Year: 2023

Empowering community health workers with mobile health: learnings from two projects on non-communicable disease care

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EMPOWERING COMMUNITY HEALTH WORKERS WITH MOBILE HEALTH: LEARNINGS FROM TWO PROJECTS ON NON-COMMUNICABLE DISEASE CARE

Research Paper

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Abstract

Community-based healthcare is a promising approach to tackling workforce shortage in healthcare, especially in the global south. Community health workers (CHWs) are lay cadres that bridge healthcare disparities by living in the community where they should provide basic health services, mainly through education. However, high attrition rates and underperformance of these health workers limit the scope of such programs. In addition, mobile health is not the hoped-for silver bullet to solve the two challenges. This paper examines two pilot projects using mobile health for non-communicable disease care from an empowerment perspective. We propose design knowledge of mobile health for the structural empowerment of CHWs. Furthermore, we evaluate their psychological empowerment by analyzing mobile health's intended and unintended consequences. Finally, our study demonstrates how empowering CHWs could help overcome the persisting challenges and lead to a sustainable and resilient health system.

Keywords: Community-based Healthcare, Mobile Health, Empowerment, Design Archaeology

1 Introduction

Non-communicable diseases (NCDs) such as diabetes and hypertension are the leading cause of death worldwide, accounting for 41 million deaths yearly (World Health Organization (WHO), 2022). The global south is disproportionately affected as more than three-quarters of NCD-related deaths occur due to a lack of effective prevention, detection, and treatment of NCDs (Lupafya et al., 2016). Simultaneously, the WHO expects a healthcare workforce shortage of 15 million by 2030 (WHO, 2016). Community-based health programs are a proven approach to relieving the health system by employing lay people in high numbers as community health workers (CHWs), which has shown remarkable improvement in addressing the burden of infectious diseases (e.g., HIV) in the global south (Fernández et al., 2022; Perry et al., 2014). However, high attrition rates and subpar performance often hinder the nationwide rollout of such programs (de Vries and Pool, 2017; Ngugi et al., 2018).

Technological advances such as mobile devices and the internet are ascribed to the potential to mitigate the challenges mentioned above (Källander et al., 2013). Recent studies demonstrate the effects of mobile health (mHealth) in the form of decision support systems or performance dashboards on the work routines and motivation of CHWs (Kateera et al., 2022; Whidden et al., 2018). Nevertheless, the challenges remain despite the positive outcomes of IT-supported CHWs. The literature mainly argues that the predominant patient-centric perspective neglects the core user of mHealth in the global south: the CHWs (Rodrigues et al., 2022).

What unites these efforts is the aim to empower CHWs to provide health services usually provided by medical personnel. Empowerment is an established construct studied as an act or a cognitive state in a work environment (Menon, 2001). Empowerment as an act refers to the transfer of power to the employee. Empowerment as a cognitive state is the employee's actual perception of empowerment. This concept has been adopted in the healthcare domain, and studies have demonstrated a positive correlation between empowerment and workforce performance, motivation, and lower attrition rates (Maynard et al., 2012). Digital technologies can serve as a tool to empower users even in distributed settings through their prevalence and affordability (Leong et al., 2015; Tan and Yan, 2020). Despite this existing work, the literature on the design of mHealth to empower CHWs is scarce (Rodrigues et al., 2022). This study's underlying assumption is that empowerment positively influences CHW retention and performance in the long term. This relationship has been empirically validated in various research in the nursing context, where empowerment led to a more satisfied and resilient workforce (Cicolini et al., 2014; Spence Laschinger et al., 2009). Therefore, this paper argues that empowerment should be instantiated as a design goal of mHealth for CHWs to support NCD care. Building on this design goal, the objective of this study is to answer the following question:

How can mHealth contribute to empowering CHWs to provide NCD care in the global south?

To attain this research question, we conducted design archaeology on two projects in sub-Saharan Africa that utilize mHealth to prevent and treat diabetes and hypertension. *mPrevent*[1] emphasizes NCD prevention through community-based education programs in Eswatini. *mTreat*[2] focuses on the early detection and treatment of uncomplicated NCD disease progressions in Lesotho. In these projects, we evaluate two separate systems by following the framework for evaluation in design science research (FEDS) proposed by Venable (2016). We propose generalizable design requirements for the design of mHealth to empower CHWs for NCD care in the global south. In our evaluation, we link the proposed design requirements and the CHWs' field experience, providing insights for the sustainable rollout of community-based NCD care. Furthermore, we highlight the socio-technical dynamics of digital empowerment as design archaeology allows us to identify unintended consequences that emerge in a real-world context.

2 Research Background

2.1 Community-based Healthcare to tackle NCDs in the global south

As the name implies, NCDs are neither communicable nor contagious; yet they can remain for the rest of a person's life (e.g., type 1 diabetes). While some NCDs are genetic, others result from metabolic risk factors, unhealthy diets, physical inactivity, tobacco consumption, or drug abuse such as alcohol. The latter can be prevented through lifestyle changes, so investment in prevention and better long-term NCD treatment are crucial (WHO, 2021). NCD significantly burdens patients and healthcare providers as they require continuous patient-centered treatment and care (WHO, 2013).

While health systems in the global south strongly focus on controlling and caring for infectious diseases, the spread of NCDs also increases. This dual burden overwhelms the healthcare system, which is challenged by a shortage of healthcare professionals (Tawfik and Kinoti, 2003). This shortage results in an incapacity to absorb the rapid spread of NCDs and apply available resources such as medication (WHO, 2021). As the shortage of professionals is ongoing - the WHO forecasts a deficit of 15 million health workers by 2030 - community-based healthcare is a promising backbone for NCD-related healthcare services (Bhutta et al., 2010).

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[1] The name of the projects made up to simplify the reading of this paper. *mPrevent* describes the app which is part of the project "Scaling up the WHO-PEN package for diabetes and hypertension in Eswatini: a nation-wide cluster-randomized evaluation of three strategies in Eswatini (WHO-PEN@Scale)" funded by the European Union's Horizon 2020 research and innovation program.

[2] *mTreat* describes the app which is part of the ComBaCaL project in collaboration with the clinical epidemiology research group at the University of Basel and SolidarMed. ComBaCaL is funded by the Swiss Development Cooperation and the World Diabetes Federation.

Community-based healthcare has been around since the early 1970s as a response to clinic-based services that excluded the poorer population living further away from medical facilities (Berman et al., 1987). CHWs usually provide health services in such outreach programs. CHWs come from modest economic backgrounds and seldom have higher education (Bhatia, 2014; Olaniran et al., 2017). Usually, they are community members and receive limited training to provide basic services such as health promotion, education, and mobilization in their communities to supplement primary health care. The connection to the community is an asset in bridging the gap between the community and health services, especially in the global south (Maes et al., 2014; Payne et al., 2017). CHWs primarily work part-time and may receive a salary or volunteer (Olaniran et al., 2017). Once trained, CHWs disseminate health information within their communities in a culturally acceptable and understandable manner (Agarwal et al., 2015; Odendaal et al., 2020). Community-based health programs have been shown to lower maternal and child mortality, reduce the burden of tuberculosis and malaria (Christopher et al., 2011), and increase enrollment in HIV therapy (Bemelmans et al., 2010). CHWs are also trained to refer patients to and organize appointments with a medical professional in case of anomalies (Scott et al., 2018).

Despite the promising outlook, community-based programs face two significant challenges. First, increasing and sustaining the performance of CHWs is a well-known challenge in providing quality healthcare. The subpar performance hinders the nationwide scaling of such initiatives, as patient safety cannot be guaranteed (Rassi et al., 2018). Second, the literature reports high attrition rates amongst CHWs of up to 50% (Ngugi et al., 2018). The reasons for these challenges are a lack of organizational support and appreciation (Olang'o et al., 2010), inadequate training (Rawal et al., 2021), inadequate pay or other economic opportunities (de Vries and Pool, 2017), and lack of support and supervision (Rassi et al., 2018). On the contrary, higher retention rates are associated with increased effectiveness and sustainability of community-based health programs (de Vries and Pool, 2017). However, literature on measures to improve working conditions and their effect on the health systems is scarce.

2.2 Digital Health for NCDs

The technology-supported NCD care provides a vivid opportunity for health equity, access to services, and health literacy (Geldsetzer et al., 2022). However, such digital services are often developed for patients in high-income countries, resulting in the inability to apply them to the low-resource settings of the global south (Geldsetzer et al., 2022). Relevant research for the global south addresses a) community-based healthcare in general and b) support for CHWs.

Nevertheless, mHealth has the potential to deliver more health services in the global south through a community-based approach (i.e., via mobile devices like apps or SMS services). These health services include (I) promotion of health and increasing public awareness about NCDs, (II) remote monitoring & care support, (III) disease surveillance & outbreak detection, and (IV) decision support systems for the treatment of NCDs (Stephani et al., 2016). Recent studies show how mHealth can increase CHW performance and facilitate CHWs to take on new tasks, for example, post-surgery care (Kateera et al., 2022) or early detection of NCDs (Zaman et al., 2021). Furthermore, regular feedback through phone calls or performance dashboards positively impacts CHW performance and motivation (Kaphle et al., 2015; Whidden et al., 2018). mHealth gives CHWs access to digital content such as videos (Praveen et al., 2014) or adaptive lifestyle suggestions to educate their patients (Silveira et al., 2019).

However, this research focuses on the effects of mHealth on the measured medical outcome of patients. It neglects the CHWs' job satisfaction, motivation, organizational commitment, and other similar mediators of performance. Such health outcome-centered approaches (e.g., randomized control trials) neglect the design, technical setup, and implementation of mHealth and how this mediates medical outcomes. Furthermore, the systems are presented as black boxes with a superficial description of features and capabilities. Consequently, designers and users can only draw limited conclusions about the effects of specific mHealth features on CHWs.

2.3 (Digital) Empowerment of Community Health Workers

Empowerment enhances employee performance, motivation, and retention (Maynard et al., 2012). Empowerment is seen as the act of transferring authority and responsibility (structural empowerment), typically from supervisors to employees leading to the perception of empowerment (psychological empowerment). This transfer allows people to make decisions autonomously, which is required to adapt dynamically to the working context (Bowen and Lawler, 1995). For example, a service employee must have the authority to respond to a customer's complaint to avoid dissatisfaction adequately.

Structural empowerment is the dimension that focuses on organizational conditions that facilitate this transfer of power. It is achieved by providing people with *access to information*, *resources*, *support*, and *opportunities* through organizational structures and workplace design (Kanter, 1977; Laschinger et al., 2001). In recent years, research on structural empowerment has included digital technologies in workplace design (Leyer et al., 2019). Structural empowerment consists of four dimensions: *Access to information* refers to information and knowledge required to carry out the work effectively and efficiently. In the context of this study, this includes information such as patient data, upcoming tasks, and medical guidelines. *Access to resources* consists of materials, means, and time available to complete the work. This includes physical resources such as medication, safety equipment, information brochures, and adequate work completion time. Means can be tools and machines such as glucometers or the computational speed of software. *Access to support* refers to guidance and feedback from supervisors and peers, which is necessary for decision-making and job performance. For example, the possibility to access a supervisor's knowledge for a diagnosis. Finally, *access to opportunities* refers to the opportunities to apply and acquire knowledge and skills. Furthermore, it includes opportunities for personal development within the organization (Laschinger et al., 2001). Structural empowerment is an antecedent of psychological empowerment (Seibert et al., 2004).

Psychological empowerment, in turn, focuses on perceived control over one's work (Spreitzer, 1995). Drawing on insights into self-efficacy (Bandura, 1977) and self-determination (Ryan and Deci, 2000), the underlying idea of psychological empowerment is that perceived control positively influences intrinsic motivation. This control is granted through structural empowerment, increasing the cognitive dimensions of *meaning*, *competence*, *choice*, and *impact* (Spreitzer, 1995). *Meaning* is the degree to which the goal of a task fits an individual's beliefs. *Competence* is strongly linked to self-efficacy (Bandura, 1977). It refers to a person's belief in their capabilities to perform a task with skill. A high sense of competence is associated with resilience and proactive behavior. *Choice* is an individual's perception of autonomy and being the locus of causality. Self-determination is often used synonymously, as Ryan and Deci (2000) agree with the central role of choice for intrinsic motivation. Lastly, *Impact* is the degree to which an individual can influence the outcome of a specific task.

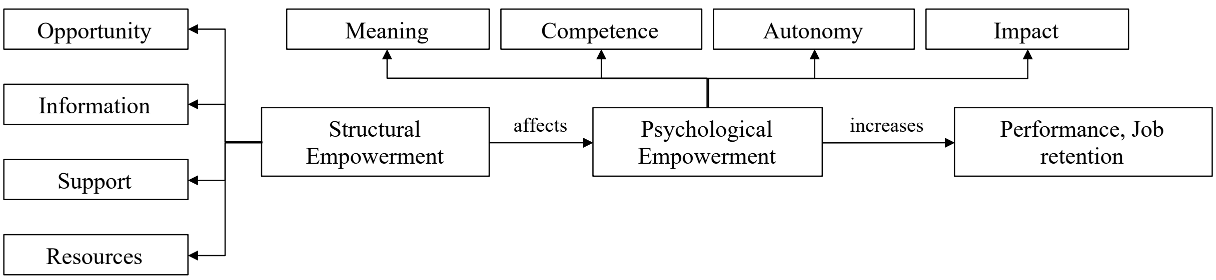

Figure 1: Conceptualization of empowerment (adapted from Maynard et al. (2012))

Empowerment has been studied in many industries with an emphasis on nursing to investigate issues with workforce performance and retention (Laschinger et al., 2001). Such studies indicate that structural empowerment needs to be initiated and affects psychological empowerment (see Figure 1). Despite its similarities, there is only a little research focusing on empowering CHWs. Jaskiewicz and Tulenko (2012) strongly link working conditions and CHW productivity. They identify adequate workload, supportive supervision, access to resources, and recognition as four essential elements to enhance productivity. Kane et al. (2016) found that CHW programs can strengthen CHWs by connecting them better to the formal healthcare system, providing them with *access to information*, and enabling them to work effectively. Nevertheless, they also found that CHWs are hindered by organizational and relational factors, leaving them feeling powerless and frustrated. However, as conceptualized above, empowerment has not been considered in this line of research.

3 The Cases of mPrevent and mTreat

This section introduces the two cases on which this study focuses. *mPrevent* is a nationwide randomized controlled trial that aims to investigate NCD service models at the community level in Eswatini (formerly Swaziland). This includes the engagement of CHWs to facilitate the extension of health promotion services to the communities through interpersonal communication. The project's overall goal is to involve the CHWs in the basic screening of people at risk of hypertension or diabetes, lifestyle counseling, referral to facilities, and monitoring treatment adherence of diagnosed clients. One aspect of the project is to equip the CHWs with a smart device (tablet or smartphone) with an offline app that supports the risk assessment and personalized lifestyle counseling of clients for diabetes and hypertension. The *mPrevent*-app supports the general data assessment of clients, provides a risk calculation for the client based on that data, and adjusts the lifestyle counseling material (videos, images, texts) accordingly. The *mPrevent*-app was developed through a DSR approach to meet the requirements of the CHWs as primary users and clients as secondary users (e.g., illiteracy rate, stigma, age, gender, and culture demands). The CHWs are enabled to communicate NCD prevention information and risk assessment guided by the *mPrevent*-app to the people. Hence, they use the *mPrevent*-app as an asset for their regular counseling visits to community households.

mTreat provides an innovative care model that uses mHealth tools to empower CHWs to screen, diagnose, and manage NCDs. The 5-year project is being conducted in two districts in Lesotho, Southern Africa. The project conducts a CHW-led, mHealth-assisted model of care, including the screening, management, and care of hypertension and diabetes in the community. The care model brings prevention, diagnosis, and care closer to the community as hypertension and diabetes need lifelong follow-ups, and the frail and elderly are sometimes concerned by non-traditional medicine provided in health facilities. In each village, a CHW visits households regularly to provide screening and lifestyle counseling to prevent and treat hypertension and diabetes. For household members diagnosed with hypertension or diabetes, they provide lifestyle counseling and first-line medications. Complex and acutely ill cases are referred to the nearest clinic. The CHWs live in the village they serve, have at least a secondary-level school certificate, and are elected by the community. The CHWs are supported with up-to-date training, equipment, and professional supervision by nurses specialized in NCDs. The project uses the *mTreat*-app to support CHWs in their daily work. The *mTreat*-app is centered around medical algorithms that guide the CHWs through administrative (e.g., client registration) and medical processes (e.g., diabetes screening). It provides decision support based on the entered data and offers treatment plans in case a client is diagnosed with hypertension or diabetes. Independent of the diagnosis, the *mTreat*-app schedules regular follow-ups depending on the client's needs for care.

4 Methodology

4.1 Design Archaeology

Generally, design science research (DSR) aims to create new design knowledge about artifacts (Gregor and Hevner, 2013; Hevner et al., 2004). This knowledge is usually generated through the design process of artifacts with its design decisions and lessons learned. In contrast, design archaeology highlights the value of artifacts-in-use to derive prescriptive design knowledge (Vom Brocke and Maedche, 2019). It complements traditional DSR as it adopts a retrospective rather than prospective approach. As a result, design archaeology promises to produce more meaningful design requirements. When studying artifacts-in-use, we can observe intended and unintended consequences (Chandra Kruse et al., 2019). We adopt a design archaeology approach to answer our research question as design knowledge on mHealth for CHWs is abundant. However, the users' perception is underrepresented. We fill this gap by studying two independent projects focusing on community-based NCD care in sub-Saharan Africa: *mPrevent* in Eswatini and *mTreat* in Lesotho. Rather than focusing on the design process, we study the artifacts in use to derive design requirements as a starting point for future DSR, emphasizing the empowerment of CHWs. Analyzing the two projects in a similar yet distinctively different setting allows us to generalize our findings. Both projects focus on similar countries in sub-Saharan Africa with pre-existing community-based health programs. While they target the increasing burden of NCDs on the health system with technology-supported CHWs, the projects focus on different intervention strategies. The CHWs in *mPrevent* offer personalized counseling to enhance disease awareness and advertise preventive lifestyle adaptations to address the NCD epidemic at its root cause. *mTreat* focuses on early detection and first-line care by CHWs. They treat the people in the communities and only refer them to a clinic in case of danger signs. The two projects enable us to compare the use of digital mobile technology in diabetes and hypertension care at the community level. We adopted the framework for theorizing in design science research to investigate similarities and differences while allowing abstraction from the instance solutions (Lee et al., 2011). However, we reverse the order of the framework as we engage in design archaeology as follows:

Abstract problem: We defined an abstract problem definition by reviewing existing literature on community-based healthcare in the global south. High attrition rates and subpar performance of CHWs are the major challenges hindering the large-scale and sustainable rollout of (IT-supported) community-based health programs.

Instance problem: We immersed ourselves in the context of each project by reviewing empirical data gathered for purposes other than this study. We analyzed stakeholder interviews, including project members, government and NGO representatives, patients, and CHWs (13 interviews in *mPrevent* and 18 in mTreat). A thematic analysis (Clarke et al., 2015) elicited a lack of organizational support, inadequate financial compensation, and inadequate training and information as problem themes.

Instance solution: Besides the abovementioned interviews, we expanded the analysis to research proposals, project mission statements, and software specifications. This analysis yielded two instance solutions and an initial set of design requirements.

Abstract solution: We tested several theoretical concepts by discussing their fit as an abstract solution objective and hypothesizing about the potential effects of mHealth adopting these concepts. We decided on empowerment as its definition of transferring authority and responsibility to employees (structural empowerment) and as a cognitive state (psychological empowerment) resonates with both instance solutions. We ensured the fit of structural empowerment by grouping the initial set of design requirements in the dimensions of access to *information*, *resources*, *support*, and *opportunities*. This process resulted in the final set of design requirements (see section 5.1).

4.2 Field Evaluation

For this study, we gathered data from November 2020 to May 2021 for *mPrevent* and from June 2021 to June 2022 for *mTreat*. After immersing in the context, we studied the artifacts in situ. Both artifacts were evaluated following the FEDS in real-world pilot studies orchestrated by medical experts with the permission of the respective ministry of health (Venable et al., 2016). Evaluating the artifacts in pilot studies allowed us "to demonstrate the functional feasibility for a potential solution to an important class of unsolved problems in the field." (Nunamaker Jr et al., 2015). The pilot cohort for *mPrevent* consisted of 18 CHWs, and *mTreat* included 10 CHWs. Before the pilot studies, the CHWs were trained in medical and technical knowledge by medical experts and members of the development team. The medical knowledge included presentations on NDCs, their prevention, diagnosis, and treatment. The CHWs practiced their knowledge by counseling each other in roleplays, where they simultaneously learned to use the artifacts. After the training, we asked them about their first experience with the artifacts and their expectations for the pilot in focus group discussions. While most CHWs spoke English, a translator participated in each focus group discussion to assist if necessary. For the interviews, the CHWs could decide to speak English or their native language. After the CHWs used the artifact over an extended time (*mPrevent* 8 weeks, *mTreat* 12 weeks), we collected a final round of data to evaluate the perception of the CHWs on the usage of mHealth and its effects on their work. We conducted individual interviews in *mTreat* and focus group discussions in *mPrevent* with all CHWs engaged in the pilot studies.

We inductively coded the data using the dimensions of structural and psychological empowerment as the coding schema (Saldaña, 2009). For example, the following statement was coded with *access to support* and *competence*. It shows how the medical algorithm supports the CHWs in the workflow (*support*), which leads to the perception that they could provide services as well or even better as medical personnel (*competence*).

"We do [the screening and treatment] as hospitals do. Or even better because here [in the workflow], I see when we check high blood pressure, we don't only use one arm but both, and I think it's a bit more accurate."

During the analysis, unintended consequences emerged from digitally empowering CHWs. Using digital artifacts in the field usually does not guarantee specific effects with certainty producing unintended consequences (Chandra Kruse et al., 2019). Therefore, we reviewed our data introducing an additional code indicating the unintended effects of empowerment. For example, the statement above was coded accordingly as it shows an overconfidence that could potentially lead to adverse effects. In both stages, the authors iteratively discussed their findings by comparing the projects leading to the identification of similarities and variations across the projects and the intervention strategies. This enabled us to abstract from the instance solutions and finalize our proposed design requirements.

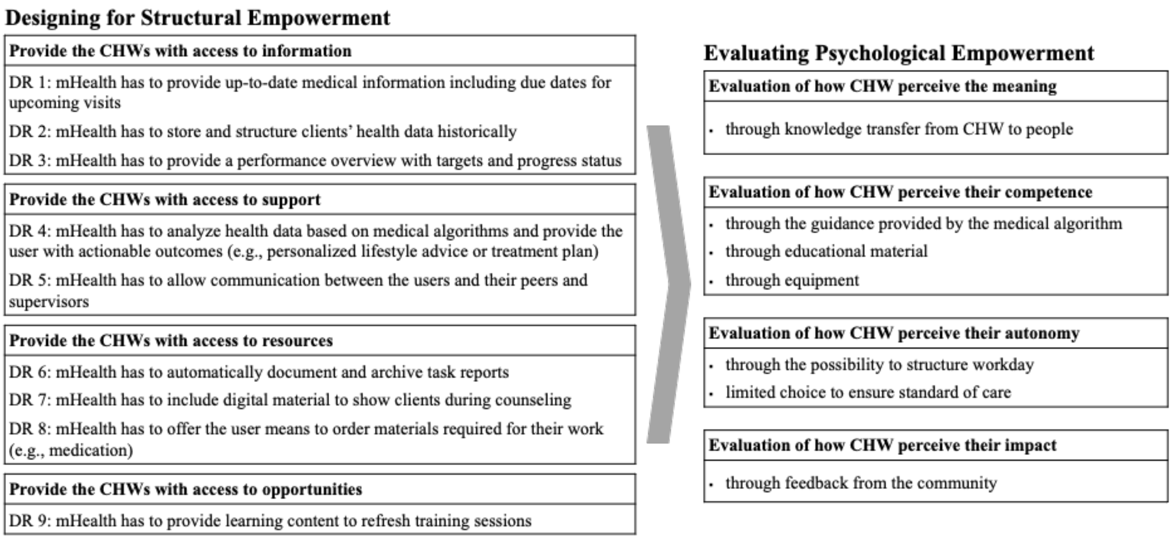

Figure 2: Overview of the findings

5 Findings

Guided by the literature (see Figure 1), we present our results in two steps. First, we present the identified design requirements for mHealth to empower CHWs structurally. We organize this subsection along the four dimensions of access to *information*, *support*, *resources*, and *opportunities*. Most design requirements universally apply for mHealth-empowered community-based healthcare. For example, DR 8 depends on the aim and is an outcome of the variations between *mPrevent* and *mTreat*. Second, we present the evaluation results of the pilot studies focusing on the empowering effects of mHealth on the CHWs along the four dimensions of psychological empowerment (i.e., *meaning, competence, autonomy,* and *impact*). Finally, we highlight the unintended consequences of empowerment identified in our analysis. Thereby, we focus on the unintended problems. A summary of our findings is visualized in Figure 2.

5.1 Requirements and Design for Structural Empowerment with mHealth

Several overarching requirements were identified during the design and development phase of both projects. The DRs formulate the demand on the artifact to empower CHWs for NCD care structurally. In the following, they are described in the context of both projects.

Provide the CHWs with access to information: Often, CHWs lack adequate and up-to-date information on their patients, community, program, and medical guidelines. One of the primary purposes of mHealth is to provide CHWs with access to information. Both cases show how the CHWs can access the required information and knowledge to carry out their work.

To plan their work, the *mTreat* -app displays upcoming appointments a CHW must attend in a schedule. A medical algorithm creates these appointments depending on the patient's condition and status. For example, the patient's blood sugar level indicates a diabetic condition. The medical algorithm creates a follow-up task for the next day to verify the preliminary diagnosis. The tasks show a due date allowing the CHWs to foresee upcoming work and attend to the patients on time. This schedule enables the CHWs to plan their work accordingly while adhering to medical guidelines (see Figure 2, DR1).

The tool provides the CHWs with relevant information about an individual client in both projects. In *mPrevent*, this data is collected by the CHWs, stored, and presented in the *mPrevent*-app, to be reviewed in each recurring counseling session. In *mTreat*, this information includes basic personal data, other medical conditions, current treatment plans, and prescribed medication. The CHWs can use this information to prepare for their visits by reviewing the patient's overall health status and tracking changes in both projects (see Figure 2, DR2).

Furthermore, in *mTreat*, a simple dashboard displays a performance overview to provide the CHWs with information about their progress toward targets and the overall state of their community. For example, they can determine how many households in their community have already screened for NCDs or how many diabetes patients they have visited in a week. In *mPrevent*, this is simplified by an overview of clients visited with timestamps (see Figure 2, DR3).

Provide the CHWs with access to support: Supporting CHWs with mHealth tools as an asset for their work is a central enabler of community-based healthcare and is at the core of our projects. The support from these tools is intended to ensure high-quality and safe health services through guidance during patient assessments, decision-making, and communication.

Medical algorithms guide the CHWs through patient assessments with validated procedures reducing the risk of erroneous clinical assessments and treatment (see Figure 2, DR4). The medical algorithms display all relevant questions to be answered, ensuring information completeness and thoroughly conducted screenings. The workflows adapt based on the collected data and trigger further assessments or visits if required. Following the patient assessment, mHealth provides the CHWs with a risk calculation (*mPrevent*) and diagnosis based on the medical history and the measures taken during the visit (*mTreat*). The risk calculation includes visualization and explanation to enhance the communication of the result with the client (*mPrevent*). The diagnosis includes an explanation and further information about the condition and treatment options. Furthermore, the system can recommend the following steps and trigger additional tasks such as patient education on the treatment plan and side effects of medications (*mTreat*).

Next, the *mPrevent*-app guides the CHWs during their counseling, and this support standardizes the information transfer. The personalized lifestyle guidelines are the center of the *mPrevent*-app to encourage behavioral change, awareness of risk factors, and overall prevention of NCDs, reducing the disease burden. In *mTreat*, the medical algorithms guide the CHWs through the treatment initiation. Medical experts can standardize procedures while simultaneously embracing some individuality depending on the patient's condition and results. However, the deviation from the standard process can be limited to the desired degree, ensuring patient safety. For example, a patient experiences side effects from the medication handed out by a CHW. Depending on the side effects and their severity, the algorithm could decrease or leave the current dosage or, in severe cases, ask the CHWs to refer the patient to a hospital. The support reduces the cognitive burden on the CHWs with automatic calculations of medication dosage (e.g., based on age, weight, and gender) or assessment of entered test data (e.g., determine if the measured blood sugar level indicates diabetes).

Finally, *mTreat* utilizes WhatsApp for communication purposes. The CHWs can access their peers, supervisors, and project SMEs through a group chat in case of questions regarding the *mTreat*-app and best practices in patient counseling. Furthermore, they can contact their supervisors directly for specific or personal matters (see Figure 2, DR5). However, communication strongly depends on the mobile network, which is often unstable or unavailable.

Provide the CHWs with access to resources: A key challenge of community-based health programs is the time spent on the work as CHWs. Often, CHWs work too many hours compared to their salary and have limited time to care for their families (e.g., farming). This can lead to dropouts as they find better work (i.e., better salary or fewer work hours) elsewhere. From an empowerment perspective, the CHWs lack access to resources like materials, means, and time.

In both cases, the apps eliminate manual documentation efforts beyond the data entry during counseling (see Figure 2, DR6). In *mTreat*, the CHWs automatically generate a report when finishing a task at the end of a counseling session. The reports are available to supervisors and government representatives as soon as they are synchronized. In *mPrevent*, the data is secured on the tablet (with password protection but can be asynchronously synchronized with healthcare facilities. An automated data transfer with the electronic health records of the health information system in the country is planned. The automated reporting frees additional time for the CHWs compared to the pre-existing community-based program where CHWs must manually document their work and deliver monthly reports to their supervisors (see Figure 2, DR7). Despite these advantages, the CHWs still experience an inadequate workload.

Furthermore, in *mTreat*, the CHWs can access materials and medication required for their work (see Figure 2, DR8). In both projects, the digitalization of materials such as fact sheets or information pamphlets provides the CHWs with educational materials for patient education without reordering. For other materials, they can order supplies from their supervisors using the abovementioned WhatsApp group chat. However, some CHWs experienced delayed delivery of essential materials, halting their work for up to two weeks. Additionally, the CHWs are asked to keep track of various materials ranging from surgical gloves to medication. They must consistently assess their stock to avoid stockouts leading to delayed patient attendance.

Provide the CHWs with access to opportunities: *mPrevent* shows how an app as an asset provides the CHWs with the opportunity to access knowledge required for lifestyle change through regular counseling. Therefore, the CHWs gain the skill of improving their counseling abilities through structure and guidance. This form of informing people repetitively may also affect their counseling on other issues (e.g., HIV prevention).

mTreat provides CHWs with multiple opportunities to foster their knowledge and skills. The initial training during the implementation is designed in an interactive way that relies heavily on role play and immediate group feedback. Over a week, the CHWs learned how to approach, screen, diagnose, and treat their patients in roleplay within small groups. Practical instead of textbook learning rapidly increased their skills, which they could share and discuss in their training group supervised by SMEs. At the end of the week, the CHWs visited a designated test village where they faced strangers for the first time. Furthermore, the complementary training material is available on a mobile learning platform used by the CHWs to refresh their knowledge (see Figure 2, DR9).

Regarding opportunities to learn new skills, the CHWs are given limited possibilities. This is mainly due to the context of the projects: the goal is to enable the CHWs to perform very concrete tasks they can fulfill in line with specific medical guidelines and patient safety measures. Moreover, CHWs do not have formal medical education permitting them to attend to their patients' conditions at their discretion. Still, the CHWs ask for certification, allowing them to increase their chances in the job market.

5.2 Evaluating Psychological Empowerment

After the pilot studies, where the CHWs used the artifacts with real clients, we questioned the CHWs about their work experience, interactions with the community, and the mHealth utility. The following results focus on the effects of mHealth instead of empowering effects generated by the programs themselves (e.g., the salary earned), as our goal is digital empowerment with mHealth.

Meaning: All CHWs report a high sense of meaning in their work as they were eager to start working already during the training. They often mention that clearing up misconceptions about NCDs (e.g., that only rich people can get them) is very meaningful to them. However, our analysis showed little to no impact from mHealth on the *meaning* dimension. While the technology has a facilitating role (see below), the projects' objectives and the CHWs' clinical education create this unified sense of meaning, as summarized by one of the CHWs in *mPrevent*: *"It gives a "diagnosis," clients never know what is wrong with them. It makes clients know that they are not healthy. As a result, some clients are now taking medication since they found out about their conditions after seeing us."*

Competence: In our analysis, the competence dimension is the most impacted dimension of psychological empowerment. One of the CHWs from *mTreat* stated the following when asked about their perceived preparedness for their work in the field:

"Honestly, I can say we got the training we deserved because we do exactly what we are trained, and we do [the screening] as hospitals do. Or even better because here [in the workflow], I see when we check high blood pressure, we don't only use one arm but both, and I think it's a bit more accurate."

Many refer to the medical algorithms as the primary source of their perceived competence. They appreciate the support during the counseling and the reminding effect of the predefined workflows. Furthermore, the educational material facilitates easy communication of the subject matter. For example, in *mPrevent*, one CHW believes that it makes working with clients easier as the digital material would help them to persuade the clients to think about NCDs and their diet. Images and videos would excite the clients and help in breaking the ice.

Finally, some CHWs note that professional medical equipment (e.g., glucometer, tape measure) and tablets would give them a sense of competence. It appears that modern equipment legitimizes their trustworthiness and capabilities for their community and even themselves: *"What I'm surprised, is that I'm a shy person. But this time [with the mTreat-app], I've seen that I'm not shy anymore, and I can speak freely to everyone."*

Autonomy: Some CHWs report dissatisfaction with the scheduling in the *mTreat*-app as *"it does not look for my personal preferences when I want to work or go to church."* The app would also not allow them to adapt to their client's availability. The CHWs arrange concrete time slots with their clients as a self-implemented workaround. For this, some use a separate notebook to note down this additional information to remember later because the system does not provide this functionality. While this is an acceptable workaround to arrange a timeslot, it could be problematic if CHWs rearrange due dates in their notebook, potentially leaving clients without medication. Our analysis yielded little perceived level of autonomy due to the design of the mHealth artifacts. The CHWs are only given limited choices since patient safety is paramount. The CHWs understand this limitation and show no sign of disempowerment. They know it is a necessary constraint that allows them to carry out their work.

Impact: Overall, the CHWs perceive their work as very impactful. They receive mostly positive feedback from their communities and are welcomed with open arms. A CHW in *mPrevent* told us, *"the App makes clients excited and interested."* The community members appreciate the new approach to healthcare delivery where they are not required to travel long distances to be seen by a doctor, often returning dissatisfied as the medication is unavailable. One CHW from *mTreat* says: *"My community seems quite satisfied even though you can't tell whether they are really fine, but when I arrive at their place, they seem happy for my service that I also come to their place, not the other way round."*

While the approach per se is not novel, mHealth facilitates the provision of sophisticated health services such as personalized lifestyle counseling and first-line treatment of NCDs. Again, the CHWs ascribe the impact of their work predominantly to the medical algorithms and the materials available to them.

5.3 Unintended Consequences of Empowerment of CHWs in NCD Care

Our analysis showed great potential to empower CHWs for NCD care using mHealth. Both artifacts were successfully evaluated in real-world pilot studies closely monitored by medical experts and the national ministry of health. Our design requirements - instantiated in the artifacts - are ascribed a significant portion of this successful pilot study by CHWs and other stakeholders. However, our analysis also uncovered an unintended consequence of digitally empowered CHWs.

First, the medical algorithms control the CHWs' latitude regarding medical procedures in the project's scope intended to guarantee safe healthcare. However, medical algorithms cannot assess a patient's eligibility to be screened and diagnosed through this community-based program. CHWs can register patients who should not receive their health services. For example, the minimum age eligible for their health services in *mTreat* is 18 years. CHWs could manipulate an underaged person's date of birth - voluntarily or under pressure from community members. As a result, the CHWs would provide health services to a person not considered in developing the medical algorithm and consequently when selecting medication and dosage. This could lead to serious harm due to inadequate dosage.

One CHW says: *"I sometimes get a call from people I never visited before. They got my number from the client I helped."* This quote indicates that some CHWs could provide health services to people outside their community (e.g., family members from a district not yet part of the program) or counsel patients in their community beyond their defined scope. While the former does not directly cause potential harm, the latter could be a dangerous and unintended consequence caused by overestimating the CHWs' role and capabilities. This overconfidence can be seen in the above quote, where the CHW indicates they could provide better services than medical personnel.

Second, in *mTreat*, many CHWs showed resentment as they encountered difficulties they did not expect before taking up their work. For example, some CHWs now see their role as teachers who bring knowledge to their communities. While they see value in this work, they expected a more active "healing" role where they take blood samples, measure blood pressure, and hand out medication. Nevertheless, most of their work involves education on NCD prevention, as most of their patients do not suffer from NCDs currently. Furthermore, few CHWs anticipated interpersonal challenges before returning to their communities. After three months, most report interpersonal challenges. In two cases, CHWs express difficulties interacting with other families due to feuds. One of the CHWs raised this issue when asked about the challenges they faced:

"We have these families whom we don't talk to as families, and even if I want to help them, they may think because our families have these clashes, [...] I am going to use their blood to bewitch them. In that way, I can send one of my colleagues for help."

Third, some CHWs experience stigmatization of NCDs as the main challenge they encounter. Since NCDs are mostly "invisible" and stand in the shadow of more prevalent diseases such as HIV and Tuberculosis, their perception is often non-existent or faulty. One CHW summarizes, *"People believe diabetes is a disease for the wealthy, and they could not have it. So, there is a huge misconception that needs to be solved." It further explains that some community members would rather not know their health status as they would not feel sick."*

The project itself and its aim create high expectations from the CHWs. The combination of the project partners' reputation and the use of mHealth lead to an initial illusion of a silver bullet to solve every problem. The quote above, exemplifying the overconfidence of the CHWs, also explains the origin of their perception: the workflows guiding the CHWs through their work. After some time in the field, the high expectations could not be met entirely, or the CHWs realized that their work requires more routine and counseling skills which they must develop over time. Finally, the CHWs can be exposed to risks caused by their digital empowerment. Female CHWs report two main safety concerns. First, their work exposes them to situations where they visit single males alone. While no causes of sexual violence were reported, some female CHWs express discomfort and wish for better protection (e.g., by a companion). Second, the value of the mobile device potentially puts them at risk of robbery. Since tablets are hardly available in both settings, the device could cause envy in the community. As a result, one CHW reported, *"I took the tablet with me wherever I went. Even to bed at night."*

6 Discussion and Conclusion

Based on two DSR projects in the context of community-based NCD care, this study provides design knowledge for mHealth that fosters structural empowerment and leads to psychological empowerment of CHWs in the global south. Our results contribute to understanding how empowerment materializes in CHWs using mHealth and identifies unintended consequences of this digital empowerment. To our knowledge, this is the first study that applies and evaluates this conceptualization of empowerment in community-based healthcare. Our results indicate the transferability of the understanding of empowerment as outlined in section 2.3 (see Figure 1).

Existing literature indicates that the two main problems of community-based care are high attrition rates and subpar performance of CHWs (Ngugi et al., 2018; Rassi et al., 2018). These challenges could have origins in the simplistic and transactional view of the CHWs' role in past programs. CHWs have been mostly employed as sensors extending the health systems' reach into rural areas it could not otherwise reach due to long travel distances and limited personnel. In a sense, the CHWs are the eyes and voice of the health system as they are trained to report incidents back to the clinics (e.g., referral of a person tested HIV-positive) and provide basic health information based on factsheets provided by the ministry of health. However, what happens before, during, and after these transactions is usually not at the center of interest. Most research takes over this perspective by focusing on healthcare outcomes neglecting the health provider and their needs.

While digital tools provide great potential to support CHWs, researchers, and designers of mHealth are still trapped in this outcome-centristic paradigm focusing mainly on mHealth as transaction machines instead of supporting their users holistically in their work (Källander et al., 2013). The predominant paradigm focusing on outcome-driven studies (e.g., randomized control trials) has established a profound understanding of the effects of community-based healthcare (Rawal et al., 2021) and how such programs can benefit from mobile technologies (Whidden et al., 2018; Zaman et al., 2021). However, we lack explanations why mobile technologies have these effects and, thereby, design knowledge available to designers and other practitioners intending to solve a similar problem in a comparable setting. As a result, community-based programs seldom scale up and run sustainably long-term.

Our study contributes design knowledge to the emerging trend in research on community-based healthcare that places CHWs (i.e., the users) at the core next to the patients (Rodrigues et al., 2022). We address the persisting problems of CHW attrition and subpar performance by adopting a new perspective on the CHWs' role in healthcare provision. We emphasize the "worker" in community health workers as we recognize CHWs as active members of the health system. This view highlights the importance of understanding their needs and preferences in designing mHealth and organizational structures. Furthermore, we move away from a transactional view of health services provided by CHWs and emphasize a longitudinal perspective in which CHWs progress over time. This change in perspective aligns with the empowerment literature postulating a positive influence of structural empowerment (as an act of transferring authority and responsibility) on the perceived empowerment leading to better performance and lower attrition rates (Maynard et al., 2012). The consideration of empowerment of CHWs has the potential to open the door to solving the persisting problems in community-based healthcare and help sustainably provide health services to the most vulnerable population.

We contribute design knowledge as guidance for practitioners to design mHealth to empower CHWs to provide high-quality health services. The existing empowerment literature established an in-depth understanding of the relationship between structural and psychological empowerment and its effect on performance, staff retention, and job satisfaction (Maynard et al., 2012). Yet, little is known about the influence of specific elements of workplace design, including digital technologies, on the workforce's empowerment (Leyer et al., 2019). We unbox the abstract construct of structural empowerment and propose design requirements that provide the CHWs access to *information*, *support*, *resources,* and *opportunities* they require for daily work. While empowerment is generally technology agnostic (Laschinger et al., 2001), we extend this view by considering mobile technology as an integral part of the CHWs' workplace design. Our design requirements offer guidance on how mHealth can distribute power even to remote locations. For example, medical algorithms can provide support independent of the time and location of the CHWs. Furthermore, it provides the CHWs with resources by taking over documentation and archival without sacrificing its own time as a peer or supervisor would.

Furthermore, we evaluate the empowering potential of mHealth in real-world pilot studies. Our study shows how using mHealth gives CHWs a sense of competence to provide high-quality health services. For example, our findings suggest an increased sense of competence created by the support provided by the medical algorithms and the digital materials available to the CHWs at any time. Yet, mHealth could also be disempowering if it limits the CHWs' autonomy by not considering their individual preferences. This study provides insights into the materialization of empowerment as we observe the CHWs' development over three to six months by employing qualitative research methods. In contrast to existing research, this approach allows us to study empowerment as a dynamic construct instead of a snapshot of a specific time when the data is gathered. Our results (e.g., the resentment after initial euphoria) suggest empowerment could be subject to temporal dynamics and open opportunities for longitudinal studies to further investigate the dynamic aspects of empowerment. For example, the empowering effect of the support provided by the medical algorithms could evolve into disempowerment as it hinders the CHWs from progressing in their personal development by restraining them to the designed procedures.

In addition, this study highlights the potential dark side of empowerment. Our analysis uncovered unintended consequences only emerging when using digital tools in the field. The predominant perspective on empowerment is a positive correlation between structural and psychological empowerment and outcome measures such as performance (e.g., high structural empowerment leads to high psychological empowerment leads to high performance; see Figure 1). Our study indicates that empowerment does not solely lead to better outcomes. For example, empowered CHWs could be exposed to risks they would not be exposed to otherwise (e.g., robbery). These unintended consequences suggest empowerment allows us to broaden our view, but a more holistic perspective is still needed. In this study, we offer design knowledge for empowering mHealth, offering a starting point to consider the needs and preferences of CHWs as active members of the health system. However, future research should expand beyond the needs and preferences and consider the work context (e.g., organizational and social structures) in designing and evaluating mHealth in community-based healthcare.

Nonetheless, this study has some limitations that need to be acknowledged. First, the design requirements have been derived from the holistic understanding of full-functional mHealth services. Therefore, the effect of an individual requirement cannot be determined but should be investigated through testable propositions to understand its effectiveness. Further, this study generally focused on the digital aspects of CHW empowerment. While the work and working conditions provide empowerment and challenges, they have not been the focus of this study. Next, this study is based on two DSR cases. There are more mHealth opportunities and tons of projects out there that address NCDs and include CHWs (Geldsetzer et al., 2022). Therefore, the selection of cases itself is a limitation. However, we selected these two projects to portray the entire care cycle of NCDs from prevention to treatment. Finally, both projects are third-party funded and involve the interest of many stakeholders. The project structure influences the design and the scope of the digital tool. The projects are not concurrent and do not follow the exact same DSR approach.

To conclude, equipping CHWs with digital devices is not a silver bullet but a challenge in design, implementation, and long-term management. This paper addresses the pressing problems in community-based healthcare (i.e., high attrition rates and subpar performance) by offering design knowledge for mHealth in NCD care. We offer insights into the empowering effects of mHealth and the unintended consequences that come with the digital empowerment of CHWs. With this study, we aim to open the door for more in-depth research on the potential of digital empowerment of CHWs for sustainable community-based healthcare and a resilient health system. Future research could further investigate mitigation strategies for the observed, unintended consequences.

Acknowledgments

The research leading to these results was conducted as part of the WHO-PEN@scale and ComBaCaL projects. The authors extend their gratitude to the Ministries of Health and all health workers and community members who actively participated in the implementation of the WHO-PEN@Scale project and the ComBaCaL project. The WHO-PEN@Scale project has received funding from the European Union's Horizon 2020 research and innovation program under grant agreement No 825823. We especially want to thank the following people for their contribution: Ntombi Ginindza & John Myeni - Ministry of Health in Eswatini; Lisa-Rufaro Marowa, Nyasatu Ntshalintshali, & Bongekile Thobekile Cindzi - Clinton Health Access Initiative. The ComBaCaL project is funded by the TRANSFORM grant of the Swiss Agency for Development and Cooperation (Project no. 7F-10345.01.01) and a grant by the World Diabetes Foundation. We especially want to thank the following people for their contribution: Thabo Lejone & Dr. Ravi Gupta – Solidarmed, Dr. Naleli Matjelo, Motlalepula Motjetje, Lekopa Tsibela, Lebohang Manyanye & Thato Ramabele – National University of Lesotho.

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