Discussion

Main findings and recommendations

This is the first systematic review which analyzes the self-management behavior of people with diabetes in SSA. Studies which analyzed **nutritional** aspects ($n = 20$) revealed a moderate level of adherence to recommended diet plans, with adherence rates ranging from 33 to 87% [16, 29–33]. Moreover, patients demonstrated a basic understanding of the right eating habits [16, 19, 22–26], but also revealed several gaps in their knowledge (e.g. regarding the sugar-level of food) [19, 24, 28]. Those which analyzed **physical activity aspects** of self-management behavior (n = 20) found that most patients were aware of the importance of aerobic exercises [22, 25, 34–37]. However, adherence rates to exercise plans varied between 29 and 46% [19, 26, 29, 31, 32, 37, 40]. Studies with information on the **medication** ($n = 26$) showed that Medication-adherence, measured by the MMAS questionnaire, was on the average 64% [29, 32, 43, 46, 50, 51]. Other studies, which utilized other (non-MMAS) methods confirmed these moderate results [22, 24, 40, 42, 52]. **Risk reduction** was assessed by 15 studies. Patients connected complications to uncontrolled diabetes, but only few were aware of the specific complications that can be developed [22, 23, 42, 46, 50, 54, 55] and how they can be prevented [25, 34, 36]. There was no study assessing the frequency of visits at medical specialists (such as an eye doctor or dentist) and only one study mentioned that all patients adhered to the recommended foot care [55]. Only three studies reported on **psychosocial aspects**. They indicated that people with diabetes seem to have a very low emotional distress level [19, 22, 40]. Although not part of the ADA self-management guidlines the use of **herbal medicine** and traditional healers was frequently mentioned [21, 25, 34, 46, 56–58]. Lowest adherence rates were assessed for patient's ability to **self-monitor their blood glucose**. On average, only 15% were able to test the blood glucose at home [23, 25, 29, 31, 32, 40–47] – and only very irregularly [19, 21, 45, 47]. Studies which tested **DSME programs** ($n = 6$) showed significant improvements for eating and activity habits [16, 18, 19], medication adherence [21] and risk reduction behavior [19]. Improvements were ascertained for the adherence to activity and medication plans [18–20] and risk reduction behavior [20], but without significance. Also without any significance, negative effects were shown in only one study for eating and activity behaviors [20].

This review is important because it shows that self-management of diabetes in SSA is insufficient. Particularly, the lack of physical activity, the inappropriate risk reduction knowledge and behavior, and the missing ability to self-monitor blood glucose are a serious threat to good glycemic control. Medication and nutritional adherence appeared to be better but are still sub-optimal. By comparing the results with results from other countries outside SSA, we observe a similar 'ranking': The three elements 'physical activity', 'risk reduction' and 'SMBG' are also the most critical parts of self-management outside SSA (adherence rates of 45–54%), while the adherence to medication and nutrition plans is better: outside SSA medication plans are followed by 87% (vs 64% in SSA). And diet plans are followed by 76% outside SSA (vs 72% in SSA) [59].

Second, the review revealed that the (western-based) ADA model of self-management fails to describe all self-care activities in SSA. One third of all patients sought alternative medicine beside of their biomedical therapy (in non-SSA countries this is done by 8% [59]). For many people it is therefore part of the self-management. Future research should focus on the (unknown) ingredients of herbal medicines and their interactions with other taken medicines, such as OHA.

Third, the provision of structured DSME programs in SSA is found to be effective. Most of the measured self-management behaviors, such as the adherence to medication or diet plans, were significantly improved by DSME programs. This supports the existing literature, which has proven that DSME is effective in non-SSA countries [60]. Therefore, we recommend to improve the current distribution of structured context-adapted DSME programs in SSA. Important factors, such as the low access to blood glucometers or the utilization of alternative medicines, need to be considered when conceptualizing these programs. Other factors, which have not been addressed in this review, need to be considered as well, e.g. the shortages of healthcare workers [61] or the lack of medicines [62]. Moreover, the implementation of structured DSME programs could be supported by technology. So called mobile health (mHealth) solutions, which have

shown to be effective against non-communicable diseases [63], could be used to guide health professionals through the education process and to follow up with patients.

Last, our results showed that there is only very limited research on psychosocial aspects in SSA. In contrast to all other self-management factors, we identified only three studies on psychosocial aspects (e.g. 21 studies on nutritional behavior or 15 studies about SMBG). Therefore, future research should put a higher emphasis on the assessment of the psychosocial situation, because factors such as stress or the missing support by the family can have a highly negative impact on people with diabetes and are associated with non-adherence to medication regimen and other self-management behaviors [64].

Limitations

An important limitation of this review is that it combines studies from 10 countries, which are culturally and economically diverse. The generalizability of the results is therefore problematic, because it was not always clear whether the individual study results were representative (see risk of bias assessment, additional files 3-5). The studies also differ in their objective, e.g. while some evaluated DSME programs, others measured the adherence to OHA. However, combining studies from various countries with heterogeneous objectives is not unusual for reviews on diabetes in SSA [65]. Furthermore, methods applied to measure outcome-parameters varied among included studies. One example is the medication adherence: in some studies people where simply asked whether they "missed medication" or "forget sometime" to take their medication, while other studies used the standardized MMAS scale. Moreover, the analysis considers only patients who have been diagnosed with diabetes. It is estimated that around two thirds of all people who suffer from diabetes in SSA remain undiagnosed [3]. Another limitation concerns the method used by all included studies: most of the measured outcomes were self-reported. The use of self-reported measures, such as the medication adherence may underestimate the non-adherence of patients [52]. Multiple methods may be required to detect those who report adherence but who may in fact be non-adherent.

Conclusion

There is a good amount of recent studies on self-management behavior of type 2 diabetes in SSA. These studies indicate that self-management in SSA is poor and a serious threat to glycemic control. Particularly, self-monitoring of blood glucose, physical activity and risk reduction behavior are insufficient. More research on the psychosocial situation is needed. Future efforts and resource investments in public health systems need to strengthen the distribution of strucutred DSME programs which need to be adapted to the SSA-context.

Additional files

Additional file 1: Search strategy used. (DOCX 12 kb)
Additional file 2: PRISMA checklist. (DOCX 26 kb)
Additional file 3: Risk assessment for cross-sectional studies. (DOCX 21 kb)
Additional file 4: Risk assessment for pre-post studies. (DOCX 14 kb)
Additional file 5: Risk assessment for RCTs. (DOCX 13 kb)

Abbreviations

ADA: American Diabetes Association; DSME: Diabetes Self-Management Education; MMAS: Morisky Medication Adherence Scale; NCD: Non Communicable Diseases; OHA: Oral Hypoglycemic Agents; SMBG: Self-Monitoring of Blood Glucose; SSA: Sub Saharan Africa

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Availability of data and materials

The datasets supporting the conclusions of this article are included within the article and its Additional files 1, 2, 3, 4, 5.

Authors' contributions

VS conceived the idea, collected data, participated in analysis and drafting of manuscript. DO collected data and participated in analysis. DB participated in analysis. All authors read and approved the final manuscript.

Ethics approval and consent to participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare that they have no competing interests.

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Chapter 4: A realist review of mobile phone-based health interventions for non-communicable disease management in sub-Saharan Africa

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A realist review of mobile phone-based health interventions for non-communicable disease management in sub-Saharan Africa

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Abstract

Background: The prevalence of non-communicable diseases (NCDs) is increasing in sub-Saharan Africa. At the same time, the use of mobile phones is rising, expanding the opportunities for the implementation of mobile phone-based health (mHealth) interventions. This review aims to understand how, why, for whom, and in what circumstances mHealth interventions against NCDs improve treatment and care in sub-Saharan Africa.

Methods: Four main databases (PubMed, Cochrane Library, Web of Science, and Google Scholar) and references of included articles were searched for studies reporting effects of mHealth interventions on patients with NCDs in sub-Saharan Africa. All studies published up until May 2015 were included in the review. Following a realist review approach, middle-range theories were identified and integrated into a Framework for Understanding the Contribution of mHealth Interventions to Improved Access to Care for patients with NCDs in sub-Saharan Africa. The main indicators of the framework consist of predisposing characteristics, needs, enabling resources, perceived usefulness, and perceived ease of use. Studies were analyzed in depth to populate the framework.

Results: The search identified 6137 titles for screening, of which 20 were retained for the realist synthesis. The contribution of mHealth interventions to improved treatment and care is that they facilitate (remote) access to previously unavailable (specialized) services. Three contextual factors (predisposing characteristics, needs, and enabling resources) influence if patients and providers believe that mHealth interventions are useful and easy to use. Only if they believe mHealth to be useful and easy to use, will mHealth ultimately contribute to improved access to care. The analysis of included studies showed that the most important predisposing characteristics are a positive attitude and a common language of communication. The most relevant needs are a high burden of disease and a lack of capacity of first-contact providers. Essential enabling resources are the availability of a stable communications network, accessible maintenance services, and regulatory policies.

Conclusions: Policy makers and program managers should consider predisposing characteristics and needs of patients and providers as well as the necessary enabling resources prior to the introduction of an mHealth intervention. Researchers would benefit from placing greater attention on the context in which mHealth interventions are being implemented instead of focusing (too strongly) on the technical aspects of these interventions.

Keywords: mHealth, Mobile phone, Non-communicable diseases, Chronic diseases, Sub-Saharan Africa, Realist review, Health policy

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Background

In sub-Saharan Africa (SSA), the prevalence of non-communicable diseases (NCDs) is increasing rapidly [1], placing a growing burden on already weak health systems in the region [2, 3]. At the same time, the use of mobile phones is continuously rising, expanding the opportunities for the implementation of mobile phone-based health interventions (mHealth interventions) [4–6]. The World Health Organization (WHO) has proposed the further development and more widespread use of mHealth interventions for the prevention, management, and treatment of NCDs and their risk factors as part of its Global Action Plan for the prevention and control of NCDs [7].

In fact, mHealth interventions are increasingly used in low- and middle-income countries, including those in SSA [8]. Three recent systematic reviews, two specifically focusing on the use of mHealth interventions for the care and management of NCDs in SSA [6] and in developing countries [9], and the other looking more broadly at the use of mHealth interventions against chronic diseases in developing countries [10], found that the included studies generally reported positive outcomes. However, the authors also noted that there was insufficient evidence to support the scale-up of mHealth interventions because there were only five studies from SSA countries [6] and only nine studies from developing countries [9, 10]. In addition, the authors highlighted that further research was needed to better understand the causal pathways linking mHealth to improved care for patients with NCDs [6].

Traditional systematic reviews, which are often focused on randomized controlled trials, usually do not allow one to uncover causal pathways or to identify contextual mechanisms that may explain whether, why, and how interventions might work [11]. Realist reviews have emerged as an alternative method for systematic reviews, aiming to provide answers for policy makers about the causal mechanisms that link context, intervention, and outcomes [12].

Understanding these mechanisms is particularly relevant for complex interventions, such as mHealth interventions, which are implemented in vastly different healthcare settings (varying from rural communities [13, 14] to major university hospitals [15]), use various functions of mobile phones (from text messaging [16–18] to picture transmission [19]), target widely different health conditions (from skin lesions [20] to maternal health [21, 22]), and are put to use by persons with very different backgrounds, behaviors, skills, and beliefs [23–25].

This review aimed to understand how, why, for whom, and in what circumstances mHealth interventions contribute to improved treatment and care for patients with NCDs. More precisely, the first question ("how?") that the review aimed to answer was: What is the specific contribution that mHealth makes to patient treatment and care? As the review proceeded, it became clear that the main contribution of mHealth interventions is that they facilitate (remote) access to previously unavailable — and often specialized — services. Therefore, the objective of this review was to answer the following specific questions: (1) What are the causal mechanisms ("why?") that explain if an mHealth intervention facilitates access to care? (2) How do patient and provider characteristics ("for whom?") influence these mechanisms? (3) What is the influence of contextual factors ("what circumstances?") on these mechanisms?

Methods

This review followed guidelines for realist reviews [11, 12, 26, 27] because the research questions could not be answered using more traditional forms of systematic reviews. Realist reviews focus on identifying (middle-range) theories, which can provide guidance to the available literature. These theories then help us to understand the mechanisms that explain why an intervention has worked in one context but not in another. However, such Context-Mechanism-Outcome (C-M-O) relationships identified in realist reviews do not imply that a specific context will *always* lead to a specified outcome. Instead, realist reviews assume that outcomes are the result of choices made by individuals whose interactions are influenced by the intervention and by the context of implementation [12, 26, 27]. (See Table 1 for the operational definition of the C-M-O model of hypotheses adapted in this review.)

Scoping the literature and searching for relevant studies

An initial scoping review was conducted to identify candidate theories (see below) and to obtain a broad overview of the available literature on mHealth interventions aiming to improve treatment and care for patients with NCDs in SSA. Following this initial search, the review question was progressively refined to focus more specifically on the contribution of mHealth to facilitating access to previously unavailable care.

A search strategy was developed, using various combinations of the following search terms: "mHealth", "non-communicable diseases", and "sub-Saharan Africa". PubMed, Cochrane Library, Web of Science, and Google Scholars, were searched and re-searched from March to May 2015. (Additional file 1 provides details of the search strategies developed for the four databases.) In addition, a hand search was performed of the *Journal of Telemedicine and Telecare*, the *Journal of Telemedicine and e-Health*, and of reference lists of screened studies and existing reviews.

Inclusion and exclusion criteria

The review included various study designs (randomized controlled trials, mixed methods, and qualitative interview

Table 1 Operational definition of the C-M-O model of hypotheses adapted in this review

C-M-O	Operational definition
Context	This is defined as the prevailing conditions and circumstances within which patients and/or healthcare providers behave or decide to use mobile phone-based health interventions for the treatment and care of non-communicable diseases in sub-Saharan Africa. For example: - Patient/provider predisposing characteristics (age, gender, etc.) - Patient/provider needs - Patient/provider enabling resources
Mechanism	The factors or active "ingredients" of a mobile phone-based health intervention which directly/indirectly influence both intended and unintended health outcomes and/or outputs of the treatment and care of non-communicable diseases in a well-defined context in sub-Saharan Africa. For example: - How easy to use the patients and healthcare providers find the mobile technology involved in the intervention - How useful patients and healthcare providers perceive the mHealth intervention to be over alternative programs and forms of accessing healthcare
Outcome	This constitutes the sustained use of mHealth interventions and — in turn — better patient access to care

studies) and publication types (peer-reviewed articles, gray literature, and other forms of research reports). Titles, keywords, and abstracts were screened by the corresponding author (DO) to identify relevant studies based on a set of inclusion criteria developed during the initial scoping review. A second reviewer (VS) also independently screened retrieved studies. If there was disagreement between reviewers, studies were retained for full-text screening. The following inclusion criteria were applied: (1) studies took place in sub-Saharan Africa (i.e., in at least one of the 47 countries in the WHO African region), (2) interventions relied on the use of (mobile) phones, (3) studies focused on NCD-related treatment and care, and (4) studies provided an evaluation of the relationship between the intervention and NCD care. No language restrictions or time limits were applied.

Full-texts of 126 studies were retrieved and independently screened by DO and VS. At this stage, studies were excluded if interventions were based on phones and not primarily on mobile phones. In case of doubts, corresponding authors of studies were consulted for clarification. Studies were also excluded if they did not report results of (clinical) outcomes and/or an assessment of the intervention by patients, professionals, or proxies (e.g., relatives or guardians). In case of disagreements between DO and VS on the eligibility of studies, these were resolved by WQ.

Identifying candidate theories

During the initial scoping review, a number of candidate theories with potential explanatory value for mHealth interventions were explored. The identified theories and models included the Middle-Range Theory of Self-Care of Chronic Illness [28], the Theory of Reasoned Action/Theory of Planned Behavior [29], Rosenstock's Health Belief Model [30], Andersen's Behavioral Model of Health Services Utilization [31, 32], Young's Choice-Making Model [33], and Davis's Technology Acceptance Model [34, 35]. (See Additional file 2 for the reasons of inclusion/exclusion.)

Following discussions within the review team, Andersen's Behavioral Model of Health Services Utilization was retained because it could potentially provide insights into the mechanisms linking contextual and individual level factors with improved access to care. According to Andersen's model, peoples' decisions to use (or access) healthcare services are determined by three main factors: (1) predisposing characteristics (e.g., age, health beliefs), (2) enabling resources (e.g., availability of providers), and (3) need (e.g., burden of disease) [32].

As the review proceeded, Davis's Technology Acceptance Model was found to provide additional insights into mechanisms that are important for explaining improved access to care through mHealth interventions. Davis's Technology Acceptance Model posits that the use and acceptance of technology is determined by two factors: *perceived usefulness* and *perceived ease of use*. According to Davis's theory, health professionals will perceive a technology to be useful if they believe that it will help them to do a better job, and they will perceive a technology to be easy to use if they believe that it can be used without effort [35].

Data extraction, analysis, and synthesis

Two data extraction templates were developed using Excel to collate information on the included studies for analysis and synthesis. One template was used to summarize the characteristics of included studies (author(s), year of publication, title, study design, and country where the study took place). The other template for results and synthesis mainly contained information on the (type of) intervention, modality of interaction, outcome/outputs, and the five categories of the theoretical model: *predisposing characteristics, enabling resources, need, perceived usefulness, and perceived ease of use*.

The data synthesis involved team discussions in relation to whether the information extracted was rightly placed in the various domains and adjusted accordingly. Common themes were highlighted, examined, and refined in the light of their theoretical contributions. This involved classifying

findings from different studies into the categories of the theoretical model in order to understand the Context-Mechanism-Outcome (C-M-O) relationship. For example, if a study reported that older age groups were more likely to make use of an intervention because they found it more useful than younger age groups, this finding was classified into the category of a *predisposing characteristic* that leads to *perceived usefulness*.

Results

Search results and study characteristics

A total number of 6201 citations were retrieved, out of which 6181 were excluded after the appraisal process displayed in Fig. 1. The raw inter-rater agreement between DO and VS was 97% (123/126) after full-text screening. Additional file 3 provides information on key characteristics of the 20 included studies. The studies were published between 2005 and 2015, and presented information on 18 interventions in various areas of care (dermatology, mental healthcare, cancer, diabetes, and hypertension).

The contribution of mHealth to improved treatment and care for patients with NCDs

The main contribution of mHealth interventions to improved treatment and care for patients with NCDs in SSA countries is that they facilitate (remote) access to previously unavailable — and often specialized — services. In fact, almost all included studies highlighted this characteristic feature of mHealth interventions [20, 36–51].

However, the configuration of mHealth interventions differed considerably across settings, concerning involved actors and the mechanisms through which they facilitated access to care. In 12 studies, mHealth interventions essentially consisted of mobile phone-based consultations between two healthcare providers, where a specialized provider could be reached by another provider, thus indirectly improving patient access to specialized care [36, 38–43, 45, 47–49, 52]. In 8 studies, mHealth interventions connected a patient to a provider, thus directly facilitating patient access to (professional) care [20, 37, 46, 50, 51, 53–55].

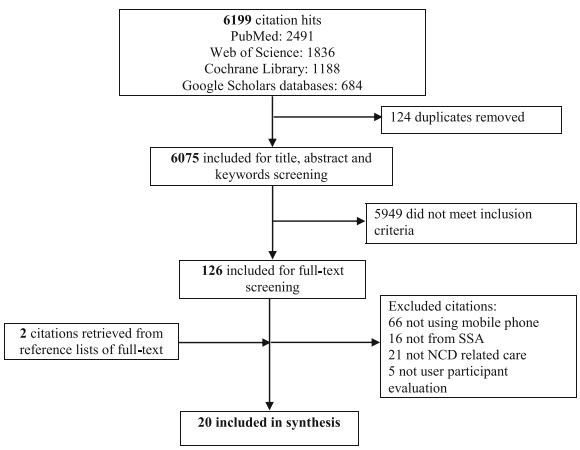

Fig. 1 Flowchart displaying the search results and the screening process for the primary studies

Participating patients or providers usually required only a few days of training on how to use the mobile technology (such as the mobile phone and its application software) and the consultation procedures [41, 43, 46–48, 50, 55]. An important feature of most mHealth interventions was that interactions between participants usually took place on the basis of standardized information exchange protocols [36, 39, 40, 42, 43, 45–47, 49, 52, 54]. These protocols helped to establish the purpose of the consultations and contributed to systematically ascertaining symptoms, diagnoses, and treatment. (See Additional file 3 for further details.)

From candidate theories toward a framework for understanding mHealth interventions

During the early stages of the review, Andersen's model and his conceptualization of predisposing characteristics, enabling resources, and need helped to focus the analysis on the role of the context in explaining why mHealth interventions contribute to improved access for some patients and in some areas but not in others. However, as the review proceeded, it became increasingly clear that the context has only an indirect influence on access to health services facilitated by mHealth interventions. At this stage, Davis's Technology Acceptance Model and his conceptualization of perceived usefulness and perceived ease of use contributed to understanding the mechanisms that link the context to improved mHealth based access to healthcare.

The two models of Andersen and Davis were then integrated into a framework for understanding the contribution of mHealth interventions to improved access to care for patients with NCDs in SSA. The framework is illustrated in Fig. 2 and shows that mHealth consultations take place either between a patient and a provider or between two providers with one provider facilitating patient access to another provider with certain specialized skills. The most important patient context factors (predisposing characteristics, enabling factors, and need) are shown on the left-hand side of the figure, while the most important context factors for (specialized) providers are shown on the right-hand side. For providers facilitating access between patients and (specialized) providers, context factors are sometimes more similar to those of patients and sometimes more similar to those of (specialized) providers.

In the center of the figure, arrows indicate the C-M-O relationship: The context factors influence the perceptions of patients and providers concerning how useful

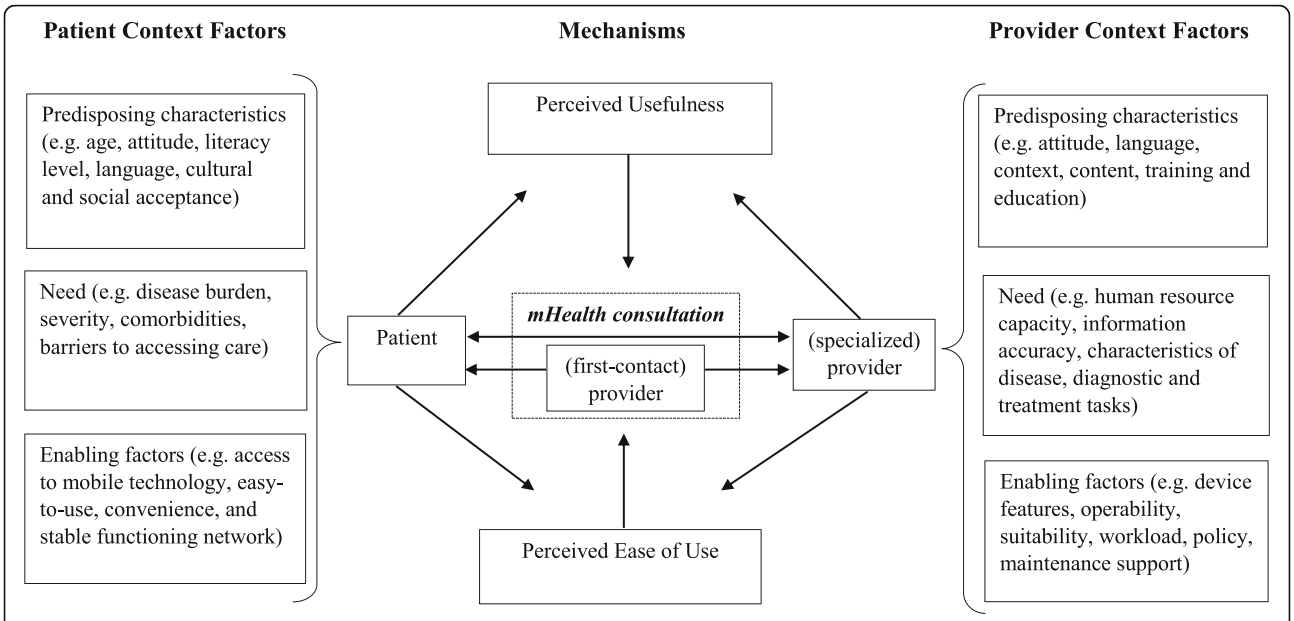

Fig. 2 Framework for understanding the contribution of mHealth interventions to improved access to care for patients with NCDs in sub-Saharan Africa

they find the mHealth intervention in comparison with other forms of service delivery, such as traditional face-to-face contacts or alternative computer-based telemedicine. Similarly, these factors also influence the perceived ease of use of mHealth in comparison with other options for service delivery. If interventions are perceived to be useful and easy to use, this will lead to the sustained use of mHealth interventions and — in turn — to better patient access to care (see Table 1).

Main findings from the literature

Table 2 summarizes the main findings from the literature, using the framework described above. It specifies separately for patients, (first-contact) providers, and (specialized) providers, what predisposing characteristics, enabling resources, and needs influence the perceived usefulness and the perceived ease of use.

Predisposing characteristics

For patients, the most important predisposing characteristic associated with the perception that a mHealth intervention was more useful than an alternative was the patients' cultural and social acceptance of the mobile technology, which involved familiarity with the technology in the community and absence of negative myths [38, 40, 41, 46, 53, 55]. Other important predisposing characteristics of patients included positive attitudes toward the intervention and the ability to communicate in a comfortable language (see Table 2). Similar predisposing characteristics were also reported for providers, i.e., positive attitudes [38, 40, 52], fluency in the language of the locality [46, 54], and sufficient training to use the technology [47, 52].

For both patients and (specialized) healthcare providers another important predisposing characteristic associated with the perception that mHealth was useful was source confidentiality [20, 39, 40, 49, 51]: Healthcare providers have to be confident that the information received via the mobile phone is accurate, and patients have to trust the (specialized) provider on the line in order to perceive the intervention as useful.

The perceived ease of use of an mHealth intervention depended most importantly on the predisposing characteristic that patients and providers were able to understand the language (see Table 2). In addition, studies reported that mHealth interventions have to be specifically designed to be easy to use for particular groups of patients, such as older age groups [55], or people with low educational levels [50, 55] or poor socio-economic backgrounds [50]. First-contact providers found mobile phone technologies easy to use if they were simple, relevant, and essentially combined local content and language [42]. Specialized providers' perception of ease of use was influenced by the accessibility of technical support, especially when there was the need to identify and solve technical problems such as software bugs [52].

Need

Patient needs were found to be particularly important factors influencing the perceived usefulness of mHealth interventions. If patients faced access barriers such as long travel times, waiting times, and high travel costs, mHealth interventions were perceived to be useful [20, 42, 45, 46, 48–50, 52, 53, 55]. Furthermore, three studies found that sicker patients were more likely to

Table 2 Detailed classification of evidence supporting the framework for understanding why, for whom, and in what circumstances mHealth interventions work in sub-Saharan Africa

	Patient		(First-contact) provider[a]		Specialized provider[b]	
Mechanism Context	Perceived usefulness	Perceived ease of use	Perceived usefulness	Perceived ease of use	Perceived usefulness	Perceived ease of use
Predisposing characteristics	• Cultural and social acceptance (familiarity/ usage of mobile technologies) [38, 40, 41, 46, 53, 55] • Positive attitude (motivated, self-empowered, activeness) [38, 55] • Age group (middle/older) [51] • Language of communication (language of locality) [46, 54, 55]	Suitability and simplicity for: • (Older) age group [55] • (Low) literacy, educational levels [50, 55] • (Poor) socio-economic backgrounds [50] • Not physically active [50]	• Positive attitude (enthusiastic, motivated, empathetic, interest, dedication, volunteer) [38, 40, 52] • Prerequisite knowledge (to provide adequate information) [47]	• Simple, relevant, combination of local content and language (interface) [42]	• Positive attitude (positive perception and trust of new technology) [52] • Basic knowledge (about the technology) [52] • Fluency in language of locality [46, 54]	• Accessible location of technical support (in-country or local software developers) [52] • Understandable language of communication (among users and software developers) [52]
Need	• Disease severity and comorbidities [20, 51, 55] • Barriers to accessing care or information (not affordable, easily, promptly, quality and/or appropriate, limited, long-distance travel, travel cost, waiting time, delaying, presenting late) [20, 42, 45, 46, 48–50, 52, 53, 55]	-	• Lack of capacity to provide needed care (limited training/education, decision-making power/ support, point-of-care clinical information, specialized care, specialty referral systems) [36, 38–40, 47, 52] • Barriers to reporting and accessing supervision [37, 40–42, 47, 51] • Need to follow guidelines [50, 54, 55]	-	• Lack of human resources (limited specialists, trained or skilled personnel, unequal distributions of professionals, over-burdened workload) [20, 36, 38–41, 43, 45, 47] • Lack of necessary systems and infrastructure (health facility, referral system, transport) [38] • Lack of accurate information [46, 47] • Task shifting to achieve early intervention and low costs of care [42, 43, 49, 54]	• Characteristics of disease conditions (extent, severity) [36, 43] • Characteristics of diagnostic and treatment tasks (feasibly assess/examine, freely question patient, probe for additional information, conduct special tests) [43, 47, 49]
Enabling resources	• Access to mobile phone [37, 45, 46, 50, 53–55] • Access to mobile technology infrastructure [45, 48, 52, 55] • Affordability of services [50, 54, 55] • Convenience, privacy, autonomy, reduced time and travel cost [20, 43] • Service/program awareness [38, 40]	• Familiar and easy-to-use mobile technology (SMS, icons) [53, 55] • Maintenance (phone recharge, repair, durability, portability) [37, 55]	• Access to phone [41, 45] • Telecommunication networks (functioning, stable, accessible, available, low-cost) [36, 39, 42, 47] • Basic infrastructural resources (information, good roads, ambulance services) [41, 47, 52] • Operating funds and logistics (availability) [38, 40, 52]	• Easy portability and operability (direct, instant, immediate) [36, 39] • Phone features (quality camera, smartphones) [36, 41] • Maintenance support (equipment/ SIM card/mobile device failure, sporadic power	• Access to phone networks (in underserved communities) [20] • Tolerable burden of workload [46, 47] • Incentives (payment) [47, 55] • Policy (network or data protection, liability, consent, confidentiality, phone usage, staff job descriptions) [43, 45, 51, 52]	• Phone features (photograph, picture quality, video functionality, interface, text messaging, appropriate screen, zoom, long-lasting battery) [36, 41, 43, 45, 47, 51] • Suitability and equivalence to existing care processes (face-to-face care, assess nonverbal behaviors) [41, 49, 51, 54]

Table 2 Detailed classification of evidence supporting the framework for understanding why, for whom, and in what circumstances mHealth interventions work in sub-Saharan Africa *(Continued)*

• Assistance/support (spouse, partner, friend, family member) [51]	• Policy and sustainability (to avoid strike actions, staff turnover rate) [40, 52] • Continuous training (workshops) and sensitization [47, 52] • Tolerable burden of workload [40]	outages, battery power problem, software bugs, theft, medical technology) [45, 52]

[a](First-contact) provider = the referring/consulting healthcare provider, usually in a provider-to-provider mHealth consultation
[b]Specialized provider = the consultant specialist or experienced healthcare provider whose expertise is being sought in mHealth consultations
Source: authors' own compilation based on the findings of the included studies in this review

use the interventions, possibly because they found it easier to use the mHealth interventions rather than, for instance, walk to a provider [20, 51, 55].

The most important need contributing to (first-contact) providers perceiving mHealth to be useful was their self-reported lack of capacity to provide adequate care [36, 38–40, 47, 52]. Furthermore, (first-contact) providers reported that they needed support in order to follow guidelines [50, 54, 55] and that mHealth could contribute to overcoming barriers to accessing supervision [37, 40–42, 47, 51]. Also for (specialized) providers, several need factors contributed to the perceived usefulness of the intervention, including, for example, an over-burdening workload [20, 36, 38–41, 43, 45, 47, 50] and a lack of adequate referral and transport systems [38, 46, 47].

Studies did not report that the needs of patients and (first-contact) providers influenced their perceived ease of use. However, specialized providers found mHealth easier to use in the context of certain disease conditions, such as acne, herpes simplex, Kaposi's sarcoma, and flame burns in dermatology, than in others (scald burns, thickness wounds, and atopic dermatitis) [36, 43] and easier for certain diagnostic and treatment tasks (sharing feedback with patients, continuous clinical follow-ups) than for others (conducting physical examinations, special tests, and probing for additional information) [43, 47, 49, 51].

Enabling resources

For patients, unsurprisingly, the two most important enabling resources necessary for a mHealth intervention to be (perceived to be) useful were access to mobile phones [37, 45, 46, 50, 53–55] (also possible through borrowing [46, 50]) and the availability of a functioning stable telecommunications network [20, 36, 39, 42, 45, 47, 48, 52, 55]. Other enabling resources were assurance of privacy [43, 48], support from partners/relatives [51, 55], reduced costs of travel, and reduced time away from home or work [24, 50–53].

Enabling resources for first-contact providers were access to basic infrastructure, such as electric power and functioning medical technologies [49, 52], ambulance services and good roads [46, 47], as well as the affordability of telecommunication services and other operating costs [50, 54, 55] (see Table 2). For (specialized) healthcare providers, the most important enabling resources were a tolerable additional workload [40, 46, 47], the use of financial incentives [47, 55], and the availability of policy guidelines regarding data protection, phone usage, etc. [40, 43, 45, 52].

Enabling resources influencing patients' perceived ease of use of mHealth interventions included the durability and portability of mobile phones [37, 55] and the low complexity of the technology, for example, short message service (SMS) and icons [53, 55]. The same enabling resources — easy portability and operability [36, 39], using technologies from basic SMS to smartphones, built-in camera, and battery-saving apps [41, 43, 45, 52] — were also found to be associated with the perception among healthcare providers that mHealth was easy to use.

Discussion

Summary of main findings

This is the first realist review of mHealth interventions for patients with NCDs in SSA countries. It shows on the basis of a wide range of included studies how, for whom, and in what circumstances mHealth interventions contribute to improved access to (specialized) care for patients with NCDs in SSA. The review did not focus on specific interventions, specific diseases, or specific providers. Instead, it adopted a middle-range perspective to identify how contextual factors influence the outcome of mHealth interventions in terms of improved access to care; in other words, how to identify C-M-O relationships.

Our framework for understanding mHealth interventions illustrates the causal mechanisms that explain how, for whom, and in what circumstances mHealth interventions facilitate access to care (see Fig. 2). As to how mHealth interventions facilitate access to care, a mHealth intervention will ultimately contribute to improved access to care only if it is perceived to be useful and easy to use. The framework therefore shows that predisposing characteristics and needs of patients and healthcare providers as well as enabling resources influence the perceptions of patients and providers that mHealth interventions are useful and easy to use.

Considering for whom or how patients and provider characteristics influence mHealth interventions, the reviewed studies revealed that a positive attitude toward the mobile technology and the ability to communicate in a common language were the most important predisposing characteristics of patients and providers contributing to the perception that mHealth was useful and easy to use. In addition, needs of patients and providers, such as a high perceived burden of disease (e.g., in cases of reduced mobility) and the perceived lack of capacity of first-contact providers to provide adequate care, influenced the perceived usefulness and ease of use.

Furthermore, studies reported that certain circumstances of enabling resources, such as the availability of a stable communications network, accessible maintenance services, and regulatory policies (e.g., on data protection), contribute to the perception of patients and providers that mHealth interventions are useful and easy to use.

Strengths and implications for policy makers and program managers

This review has several strengths. Following a realist methodology, it has included a wider scope of evidence than previous reviews [6, 10], and it has focused on the policy-relevant questions of how, for whom, and in what circumstances mHealth interventions facilitate access to care. The framework presented in Fig. 2 and the more specific context factors summarized in Table 2 have major implications for policy makers and program managers.

Firstly, given that predisposing characteristics of patients and providers influence the success of mHealth interventions, it is important that these factors are taken into account during the planning stages prior to the introduction of a new mHealth intervention. For example, program managers should consider evaluating the cultural and social acceptance among patients and providers to use the mobile technology when selecting a particular setting for the intervention. In particular, healthcare providers should be recruited who are enthusiastic and motivated to use mHealth as part of their job. Furthermore, interventions should be designed in such a way that patients, providers, and technical support will be able to communicate in a common language; otherwise, interventions are unlikely to be perceived to be useful and easy to use.

Secondly, and similar to the first point, it is important for policy makers and program managers to consider the specific needs of patients and (first-contact) providers to access (specialized) healthcare providers when preparing for the introduction of an mHealth intervention. For example, mHeath interventions will be particularly useful for severely ill patients or patients who face barriers to access (specialized) care, e.g., because they have difficulties in walking. Similarly, those (first-contact) providers who have a particular need for advice and supervision for treating certain groups of patients will perceive mHealth to be particularly useful. In addition, the influence of need factors on the perceived ease of use of (specialized) providers should be considered when preparing the introduction of an mHealth intervention, e.g., that mHealth is better for sharing feedback and continuous follow-up than for special tests and for probing for additional information [43, 47, 49].

Thirdly, policy makers and program managers have to be aware that the availability of enabling resources is essential for the successful implementation of an mHealth intervention. Enabling resources include, for example, easy access to mobile phones/devices, a stable and accessible communications network, and access to basic infrastructural resources, such as roads and ambulance services, which are necessary for mHealth supported referral systems [20, 36, 37, 39, 41, 42, 45–48, 50, 52–55]. Furthermore, policies on data protection and policies limiting the extra workload of mHealth interventions for professionals, possibly providing additional financial incentives, can support the sustained use of mHealth. See the checklist for policy guidance in Table 3.

Limitations

This review has a number of limitations. First, it does not answer the question of whether mHealth interventions facilitate improved access to care for patients with NCDs. It therefore does not contribute to the debate of whether mHealth interventions should be scaled up. Second, given that this review included a broad range of studies with various study designs, the inclusion of a specific study's finding into the review depended on rather subjective judgments. Following guidelines for realist reviews [11, 12, 26, 27], it was necessary to make decisions about whether a study's findings were relevant for the development of the framework and whether inferences drawn by an original study were sufficiently supported by evidence. Third, despite an extensive literature search and the inclusion of a wide range of studies, the available evidence on mHealth interventions in SSA remains rather limited. Therefore, the contextual factors summarized in Table 2 are rather indicative. It is very likely that there are further predisposing characteristics, enabling resources, and needs that are relevant for explaining how, for whom, and in what circumstances mHealth interventions work beyond those identified in our review. Future research is needed to confirm the theoretical framework developed in this paper and to operationalize some of its categories. For example, concerning the interplay of predisposing characteristics and perceived usefulness (see Table 2), research is needed to confirm that cultural and social acceptance is a predictor of perceived usefulness. This requires an operationalization for measuring cultural and social acceptance and for quantifying its impact on the sustained use of mHealth. Similarly, more research is necessary to better understand the interplay between need and specialized providers' ease of use. For example, researchers should explore the suitability of mHealth applications for different diseases and concerning different diagnostic and treatment tasks. This could include an assessment of the ease of use of mHealth for sharing feedback with patients with different diseases or different levels of severity, e.g., diabetes versus hypertension or diabetes with and without complications, and the differential effects on health outcomes.

Conclusions

The implementation of mHealth interventions in SSA has great potential to improve treatment and care for

Table 3 A checklist for guiding the selection, development, implementation, evaluation, and policies regarding mHealth for treatment and care of non-communicable diseases in sub-Saharan Africa

Patient context factors
• The personal characteristics of patients, which predispose them to utilize the services provided by the intervention. For example:
a. Enthusiasm to use mobile phone/device
b. Educational/literacy level
c. Age (may be more sustainable among middle/older age groups)
d. Local content/language of locality
e. Cultural and social acceptance
• The needs of patients to access the required healthcare services. For example:
a. Disease severity and comorbidities
b. Barriers to accessing care/information
• The necessary enabling (personal and community) resources to facilitate the implementation of the intervention. This includes:
a. Access to mobile phone/device *(essential)*
b. Stable and accessible communication networks and technology infrastructure *(essential)*
c. Convenience and privacy *(essential)*
d. Socio-technical support *(essential)*
e. Affordable services *(critical)*
f. Awareness raising *(for increased participation)*
Provider context factors
• The personal characteristics of healthcare providers, which predispose them to deliver health services through a mHealth intervention. For example:
a. Experience and competence
b. Positive attitude toward technology
c. Basic knowledge of the technology involved
d. Fluency in language of locality
e. Understandable language of communication among users and technical support team *(software developers)*
• The needs of healthcare providers to deliver the required healthcare services. For example:
a. Characteristics of disease conditions *(extent, severity)*
b. Characteristics of diagnostic and treatment tasks
c. Burden of workload
d. Adequacy of referral and transport systems
• The necessary enabling (personal and community) resources to facilitate the utilization of the intervention. This includes:
a. Access to mobile phone/device and stable networks *(in underserved communities)*
b. Easy portability and operability *(features, apps, functionalities, etc.)*
c. Available basic infrastructural resources *(good roads, ambulance services)*
d. Suitability and equivalence to existing/alternative care processes *(attractive)*
e. Tolerable burden of workload and incentives *(essential)*
f. Maintenance-technical support *(essential)*
g. Continuous training and sensitization
h. Low operating costs and available funds/logistics
i. Policy and regulation *(network/data protection, staff job descriptions, and contracts, etc.)*

patients with NCDs, but the causal mechanisms explaining why, how, for whom, and in what circumstances these interventions work used to be unexplored. Our realist review shows that the contribution of mHealth interventions to improved treatment and care for patients with NCDs is that they facilitate (remote) access to previously unavailable — and often specialized — services. In addition, our framework for understanding mHealth interventions illustrates that predisposing characteristics and needs of patients and healthcare providers as well as the availability of enabling resources in the community influence the perceptions of patients and providers that mHealth interventions are useful and easy to use — and these perceptions are essential for the successful implementation of an mHealth intervention.

The implication of these findings for policy makers and program managers is that predisposing characteristics and needs of patients and providers as well as the necessary enabling resources should be considered during the planning stages prior to the introduction of an mHealth intervention. In addition, researchers would benefit from placing greater attention on the context in which mHealth interventions are being implemented — as the context largely determines the predisposing characteristics and needs of patients and providers as well as the enabling resources — instead of focusing (too strongly) on the technical aspects of these interventions.

Additional files

Additional file 1: List of databases accessed and the search strategies used. (DOCX 20 kb)

Additional file 2: Theories included or excluded in review. (ZIP 28 kb)

Additional file 3: Description of the included articles providing the information for the synthesis and conclusions in this review. (DOCX 24 kb)

Abbreviations

C-M-O: Context-Mechanism-Outcome; mHealth: mobile phone-based health; NCD: non-communicable disease; SSA: sub-Saharan Africa; WHO: World Health Organization

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Authors' contributions
DO and WQ conceived and designed the study. DO and VS collected data. DO prepared an initial draft of the manuscript, which was subsequently revised by VS and WQ. All authors participated in data synthesis and analysis, and all read and approved the final manuscript.

Competing interests
The authors declare that they have no competing interests

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Not applicable.

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Not applicable.

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Chapter 5: A mixed-methods study to review non-communicable disease management in Ghana

Daniel Opoku, Victor Stephani, Reinhard Busse, Wilm Quentin

African Health Sciences [in review]

A mixed-methods study to review non-communicable disease management in Ghana

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Abstract

Background

In the combat against the growing burden of non-communicable diseases (NCDs), improving disease management is crucial, same as the need for many other policy interventions, including health promotion, prevention, and health systems strengthening activities. Ghana is one of the countries in Sub-Saharan Africa making significant efforts in this regard. However, how the health care system in Ghana addresses the growing burden of NCDs is yet to be explored. This review aims to examine the approach of the health care system in Ghana towards NCD management and to identify areas for improvement.

Methods

A mixed-methods approach was used to systematically review peer-reviewed studies and grey literature reporting the treatment and care of NCDs in Ghana, as well as interview transcripts of 13 policy-makers who were responsible for developing Ghana's policy and strategy for the prevention and control of NCDs. The analysis was guided by the WHO health system framework focusing on the six building blocks.

Results

91 studies conducted from 1990 – 2016, 13 interviews of policy-makers and other institutional documents were relied upon to examine the approaches for managing a wide range of NCDs identified in Ghana and the associated reform initiatives in the health care system. Specific attempts to improve health services delivery includes task-shifting NCD management to community health workers at the primary health care level and integrating complementary and alternative medicine (CAM) into the national health system. The implementation of the national health insurance scheme has been a crucial measure to

improve care, but it suffers serious setbacks, particularly the alleged high out-of-pocket spending for NCD-related care. Special (programmatic) interventions to address specific NCDs like hypertension and diabetes have also included mobile phone-based health (mHealth) interventions, but they all remain at (pilot) project levels.

Conclusion

In Ghana, CAM play an important role in NCD management and need to be explored in the context of rigorous science. Both CAM practices and practitioners need to be effectively regulated. There is the need to critically assess out-of-pocket spending for NCD-related care. For special programmatic NCD interventions, useful frameworks now exist to guide sustainability and national scale-up.

Keywords

Non-communicable diseases, NCDs, disease management, review, mixed methods, qualitative research, sub-Saharan Africa, Ghana, health system, health policy,

Background

With the drastic decline of communicable, maternal, and neonatal diseases as cause of death and burden of disease across the globe [1], and particularly in Africa [1, 2], the epidemiologic transition toward noncommunicable diseases (NCDs) is in full swing. By 2030, 42% of all projected deaths in sub-Saharan Africa (SSA) will be caused by NCDs, which will then surpass communicable diseases as the leading cause of death in the subregion [3, 4]. In some African countries such as Ghana, statistics show that already today about 43% of the total annual deaths are caused by NCDs, led by cardiovascular diseases [5–7].

The World Health Organization (WHO) has been leading global efforts to prevent and control NCDs [8], defining a global target of reducing premature mortality from NCDs by 25% by 2025. To achieve this, improving the management of NCDs is crucial but also many other policy interventions, including health promotion, prevention, and health systems strengthening activities, are needed[8, 9].

Ghana is one of the countries in SSA that has made significant efforts to address the growing burden of NCDs. Since 1992, a wide range of policies and programmatic responses have been initiated to reduce the incidence of NCDs and to prevent NCD associated complications and disabilities[10]. A previous study identified numerous government policies and interventional programmes that have focussed mostly on health promotion and prevention of NCDs [11, 12]. Less is known about how the health care system in Ghana addresses the growing burden of NCDs.

Therefore, this study aims to examine the approach of the health care system towards NCD management in order to identify areas for improvement.

Methods

The study employed a mixed-methods approach to systematically review data gathered from peer-reviewed literature, institutional documents and interviews of policy makers with working experience relating to NCD management in Ghana. First, it was important to define the scope of this study based on the 3 main themes – NCDs, NCD management and health systems – to aid the review synthesis. According to the WHO, "…NCDs, also known as chronic diseases, tend to be of long duration and are the result of a combination of genetic, physiological, environmental and behaviours factors. The main types of NCDs are cardiovascular diseases (like heart attacks and stroke), cancers, chronic respiratory diseases (such as chronic obstructive pulmonary disease and asthma) and diabetes" ([9] p. 1). NCD

management, according to the WHO, "…includes the detection, screening and treatment of NCDs as well as palliative care" ([9] p.4). From a health care systems' perspective, this involves all people, facilities, resources, guidelines, policies and practices/activities that aim to prevent, eliminate, cure, and/or delay the onset of complications and disabilities, and to improve patients' quality of life [13, 14]. WHO has defined health systems as consisting of six building blocks [15], including (1) healthcare service delivery, (2) health workforce, (3) health information system, (4) medical products/technologies, (5) healthcare financing, and (6) leadership/governance. This framework guided the analysis of NCD management in Ghana.

Systematic review

In October 2016, we performed a systematic review of peer-reviewed literature. A search was conducted in English using a search strategy adjusted for three databases most commonly accessed in this field (i.e. PubMed, Web of Science and Google Scholar) with no limitations on the date and language of publications. The search terms were broadly *"non-communicable diseases"*, *"disease management"* and *"Ghana"* (Details in Additional file 1). Two independent reviewers reviewed the list of 1215 retrieved studies using a set of exclusion criteria provided in Figure 1. After removal of duplicates, the titles, keywords and abstracts of 990 studies were screened. The full-text of 153 articles were evaluated (Figure 1). DO and VS independently reviewed all abstracts and full texts and evaluated eligibility for inclusion. There was high agreement (96.7%) between the two reviewers with regard to the selection of 91 studies included in the analysis. Conflicts were resolved through discussions between DO and VS. All included studies provided partial or comprehensive information about the management of any kind of NCDs in Ghana, including the resources involved.

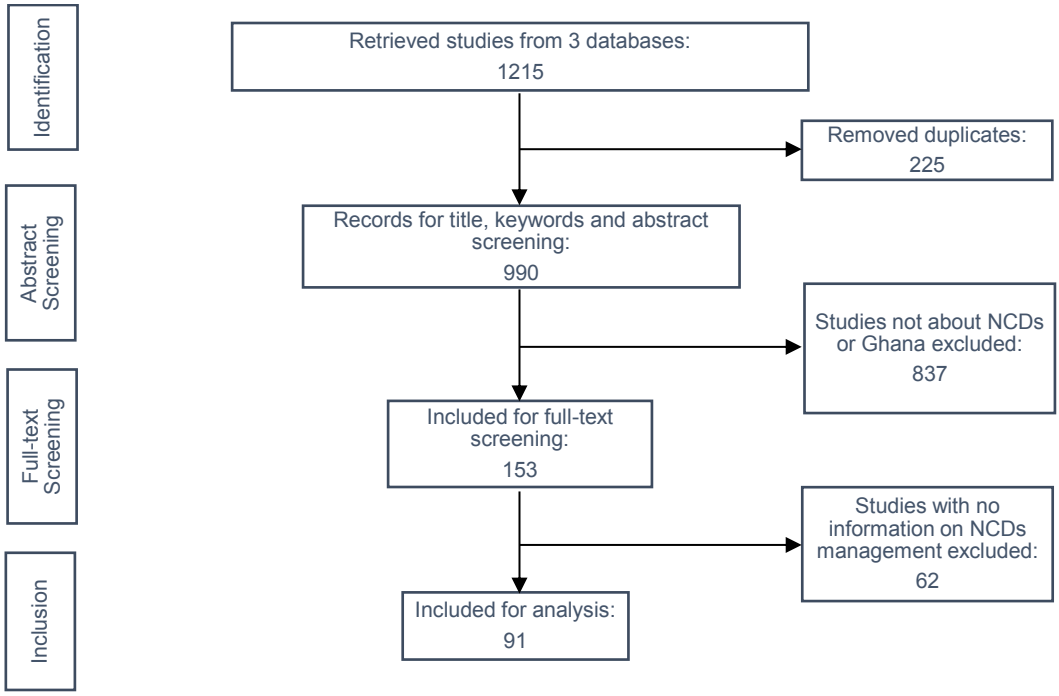


Figure 1: Screening process for selecting included studies

Interviews of policy makers

Using a semi-structured interview guide, 13 policy makers who were responsible for developing the 2012 National Policy for the Prevention and Control of Chronic Non-Communicable Diseases in Ghana [16] were interviewed between November 2015 and January 2016. Questions were asked about participants' working experience with NCDs, assessment of NCD management in Ghana, specific programmes that are geared toward NCD care and management, recent major changes or transformations in NCD management as well as policy and guidelines, the challenges associated with NCD management and the measures that have been put in place to address them. A detailed description of the qualitative methods employed, and participants interviewed is provided in Opoku et al. [17].

Institutional documentary review

A more general google search was also conducted to retrieve (non-peer-reviewed) information on NCD management in Ghana. In addition, the websites of the Ghana Ministry of Health, Ghana Health Service, National Health Insurance Authority, Ghana Statistical Service, WHO and the World Bank were searched to retrieve information on relevant NCD management initiatives, financing, and policies, which may not be described in peer-reviewed literature. The online databases of the two oldest and most popular public universities in Ghana –

University of Ghana and Kwame Nkrumah University of Science and Technology – were also searched to retrieve relevant theses and unpublished manuscripts.

Analysis

This review involved content analysis of a large dataset, extracted using computer assisted qualitative data analysis software – ATLAS.ti Version 7. In addition to the data extracted for demographic, socio-economic and medical characteristics of NCD patients, relevant portions of the included studies and documents were assigned codes belonging to the broad categories of: a) *healthcare services delivery,* b) *health workforce,* c) *health information system* d) *medical products/technologies,* e) *healthcare financing,* and f) *leadership/governance*. These categories are largely based on the WHO Health System Building Blocks Framework (World Health Organization 2007).

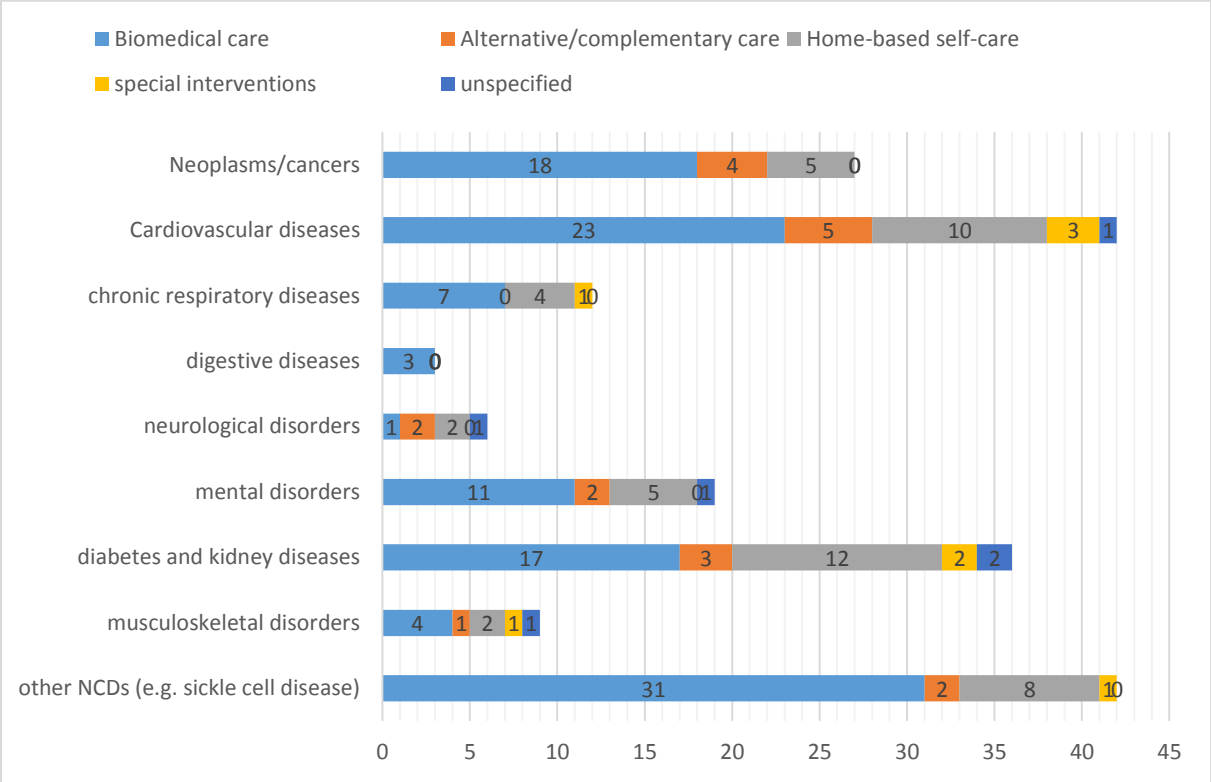
Following narrative synthesis approaches [18] and content analysis methodologies [19], the study focused mainly on assessing the main approaches of NCD care and treatment within the health system of Ghana as well as the major reforms in the service delivery, health workforce, information, medical products and technologies, financing, and leadership/governance in order to advance NCD management.

Results

Study characteristics

Ninety-one (91) publications were included in this review. They comprised 3 commentary and discussion papers, 4 theses, and 84 peer-reviewed studies of different designs and complexities. Studies were conducted from 1990 to 2016 mostly in urban areas. Figure 2 shows that most studies focused on management of cardiovascular diseases, diabetes and kidney diseases. The figure also shows the main care settings, where studies took place. Most studies stem from biomedical facilities or address self-managed (at home). Interestingly, also the use of herbal medicine and faith-based treatment has been reported for most major categories of NCDs (Figure 2). Examples of the special interventions found are provided in Table 3 with details.

Figure 2: Total number of studies, classified by type of NCD and care setting.



Source: Authors' own compilation based on 91 included studies from 1990 – 2016, pubilcations are grouped by disease category according to the Global Burden of Disease study.

Further study characteristics, including the types of NCDs identified, are provided in Additional file 2a.

In addition, transcripts of interviews with 13 policy-makers, who were actively involved in NCD-related health policy-making in Ghana and had an average of 26 years working experience, were reviewed (see Opoku et. al [17] for summary characteristics of the policy-makers interviewed). Institutional documents were also reviewed, including a report from the Economist Intelligence Unit [4], the National Policy for the Prevention and Control of Chronic Non-Communicable Diseases in Ghana [16], as well as Ghana's National Health Insurance Act, 2012 (ACT 852) [20].

Demographic, socio-economic and medical characteristics of NCD patients

Although not all the included studies reported on patients, a total number of 34,112 patient-participants were identified. However, it appears same patient-participants may have been reported several times in some of the studies [21–31]. This notwithstanding, about 0.65% (222) of the patient-participants were under 5 years old [12, 32, 33] and 50.96% were above 18 years old [21, 28–85] who were accessing/adhering to various forms of treatment/care.

Only a few of the patient-participants were reported to have had tertiary (579) and secondary (1,975) level education, as compared to no formal educational background or up to basic level (2,333). Generally, female patients involved in the included studies were 53.4% more than the male participants (See Additional file 2b).

Thirty-two (32) of the included studies took place in urban dwellings, compared to the seven (7) in rural areas [26, 27, 52, 55, 62, 73, 86]. This gives an indication that, generally, the majority of the reported patient-participants were pulled from urban places of residence.

Health services delivery for NCD management in Ghana

Biomedical facility-based care

Biomedical facility-based forms the backbone of the Ghana health system and most studies investigated care provided to NCD patients at these facilities (see Figure 2). Biomedical facility-based care is mainly provided by the public sector, which is structured in three levels: primary/district level, secondary/regional level, and tertiary/specialized institutional level (see Table 1). At the primary level, there are three main types of public providers, including Community-based Health Planning and Services (CHPS) compounds, community (poly-) clinics, and (general) district hospitals, which are staffed by a wide range of different categories of health workers (see Table 1). Private providers include chemical shops, pharmacies and drug peddlers. At the secondary level, regional hospitals are the most important providers, while public university teaching hospitals and some private facilities constitute the tertiary level of care. Some specialists are available at the secondary level but most of them are available only at the tertiary level.

Table 1: Summary of biomedical facility-based care for NCDs reported in the review

Level of care	Type of facility	Staff	Treatment/services	Reference
Primary/ district level	Community-based Health Planning and Services (CHPS) compounds, drug peddlers, chemical shops, (private) pharmacies, community (poly)-clinics, (general) district hospitals	Community health workers (CHWs), community-based rehabilitation workers (CBRs), community mental health workers (CMHOs), community psychiatric nurses (CPNs), clinical psychiatric officers (CPOs), nurses,	Outpatient treatment, prescriptions and dispensaries, tests, monitoring, hospitalization	[23, 24, 26–28, 36, 56, 71, 87–91]

		midwives, district medical officers/doctors,		
Secondary/ regional level	General medical and surgical clinics, (private) specialist clinics, Regional hospitals	*Medical staff*: clinical support staff, nurses, general Practitioners (GPs)/physicians/doctors, Some specialists (ophthalmologists, psychiatrists, etc.); *Non-medical staff*: administrators	Some specialized services and tests, prescriptions and dispensaries, hospitalization, operation/surgery	[10, 70, 71, 79, 87, 88, 92–94]
Tertiary/ specialized institutional level	Public institutions (university/teaching hospitals) and some private institutions	Nurse educators, professional nurses, doctors (house officers), specialists (diabetologists, nephrologists),	*Medical services*: general surgical outpatient treatment, attentive/routine care, counselling, monitoring, prescriptions and dispensaries, specialized/specialist care (for referred cases, e.g. diabetes, dialysis, nephrology, kidney transplantation, dental care), self-care instructions, follow-ups, hospitalization, surgery/operation;, *Non-medical services*: developing treatment guidelines, training healthcare providers	[10, 29–31, 35, 38, 41, 44, 45, 48, 52, 53, 60, 61, 63, 71, 75–78, 83, 87, 88, 90, 91, 95, 95–108]

Source: Authors' own compilation based on 91 included studies from 1990 – 2016

Since 2005, significant efforts have been made to strengthen the primary health care system via introduction of the Community-based Health Planning and Services (CHPS) compound model, especially for mental disorders [23–25] and cardiovascular diseases (hypertension) [42, 109, 110]. The CHPS compounds are mostly located in (rural) communities and are staffed by community health workers, sometimes including also community psychiatric nurses (CPNs), who serve as the primary point of care. CHWs take care of NCD patients most at the onset of a disease before referring them to more specialized healthcare providers, usually when patients exhibit signs of complications [23–25, 42, 109, 110].

There is some level of coordination amongst the providers, at least through the referrals for (specialised) care services to (higher level) facilities. Interestingly, also CAM practitioners such as herbalists referred patients to biomedical facilities. In the particular case of diabetes care, Akanbonga [36] found that:

> *"out of the 34 traditional herbalists who said they manage diabetes mellitus, 25 (73.5%) said they do refer diabetics to biomedical health facilities mostly for blood sugar tests or monitoring."* ([36] p.67)

Nevertheless, this review found no clear guidelines as to which facilities patients with NCDs should access as the first point of care, and how to navigate through the various levels of the biomedical facility-based care. In fact, de-Graft Aikins [109] explained that:

> *"There is persistent over-utilization of secondary and tertiary healthcare services because of weak gate-keeping at the level of community healthcare."* ([109] p.2)

Home-based self-care

The responsibility of self-care was found as rather onerous tasks of the patients and their families/relatives – usually the immediate family members – who served as caregivers. It was ultimately to protect against developing complications and the individual actions taken were mainly dietary modification but also self-monitoring, medical adherence, other healthy behaviours (e.g. exercise), awareness/knowledge of complications and 'body-listening' or watching body reactions [7, 12, 31, 36, 42, 48, 50, 51, 56, 57, 62, 69, 85, 86, 89, 95, 100, 103, 105]. This did not preclude drawing on both personal experiences and observations of others, strong belief and its virtue of cure and survival, cultivating plans for personal advancement as well as various strategies which particularly helped patients and their families maintain a balanced psychological state [41, 50, 86, 87, 100, 109].

Again, it was ascertained from the majority of included studies that, patients-participants also relied on support groups, especially for diabetes [56, 95] and sickle cell disease [51], as well as a set of support systems involving culture, social, beliefs and spirituality in order to cope with NCDs to a considerable extent [29–31, 33, 36, 41, 50–52, 56, 65, 73, 74, 82, 85, 89, 100, 111].

Complementary and alternative care (CAM)

Consultations with herbalists and/or spiritualists also provided complementary and alternative care (CAM) among the NCD patient-participants. This was mainly premised on the quest for

an anticipated time-bound cure or healing for otherwise 'incurable' NCDs such as epilepsy, cancers, hypertension, diabetes (type II) and oral health conditions. And patients who sought these local non-hospital treatments/remedies largely did so before, rather than during or after hospital treatment [28, 31, 36, 40, 41, 68, 69, 74, 89, 95, 109]. Critically, one policy-maker interviewed in this review assessed the situation as follows:

> *"One of the major challenges we have in this country is the issue of herbal medicines. Because the hospital services are not apt, because people get frustrated when they go to the hospitals, people in the quiet would tend to go out for herbal medicines because they are told – and I'm using diabetes as an example here – that this condition can be cured or it will be treated at this time and then you would get cured. Every human being would like his disease to be cured, not to be controlled."* [TR:3]

It has been recommended by Akanbonga [36] that public herbal clinics could be established in attempt to integrate these services into the national health care system. Actually, one of the interviewed policy-makers revealed that:

> *"there are some [biomedical-based] facilities making efforts to integrate herbal medicine into the practice. So, if you go there, they would ask you whether you want the herbal or the orthodox. As you know, the KNUST trains people in herbal medicine. So, it's supposed to be a collaborative thing and maybe initially we those [policy makers] in the Ministry of Health were not proactive enough, but now we have no choice!"* [TR:8]

Table 2 presents a summary of the modes of treatment identified in this review and it includes herbs, diet restrictions, prayer/spiritual means and some extreme forms of treatment like falling into fire prescribed for certain NCDs like epilepsy [30, 36, 40, 41, 89, 90, 100, 109].

Table 2: Summary of identified alternative/complementary treatment

Local treatment	Type of facility	Provider	Treatment/services	Reference
Herbalism/herbal treatment	Homes, public herbal clinics (recommended)	Herbalists	Herbs/herbal products, diet restrictions or modification, organic foods and food supplements, homeopathy, various remedies, extreme treatment methods (e.g. falling	[30, 36, 40, 41, 68, 89, 90, 100, 109]

			into fire)	
Divination/faith-based treatment	Prayer camps, churches, mosques, traditional shrines, religious bodies	Spiritualists, spiritual/religious leaders (pastors, clergy, malam, prophet, traditional priest, divine instructors)	Prayers and fasting, healing and deliverance, other spiritual means and supernatural activities	[30, 36, 41, 50, 86, 89, 90, 100, 109]

Source: Authors' own compilation based on 91 included studies from 1990 – 2016

Health workforce for NCD management in Ghana

The spectrum of health workforce for NCD management identified in this review ranges from (highly) skilled personnel to grassroot (volunteer) community-based health workers. Unfortunately, this review did not find a clear aggregate of the health workforce specified for NCD management in Ghana. Nevertheless, based on the identified number of patient-participants and health workforce in the 91 included studies, a total of 1352 health workforce were identified, including 207 community-based health workers and 62 traditional herbalists. Thus, based on the number of patient-participants, the health workforce for NCD care could be estimated at a 1:25 ratio (see Additional file 2a). Here too, this estimate does not represent the true estimation of the overall health workforce for NCD care in Ghana, but it is simply to demonstrate the possible gaps in the level of health workforce for NCD treatment and care in Ghana.

Efforts to address gaps in the health workforce [16] have included specific attempts on task-shifting Cardiovascular Disease (CVD) care [42, 109, 110] and mental care [23–25] to community health workers in order to improve quality and access at the primary care level. Moreover, policy-makers interviewed in this review ascertained that, building such competences at the primary care level may mitigate the excessive referrals of every NCD case to the major hospitals that are already overburdened:

> *"The major problem that the country has faced is the fact that the management of non-communicable disease at the lower level has been a challenge because most of the time they cannot do much of investigations, so people tend to be referred to the higher-level facilities."* [TR:3]

Also for traditional healers/providers, most of them involved in CAM practice were found to be predominantly men, of low-level education, private and they have inherited the practice from relations [11]. This review revealed that:

"…all kinds of herbal medicines are packaged and sold [by peddlers] in the public transports and one medicine can cure almost all chronic diseases. But you see the way the people believe it… That's is the power or the force we are talking about and it is always connected to religion…So if people have problems, they would allude it to the spiritual component first…" [TR:8]

Health information system for NCD management in Ghana

According to this review, several performance assessments of interventions for both the general health delivery system and for NCDs specifically have been conducted. For instance, between 1990 and 2016, 91 studies have been identified as published and accessible via internet (see Additional file 2). In addition, the National Policy for the Prevention and Control of NCDs in Ghana [16], the National Strategy for Cancer Control in Ghana, and the National Health Insurance Scheme (NHIS) [20] among other policies and strategies have been developed in order to respond effectively to the growing burden of NCDs in Ghana.

Also, specific reference to the Regenerative Health Programme – an awareness programme to promote healthy behaviours (i.e. diet and exercise) – at the Ministry of Health was made by the policy-makers interviewed. Again, the policy-makers mentioned that registries for common NCDs are being established at the tertiary referral hospitals like the cancer registry at the Komfo Anokye Teaching Hospital (KATH) in Kumasi as part of efforts to strengthen the health information system. However, most of them considered that the uptake of these initiatives and utilization of sound evidence/recommendations are very slow and low.

Medical products and health technologies for NCD management in Ghana

In addition to the mainstream treatments, several innovative interventions have been explored in the bid to ensure equitable access to quality healthcare. These included: nasal continuous positive airway pressure for respiratory distress (new medical device) [80], clinical reminder system for diabetes management (mHealth) [34], community-based hypertension improvement project (telemedicine) [110], Ghana diabetes project [95], therapies [39, 43, 99, 104], new surgical procedures [53, 90], quality assurance (training) programs [10, 88] and the priority health services package of the NHIS [10, 109].

Among the special interventions targeted at improving NCD management, six (6) programmes [34, 43, 80, 84, 88, 110] were identified between 2001 and 2016 which were not captured in the catalogues of two recent reviews [10, 112]. They were all found to be vertical

interventional programmes related to service delivery organisation, mainly focusing on specific NCDs – hypertension, diabetes, chronic non-specific low back pain, respiratory distress, anaemia and eye care (See Table 3). Five out of the six interventions were unclear whether they were still being implemented at the time of this review [34, 43, 80, 84, 110]. The only exception was the eye care programme which has become a de facto regional programme in the Upper East Region of Ghana [54, 88].

Notably, the latest evaluated interventional programme was found in 2016 to be a community-based hypertension improvement project [110]. This intervention used mobile phone-based health (mHealth) innovations and included the use of mobile phone by which SMS messages were sent for patient education, appointment reminders and treatment adherence support. Another mHealth intervention found was the electronic clinical reminder system programme in which persons living with diabetes were sent reminders on their cell phones to honour clinical appointments [34].

Despite the seemingly successful implementations so far, none of the programmes had been implemented at national scale-up level. With reference to mHealth interventions for managing NCDs, the views of the policy-makers interviewed in this review about how to achieve sustainability and scale-up have also been explored and reported extensively in Opoku et al. [17]. Suffice it to say that they understood well the potentials of these technology-based interventions and strongly supported their expansion insofar as all the necessary factors – predisposing characteristics, need and enabling resources – to support successful implementation are very well considered.

Healthcare financing for NCD management in Ghana

Bosu [10] and de Graft-Aikins et al. [7] in particular have ascertained that the implementation of the NHIS in 2005 – after its introduction in 2003 – has impacted greatly on NCD management. The NHIS provides for its growing subscribers substantial financial relief for healthcare [16, 20]. Since its revision in 2012 [20], the scheme has placed, for example, some diabetes medicines on the exemption list to ease the financial burden of diabetes care.

Despite these efforts, the 13 policy-makers interviewed in this review maintained that the scheme is still focused on infectious diseases. Also, they alluded to limited financial resources as the major barrier to improving NCD management and therefore prescribed that, as a matter of urgency, government should make clear budgetary allocations to enhance the NHIS and the health system for improved access to NCD care. In fact, they claimed that

patients must still pay out-of-pocket (OOP) to access most NCD care services and certain medications. It was revealed that:

> *"Even those [medications] which are covered [by the NHIS], public institutions and private institutions will tell you that national health insurance is owing them 8 months arrears. So, I cannot go and borrow money and buy drugs and come and give them to you. Mind you the money I borrow is with interest and national health insurance does not pay with interest. That's one. Secondly, with some of the drugs, the price used by national health insurance is 2012 prices so I'm at a lost. So, if you want your medicine, I will write it for you to go and buy."* [TR:2]

Leadership and governance for NCD management in Ghana

Ghana has gone through several reforms with an increasing effort towards improving the management of NCDs. In this review, we observed that most of the reform initiatives have been directed towards biomedical care. Nonetheless, efforts have also been made to streamline alternative/complementary care largely for chronic diseases care by establishing, for example, the Ghana Traditional Medicine Practice Council (GTMPC) [36] and the Ghana Federation of Traditional Medicine Practitioners (GHAFTRAM) [10, 36, 56] as regulating and registration bodies/associations for these practices.

Bosu in 2012 [10] published a comprehensive review of the policy and programmatic responses to chronic NCDs in Ghana. He extracted data from a wide range of data-sources including news agencies to cover from 1970 to August 2009 all the recommended strategies, policy and programmatic responses for prevention and management of NCDs in Ghana (*please see Additional file 3 for details*). Similarly, Escribano-Ferrer et al. [112] conducted a study in 2016 and here too, an extensive review was done to map out reform initiatives targeted at improving quality of health care in Ghana. A total of 489 interventions including those for NCDs were identified between 1988 and 2014 that addressed quality of health care in Ghana.

Prominent among the list of the reform initiatives were (1) the establishment of the Non-Communicable Diseases Control and Prevention (NCDCP) Programme in 1992 as the dedicated programme for all NCD-related activities in Ghana, (2) the implementation of the NHIS in 2005, and (3) the establishment of the Regenerative Health and Nutrition Programme in 2006 to focus inter alia on behavioural change communication and creating enabling environments to promote health lifestyle among the people of Ghana.

Discussion

Summary of main findings

Guided by the WHO health system framework focusing on the six building blocks, this review relied on 91 studies of varied designs, 13 interviews of policy-makers and other institutional documents to examine the approaches for NCD management in Ghana and to identify areas for improvement. In total, 34,112 patient-participants and 1352 health workers (including 62 traditional herbalists) have been reported in this review to simply indicate, but not to represent, the patients and providers who respectively seek and provide care/treatment for a wide range of NCDs, including neoplasms/cancers, cardiovascular diseases, chronic respiratory diseases, digestive diseases, neurological disorders, mental disorders, diabetes and kidney diseases, musculoskeletal disorders, other NCDs and injuries.

The review found that these chronic NCDs have mostly been seen at biomedical facilities than by herbalists, for example. Also, specific attempts have mainly focused on biomedical care, especially task-shifting CVD/hypertension management to community health workers, in order to improve access to quality primary health care. Also, self-care (at home) by patients and their immediate family relatives – supported by a set of social support and belief system – was mainly to prevent possible complications and has been a key element for proper management of NCDs in Ghana. Complementary and alternative medicine (CAM), such as herbal medicine and faith-based treatment at religious institutions, have also been playing important role in NCD management in Ghana, despite the lack of scientific evidence to support the practices.

Based on the studies reporting on health workforce in this review, skilled health workers for NCD care is rather inadequate and traditional/herbal practitioners seemed highly unregulated. In general, utilization of sound evidence and uptake of successful initiatives to improve the health information system were found to be low and very slow, amidst the development of new programmes such as the Regenerative Health and Nutrition Programme established in 2006.

Similarly, innovative technologies and interventions have been explored, including the use of mobile phones to support the improvement of hypertension and diabetes management, among others. However, all remain, at best, as pilot projects. The introduction of the National Health Insurance Scheme (NHIS) has been a major effort towards ensuring that needed care and services are adequately paid for without financial catastrophe or impoverishment. Unfortunately, the scheme is still focused on infectious diseases and bedevilled with inadequate funding allocations. In addition to the implementation of the NHIS, major reform

initiatives that have been embarked upon between 1988 and 2014 include the establishment of the establishment of the Non-communicable Diseases Control and Prevention (NCDCP) Programme, the Ghana Traditional Medicine Practice Council (GTMPC), and the Ghana Federation of Traditional Medicine Practitioners (GHAFTRAM).

Implication for policy and research

This review has several implications for policy and research. Firstly, given that it is often difficult to understand how to improve health systems towards desirable health outcomes [113], this review provides a systematic understanding of the complex links and interactions among the different components of the Ghanaian health system – i.e. the health services delivery, health workforce, medical products and technologies, health information and healthcare financing – and identifies the critical areas necessary for improvements at the instance of NCD management. It sets out the basis for further in-depth analysis of the pattern of healthcare practices at the forefront of NCD management in Ghana.

Secondly, similar to other study findings [113, 114], patients reported in this review resorted to the informal sector practices of traditional/herbal medicine and divination/faith-based healing, partly due to the weaknesses in the health system, and partly due to misconceptions. These major barriers are well-known to both researchers and policy-makers in Africa [113, 114], and there should be concerted efforts to integrate the use of CAM into the national health care system [115]. Where the necessary regulations and resources are put in place, such efforts may include making CAM a part of the formal primary health care system by setting up more public herbal clinics to also serve as a gate-keeping system, to enable early detection of NCDs, and to facilitate the necessary referrals for appropriate (specialised) care.

Thirdly, as it has been revealed by the 13 policy-makers interviewed in this review, the implementation of the NHIS, albeit a crucial measure to improve care, suffer serious setbacks against NCD management. Indeed all countries use out-of-pocket (OOP) spending as a source of revenue and/or to reduce demand for services [116], but the claim that patients still pay OOP to access NCD-related care services that are otherwise (to be) covered by the NHIS is of grave concern. Therefore, there is the need to critically assess the financial access barriers, trends in spending, and policies relating to OOP, similar to the study that has been conducted on high income countries recently [116]. Again, Ghana needs to go further with the current traditional structure of the NHIS [20] and devise innovative payment mechanisms, which may include pay for performance (P4P), pay for coordination (P4C), bundled payments and

shared-savings models [117]. Perhaps it is also more crucial at this time for Ghana to adopt a system of long-term care insurance [118], with schemes dedicated for programmes utilizing integrated care models [119] and innovative technologies like mHealth (e.g. mobile phones-based health interventions) [17, 120].

Finally, six special (programmatic) interventions targeted at addressing specific NCDs including hypertension and diabetes were identified in this review. Uniquely, two of these interventions utilized mobile phone technologies successfully, hence supporting the evidence on the potentials of mobile phone-based health (mHealth) interventions for NCDs in developing countries [121, 122]. However, these interventions were all found at (pilot) project levels and therefore, need to be further explored. In fact, useful frameworks now exist to guide policy-makers, programme managers and researchers towards the sustainability and scaling up of these technology-based interventions the sub-region [17, 120, 123].

Limitations

Finally, it is important to acknowledge that the limitation of this review was that it included a broad range of studies of varied designs and complexities which resulted in a subjective decision as to what study findings to include. Possibly, we may have missed out on relevant findings for this review. Also, despite the extensive search of literature and the broad inclusion of published studies, interviews of policy-makers and institutional documents, aggregated evidence on health care financing for NCD management is limited. Therefore, further research is required to analyse the financial resources and payment systems available for NCD care in Ghana.

Conclusions

Ghana represents a significant epidemiological transition of disease burden in sub-Saharan Africa (SSA) with NCDs now part of the top ten causes of death in the country. However, the health care system remains focused on infectious diseases and efforts to improve the growing burden of NCDs have largely focused on prevention. Therefore, using the WHO health system framework, this review examined NCD management approaches in Ghana in order to identify areas for improvement. This review found that, while biomedical facility-based care remains the mainstream pathway for NCD care, complementary and alternative medicine (CAM) as well as home-based self-care play important roles in NCD management to the extent that, their integration into the primary health care system is strongly recommended. Additionally, that both CAM practices and practitioners need to be supported by scientific

evidence and be effectively regulated. In addition, innovative technologies and interventions have been explored, including the use of mobile phone technologies. The introduction of the NHIS has been a major effort towards ensuring access to quality health care, despite the serious challenges against NCD management. Other major reforms have also been embarked upon between 1988 and 2014 including the establishment of the Non-communicable Diseases Control and Prevention (NCDCP) Programme and the Ghana Traditional Medicine Practice Council (GTMPC).

The implications for research, policy and developing interventions include that both CAM practices and practitioners need to be supported by scientific evidence and be effectively regulated. In addition to ensuring lower out-of-pocket (OOP) spending for NCD-related care, there is the need to critically assess the financial access barriers, trends in spending, and policies relating to OOP. Also, useful frameworks now exist to guide policy-makers, programme managers and researchers towards the sustainability and scaling up of the special (programmatic) interventions found at (pilot) project levels, especially those utilizing mobile phone technologies (mHealth).

Table 3: Special programmes and interventions for NCD management in Ghana implemented after August 2009 and not captured in Bosu, 2012

Programme/ Intervention	Main aim/ objective of the intervention	Scale of implementation	Period of Imple-mentati-on /eva-luation	Reported NCD management related outcomes/opportunities of the intervention	Reported NCD management related challenges/recommendations of the intervention	Status of implementation
Community-based Hypertension Improvement project (Lamptey et al., 2016) [110]	To offer screening and monitoring of NCD risk factors as well as prevention service through maternal and child health service delivery points (via community health officers) and private drug outlets at the community level.	community level (unspecified)	2016	• community-based cardiovascular nurses provide treatment for moderate uncomplicated hypertension with referral to district level when needed • walk-in system for free screening of all adults for hypertension at maternal and child health clinics and private drug outlets • illustrates the application and testing of innovation in an integrated NCD programme within a community-based primary healthcare programme. The innovations include: o task shifting o use of tablets for diagnosis, treatment, data collection and information management o telemedicine for improved management of patients, consultation and access o use of a cloud-based patient monitoring system for case management, sharing health information, research and management o use of SMS messages for patient education, appointment reminders and treatment adherence support	Unspecified	Unclear

Electronic clinical reminder system (Adjei et al., 2015) [34]	To remind persons living with diabetes to honour their clinical appointments	Facility-based level (NDMRC in Accra)	2015	• success rate of caregivers/physicians using the system for diabetes management was 85% • mean reductions of all the metabolic risk factors (BMI, systolic blood pressure, diastolic blood pressure, pulse rate and fasting plasma glucose) in the intervention group were significantly greater than the control group • significant reduction in metabolic risk factors in intervention group as compared with control groups, after adjusting for pre-specified covariates (age, sex, primary language use and use of NHIS) • 100% of persons living with diabetes in the intervention honoured their appointments 6 months into the intervention as compared to 88% in the control group. • cumulatively, 89.4% in the control group as compared to 97.8% in the intervention group honoured their clinical appointments during the 6 month period • ability to prompt physicians to adhere to required clinical guidelines • Potential significant downward trend in fasting capillary glucose among diabetic patients • Potential significant decrease in blood pressure among patients with hypertension	• participants or their care givers are required to have cell phones to receive the reminders and those without cell phones were excluded	Unclear
Behavioural Graded Activity (BGA) in patients with chronic non-specific low back pain (Bello et al., 2015) [43]	To modify health behaviours and risk factors through targeted action on beliefs and positive coping strategies	facility-based level (2 selected facilities in Eastern region)	2013 – 2014	• the relative efficacy of BGA and the conventional therapy were homogenous except that BGA group scored higher on the pain component of SF-36 QoL. • Both BGA and conventional therapy showed significant improvements over the baseline scores through to the end treatment in all the main measures • Patients in BGA group spent relatively less (GH₵24.1 ± 40.8) for health care costs than patients in conventional therapy (GH₵29.4 ± 17.7)	Unspecified	Unclear

Medical device intervention: nasal continuous positive airway pressure (CPAP) for children with respiratory distress in four district hospitals in Ghana (clinical trial) (Wilson et al., 2014) [80]	To demonstrate that nurses in emergency wards were able to safely apply CPAP to children with respiratory distress, and that the device decreased respiratory rate in these children	facility-based level (four hospitals)	2011 – 2013	• 13 nurses made statements in support of CPAP use (i.e. it is effective) • 16 of 28 participants expressed a desire for more robust training or retraining	• Nurses' perceived competence with CPAP was discordant with assessed competence • Limitations in equipment maintenance and limitations in training of personnel impede sustainable use of nasal CPAP in district hospitals in Ghana •), 10 cited patient discomfort, and 1 cited the potential for CPAP to cause harm • 8 nurses complained about the cumbersome nature of the CPAP set-up, particularly securing the tubing to the head-dress • 2 nurses cited dysfunctional equipment and shortage of nasal prongs • 6 commented that often too few personnel are in the emergency ward to monitor a child on CPAP • need for sustainability research	Unclear
Hospital-based eye care programme in Bawku (Gyasi, 2006) [88]	To provide quality, affordable and accessible eye care services in the region	Regional level (Upper East region)	2000 – 2004	• 9,933 cataract operations done, with 97 percent receiving intraocular lens (IOL) implants • Cataract surgical outreach centres in all district hospitals established • Role of district hospital-based ophthalmic nurses in patient preparation, post-operative management and referral of complications enhanced • Community-based rehabilitation workers (CBRs) used in case finding and referral to hospitals • Surgical quality assurance through a computer-based continuous outcome-monitoring programme performed • Client satisfaction evaluation through yearly qualitative surveys conducted • A cataract surgeon to support the ophthalmologists and nurses to give ocular anaesthetic available	• Length of training ophthalmologists be shortened from currently 6 years fellowship training under the West African College of Surgeons programme to probably 3 years (similar to the East African system) • Integrate outreach cataract services into all regional programmes with adequate resources • Utilize available resources including human resources e.g. ophthalmic nurse • Train CBR workers and community health nurses to diagnose and refer cataract patients to district hospitals. • Recognise and accept cataract surgeons who are perfectly up to the task instead of the existing practice of general medical assistants who are managing wide range of medical conditions.	Ongoing
Microencapsula-ted ferrous fumarate sachets	to use a new form of iron and a delivery system to	Community level (Kintampo	1999	• significant increase in hemoglobin concentrations from baseline to the end of treatment study • Fifty-seven percent (281 of 493) of infants advanced	• 16% of the mothers of children in the intervention group reported having problems giving their children sprinkles	Unclear

(Zlotkin et al., 2001) [84]	treat anemia in infants that is likely to produce better adherence to treatment	district)		from an anemic to a nonanemic state (hemoglobin ≥ 100 g/L • The relative risk of remaining anemic after 2 months of treatment was 1.03 times (3%) less than conventional intervention • after 2 months of treatment, there was a significant increase in ferritin concentrations, but the mean value was significantly higher in the conventional therapy group than in the intervention group • No treatment effect was found for weight-for-age or weight for-height *z* scores • 83% of the children in the sprinkles group complied with treatment on ≥4 d/wk, 66% never missed a day, and 5.5% received no sprinkles during the preceding 7 d.	(eg, children did not want to eat the food into which the sprinkles were added). • Their mothers did not perceive that the sprinkles changed the color or texture of the food to which they were added. • Reported side effects were rare and mild and consisted mainly of diarrhea. Diarrhea was reported in 62 of 486 (12.8%) subjects in the intervention group. • Further studies to test the effectiveness of the intervention are warranted	

Source: Authors' own compilation based on 91 included studies from 1990 – 2016

Abbreviations

NCDs – Non-communicable diseases

NHIS – National Health Insurance Scheme

WHO – World Health Organization

FDA – Food and Drugs Authority, Ghana

CHPS – Community-based Health Planning and Services

CHWs – Community Health Workers

CMHWs – Community Mental Health Workers

CMHOs – Community Mental Health Officers

CPOs – Clinical Psychiatry Officers

CPNs – Community Health Nurses (CPNs)

CBRs – Community-Based Rehabilitation

GPs – General Practitioners

CAM – Complementary and Alternative Medicine

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Chapter 6: Determining the potential of mobile phone-based health interventions in sub-Saharan Africa: a study from Kumasi, Ghana

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Ghana Medical Journal [in review]

Full title: Determining the potential of mobile phone-based health interventions in sub-Saharan Africa: a study from Kumasi, Ghana

Running title: Determining the potential of mHealth

Abstract

Background: Numerous reviews have reported generally positive outcomes of mobile phone-based health (mHealth) interventions in the sub-Saharan African countries, also for people with non-communicable diseases.

At the same time the mHealth landscape is burdened by a lack of sustainability. It has been shown that several context factors influence a successful implementation. There is a need to analyse these context factors before the development and implementation of mHealth interventions.

Method: The clinical setting of the study was the 'Komfo Anokye Teaching Hospital' in Kumasi, Ghana. Patients attending the diabetes clinic were surveyed. Questions were derived from a recently published realist review, which identified important factors influencing the long-term success of mHealth in the sub-Saharan African region.

Results: One hundred and fifty (150) patients were surveyed. The survey revealed that patients at the diabetes centre had a positive attitude towards mobile phones, but also a low familiarity with its functionalities. Whereas patients faced several access barriers to care, most enabling resources for the successful and sustainable implementation of mHealth interventions such as the access to mobile phones and electricity were available.

Conclusion: It was successfully shown how a preliminary analysis of the potential for mHealth can be performed. There is a high potential for mHealth in the setting of the diabetes clinic in Kumasi, Ghana. In a next step, mHealth interventions should be developed and tested in a larger study.

Keywords: Ghana, mHealth, Diabetes, potential

Introduction

The rapidly growing mobile phone infrastructure in sub-Saharan African (SSA) countries has led to the emergence of mobile phone-based health interventions (mHealth interventions) over the past decade [1-3]. Numerous reports and reviews have reported that mHealth can have a positive effect on health outcomes, also for patients with non-communicable diseases (NCDs) [4-6].

While the body of evidence for the efficacy of such interventions is growing, the mHealth landscape is burdened by a lack of sustainability. Many interventions are not extended beyond the duration of the project-phase [7].

Publications in the last years have therefore increasingly analysed why some interventions are more successful than others [8-10]. It was illustrated that several contextual factors, e.g. the availability of a reliable electricity infrastructure, heavily influence a successful and sustainable implementation [11]. However, many interventions were implemented without an analysis being made as to whether the respective context would be ready for mHealth [12,13]. It is important that future projects are only implemented after a preliminary analysis of the local context has been carried out.

Therefore, the aim of this study is to analyse whether a mHealth intervention would work in a particular context of an SSA country.

Method

Context

The clinical setting of the study was a diabetes clinic, located at the Komfo Anokye Teaching Hospital (KATH) in Kumasi, Ghana. Diabetes was chosen because prevalence rates are constantly increasing in SSA and it is recognized as a serious challenge to the health care system in Ghana [14,15]. The KATH is a thousand bed tertiary medical facility located in Kumasi (capital of the Ashanti Region) and serves a population of over 4.7 million. It is the second largest hospital in Ghana [16]. The diabetic centre of the KATH is situated in the middle of the hospital campus.

Designing the questionnaire

The questionnaire was designed based on the contextual factors from a recently published realist review, which has identified the mechanisms that explain why some mHealth interventions are likely to be more effective than others [11]. The review is primarily based on Andersen's healthcare utilization model and describes the utilization and/or success of

mHealth as a function dependent on predisposing characteristics, need and enabling factors (PNE factors) [17].

Table 1: PNE-Factors contributing to the success of mHealth, derived from Opoku et al [11]

Predisposing characteristics	- patients' cultural/social acceptance - positive attitude towards mobile technology - age, language, education level - socio-economic background
Needs	- barriers to care - disease severity
Enabling resources	- access to mobile phones - availability of a functioning stable telecommunication network - assurance of privacy - support from partners/relatives

For instance, if the target population has a very negative attitude towards mobile phones (*predisposing characteristic*), if there is no access to mobile phones (*enabling resource*) or if the disease severity is low (*need*), it is likely that a mHealth interventions would fail. The PNE-factors identified by the realist review are depicted in table 1. For the questionnaire, all PNE-factors were translated into closed and open-ended questions, as well as statements with a 5-point Likert-scale. Questions were discussed among VS and DO. The final questionnaire (additional file 1) was reviewed by all authors. The Committee on Human Research, Publications and Ethics, of Medical Sciences, Kwame Nkrumah University of Science and Technology approved the questionnaire and the study protocol in September 2017 (Reference number: CHRPE/RC/229/17).

Recruitment and data collection:

Patients suffering from diabetes were interviewed using a structured questionnaire during September - October, 2017. They were recruited while they were waiting for their appointment at the clinic. The study was introduced and briefly explained in the local language (Twi) or English depending on the respondent's choice. After the introduction, patients were directly asked whether they are willing to participate. If they agreed, informed consent was obtained. The interview was either conducted in Twi or English, as the participant preferred.

Results

In total, 150 people with diabetes participated in the study; 72% were female and the majority (83%) resided in urban areas. Patients had been living with the disease on average for 11.5

years. Most did not know which type of diabetes they have: 17% knew that they are diagnosed with type 2 diabetes and 7% reported to have type 1 diabetes.

Predisposing characteristics:

The predisposing characteristics of the patients from the diabetes clinic are depicted in table 2. The results show that mobile phones were widely used in patients' communities, and that the attitude towards mobile phones was very positive. However, the familiarity with mobile phones appeared to be moderate. All patients knew how to make and receive calls, but only 22% were able to text with the phone, and only 9% were able to browse the internet. The average age of the patients was 58 years. The majority said that they received secondary school or higher level of education, but 43% stated that they could neither read nor write. English was spoken by two thirds of the patients; the other third spoke only Twi.

Age (years)	58 (+/- 10.32)				
Speak English	105 (70%)				
Non-literate	64 (43%)				
Regular income	87 (58%)				
Education level:					
None	27 (18%)				
Primary	40 (27%)				
Secondary	71 (47%)				
Tertiary	12 (8%)				
Main functions of phone usage:					
Calling and receiving	145 (100%)				
Texting	32 (22%)				
Internet	13 (9%)				
Using apps	22 (15%)				
	1 Strongly agree	**2 Agree**	**3 Neither**	**4 Disagree**	**5 Strongly disagree**
"Mobile phones are very common and widely used in my community"	102 (68%)	43 (28%)	3 (2%)	2 (1%)	0 (0%)
"I am familiar with using a mobile phone"	30 (20%)	69 (47%)	30 (20%)	13 (9%)	6 (4%)
"I have a positive attitude towards a mobile phone"	122 (82%)	17 (11%)	5 (3%)	4 (3%)	1 (1%)

Table 2: Predisposing characteristics of patients with diabetes

Needs

On average, the patients needed almost 100 minutes to get to the diabetes clinic. They strongly agreed with the statement that the cost of the treatment is too expensive, and that adhering to the treatment is difficult. Satisfaction with the availability of the health staff and overall treatment appeared to be moderate. Moreover, many reported that they suffer from complications due to their diabetes, and almost all (85%) stated suffering from other diseases in addition to diabetes. Hypertension was the

most often mentioned co-morbidity followed by eye-problems and diseases such as typhoid or asthma. All need factors are depicted in Table 3.

Patients with co-morbidities	128 (85%)				
Distance between home and diabetes clinic	96.9 min				
	1 Strongly agree	**2 Agree**	**3 Neither**	**4 Disagree**	**5 Strongly disagree**
"The cost of the treatment is too expensive"	83 (56%)	32 (22%)	19 (13%)	10 (7%)	5 (3%)
"Following and adhering the diabetes-treatment is difficult"	60 (40%)	26 (17%)	3 (2%)	42 (28%)	18 (12%)
"I suffer from complications due to my diabetes"	60 (40%)	55 (40%)	14 (9%)	13 (9%)	7 (4%)
"The diabetes treatment is sufficient and satisfies all my health needs"	23 (15%)	53 (36%)	29 (20%)	28 (19%)	16 (11%)
"The health staff is always available when I need them"	61 (41%)	18 (12%)	21 (14%)	37 (25%)	13 (9%)

Table 3: Needs of patients with diabetes

Enabling resources

Nearly 100% of the patients with diabetes had access to a mobile phone. The vast majority (91%) owned a mobile phone, while 5% shared the phone with their family members. Forty-two (42%) of the mobile phones were smartphones (phones capable of doing more than text messaging and making/receiving calls). Most agreed with the statement that there is always electricity to charge the phone. The mobile phone network was perceived as less reliable than the electricity network. In terms of the support by family and relatives, many patients assumed that they would receive their support when healthcare is delivered with a mobile phone. In case a phone is broken many reported that they would rather buy a new one than repair it. One third mentioned that they cannot assure privacy on their phone, e.g. because family members have access to their phone (Table 4).

Table 4: Enabling resources for patients with diabetes

Access to a mobile phone	
Personal mobile phone	136 (91%)
Family mobile phone	8 (5%)
No mobile phone	6 (4%)
Access to a smartphone	62 (42%)
Access to a cell phone	82 (58%)
Recharging the phone	
Every day	44 (30%)
Every couple of days	77 (54%)
Every week	23 (16%)
Repairing the phone	
Never	118 (82%)
Once per year	21 (15%)
More often	5 (3%)
Health support from the family	137 (55%)

	1 Strongly agree	**2 Agree**	**3 Neither**	**4 Disagree**	**5 Strongly disagree**
"There is a constant supply of electricity to charge the phone"	80 (55%)	50 (34%)	13 (9%)	2 (1%)	1 (1%)
"The mobile phone network is reliable and functioning stable"	35 (24%)	45 (31%)	45 (31%)	16 (11%)	5 (3%)
"I have convenience, autonomy and privacy on the phone"	82 (56%)	8 (5%)	9 (6%)	31 (21%)	17 (12%)
"Services on the phone (e.g. airtime) are affordable"	66 (46%)	31 (21%)	8 (6%)	25 (17%)	15 (10%)

Discussion

This is the first study which determined the potential of mHealth by using PNE factors.

In the case of the diabetes clinic in Kumasi, Ghana it turned out that the predisposing characteristics (e.g. high acceptance of mobile phones in the community, positive attitude towards mobile phones), the higher need (e.g. patients faced several access barriers to care, suffered from diseases beside of their diabetes) and the availability of the enabling resources (e.g. access to mobile phones, electricity) would translate into a high potential for future mHealth interventions.

The study provides important findings on several factors specific to the patients from the diabetes clinic in Kumasi and shows therefore the importance of such a preliminary analysis:

First, the subscription rate at the Diabetes clinic (meaning the share of people who have access to a phone) was nearly 100 %. This is higher than average subscription rates in Ghana

(67%) [18]. A mobile-phone based health interventions would therefore be able to include almost all patients from the clinic.

Second, 42% of the patients had access to smartphones (phones capable of using third party applications and browsing the internet). This is higher than the total average in SSA (34%) [18]. This bears opportunities for future mHealth interventions, since the ability to provide information via applications, in combination with voice calls or text messages, is perceived as a key to improving the situation of patients and their access to care [19].

Third, despite high cultural and social acceptance of the mobile technology, the familiarity with mobile phones turned out to be low. This could be due to the higher average age of the here analysed community. Elderly people tend to have a lower familiarity with the full spectrum of all mobile phone functions [20]. However, a low 'phone literacy level' needs to be considered when implementing an intervention. Providers need to ensure, that the patients are capable of using all, or at least most, functions of the intervention. This may require workshops or training-lessons which would also improve patients' overall ability to use the mobile phone as a tool to research, organize, evaluate and communicate information [21].

The analysis has implications for policy makers, researchers and industry representatives who are involved in the development of mHealth solutions. The approach could be adapted and utilized in order to identify regions with a higher potential for mHealth. If a region qualifies for mHealth (such as the diabetes centre at KATH), prototypes of particular interventions (e.g. an appointment reminder system via SMS) could be developed and tested. Furthermore, some aspects, such as the identified low familiarity with mobile phones, could be already considered during implementation-phase. This 2-step approach (feasibility analysis plus large-scale study with prototypes) could be used as a *cookbook* towards a more sustainable implementation of mHealth. And it would therefore counteract the widespread problem that many mHealth interventions have not moved beyond the pilot phase.

Strengths and limitations of the study

A major strength of the study is that the analysis and the questionnaire are scientifically grounded.[11] However, other factors such as an enabling legislation or the planning and funding of the project-stakeholders, might also have a significant influence on a successful implementation and were not considered in this analysis.

Another limitation of the study is its sample size. For a more representative sample more people would have to be interviewed over a longer period of time. A further limiting factor could have been that all outcome parameters are self-reported. Some parameters may be

therefore biased, e.g. self-reported familiarity with mobile phones or the distance to the clinic. However, the interviewer tried to avoid this bias by explaining and repeating a question, when it was needed.

Finally, the study included only patients who have been diagnosed with diabetes and have already been to the diabetes clinic in Kumasi. It is estimated that two thirds of all people with diabetes remain undiagnosed and have therefore never attended a diabetes clinic [14]. The identified potential does therefore only count for the patients of the diabetes clinic at KATH and cannot simply be transferred to other population-groups.

Conclusion

It has been successfully demonstrated how the potential of mHealth can be measured in a particular environment. In the case of diabetes patients from Kumasi, Ghana, the potential was shown to be high. The use of mHealth would therefore most likely result in better treatment and care.

Abbreviations

KATH	Komfo Anokye Teaching Hospital
mHealth	Mobile health
NCDs	Non-communicable diseases
PNE factors	Predisposing characteristics, need and enabling factors
SSA	Sub-Saharan African

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Chapter 7: Achieving sustainability and scale-up of mHealth interventions in sub-Saharan Africa: The views of policy-makers in Ghana

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Achieving Sustainability and Scale-Up of Mobile Health Noncommunicable Disease Interventions in Sub-Saharan Africa: Views of Policy Makers in Ghana

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Abstract

Background: A growing body of evidence shows that mobile health (mHealth) interventions may improve treatment and care for the rapidly rising number of patients with noncommunicable diseases (NCDs) in sub-Saharan Africa (SSA). A recent realist review developed a framework highlighting the influence of context factors, including predisposing characteristics, needs, and enabling resources (PNE), for the long-term success of mHealth interventions. The views of policy makers will ultimately determine implementation and scale-up of mHealth interventions in SSA. However, their views about necessary conditions for sustainability and scale-up remain unexplored.

Objective: This study aimed to understand the views of policy makers in Ghana with regard to the most important factors for successful implementation, sustainability, and scale-up of mHealth NCD interventions.

Methods: Members of the technical working group responsible for Ghana's national NCD policy were interviewed about their knowledge of and attitude toward mHealth and about the most important factors contributing to long-term intervention success. Using qualitative methods and applying a qualitative content analysis approach, answers were categorized according to the PNE framework.

Results: A total of 19 policy makers were contacted and 13 were interviewed. Interviewees had long-standing work experience of an average of 26 years and were actively involved in health policy making in Ghana. They were well-informed about the potential of mHealth, and they strongly supported mHealth expansion in the country. Guided by the PNE framework's categories, the policy makers ascertained which critical factors would support the successful implementation of mHealth interventions in Ghana. The policy makers mentioned many factors described in the literature as important for mHealth implementation, sustainability, and scale-up, but they focused more on enabling resources than on predisposing characteristics and need. Furthermore, they mentioned several factors that have been rather unexplored in the literature.

Conclusions: The study shows that the PNE framework is useful to guide policy makers toward a more systematic assessment of context factors that support intervention implementation, sustainability, and scale-up. Furthermore, the framework was refined by adding additional factors. Policy makers may benefit from using the PNE framework at the various stages of mHealth implementation. Researchers may (and should) use the framework when investigating reasons for success (or failure) of interventions.

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KEYWORDS

implementation science; mHealth; eHealth; noncommunicable diseases; disease management; sub-Saharan Africa; qualitative research; health policy

Introduction

Background

With the drastic decline of communicable, maternal, and neonatal diseases as cause of death and burden of disease across the globe [1], and particularly in Africa [1,2], the epidemiologic transition toward noncommunicable diseases (NCDs) is in full swing. By 2030, 42% of all projected deaths in sub-Saharan Africa (SSA) will be caused by NCDs, which will then surpass communicable diseases as the leading cause of death in the subregion [3,4]. In some African countries such as Ghana, statistics show that already today about 42% of the total annual deaths are caused by NCDs, led by cardiovascular diseases [5-7].

At the same time, most countries in SSA have become eager adopters and innovators of the use of mobile and digital technologies. In Ghana, as early as 2013, "[m]ore than four out of every five households (80.3%) in the country own[ed] a mobile phone" [8], thereby expanding the opportunities for the implementation of mobile phone–based health (mHealth) interventions [9,10]. Numerous studies and reviews have reported positive results of mHealth interventions against NCDs [11-15]. The World Health Organization (WHO) promotes the further development and more widespread use of mHealth interventions as part of its Global Action Plan for the prevention and control of NCDs [16]. Nevertheless, most mHealth interventions remain at the stage of pilot projects, and they are almost never scaled-up to entire countries [10,13,17-19].

Efforts at international and European levels have aimed to provide guidance to countries to support scale-up of mHealth interventions and integration into routine care practices [20-22]. For example, WHO and the International Telecommunication Union have produced a detailed toolkit to support the development of national electronic health (eHealth) strategies [21]. The toolkit is focused on the role of enabling legislation and regulation, government and sector buy-in, and planning and funding for implementation and sustainability. More recently, the European Union–funded Momentum project for successful implementation of telemedicine into routine health care has published a list of 18 factors to make telemedicine a success, which also include legislation and sector buy-in, but further recommend consideration of the cultural readiness toward telemedicine and the identification of a compelling need [22].

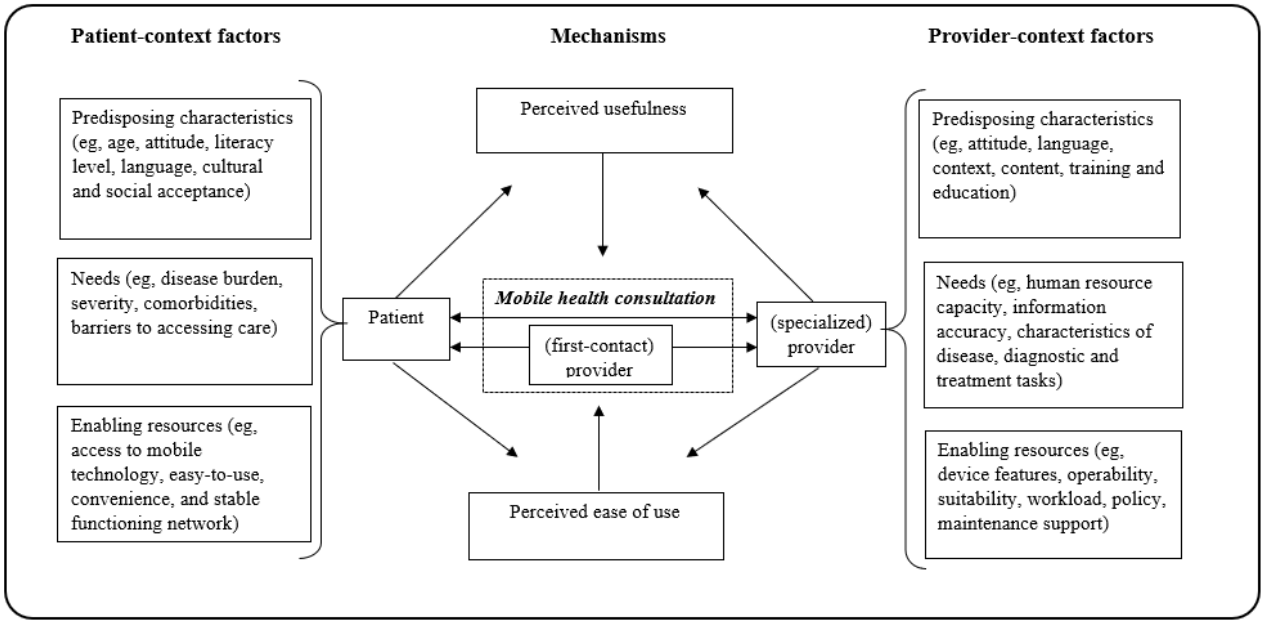
In a recent realist review, Opoku et al [23] developed a theoretical framework that aims to provide guidance to policy makers and other decision makers working on implementing, sustaining, and scaling-up mHealth interventions for NCD management in SSA. The framework hypothesizes that "predisposing characteristics and need of patients and healthcare providers as well as the availability of enabling resources in the community influence the perceptions of patients and providers that mHealth interventions are useful and easy to use—and these perceptions are essential for the successful implementation of an mHealth intervention" [23]. As shown in Figure 1, the framework focuses attention on the influence of context factors, including predisposing characteristics, needs, and enabling resources (PNE), for the long-term success of mHealth interventions. Therefore, we use the term *mHealthPNE framework* for the rest of the paper.

The mHealth PNE framework is grounded in the experiences of patients and health care providers as reported in 20 studies of 18 mHealth interventions for NCDs [14,24-42] conducted in 10 SSA countries. It combines the Andersen behavioral model of health services utilization with the Davis technology acceptance model [43,44]. The framework focuses attention on a large set of—yet to be further refined—contextual factors that can be grouped under PNE. For example, cultural readiness mentioned as one of the 18 factors of the momentum group would fall under *predisposing characteristics*, whereas establishment of an appropriate legal environment would fall under *enabling resources* and identification of patients' needs under *needs*. However, it remains unknown whether the context factors that have so far been identified under the categories of PNE are in line with the views of policy makers and other decision makers about the most important conditions for implementation, sustainability, and scale-up.

Ghana is one of the countries in SSA where efforts to support the development of mHealth interventions have been most pronounced [45-48]. These efforts include the development of the Ghana eHealth Strategy, which aims at supporting the improvement of the overall performance of the health sector [47]. In addition, several mHealth interventions have been implemented, including the Millennium Villages telemedicine project in the Amansie West district [49] and the Mobile Technology for Community Health program in 7 districts [50,51]. As a result, policy makers in Ghana can be expected to have considerable experience with mHealth interventions, and they are likely to have thought about factors that support intervention sustainability and scale-up.

The views of policy makers and other decision makers will ultimately determine the implementation, sustainability, and scale-up of mHealth interventions in SSA. To assure that the mHealth PNE framework is useful as a guide for policy makers, it is important that the framework is sufficiently aligned with their thinking, that is, policy makers should find the categories of the framework useful when considering the most important factors for implementation, sustainability, and scale-up. In addition, the experiences of policy makers may provide additional insights about the important factors contributing to a successful implementation, sustainability, and scale-up of mHealth NCD interventions that might be missing in the existing literature [23].

Figure 1. Mobile heatlh predisposing characteristics, needs, and enabling resources framework.



Objectives

Therefore, the aim of this study was to understand the views of policy makers with regard to the most important factors that should be considered to assure successful implementation, sustainability, and scale-up of mHealth NCD interventions, thus contributing to the improvement of the mHealth PNE framework. More specifically, the study sought to (1) assess policy makers' knowledge of and attitude toward mHealth NCD interventions, (2) identify whether the categories of the framework are useful to structure the thinking of policy makers, and (3) integrate the perspectives of policy makers into the various components of the framework.

Methods

Application for ethical review of the study was submitted to the Committee on Human Research, Publications, and Ethics at the Kwame Nkrumah University of Science and Technology, School of Medical Sciences, and Komfo Anokye Teaching Hospital, Kumasi, Ghana, and final approval was received on February 25, 2016. The study was conducted using qualitative methods (interviews) and by applying a qualitative content analysis (QCA) approach [52]. The paper was drafted following the Consolidated Criteria for Reporting Qualitative Studies [53].

Qualitative Interviews

Informed consent was first sought and participants were given sufficient information, including about the risks and benefits of participating in the study. Guided by a semistructured questionnaire (Multimedia Appendix 1), qualitative interviews were conducted by DO between November 2015 and January 2016 among stakeholders at the health policy direction level, who were actively involved in national health policy decision making and implementation in Ghana. These one-to-one interviews lasted for an average of 45 min and were recorded for transcription and analysis. In addition, field notes were taken for purposes such as capturing off-tape records and explaining why an interview might have been poorly conducted.

Participants

Participants were from diverse backgrounds and generally worked at high levels of hierarchy and responsibility in different institutions. They had a long-standing experience working in various sectors of the Ghana national health system, particularly on NCDs and other related subjects. All participants were involved in drafting and developing the 2012 National Policy for the Prevention and Control of Chronic Non-Communicable Diseases in Ghana. As such, all participants had been involved in defining the technical direction and framework for implementing NCD-related programs in the country [54].

Selection Criteria

A list of the members of the technical working group for Ghana's national NCD policy was retrieved from the document titled *Strategy for the Management, Prevention and Control of Non-Communicable Diseases in Ghana* by the Republic of Ghana, Ministry of Health [54]. The list consisted of a total number of 19 members who were contacted by DO and who received information about the study via emails, telephone calls, and Skype calls. They were medical doctors, including general practitioners and public health consultants, epidemiologists, political scientists, (public health) lecturers, public health researchers, health educators, program managers, disease surveillance officers, international health specialists, program coordinators, (public health) pharmacists, dieticians, public health practitioners, policy advisors or analysts, planning officers, and freelance nutritionists. Participation was voluntary, and participants were assured that information such as names and addresses that could lead to their identification would be avoided to ensure privacy. Those who responded were followed up for the interviews. No restrictions were imposed except that

the participation was based on the availability and willingness to contribute during the period of data collection.

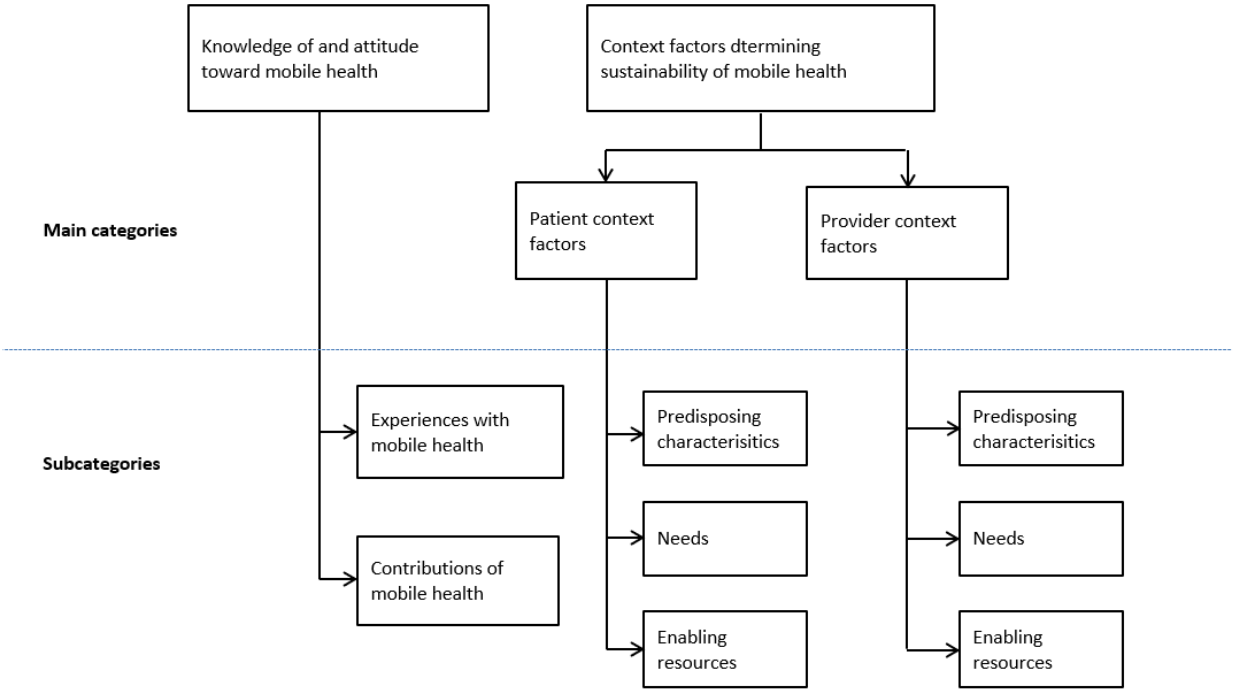
Analysis

Following the QCA approach [52,55], the coding frame in Figure 2 was used for the analysis. It was largely based on the mHealth PNE framework. The framework theorizes that successful implementation of mHealth interventions is determined by context factors— *predisposing characteristics, enabling factors, and needs* —of patients and health care providers, which influence their perceptions on the usefulness and ease of use of the intervention [23]. Thus, for example, whether a mobile phone–based self-monitoring blood glucose intervention designed for diabetes care in Ghana will be successful or not depends on whether both diabetic patients and their health care providers perceive the intervention to be useful and easy to use.

According to the framework, the perceived usefulness and ease of use of an intervention are determined by (1) patients' predisposing characteristics, such as age, attitude, literacy, language, and cultural or social acceptability; (2) their need, such as reducing financial burden of care and avoiding long travel or waiting time; and (3) the factors that will enable them to utilize the intervention well, which may include access to a mobile phone and a stable network [23]. In addition, perceived usefulness and ease of use of providers depend on predisposing characteristics (eg, technology-related training), needs (eg, human resource capacity), and enabling resources (eg, tolerable workload and incentives) [23].

The interview transcripts for the analysis were first coded by DO and subsequently reviewed by both DO and WQ, according to the various components of the framework and grouped into main categories and subcategories. The 2 main categories were *knowledge of and attitudes toward mHealth* and *context factors determining sustainability of mHealth (patient-context factors* and *provider-context factors).* The results were analyzed mainly based on the 3 subcategories of the framework (ie, *predisposing characteristics, needs, and enabling resources*) and then presented thematically under each of the main categories. The analysis also sought to identify other potentially relevant factors missing in this framework.

Figure 2. Coding frame for analysis based on the mobile health predisposing characteristics, needs, and enabling resources framework.



Results

Characteristics of Participants

Out of the 19 policy makers who were contacted, 13 participated in the study. The participant policy makers had long-standing experiences with an average of 26 years in managing various health programs, interventions, and departments and were actively involved in health policy making processes in Ghana. With the exception of 4 participants who had retired at the time the interviews were conducted, all were serving in high-level (national) capacities at the Ministry of Health, Ghana Health Services, academia, and the public and private sectors. Table 1 summarizes the characteristics of the participants.

Table 1. Characteristics of the participant health policy makers and managers in Ghana.

Gender[a]	Age (years)	Working experience with noncommunicable diseases	Experience (years)
Male	>50	Medical practice, program management, policy	21
Male	>50 (retired)	Medical practice, program management, policy	36
Male	>50 (*retired*)	Medical practice, teaching, research, program management, policy	41
Male	>50	Research, health information management, policy	33
Male	>50	Health education, training, research, communication, program management, policy	25
Male	40-44	Health regulations, disease control and prevention, policy	19
Male	40-44	Medical practice, disease control and prevention, policy	13
Female	45-49	Clinical practice, health promotion, policy	20
Male	45-49	Teaching, research, consultancy	16
Female	>50 (retired)	Health promotion, disease prevention, policy	>30
Male	>50	Health sector coordination, program management, policy	30
Male	>50	Teaching, research, consultancy	21
Female	>50 (retired)	Health promotion, advocacy, policy	34

[a]Source: authors' own compilation.

Table 2. Identified beneficial applications of mobile health interventions.

Health promotion and prevention[a]	Education and awareness creation (R[b]: 1, 5, 7, 10), follow-up (R: 1), information centers (R: 11), interactive platform (R: 12)
Health care delivery (maternal and child health care)	Scheduling/adherence/compliance/reminder (appointment and medication) (R: 1, 2, 3, 7, 11, 12), (emergency/specialist) referrals (R: 2, 3, 13), follow-up (R: 1, 11), community-based health care (R: 4, 11), digitalized hospital records (R: 6, 8), record-keeping (vital statistics) (R: 4), creating access to health care (R: 4), health information and follow-up (for pregnant women) (R: 13)
Noncommunicable disease–related management	Education (regenerative health and nutrition) (R: 4, 8, 11), specialized care (for complicated cases) (R: 9, 12), appointments/reminders for testing fasting blood sugar (R: 3), checking/monitoring vital signs (blood pressure and retina check) (R: 4), control and prevention of hypertension (awareness creation, and reminders for drug refill) (R: 7), early detection of complications [R: 9], cancer registry (R: 11), follow-ups (R: 11)

[a]Source: authors' own compilation.

[b]R stands for respondent and the following numbers assigned in this study.

Knowledge of and Attitude Toward Mobile Health Interventions

Interviewed policy makers had considerable knowledge of mHealth interventions, broadly in relation to the general field of health (prevention and health promotion and health care delivery—maternal and child health care) and some specifically relating to NCDs (hypertension prevention and control). Table 2 presents the beneficial applications of mHealth interventions, sorted out according to the highest number of participants who identified them. Some of the policy makers actually had a long-time experience with mHealth and had been involved in the use of mobile phones to support health care delivery, either as providers or as patients themselves.

All interviewees agreed that mHealth interventions can contribute to improved NCD management in Ghana. They identified a range of potentially beneficial applications: awareness creation and (regenerative) health education, early detection of NCD conditions, reduction of waiting time, follow-ups and monitoring, keeping track of the appointments of patients, vital statistics and adherence to medication, emergency alert, creating registries, record keeping, dissemination of evidence, and ensuring sustainable health care. Most importantly, the policy makers highlighted that mHealth could potentially help patients to better manage their NCDs and improve treatment compliance:

> *[it] can keep patients in care, reduce morbidity, reduce mortality. Definitely because it's all a matter of keeping them [ie, patients] in care and ensuring that they learn the good practices and all that. So, I think it would help the outcomes; we will get better outcomes, reduce the disabilities from NCDs, and also reduce the mortalities from NCDs, definitely!* [Respondent: 1]

> *For me the biggest impact is that it will help to manage treatments, it will reduce treatment failures, and it will help people to be more productive so that people can then take better care of themselves and not spend all the time going to the hospitals.* [Respondent: 4]

At the same time, interviewees noted that mHealth interventions provide a solution for only some of the problems of NCD management in Ghana:

> *I always get worried when people try to use technology as a "fix all". Technology is not a fix all, it fixes some problems but not all problems and it's contextual.* [Respondent: 1]

Given the complexity of NCD management, mHealth consultations were considered to be safe and suitable mostly for follow-ups, after an initial contact between patients and providers has been established:

> *...there are huge potentials when it comes to the use of mobile phones but for noncommunicable diseases, the evidence is not very clear for us...from our experience it has to be a "postcontact" intervention. There is always the first contact that has to be made [at the facility] and thenthe intervention kicks in as a follow-up,only after the initial contact. If you don't have initial contact with the hospital, the opportunity to rope in ICT to help you to readjust and to be healthier becomes a bit of a problem.* [Respondent: 4]

However, the policy makers maintained that the use of mobile phones in health care is becoming an important strategy in Ghana, particularly in reducing maternal mortalities and controlling epidemics. In fact, the policy makers were enthusiastic about the potential of mHealth to improve NCD management in Ghana:

> *It is a very good idea, brilliant idea! I mean it is something that we've always been talking about that people should be able to stay in their houses and manage or even call doctors to come or even call for advice from doctors.* [Respondent: 5]

Perspectives of Policy Makers on Context Factors Determining Sustainability of Mobile Health in Ghana

This section presents the interview results categorized along the 3 context factors of the analytical framework, that is, *predisposing characteristics, needs, and enabling resources*. Table 3 provides a summary of the identified factors supporting and/or expanding the framework, arranged in a descending order of the most frequently mentioned factors by the participants.

Predisposing Characteristics

According to the framework, the most important predisposing characteristics supporting the implementation of mHealth interventions are a positive attitude, cultural/social acceptance, and a common language of communication. The interviewed policy makers, however, identified age, literacy, and level of education, as well as providers' continuous training, upgrade, and education as more important factors:

> *The youth are very good at these things and so if you work it out with them it would work. The problem is, are the youth the people who actually go for the services? And so, the majority of the people who would be having noncommunicable diseases are not the youth and they are the people who would not understand this.* [Respondent: 3]

> *My fear is the illiteracy rate. How many people with mobile phones know how to send a text message? How many people can even store or delete numbers or messages? They don't know, they have the phones for receiving calls and making calls, that's all!* [Respondent: 2]

> *We need to do more in terms of training our providers. We call it the two ends, or supply and demand. That is, we supply and the population would demand. So, let us tailor a kind of training for the suppliers of the services in terms of the use of mobile phones and then also teach some of our clients on the use of the mobile phone in terms of getting access to some of these specialists, because I still want to believe that the management of NCDs is a specialized service, which cannot be left in the hands of 'ordinaries'.* [Respondent: 11]

They also stressed that, more generally, trust and confidence among health care providers is a prerequisite for successful implementation of mHealth:

> *The other thing would have to do with the [health] staff attitude. The major question is that, for example, if I [a specialized health care provider] at Korle-Bu teaching hospital [in Accra] give instructions to those [health care providers] in the rural areas, how sure am I that they are doing what I am instructing them to do? And if anything at all should go wrong, who is to be blamed, me or those out there? So, amongst the health staff, there are usually pessimistic views and so some of them will not be interested in these innovations but others might.* [Respondent: 9]

In addition, interviewees highlighted that attitudes of patients related to myths, misconceptions, fear of change, and phobia for technological innovations may negatively impact patients' perceptions about the usefulness of mHealth interventions:

> *We need to look at people's phobia for technology and see how that barrier can be broken.* [Respondent: 6]

> *Maybe we still maintain the old ways of doing things; we don't like change. Africans in general, but Ghanaians especially, we fear change. It is a fact that we fear about what if it doesn't work out well and who takes the fall for it!* [Respondent: 10]

With regard to predisposing characteristics influencing the perceived ease of use, interviewees believed that urban populations are more familiar with mobile technologies. However, in general, the Ghanaian population was thought to be ready to use mobile phones for health care given the high penetration of the technology.

Table 3. Summary of the identified factors supporting the mobile health predisposing characteristics, need, and enabling resources framework.

Mechanism context[a]	Patient		First contact/specialized provider	
	Perceived usefulness	Perceived ease of use	Perceived usefulness	Perceived ease of use
Predisposing characteristics	(Local) language [R[b]:5,6,11,12]; myths, fear/phobia, misconceptions [R:2,5,6,10];*informed, convinced, trust, and confidence (satisfaction)* [R:2,8,11]; *locality (urban/rural)*[c] [R:2,8]; socioculture [R:4,7]; acceptance [R:5,6]; (positive) attitude [R:5,12]; self-motivation [R:3]; age [R:8]; *gender* [R:8]; social class (middle) [R:1]	Literacy and level of education [R:1,2,3,4,5,6,7,11,12]; age (youth ≥10 years, adults) [R:2,3,5,7,10,13]; penetration, and familiarity (urban) [R:1,5,6,13]; training, know-how, confidence [R:3,4,5,12]; basic, simple [R:6,8]; *personalization* [R:8,11]	(Positive) attitude interest, dedication, willingness, and motivation [R:1,8,12]; *good (provider-patient/community)* relationship [R:4,8,11]; language [R:5,9]; trust and confidence [R:11]; ready to support [R:13]	Continuous training, upgrade, and education [R:4,7,9,10,11,12]
Need	Health care access barriers (poverty, transportation, ineffective health facilities, distance, travel and waiting time, cost, urgency and quality of care, stress reduction, and satisfaction) [R:2,3,4,9,10,12,13]; disease condition (severity, upsurge, uncertainties of care) [R:1,2,4,6,9,13]; *need for urgent/special care* [R:7,8,9,13]	*Technology-drivenneed/demand* [R:2,3,4,6,13]	Reduce burden of cases/workload [R:2,6,10,11,12,13]; lack of human resources (limited specialists, unequal distributions of professionals, lack of motivation) [R:9,11,12,13]; *integrated care* [R:3,10,13]; lack of necessary systems and infrastructure (health facility, referral system, transport) [R:9,11]; *continuity of care* [R:1,13]; lack of accurate information [2,11]; reduce morbidity/mortality [R:11,12]; *exchange of expertise* [R:9]; cost-saving [R:9]; enhance emergency care [R:11]	Characteristics of disease, diagnostic and treatment tasks (stage) [R:4,9,11,12]; information need [R:2,10]
Enabling resources	Functioning infrastructure (mobile network/connectivity, transport system, electricity, basic test equipment) [R: 1,4,6,7,8,9,11,12,13]; access to mobile phone [R:1,4,6,7,8,11,12,13]; availability and affordability of (telecommunication) services [R:1,3,5,6,11,12,13]; *partnership and support* [R:2,3,7,9]; awareness creation [R:2,5]; *avoidance of abuse* [R:4,12]; convenience [R:6]; confidentiality and privacy [R:8]; (community) support [R:10]	Portability and easy to use [R:6,13]; *(family) support* [R:8]; maintenance (battery recharge) [R:12]	Legislation and policy (phone usage, liability, funding mechanisms and reimbursement, data security and privacy, staff job description, partners) [R:1,2,4,5,6,7,8,9,13]; *(government, institutional, sectoral, stakeholders') support)* [R:1,4,5,7,9,10,12,13]; infrastructure (functioning network services, equipment) [R:1,5,6,8,10,11]; financial resources and incentives [R:1,6,9,10,11,12]; quality, availability and affordability of services [R:1,7,10,12]; sustainability plan [R:7,10,12,13]; phone access [R:1,4,10]; *documentation and record-keeping* [R:1,2,9]; cost-effectiveness [R:5,8,10]; *evidence-informed (research, expert advice)* [R:5,10,11]; awareness [R:10]; (mobile health) guidelines [R:1]; *abuse/corruption* [R:11]	Simple, safest and easy technologies/intervention (apps and softwares) [R:1,4]; type of (available) technologies [R:1]; maintenance [R:6]; phone features (screen, tailored operability) [R:7]

[a]Source: authors' own compilation based on interview results.

[b]R indicates the reference citations.

[c]Text in italics are the additional patient- and provider-context factors of the mobile health PNE framework identified in this study.

Needs

The framework stipulates that patient and provider needs, such as access barriers for patients (eg, long travel times and costs) and providers' lack of capacity to provide adequate care, influence the utilization of mHealth interventions in SSA. In this study, the interviewed policy makers suggested that patients who face health care access barriers of various forms and nature are more likely to perceive mHealth interventions as useful (see Table 3). They considered patients with severe conditions and/or in need of special/urgent care to benefit most from mHealth interventions, particularly if the interventions contribute to reduced travel times and better access to providers:

> *It would be useful; it would reduce a whole lot of travelling time and reduce some stress levels in getting vehicle/transport. It may even cut down on mortality because it can enhance emergency treatment and emergency care.* [Respondent: 11]

> *It would be very much useful in our settings and circumstances where many people do not even have access to the health facilities because of absence of the health facility, low numbers of health workers; that is, the low patient to health worker ratio. If health professionals can be reached via mobile phones or other ICTs, that would improve the chances of more people getting access and it would even lead to realizing the universal health coverage.* [Respondent: 12]

> *Once we are able to do this, we would save more lives and then again we would have lesser cases developing into complications to demand more attention and more time from the experts."* [Respondent: 9]

Furthermore, interviewees mentioned several tasks for which mHealth interventions would respond to the needs of health care providers, thus contributing to perceived usefulness and ease of use of mHealth interventions. For example, to reduce the workload on providers and to use mobile phones for regular monitoring of blood sugar levels of diabetic patients:

> *We are aware that the health system in Ghana is stricken by lack of facilities and diagnostics, and the health staffs are not motivated to go and stay in the rural areas...and because we won't have enough doctors and enough experts in the rural areas then we can't run away from telemedicine.* [Respondent: 9]

> *...if we are talking specifically about testing fasting blood sugar, it shouldn't be that the patients wait at the clinic...because we all know that the patients have to fast and for a diabetic, once you haven't taken the blood sample s/he cannot eat. There should be enough health care providers available at all times to attend to them immediately. And so that should be organized well, a mobile phone can help do that easily...* [Respondent: 3]

> *I think it is time we do it, it would even reduce the workload on me [the provider].* [Respondent: 2]

Notably, the framework did not specify which particular needs of patients influence their perceived ease of use of mHealth interventions. Nonetheless, the interviewed policy makers suggested that the general trend to use information technology for other services may create a need to use mHealth in the management of NCDs, while simultaneously making it easier to use the technology:

> *We are in a technology age; whether we like it or not, technology is taking over and the earlier we get ourselves involved the better, because there would be a time where all banking would be done online. So, the fact that one is not computer literate nor mobile phone literate it cannot be assumed that the world should wait for us. So, it has to be done and it is being done.* [Respondent: 3]

Enabling Resources

Enabling resources were the most emphasized considerations of the interviewees in determining the sustainability of mHealth. The framework suggested that the 2 most important enabling resources for the successful implementation of mHealth interventions were access to mobile phones (or devices) and the availability of functioning stable telecommunication networks. Accordingly, the interviewees maintained and also suggested that mHealth interventions could be perceived as useful by both patients and health care providers if access to mobile phones, availability and affordability of the infrastructure for good quality (telecommunication) services, reduced burden of work for providers, the avoidance of system abuse, financial resources, and government and institutional support as well as legislation and policy support are assured (see Table 3).

> *Now we are having a lot of mobile phone services but we do have challenges with them. We need to have stable mobile phone services that are good. The services must be available everywhere.* [Respondent: 3]

> *When you are doing a project and you have somebody funding it like we did for the [mHealth] project, it's cool. But then when the project comes to an end and the realities dawn on us, our governments should give money for some of these things.* [Respondent: 1]

> *It has to be a priority and all these things have to fit in the priorities of the Ministry of Health.* [Respondent: 5]

In addition, policy makers suggested that legislation, policies, and guidelines are needed to guide the activities of (health care) providers. However, they maintained that such policies for the explicit purposes of mHealth interventions should be appropriately informed by the evidence from, for example, pilot projects that first need to be conducted. Furthermore, they highlighted that the availability of financial resources would be an important enabling resource but that financial support and commitment from governments for mHealth interventions still remains low because of resource constraints.

> *[...] Yea, will you buy vaccines or you buy phones. I will rather buy vaccines than buy phones. Those are the realities that we deal with as people at the policy level. [...] So those are the trade-offs that we make at the national level and it's not an easy trade-offs [...] Also we need to really come out clearly what the parameters should be. We developed a mobile device guideline and we did advocate that the mobile phone is a medical device and so the health facilities have to provide them.* [Respondent: 1]

> *I believe in doing pilot projects before developing the policies because the findings of the pilot project should guide the policy. So, the immediate thing is to have a project with the NCD programme... it can be part of the priorities of the Ministry of Health."* [Respondent: 5]

Interviewees identified several conditions that would enable patients to easily use mHealth interventions, including, for example, family support and availability of maintenance services. In the same vein, they emphasized that attention should be given to the suitability of the technologies for health care

providers including certain specific features, such as the size of the screen.

> *...one mobile phone platform they created for health professionals to monitor those [patients] who are on medications, they secured an Android phone for all of them, I mean something with a bigger screen that they could do so many things on it. I think it has been tailored.* [Respondent: 7]

Discussion

Principal Findings

To our knowledge, this is the first study that has investigated the views of policy makers about factors that support successful implementation and scale-up of mHealth interventions. We found that policy makers in Ghana were well informed about the potential of using mobile phones for health promotion, prevention, and health service delivery—and they strongly supported the further expansion of mHealth in the country. The results of the study also showed that the mHealth PNE framework's categories of *predisposing characteristics, needs, and enabling resources* are a useful guide for policy makers in ascertaining what critical factors would support the successful implementation of mHealth interventions. None of the policy makers stated any view that suggested that the framework has shortcomings. Rather, the responses of interviewed policy makers showed that they are thinking of many of the factors suggested by the mHealth PNE framework but that they tend to focus more on enabling resources than on predisposing characteristics and need. Finally, policy makers added several relevant factors under the categories of the mHealth PNE framework that should be considered when aiming to assure sustainability and scale-up of mHealth interventions.

These findings have several important implications for policy makers and researchers, as well as for the further refinement of the mHealth PNE framework. First, this study shows that policy makers are aware of many of the factors that have been described in the literature as particularly important for assuring successful implementation and scale-up of mHealth interventions for NCDs. For example, in line with previous literature [23], the participating policy makers highlighted that a positive attitude of both patients and providers toward mobile technologies is one of the most important factors influencing the perception of patients and providers that mHealth interventions are useful and easy to use. Similarly, their assessment that patients in need of special/urgent care are likely to benefit most from mHealth is in accordance with previous findings in the literature. This implies that policy makers in Ghana broadly agree with the findings of our systematic review [23] that it is important to consider context factors, that is, PNE, when developing and implementing mHealth interventions for NCDs. In fact, these context factors can be more important than the technical aspects of an intervention in determining its success [23,56-58].

Second, as the thinking of policy makers tends to focus on enabling resources, such as functioning telecommunication infrastructure, sustainable financing, and support from stakeholders, the mHealth PNE framework can be useful to facilitate a more holistic and systematic assessment of other factors supporting successful implementation, sustainability, and scale-up of mHealth interventions for NCDs. For example, future revisions of the Ghana eHealth Strategy [47] may benefit from considering the categories of the PNE framework to assure that new policies are developed, which will be adjusted to the needs of patients and providers, while taking into account their predisposing characteristics. The mHealth PNE framework (see Table 3) provides a long list of predisposing characteristics of patients and providers as well as of their needs, which can be used as a guide by policy makers during implementation, sustainability, and scale-up.

Third, this study has contributed to the refinement of the mHealth PNE framework by identifying additional patient- and provider-context factors that should be considered during implementation, sustainability, and scale-up of mHealth interventions. This includes patients' predisposing characteristics, such as gender, urban/rural location, and personalization of technologies; patients' need, such as their need for urgent/specialized care; and patients' enabling resources, such as avoidance of abuse, partnership, and (family) support. Concerning providers, policy makers identified additional predisposing characteristics, such as good (provider-to-patient/community) relationships; additional need factors, such as the need for exchange of expertise and for continuity of care; and additional enabling resources, such as support from government and other stakeholders (see Table 3). Interestingly, policy makers noted that the increasing utilization of mobile phones by patients for services of other sectors, for example, in the financial/banking sector [59,60], may create a desire (or *need*) to also have mobile phone–based services in the health sector, which, in turn, may contribute to patients finding these technologies easy to use.

Finally, although the study shows that the categories of the framework are useful for policy makers, further (quantitative) research is required to test the validity of the framework and to explore the relative importance of the identified context factors for successful implementation, sustainability, and scale-up of mHealth interventions for NCDs. This may include, for example, studies testing the relevance of the identified context factors during the implementation of the WHO's Package for Essential NCD Interventions (ie, integration of NCDs into primary health care) [9,61] using mobile technologies.

Limitations

This study has several limitations. The recruitment of participants relied on the list of members of the technical working group for Ghana's national NCD policy. This does not constitute a representative sampling of all relevant policy makers, and it has a bias toward the inclusion of policy makers with expertise in the area of NCDs, whereas possibly missing policy makers with expertise in the area of mHealth. However, the selected policy makers demonstrated that they had considerable knowledge in the area of mHealth, in addition to their long-standing experience from working in the health sector in Ghana.

The scope of this study was also limited by the use of qualitative methods. As a result, the contextual factors summarized in Table

3 are rather indicative. It is very likely that there are further predisposing characteristics, enabling resources, and need that are relevant for the implementation and scale-up of mHealth interventions for NCDs beyond those identified by the interviewed policy makers or by our systematic review [23]. In addition, the relative importance of the identified factors remains unknown. Therefore, more research is needed to confirm the mHealth PNE framework and to operationalize some of its categories. For example, concerning the interplay of predisposing characteristics and perceived usefulness (see Table 3), quantitative research is needed to confirm that a positive attitude toward mHealth is a predictor of perceived usefulness. This requires an operationalization for measuring a positive attitude and for quantifying its impact on the sustained use of mHealth for NCDs. Ideally, the mHealth PNE framework would be tested using a large dataset from a multicountry mHealth trial, allowing sufficient variation in the context factors that are hypothesized to influence long-term success of interventions.

Conclusions

There is great potential for mHealth interventions to improve treatment and care for patients with NCDs in SSA. However, the views of policy makers about factors that support the successful implementation, sustainability, and scale-up of these interventions used to be unexplored. Our qualitative study found that policy makers in Ghana are aware of many of the factors that have been described in the literature as particularly important for assuring successful implementation, sustainability, and scale-up of mHealth interventions for NCDs. In addition, the study showed that the mHealth PNE framework is useful to guide policy makers toward a more holistic and systematic assessment of context factors that support intervention implementation, sustainability, and scale-up, such as predisposing characteristics of patients and providers, as well as their need. Furthermore, the study allowed to refine the mHealth PNE framework by identifying additional context factors under the categories of PNE that support implementation, sustainability, and scale-up of mHealth interventions for NCDs.

The implication of these findings is that policy makers may benefit from using the mHealth PNE framework at various stages of implementation and scale-up of mHealth interventions for NCDs. However, it is important to be aware that the framework is still in its early stages of development. Researchers may (and should) use the framework when investigating reasons for success (or failure) of interventions. Over the years, such an emerging body of evidence will contribute to confirming and/or refining the factors proposed by the mHealth PNE framework, and it may ultimately allow quantifying the relative importance of these factors.

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Conflicts of Interest

None declared

Multimedia Appendix 1

Semistructured questionnaire.

[PDF File (Adobe PDF File), 107KB - mhealth_v7i5e11497_app1.pdf]

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Abbreviations

eHealth: electronic health
mHealth: mobile health
NCD: noncommunicable disease
PNE: predisposing characteristics, need, and enabling resources
QCA: qualitative content analysis
SSA: sub-Saharan Africa
WHO: World Health Organization

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Chapter 8: Conclusions

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Non-communicable diseases (NCDs) – also known as non-infectious chronic disease conditions – have become a major public health challenge across the globe. Most deaths associated with NCDs are considered as premature or preventable, and they are increasingly occurring in sub-Saharan Africa (SSA). However, the health systems in SSA have not yet been strengthened enough to reverse the upsurge trend of NCDs on the one hand, and to meet the health needs and desires of persons living with any of these chronic diseases on the other hand. But then, there are opportunities available to help improve the situation and it includes the use of the various forms of information and communication technologies (ICT) for health (digital health).

Digital health has been traced to as far back as the 19th Century and the concept is found to be as old as the time when telephone was invented (10th March 1876). Since that time, the concept of using ICT for health has evolved through various technological innovations including telemetry in medicine – transmission of information from examination of patient using telephone – and more recently the use of mobile devices, technologies and services for health purposes (mobile health or mHealth).

Especially for SSA, mHealth in particular offers a wide range of potential benefits and contributions. First, given that most countries including Ghana have modelled their national health systems toward primary health care in accordance with the 1978 Alma-Ata Declaration, digital health technologies is considered as a critical operational lever for the primary health care strategy. Second, there is a clear conviction that without the support of digital health technologies and innovations, it would be difficult for countries seeking to ensure that health care services are good enough to improve the health of those receiving the services and that the cost of health care does not put people at risk of financial hardships while accessing the services. Finally, in the wake of the post 2015 Sustainable Development Goals (SDGs), digital health technologies have been underscored as viable help for the attainment of healthy living and well-being for all persons (i.e. SDG 3).

In the context of NCD management, self-management has been identified as a key element for disease management. However, self-management is poor among patients with type 2 diabetes, if not lacking, and posing a serious threat to glycemic control. Specifically, the levels of risk reduction behaviours, physical activities and self-monitoring of blood glucose are insufficient in SSA. It would require future efforts and resource investments in public health to be directed toward this course. Also, mHealth interventions have generally had positive outcomes and could help improve diabetes self-management in SSA. The

challenge here is that, the evidence to support the effectiveness of mHealth interventions against NCDs is rather limited.

There requires more research to continue the attempt to determine the specific effects of different types of mHealth interventions on different types of NCD outcomes. But then it is also possible that, using the traditional forms of research methods, such as randomized control trials and Cochrane systematic reviews, is arguably difficult to ascertain the effectiveness of these complex interventions. New approaches of research methodology like the realist review have provided an alternative method for systematic reviews in order to help policy makers with a comprehensive understanding of the causal relationship between context, intervention, and outcomes, instead of focusing mainly on the outcomes as it is in the case of traditional systematic reviews.

This study explored with the realist review of mHealth interventions for NCD management in SSA countries. The review successfully established that, the contribution of mHealth interventions to improved treatment and care for patients with NCDs is that they facilitate (remote) access to previously unavailable — and often specialized — services. However, this is possible where the predisposing characteristics and need of patients and healthcare providers as well as the availability of enabling resources in the community influence the perceptions of patients and providers that mHealth interventions are useful and easy to use. These perceptions are essential for the successful implementation of an mHealth intervention. Therefore, prior to the introduction of a mHealth intervention, policy makers and program managers should consider the predisposing characteristics and need of patients and healthcare providers as well as the necessary enabling resources during the planning stages.

Based on the realist review, a new theory or concept has been propounded and it proffers an explanation to the factors underpinning the successes and failures of mHealth interventions. It is referred to as the mobile health predisposing characteristics, need, and enabling resources framework (mHealth PNE framework).

In no doubt, the development of mHealth interventions is growing in SSA and Ghana is one of the countries where efforts to harness the potentials and contributions of mHealth have been explored. To focus on Ghana here, further efforts in Ghana to ensure access to quality health care have included the implementation of a national health insurance scheme and the establishment of NCD programmes. Despite these efforts, there are peculiar challenges relating to the approach of the health system in Ghana for NCD management. This includes the high out-of-pocket spending for NCD-related care, which has created financial barriers for especially diabetic patients to access health care. Also, special programmatic

interventions for NCDs have remained at pilot project levels so far. Policy makers, programme managers and researcher should use the mHealth PNE framework to guide them toward scale-up and sustainability of the successful projects.

In the specific case of diabetes management in Ghana, the opportunities and challenges of implementing mHealth interventions for improving diabetes management for persons visiting a diabetes clinic in Ghana has been explored in this study. The potential was high and the use of mHealth is more likely to yield better treatment and care for diabetes patients and to help improve the identified areas in the health system of Ghana that need improvements, including the sustainability and scale up of pilot projects.

For the larger SSA, also the opportunities and challenges of implementing mHealth interventions for NCD management have been explored in this study. It focused on mobile phone-based health interventions and technologies, using rigorous methodologies and novel approaches for the research. Here too, the potential is high for the use of mHealth.

With the aims to identify how, for whom and in what circumstances mHealth interventions help improve NCD management, this study conducted a realist review and this exercise has also resulted in the development of an innovative framework for understanding the contributions of mHealth interventions to improved access to care for patients with NCDs in SSA. In fact, the realist review methodological approach that led to the development of the innovative framework in this study was the first time being used for the review of mHealth interventions for patients with NCDs in SSA countries. This is a major advancement in the digital health field of research, especially for investigating reasons/factors associated with successes or failures of technological innovations for health. The framework itself and the processes involved in its development have three major implications; two for research and development, and one for policy and practice.

For research and development, the framework has proven to be a useful quantitative research instrument for designing research questionnaire for survey and can as well be used as a model for quantitative data analysis. This has already been demonstrated by one empirical research study included in this study and currently undergoing peer-review for publication. The research study adopted the framework to conduct a quantitative survey among patients visiting a diabetes clinic in Ghana with the objective to determine the probable contributions of a potential mHealth intervention for diabetes management.

Similarly, the framework has also proven to be useful qualitative research tool for analyzing exploratory semi-structured interviews. Here too, the first qualitative research study – included in this study – has been conducted in order to explore the views of policy makers on how to achieve sustainability and scale-up of mHealth interventions in SSA. The research study has already gone through peer-review and has been accepted for publication soon.

For policy and practice, the framework has now provided the opportunity to guide policy makers toward a more comprehensive and systematic assessments of the critical factors that support mHealth interventions at various stages of implementation, sustainability and scale-up.