Providing health reports to influential people in rural communities in Sub-Saharan Africa

A study on how influential community members can affect health behaviour in Ethiopia and Malawi.

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Master Thesis

Programming and System Architecture

60 credits

Department of Informatics

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UNIVERSITY OF OSLO

May / 2023

Abstract

In several Sub-Saharan countries, Community Health Workers (CHWs) play a vital role in providing primary healthcare to the communities. However, other influential people in the community, like health volunteers, chiefs, teachers, traditional healers and religious leaders, could contribute better to affect public health if they have access to current health information. Unfortunately, Health Management Information Systems in Ethiopia and Malawi lack the capability to share information with individuals outside the formal health services. To address this issue we developed an application, “Health reports”, in the iCHIS system that allows CHWs to create and share reports containing aggregated data. To design the application, four key areas were considered: roles, chart literacy, digital access and report content. The method consisted of fieldwork in Ethiopia and Malawi, where we interviewed influential roles in the community. We experienced a considerable difference in chart literacy, health topics and accessible resources between the roles. As a result, the application is designed to be adjustable, enabling CHWs to choose different chart types, health topics, add customisable text phrases and decide whether to share digitally or in print. CHWs were able to set up and share reports to people outside the health system.

Acknowledgement

We would first want to thank our supervisor Jens Johan Kaasbøll for all the guidance and support throughout this thesis. Thanks for staying with us during several weeks in Ethiopia and Malawi through dozens of yatzy games.

We would like to thank the University of Gondar and Binyam Tilahun for arranging fieldwork and taking care of us during our stay in Ethiopia. Thanks to Lawrence Byson for helping us during the development of our application.

Further, we would like to thank the University of Malawi for serving us during our stay in Malawi. A special thanks should also be given to Chipo Kanjo for being our main contact person and having us for dinner.

Lastly, we want to thank the people we met during fieldwork for their time and contribution to this thesis.

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1 Introduction

Through our fieldwork in Ethiopia and Malawi, we have identified an opportunity to enhance public health by engaging with influential members in rural communities. Research has confirmed that various people within the community have the ability to impact public health. One of these roles is health volunteers, that according to a study from Malawi, serve an important role when it comes to providing care and support in communities (Angwenyi et al., 2018). They work alongside Community Health Workers (CHWs), who are employed within health care to offer primary healthcare services, including patient follow-ups, vaccinations, childcare and family planning (Glenton et al., 2021). In addition to CHWs and volunteers, schools, religious leaders, chiefs, and traditional healers have also proven to be influential roles in the community. For instance, a study from Zambia showed how including chiefs and providing them with data resulted in an uptake in community-led total sanitation (Osbert et al., 2017).

Providing these roles with information about the current health situation can enable them to use their influence to positively affect public health. The fact that only CHWs have access to the Health Management Information System makes providing this information to the other roles difficult to achieve. The digital health information system used by the CHWs is built on DHIS2 and has reporting functionality. However, this reporting module requires high proficiency both in health data and the software. Hence, we made a simple-to-use reporting app for the CHWs to use on their tablet.

The application is called “Health Reports” and can export health information from the Health Management Information System to outsiders like volunteers and religious leaders. The information is formatted as a report containing aggregated data displayed in charts and custom text phrases. We study how such reports should be designed and how these reports are received by influential roles. Other than the study from Zambia, there is little existing research on providing health data to other roles. Therefore, all our findings represent novel knowledge.

The research is conducted in deep rural areas in Ethiopia and Malawi. People in these communities live far from health facilities and have limited access to health services. These people largely rely on the health services provided by the Community Health Workers (CHWs) and volunteers.

Bua health centre

Research questions

The study consists of two iterations. The first iteration involves fieldwork conducted in Malawi. Iteration two consists of the development of the application and fieldwork done in Ethiopia and Malawi. The research is based on interviews and observations mainly done at health posts and clinics in the two countries. This research can be characterised as an experimental qualitative research method. The research aims to answer five questions:

- **Application**: How should the app be designed and built?
- **Roles:** Which roles could benefit from receiving health reports?
- **Chart literacy:** How should the data be presented in the report?
- **Digital access:** What kind of resources do the different roles have?
- **Report content:** Which health topics do the different roles find relevant in a report?

Roles

One part of the research has been to identify roles that have daily tasks that affect public health and their grade of influence in the community. The research also aims to find the most suitable roles for distributing the reports. There is little research on providing influential roles in the community with health reports. Therefore, the process of identifying relevant roles is based on research around the possibilities these roles have to affect public health and our own research in Ethiopia and Malawi.

Chart literacy

Chart literacy has been another part of our research. The study investigated how familiar different roles are with charts and identifies possibilities and limitations for each role. Identifying each role's chart literacy is based on observations of different roles reading charts, together with follow-up questions.

Digital access

The access to smartphones and printers determines whether sharing the report digitally or by paper is most suitable. We have therefore researched upon the access to digital devices, and if there exists variation between what the different roles prefer.

Report content

Determining which health topics are related to each role's daily work is important to find out, as variation may exist. Creating report content adjusted to this variation would most likely be vital to exploiting their potential to impact health behaviour.

Chapter overview

In this thesis, we cover existing research on roles, presentation format, digital access, and report content in Chapter 2. Chapter 3 provides an overview of our own research and explains the method we used in our fieldwork. Chapter 4 describes the prototypes we used, the application development, prioritisation, and user testing. Chapters 5-8 cover the last four research questions and present our findings for each question. In Chapter 9, we compare our findings to existing research. Finally, chapter 10 concludes our thesis

2 Background

2.1 Existing health structure

2.1.1 Ethiopia

The health care system in Ethiopia is divided into a three-tier health delivery system, as shown in Figure 1. The primary level comprises primary healthcare units, including health posts, health centres and primary hospitals. The secondary level is provided by general hospitals, and the tertiary level is offered by specialised hospitals (Alebachew, Abebe & Waddington, Catriona, 2015).

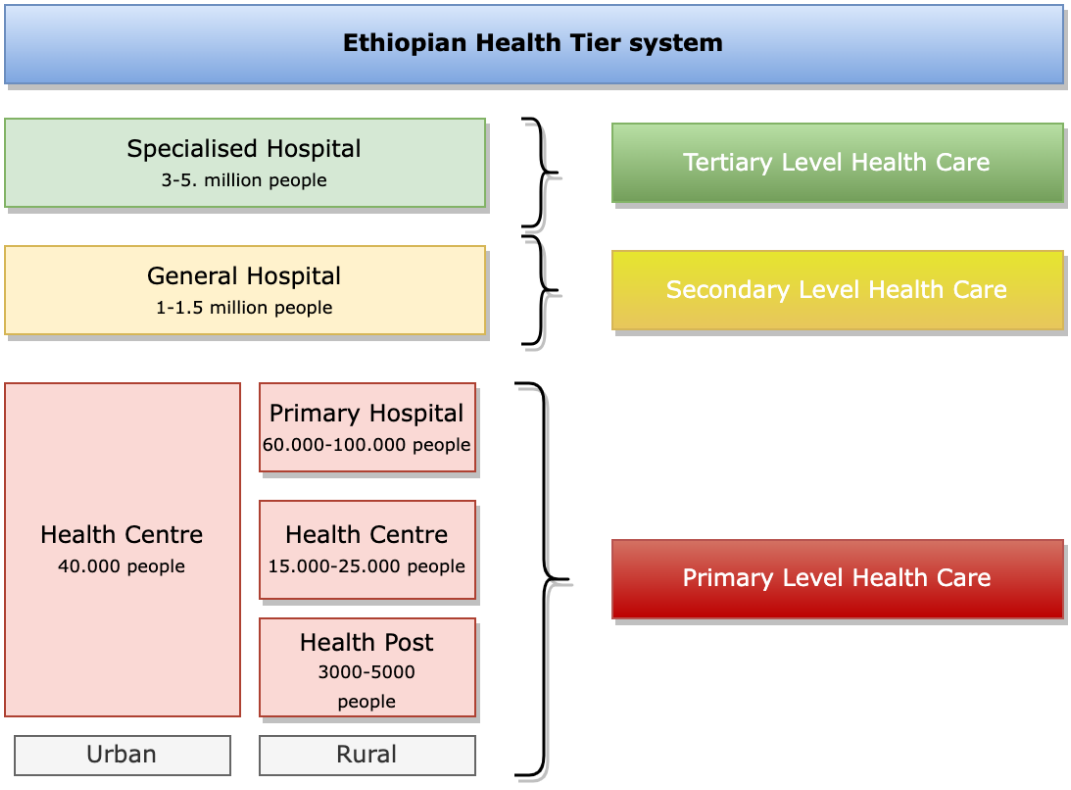


Figure 1 - Health Structure Ethiopia

Our research has focused on the primary level of healthcare in rural areas, specifically health posts and health centres. In 2004, a Health Extension Programme was launched in Ethiopia, which involved placing a health post in every kebele (smallest administrative division in Ethiopia), and assigning two CHWs, called Health Extension workers, to each health post (Yitbarek et al., 2019). These workers are tasked with addressing the healthcare needs of families and communities, and they receive a paid salary for their work (Alebachew, Abebe & Waddington, Catriona, 2015).

The Health Extension Package was created to improve essential health services and consisted of 16 health packages. Six years later, the Health Development Army was included. The Health Development Army consists of a group of volunteers from the community who undertake various preventive and promotive health services alongside the CHWs. They have numerous essential tasks in the community, including supporting health information delivery programs, tracking pregnancies and illnesses, assisting in immunisation campaigns and transmitting messages between households and Health Extension workers (Yitbarek et al., 2019). The Health Extension Programme has since been optimised into 18 packages.

2.1.2 Malawi

The public sector provision of health care in Malawi is organised into four tiers, as presented in Figure 2. These tiers include community level, primary, secondary and tertiary levels. The Malawian system differs from the Ethiopian system in the primary and community levels. In Malawi, the primary level includes rural hospitals, health centres, dispensaries and maternity facilities, while the community health service consists of health posts, outreach centres and village health clinics (Ministry of Health, 2017).

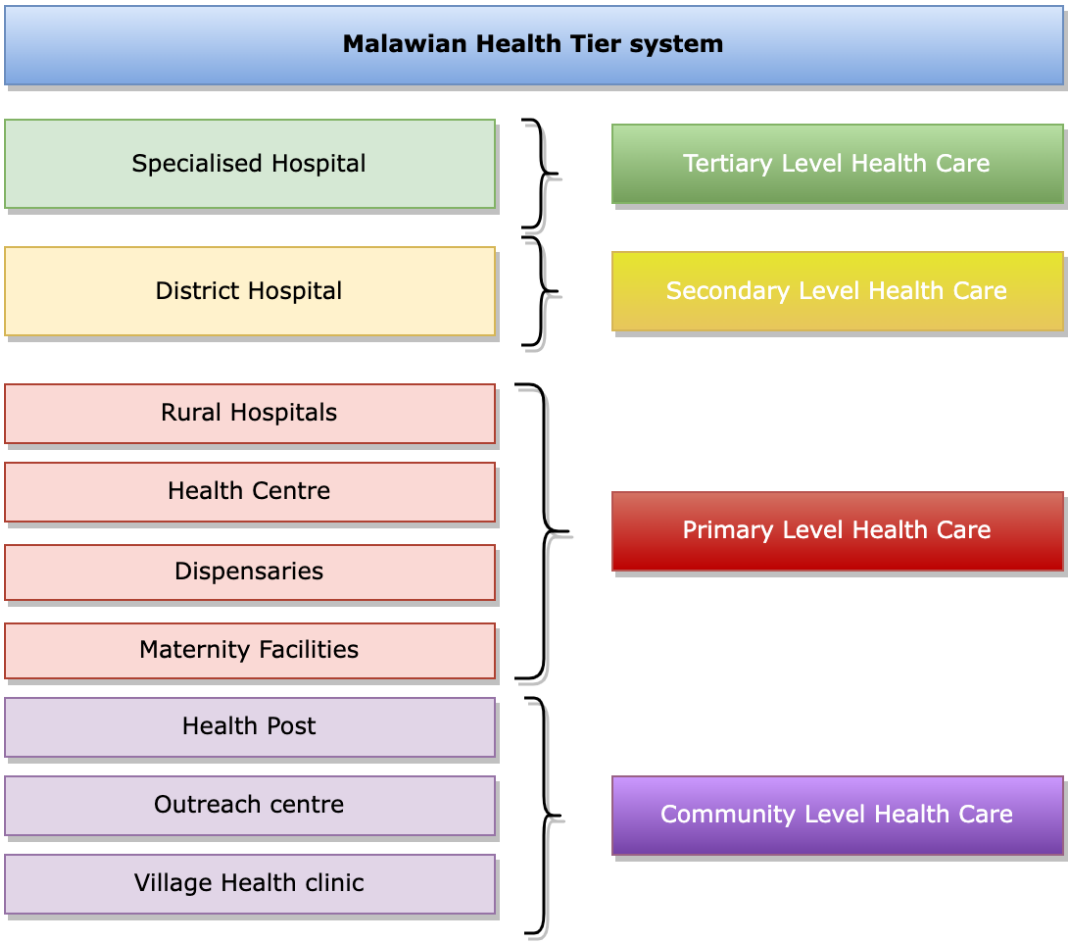


Figure 2 - Health structure Malawi

At the community level, we can find health volunteers and the CHWs, called Health Surveillance Assistants. The CHWs are significant in health care, and responsible for providing community health services. Some of these areas include promotive, prevention, surveillance, basic curative and rehabilitative services. In addition, they are responsible for supervising volunteers. The volunteers work at a household and community level, and their tasks often involve referrals, follow-ups, case findings, as well as communication and social mobilization (Ministry of Health, 2017).

Further, Malawi also has Village Health Committees (VHC), that exist at a community level. They help promote primary healthcare activities through volunteers, oversee plans and hold regular meetings in order to gather information and provide feedback to the community (Ministry of Health, 2017).

In Malawi, 83% of the population lives in rural areas (Mastellos et al., 2018). This turns a large amount of the primary health care into the CHWs' responsibilities.

2.2 DHIS2

A health management information system (HMIS) is a system designed to collect, store, analyse and manage healthcare data. In 2004, the University of Oslo released a web-based HMIS-software called DHIS2 (District Health Information Software 2). DHIS2 is an open-source platform that is free of charge, allowing anyone to access the source code, modify, and redistribute the software. Currently, DHIS2 is used in over 100 different countries, making it the world's largest HMIS platform (*About DHIS2*, n.d.).

DHIS2 is commonly used as the national health information system for data management, analysis, health program monitoring, evaluation, facility registrations and more, in low- and middle-income countries (Byrne & Sæbø, 2022). It can also be used for individual health programs. The platform supports both aggregated and individual-levelled data and is designed to cover local and national needs in different countries. DHIS2 systems can be accessed through a web browser or an Android application.

2.3 Existing information systems

2.3.1 Existing health information system in Ethiopia

To be able to implement our report application into the existing HMIS system, it is essential to understand how today's system works. All the CHWs are equipped with a tablet and use a tablet application to collect health data from the villages, do patient follow-up and share health data. This application is not from the DHIS2 system, but a part of a system developed in Ethiopia called Agrarian Community Health Information System (Federal Democratic Republic of Ethiopia Ministry of Health, 2019). In the application, CHWs can register households and relate these households to corresponding villages. Each household's members are registered, in addition to households' coordinates, contact information and distance from the nearest health post.

This information is important to secure sustainable patient follow-up and to produce the aggregated health data that our app would depend on.

The app also has a report module that makes it possible to export a table with aggregated health data. It can generate tables based on a selected period, districts and health elements. These tables are in use in the monthly team performance meeting between the security, education leader, school leader and health sector.

2.3.2 Existing HMIS in Malawi

In Malawi, there was a need for an integrated health system, as the existing system was fragmented and siloed, consisting of various systems, as mentioned in the article “Community of Practice in Practice”(Kanjo et al., 2022). As a response to this need, the Ministry of Health developed a Health Information System called iCHIS, which stands for Integrated Community Health Information System, that was based on DHIS2, since the DHIS2 was already in use at the national and district level. iCHIS allows users to manage longitudinal health data records, multi-level access to data, patient-level data analytics and system interoperability (Kanjo et al., 2022). In some districts in Malawi, CHWs have started to be included in this system by using tablets provided by UNICEF, while other districts still rely on a paper-based system. iCHIS has a data visualizer tool where it is possible to generate charts. It is only possible to create a single chart at a time, not create a full report.

2.4 Roles

As mentioned in the introduction, CHWs are an essential part of the healthcare system in both Ethiopia and Malawi. Still, the inclusion of roles outside primary health care can prove to affect public health. Volunteers, chiefs, religious leaders, traditional healers and school leaders are all a part of the community and have respected opinions. They could make a difference regarding health behaviour, given the right information. Further, we will account for why these roles could be relevant candidates for being provided with health information.

2.4.1 Community Health Workers

The study “Community health workers at the dawn of a new era: 5. Roles and tasks” explains the different roles the CHWs have in a community and their importance. The CHWs' most common role in a community is health promotion. This can include breastfeeding and child nutrition, family planning, immunisation, and other behaviours linked to mother and child health, as well as the promotion of safe sex and encouragement of HIV testing (Glenton et al., 2021). The study also found that CHWs are important when it comes to the diagnosis and management of illnesses, such as the recognition of danger signs in children and pregnant women, recognising malaria symptoms and, increasingly, the diagnosis and management of common childhood illnesses. Other services they often provide are preventive care, community mobilisation, treatment/clinical curative care and epi-demographic surveillance (Glenton et al., 2021).

The CHWs are the people who have the most knowledge about health, hold the latest health picture and have access to a digital device; this makes them relevant distributors of health reports in the community. In that case, one important issue to consider is if the CHWs have the time, energy, and resources to be providers. As the mentioned study explains, it is important to have a “proper understanding and appreciation of the potential stressors and strains that the role of CHW carries with it” (Glenton et al., 2021, p. 4). Still, one of the mentioned issues in Ethiopia is the lack of trust from the community in the services the CHWs provide. Providing them with evidential information could be a way to achieve this to prove the effectiveness of their work in the community. Following a program, like the immunisation program or the number of HIV cases, may motivate the CHWs to improve their performance or be helpful to confirm that initiatives have been effective.

According to “Role Clarity Guidelines for Community Health Workers”, the CHWs arrange meetings and training with volunteers and establish and assist in meetings with the Village Health Committee. In addition, they travel to schools and educate children. This proves that the CHWs are involved with other roles in the community and already have easy access to provide them with information.

The above arguments give us reasons to consider CHWs as the distributor of health information. In addition, the CHWs could also be seen as a receiver, as it could be cases where the CHWs find reports useful. This could be to follow the progress of an immunisation program or track the spread of disease.

2.4.2 Volunteers

Volunteers play a vital role when it comes to providing care and support in communities (Angwenyi et al., 2018). Their contribution has resulted in multiple health indicator gains, within child health, maternal and reproductive health, HIV/AIDS, and malaria in Sub-Saharan Africa. The same study defines volunteers in Malawi as “individuals who willingly offer their time, skills, and knowledge to work with communities to improve the health status of communities they reside in without expecting financial remuneration” (Angwenyi et al., 2018, p. 4). Malawi has been dependent on volunteers for many years. Since the 1980s, volunteers have provided home-based care as informal caregivers. As mentioned, more than 80% of the population lives in rural areas, which highlights the importance of community-level care in the country.

The volunteers appear to be the key to bringing information from the health services to the people in communities in Sub-Saharan Africa. In Ethiopia, the information they deliver to the community is about preparing for birth, keeping track of pregnancies, illnesses and helping during immunisation campaigns (Yitbarek et al., 2019). They transmit messages between the CHWs and the households. In Malawi, the majority of a volunteer’s tasks are at a household and community point of care (Ministry of Health, 2017). They are responsible for distributing and promoting the use of condoms, encouraging breastfeeding, promoting family planning, as well as tracing, screening, and identifying tasks. Volunteers in both countries receive support and supervision from CHWs through meetings, which is anticipated to strengthen the communication and link between them.

Since the introduction of volunteers in Ethiopia, maternal health services have shown a massive increase. The percentage of antenatal care increased from 20% in 2005 to 62%

in 2016. They also experienced an increase in institutional delivery and postnatal care (Yitbarek et al., 2019). This emphasises the impact volunteers can have on a community.

A study from Kenya also finds volunteers essential to bridge the gap between the community level and the wider health system (Aseyo et al., 2018). Volunteers are described as having an important role in the promotion of hygiene practices and delivering behaviour change strategies. The study explains that training and support are vital for those who are involved with changing other people's health-related behaviours and that volunteers need to implement new skills to evaluate behaviour change. Volunteers in Kenya are tasked with improving community health, and they are expected to conduct monthly household visits where they collect basic health information and identify health issues that require the involvement of employees in the formal health sector.

A common feature for volunteers in all the mentioned countries, is the non-payment. The volunteers in Kenya explained that it would be easier to spend more time doing volunteer work if they received some kind of payment. Still, many volunteers seem to take pride in volunteering without receiving benefits, and it is difficult to draw the line between encouraging this ethical behaviour and when it becomes inequity (Angwenyi et al., 2018). Another common feature is their importance and work at a household and community level. They receive information and training from CHWs in their country, and further provide this information to people in the community. In Kenya, the training was not standardized, and the study experienced a large variation in health topics and duration within the training. This contrasts with Ethiopia, where the CHWs seem to follow the Health Extension Program when training volunteers (Alula M. Teklu & Yibeltal K. Alemayehu, Girmay Medhin, et al, 2020). This is reflected in the increased results mentioned in Ethiopia.

Volunteers are essential when it comes to providing community-level care. Being the bridge between the CHWs and the community, and the effect that has on public health

makes them likely to be relevant receivers for health reports. There are good reasons to believe that reports could make the volunteers better able to monitor diseases and track the progress of different health programs. In addition, the health reports could also be used to remind volunteers about general health information, such as symptoms on COVID-19. Volunteers are, different from all the other roles, voluntary, and delivering health reports to them could also be a way to appreciate their work.

Community-level care relies heavily on volunteers who act as a vital link between the CHW and the community. Due to their significant impact on public health, they are the ideal receivers for health reports. Reports can assist volunteers in effectively monitoring diseases and tracking the progress of various health programs. Moreover, these reports can also serve as reminders of keywords from CHW training sessions or provide other relevant health information. Health reports can also serve as a means of appreciating the volunteers' efforts, especially if they provide evidence of improvements.

2.4.3 Religious leaders

A comprehensive study that summarizes case studies from Mali, Zambia, Uganda about religious entities' contribution to health in Sub-Saharan countries in Africa, concludes that religious entities make a significant and unique contribution to health services. Religious leaders are trusted and respected by their followers and the messages they prompted were likely to be accepted in good faith (Schmid et al., 2008). They have the potential to be powerful agents in the promotion of public health agendas. Inter-religious dialogue and coordination at national and local levels is particularly beneficial. They also found that several religious leaders contribute to health promotion and education in a number of areas, for instance, promoting family planning and hygiene, or fighting female genital mutilation and HIV-related stigma (Mali).

The study recommends that religious leaders at all levels should be encouraged and trained to be actively involved in culturally appropriate health-promoting activities. In addition, it also recommends that religious leaders should be offered material that can encourage their active participation in health promotion.

Religious leaders play a significant role in promoting public health, which makes them relevant receivers of health reports. Health reports could be the “material” the study from Mali, Zambia, Uganda finds important to increase religious leaders' participation in health promotion. Reports could be a way to help leaders identify which health topics are most concerning. For instance, could informing about an increase in pregnancy be an effective way to reduce child mortality, as leaders could use their influence to encourage pregnant women to complete their antenatal care check-ups.

2.4.4 Schools

There is a strong connection between health and education recognised worldwide (Mukamana & Johri, 2016). Schools are recognised as an environment that can play an important role in improving the health and well-being of young people by several international agencies, such as the United Nations Children´s Fund and the United Nations Educational and Scientific and Cultural Organization (Mukamana & Johri, 2016). School-age young people are in danger of getting injuries that lead to death and disability and are greatly affected by nutritional deficiencies, tobacco, alcohol and drug use, and HIV/AIDS. Developing countries are more affected by such health problems since they have limited resources, and a large part of the population is children. Considering these facts makes it clear that people connected to schools are important roles that should be accounted for when developing new health initiatives, such as a health report tool.

A study that looks into how to achieve health promotion in schools has found that providing teachers with resources that are theoretical and factual based is important to success with health promotion in schools (IUHPE, 2019). Health information, formatted as a health report, seems to fit such a requirement, as it would create a decision base based on evidential findings rather than indicia.

The same study also finds that developing partnerships between education and health sector policy is key to success in promoting health in schools (IUHPE, 2019). A

systematic review of school-based interventions for health promotion and their impact in developing countries also finds collaboration as key to success, saying that “the collaboration between health and education institutions, national, regional or community leaders, parents, students and other relevant actors whose support is necessary to ensure the feasibility and the sustainability of school-based interventions” (Mukamana & Johri, 2016). The study also finds this collaboration as crucial to achieving long-term goals, such as behaviour change, and maintain planned activates over time. A collaboration where the CHWs provide the school with health reports seems to be relevant in light of this study.

The systematic review also finds that making it possible for the teachers to have active participation in health promotion is an important feature for success with health intervention. The review also finds that this feature is important to offer to the students and their parents, as these people are key players in succeeding with school-based interventions (Mukamana & Johri, 2016). Creating health reports that are updated frequently, free, and open for everyone would contribute to more participants and could, as a result of that, lead to more engagement around public health, both among teachers, students, and parents.

2.4.5 Traditional healers

The majority of adults in Malawi seek out the local traditional healer before the CHWs when experiencing health issues. This can cause the formal healthcare system to not be able to identify cases in time (Joseph Wu et al., 2018). In case of outbreaks, this can delay the detection and increase the further spreading of an infectious disease. If traditional healers could be informed through a health report about current health threats, it might be a solution to increase their health knowledge and allow them to refer people to a health facility when needed.

In Ethiopia, a study was performed in 2010 to assess the contribution of traditional healers’ clinics to the public health care system in Addis Ababa. The traditional healers were sought out by people wanting health care, who viewed them as a good option.

According to the study, people chose the healers because of efficacy, safety and affordability, and a majority of the patients were satisfied with their received treatment (Birhan et al., 2011). Still, the study shows that only 1 of the 10 traditional healers interviewed referred patients to a hospital. Considering that more than 80% of healthcare needs in Ethiopia are met through traditional healthcare practices, this can result in many patients relying entirely on traditional medicine.

The lack of communication between these two parts can cause the same effect as in Malawi. Treatable cases can be discovered too late, and infectious diseases can have time to spread further. Providing traditional healers with reports regarding the current health statistics might be a small, more affordable step in assuring their knowledge and bridging the gap between formal health care and traditional medicine.

2.4.6 Chiefs

As mentioned, our primary target for receiving reports was the chiefs in the villages. In a research conducted in Zambia that was performed to assess the impact of leveraging traditional leadership on access to sanitation (Osbert et al., 2017), chiefs proved to be powerful influencers when included.

Zambia implemented community-led total sanitation because “14.7% of all households and 24.0% of rural households have no access to toilet facilities and report using the bush, for example, open land or agricultural fields, for defecation.” (Osbert et al., 2017). The open defecation led to contaminated water, food, and soil, which further led to various diseases and health issues among the people. The article focuses on the chiefs’ impact in improving this situation.

In the research, some chiefs received an orientation before the initiation of community-led total sanitation, while others did not. This orientation consisted of creating awareness regarding community-led total sanitation among the chiefs by providing them with data on access to sanitation. It also included comparisons between neighbouring chiefdoms and acknowledging the impact of different roles. Other key stakeholders were also

invited to attend. The result was a higher increase in sanitation coverage in the chiefdoms where the chiefs did receive this type of orientation. The number of individuals with household-level latrine access in these areas increased by as much as 30.4%.

If we apply this to our research, we believe that including chiefs could result in a wider spread of information in a village and better results. As we now have seen, the support and orientation of chiefs resulted in an uptake of community-led total sanitation (Osbert et al., 2017). If they were the ones receiving a report regularly, they could, for instance, be able to initiate more preventive work or create more awareness amongst the people. The chiefs' roles in Zambia were the distribution of communal land, the administration of justice, and the organisation of communal projects. They are actively involved and represent a powerful role in a community. The same could apply to Malawi and Ethiopia; if it does, providing them with reports could increase health awareness in their area.

2.5 Chart literacy

One of the essential requirements in health reports is that the different roles understand the reports they receive. In our research, we have tried to identify if it exists any difference between the different role's ability to understand charts.

A study from 2009, performed on participants in Germany and USA, investigated how cultural differences affect peoples' chart literacy. People in the study were given 13 different graph items and were required to answer some questions related to each one. All the charts had a medical context, such as communication of medical risks, treatment efficiencies, and prevalence of diseases. The study is relevant to our research, as most of the tasks the participants were given had similarities with the tasks our participants in Ethiopia and Malawi received. To determine peoples' chart literacy, the researchers in the study developed a graph literacy scale that consisted of three different levels:

level 1. **Reading the data:** find specific information in a graph. For example, be able to read the height of a particular bar within a bar chart.

level 2. **Reading between the data**: to find relationships in the data as shown on a graph. For instance, one should be able to read the difference between two bars or sum up several slices on a pie chart.
level 3. **Reading beyond the data**: make inferences and predictions from the data. For example, be able to project a future trend from a line chart, understand the importance of attending to scale ranges and scale labels when comparing two charts, and use the existing labels to interpolate scale labels that are missing.

The result from the study showed that most of the people (85% on avg.) were able to read data (level 1). Level 2 and level 3 were more difficult, where only 68% on average were able to read between the data, and 65% on average were able to read beyond the data.

The study also found a correlation between people's education level and their graph literacy level, where they saw that a certain level of meta-knowledge about graphs acquired through formal education is required to understand graphs (Mirta Galesic, Rocio Garcia-Retamero, 2010, p. 451). Compared to the USA, Germany had fewer differences in the graph literacy between those who had education and those who had not. More math and science education at an early age were pointed out as a possible reason for the smaller difference.

It should be taken into account that this research is conducted in countries that have one of the best primary educations in the world (OECD, 2019). In developing countries, such as Ethiopia and Malawi, only two-thirds of children are estimated to complete primary school. Children who attend school do not learn the literacy and numeracy they need to thrive (UNICEF, 2023). International Mathematics and Science Study from 2015 also showed that lower-middle income countries scored well below the international standard when it comes to mathematic skills (*International Math and Science Study Results*, 2016). This study was done in lower-middle countries, and the situation in lower-income countries is probably worse. The signs of poorer education in Malawi and Ethiopia, in

light of the findings from the study about a correlation between chart literacy and grade of education, should give clear signs that it exists poorer chart literacy among people in Malawi and Ethiopia, compared to USA and Germany.

The study found that 15% were not able to tell what a simple data point in a chart represents (level 1) in two high-income countries, which is concerning. There are reasons to assume similar results from Malawi and Ethiopia, which brings real concerns about whether charts are an adequate communication form at all. It may need to be discussed if even the simplest charts are too difficult, especially for the lowest-educated groups, such as volunteers.

Level 2 and level 3 measure two other important skills that should be mastered if the reports should lead to improved public health. Level 2, about being able to *read between the data,* is relevant when finding relationships between data in a graph. If the reader is not able to differentiate between high or low bars or understand what the total sum of all bars represents, it would not be easy to transfer the information from the charts to relevant actions that could improve public health.

Level 3, about reading beyond data, would also be a skill that would strengthen the reviewer's ability to improve public health. One thing is to take action upon the data as it is today, but if the receiver, in addition, is able to make predictions about further progress for a disease, it would make them more prepared and open the ability to take necessary actions earlier. Level 3 also measures the ability to understand scale rangers and scale labels when comparing two charts, which is necessary if the user should be able to achieve a more in-depth understanding of the current health situation. For instance, if a chart in a report shows "Penta vaccination coverage in percentages according to national vaccination program" and another chart in the same report shows "Number of people fully vaccinated with Malaria-vaccines last month", it is important that the reader understands that these two charts cannot be compared without considering different factors. First of all, the reader needs to take into consideration that the first chart shows percentages, and the second chart shows numeric numbers. Secondly, the

first chart is in relation to a vaccination program, whereas the second chart is just doses given independent of any program. Lastly, the first chart does not say which timespan it applies for, but the second chart applies for a certain month. All these considerations are necessary if the reader should be able to compare and see a correlation between different charts in a report.

Conclusion

The study from USA and Germany clearly states that reading charts are difficult. The study confirms that education affects the ability to understand charts. The different levels of chart literacy could be used to determine what we could expect from each role. The study clearly says that “finding relations in charts” (level 2) and “making predictions based on them” (level 3) is challenging. Mastering levels 2 and level 3 is significant when it comes to improving public health. Reading a data point is not enough. The reader also needs to transform the data into actual actions. This is difficult for those who are not able to determine if a data point represents a good or bad value or not able to predict what the next month will look like.

For those who have the lowest education, it could be discussed whether they should receive charts or if an oral communication form would be more suitable. In addition to not understanding what the charts show, there is also a risk that people misunderstand it. This can draw attention away from the actions that already exist and are effective, or in the worst-case, lead to actions that worsen the health situation.

2.6 Digital access

To evaluate if the reports should be shared digitally or on paper reports, it is important to find out the CHWs and other roles access to electricity, digital devices and internet connectivity.

According to a study regarding training CHWs on the use of information and communication technologies, the use of smartphones as health solutions is increasing. There are now applications for monitoring and recording patients and aiding in clinical

decision-making (Mastellos et al., 2018). According to the same study, SMS solutions were popular in health at the time, which indicates that most people had access to a regular mobile phone.

According to an article written by Global System for Mobile Communications (GSMA), the mobile broadband coverage rate in Sub-Saharan Africa has increased from 50% in 2014 to 83% in 2021 (Delaporte, 2023). According to the article, the percentage of Sub-Saharan Africa's population using mobile internet was 22% in 2021, with 40% of adults over 18 years old using it. This is a significant increase from the 11% who used mobile internet in 2014 (Delaporte, 2023). Another report from GMSA, estimates that 10% more Ethiopians would have a mobile subscription by 2025, compared to 2021 (*The Mobile Economy Sub-Saharan Africa 2022*, 2022). The report also finds the same trend in many other Sub-Saharan countries, such as Nigeria, Tanzania and Domestic Republic of Congo. In 2016 a study from Malawi found that among 50% of CHWs across five districts in Malawi were reported to have smartphones (Cooper & Smith, 2016). It is reasonable to assume that this number is significantly increased today, if considering both the time that has passed since this study was conducted and the recent surge in digital access in Sub-Saharan Africa.

As mentioned in Chapter 2.3.2, is the iCHIS-system rolling out in Malawi, where the CHWs are provided tablets along with training. Tablets are also in use by the CHWs in Ethiopia. This, together with the increased use of smartphones overall, and especially as health solutions, provides us with an advantage when it comes to creating solutions for displaying and sharing our application. The high use of smartphones also indicates a high digital understanding among the CHWs that could prove to be beneficial for the report tool.

Using tablets or smartphones opens the possibilities with visual representation and quick sharing through applications like WhatsApp or Mail. In South Africa and Kenya, smartphones were used to communicate with peers via WhatsApp Groups regarding maternal healthcare (Cunningham et al., 2016). This shows that the solution to use

WhatsApp as a platform might be well known and, therefore, may be suitable for sharing reports.

There is still an issue with internet connectivity and access to electricity in both Malawi and Ethiopia. A study conducted in Ethiopia, Malawi, Kenya and South Africa showed that there was a lack of electricity, internet service and electronic devices in all of the countries. This was in 2016, meaning the countries could have been more digitalised during the last years. Still, 17 out of 19 interviewed clinics lacked internet access (Cunningham et al., 2016). In addition, it showed a lack of electricity in deep rural health centres in Ethiopia and rural and deep rural clinics in Zomba, Malawi.

The mentioned study showed that regarding the registration of maternal care in all the countries, the default data capture method was based on paper-based registries. In the Zomba district, there were no computers in the clinics interviewed, which also describes why a paper-based system is still in use. In the article “Training Community Healthcare workers on the use of information and communication technologies: a randomized controlled trial of traditional versus blended learning in Malawi, Africa”, it is stated that CHWs in rural communities can experience limited access to digital devices, such as computers and smartphones (Mastellos et al., 2018). This was also in Malawi, which shows that this country might struggle with access to technology overall. Regarding printers, they were only mentioned in South Africa (Cunningham et al., 2016).

In conclusion, it seems that access to smartphones is increasing within healthcare, compared to the access to printers and computers. Based on this, our application should have the feature to create and share reports using phones. The lack of access to internet and electricity is an issue, but with the rising need for technology, there is reason to believe that this will not be an issue in the future.

2.7 Report content

Further, it is important to determine the health topics that should be included in a report. Do the topics vary between roles? If that is the case, the content of the reports might

need to be adjusted to meet each role's needs. We will have a look at the different health topics that are deemed important in both countries, as well as the roles included.

2.7.1 Ethiopia

As mentioned previously, the Health Extension Programme was launched in Ethiopia, containing 16 health packages. These 16 different categories can help create an understanding of areas of importance in the country. They consist of three large categories presented in "Table 1".

Category	Topic
Family health	Maternal and child health
	Family planning
	Immunisation
	Nutrition
	Adolescent reproductive health
Disease Prevention and Control	HIV/AIDS and other sexually transmitted infections (STIs)
	Tuberculosis (TB) prevention and control
	Malaria prevention and control
	First aid emergency measures
Hygiene and Environmental Sanitation	Safe excreta disposal
	Safe solid and liquid waste disposal
	Water supply and safety measures
	Food hygiene and safety measures
	Healthy home environment
	Control of insects and rodents
	Personal hygiene

Table 1 - Health Extension Programme

As mentioned, it increased to 18 packages, whereas the last to is within the category of Health Education and Communication. This program includes both the CHWs and the volunteers in Ethiopia (Alula M. Teklu & Yibeltal K. Alemayehu, Girmay Medhin, et al, 2020).

In an article regarding parents' communication on sexual and reproductive health issues, it is expressed that adolescents and youths experience unwanted pregnancies, unsafe abortions, and sexually transmitted infections such as HIV/AIDS. This study focused on high school students (Ayalew et al., 2014). In primary schools, an issue seems to be intestinal parasitosis caused by poor water, sanitation and hygiene conditions. Nearly all students who participated in the study reported that their school had a health club and that they received hygiene education. Still, intestinal parasitosis seems to be an overall issue in Ethiopia, affecting children at school age (Aschale et al., 2021).

Further, we have religious leaders. According to a study carried out in Sub-Saharan Africa, religious entities often promote family planning, hygiene and HIV (Schmid et al., 2008). There were also specific services provided by faith-based groups, which included the mentioned topics, as well as nutrition and immunisation. We have no specific research on religious leaders from Malawi and Ethiopia, which is why they will be grouped as one in the summary in "Table 3".

2.7.2 Malawi

In the document "Role Clarity Guidelines for Community Health Workers" provided by the Ministry of Health in Malawi, is an overview of what CHWs, volunteers and the Village Health Committee's areas of importance are regarding health issues. The list is long, which is why we created a summary with the most repeated issues to create a foundation for later comparison. This is shown in "Table 2".

Role/group	Areas of importance
Community Health Worker	Their highlighted areas are HIV, immunisation, nutrition, diarrhoea, tuberculosis, maternal health, family planning and antenatal care. Further, they care about water, outbreaks, mental health, postnatal care, breast feeding, cholera, dehydration, respiratory diseases in children, malaria, reproductive health, measles, and diseases for children < 5.
Volunteer	Their focus is mainly the same as the CHWs, with HIV, nutrition, antenatal care, family planning and maternal health. In addition, they have areas like sanitation, water, breast feeding, reproductive health, mental health, malaria, tuberculosis, diarrhoea, cholera, dehydration and promoting birth registration.
Village Health Committee	Their focus is sanitation. The use of latrines, decreasing open defecation and promoting personal hygiene. Further, they cared about protecting their water source and limit cases of diarrhoea. They work actively to promote better health behaviour but is still aware of current spreading diseases such as cholera.

Table 2 - Overview of areas of importance in Malawi

This information is supported by the areas mentioned for CHWs in the study, “Community health workers at the dawn of a new era: 5. Roles and tasks” (Glenton et al., 2021).

As mentioned previously, there are other roles that have a connection to health issues. When it comes to schools, the CHWs check the immunisation status, link school children

to school meals, conduct mass drug administration, educate about children's rights and responsibilities, and refer children with mental health issues (Ministry of Health, 2017). According to the same source, sanitation is important, but the health nurse is responsible for that area. In order to align these topics with the CHWs, volunteers and the Village Health Committees interests, we will summarize the topics as immunisation, nutrition and sanitation.

In the research mentioned in Chapter 2.4.5: "Traditional healers" from Addis Ababa, the reason people went to the traditional healers were diseases like swelling, herpes, zoster, wounds, fracture, haemorrhoids, paralysis, back-pain, liver diseases, cancer and eczema (Birhan et al., 2011). Few of these diseases align with previously mentioned topics, which is why they will not be included further.

Lastly, we have the chiefs. According to a study from Malawi, chiefs played an important role when it came to implementing maternal, new-born and child health policy (Walsh et al., 2018). This was implemented through campaigns and encouraging women to deliver at the health facility. Both the women and the chiefs would be fined if they did not follow the policy. The chiefs are also described as the link between hospitals and the community, especially in regards of antenatal care, delivery attendance and under five clinics. In the study from Zambia, mentioned in 2.4.6, they were involved with the sanitation in a village. Even though they were attending orientations, their commitment led to results which makes sanitation a topic of interest (Osbert et al., 2017).

2.7.3 Summary

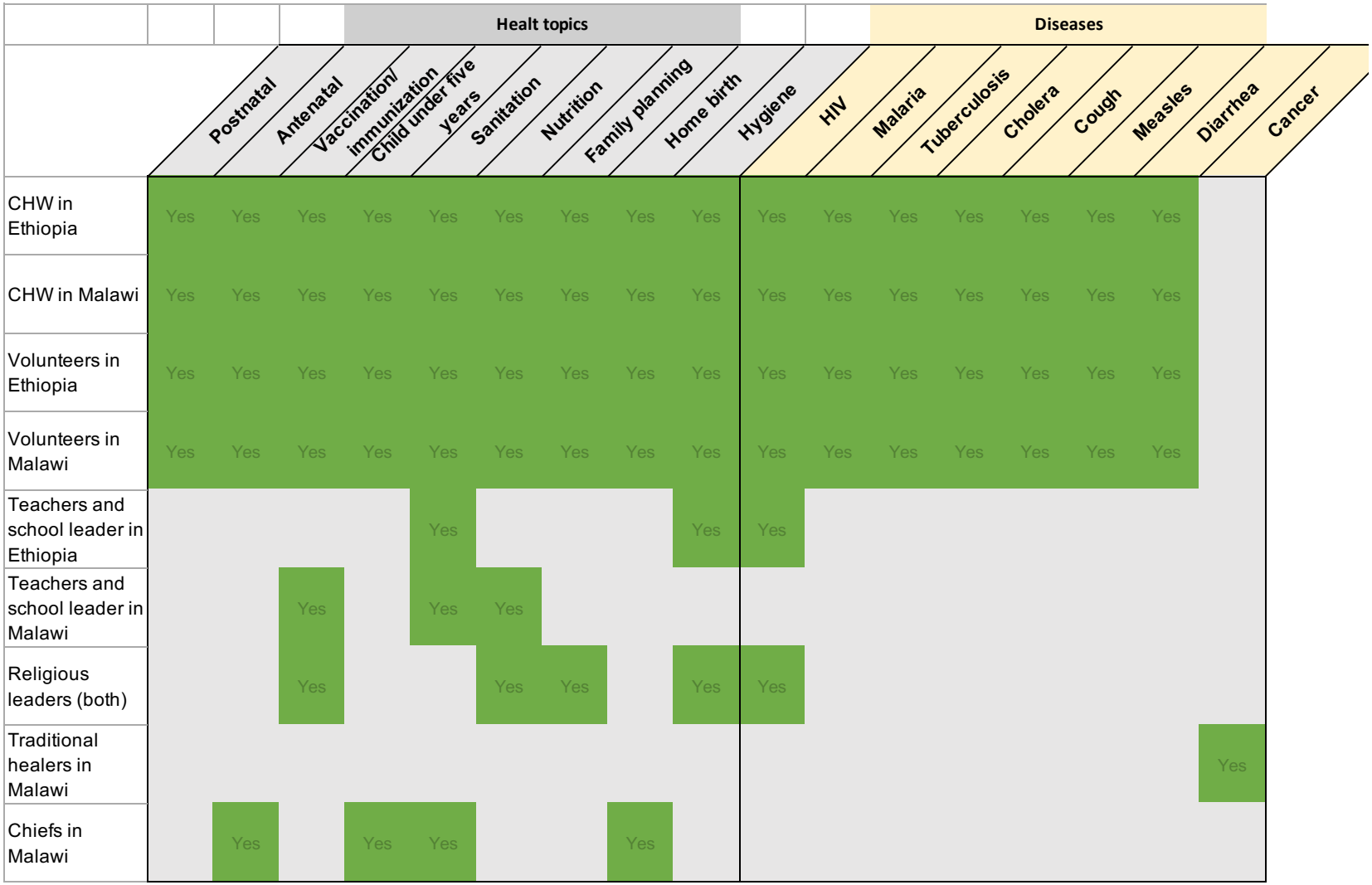


Table 3 - Summary of health topics that interest different role

3 Method

3.1 Approach

In order to provide an answer to our research question, we conducted fieldwork in both Malawi and Ethiopia. We chose a qualitative research approach because the gathered data would be non-numerical. The fieldwork was part of a larger research project, Integrated Community Health Information System (iCHIS), in collaboration with the University of Malawi.

Our research method was field experiments, and the process can be divided into two iterations. The first iteration consisted of conducting interviews. We used predefined questions combined with paper prototypes to collect information. Our goal was to collect answers to our five research questions: application, roles, chart literacy, digital access, and the report content. The second iteration consisted of developing an application for the CHWs where they could create reports and modify the application based on their evaluation. Furthermore, it consisted of feedback on the health report from relevant people outside the formal health service. There were fewer interview questions in this iteration, and the focus was on the evaluation and development of our application. It was during this time that we collected the most data. In addition, we had sample reports (4.4) to provide them with an example of what the result of our application looks like.

According to Ketil Stølen's book, "Technology Research Explained", the ideal evaluation method is a process that contains a combination of generality, precision, and realism. We adopted all these aspects into our research to avoid experiencing unnecessary weaknesses in our method. The field experiments provide us with realism, but less precision due to uncontrollable factors. The precision derives from the interviews and use of prototypes. All that lacks is a generality, but as Stølen mentions, almost all research involves logical reasoning, which falls under that category. One way we implemented logical reasoning was in the conclusion of who should generate and distribute reports in a community. By including these three elements, we are more guaranteed to increase our credibility and justify our findings.

Furthermore, we could apply triangulation to our method. By using Type 2 triangulation (Stølen, 2023), we could repeat our process on a set of new subjects, or a different location, but look to find the same information throughout. This provides us with a larger set of data and room for comparison between the different groups. This is reflected in our iterative work with CHWs and other roles in both Ethiopia and Malawi.

The data we managed to collect was largely influenced by the time we had and the available resources. During each trip, we only had a limited number of days to conduct as many interviews as possible. The number of meetings was often few because of the remote locations of many of our destinations. It could take a whole day to visit a single facility. The remote locations were often combined with unfavourable driving conditions, such as bumpy roads and too much water, such as shown in “Picture 1”. This resulted in late arrivals and flat tires. In addition, in Malawi, there was a lack of fuel during our visit, which resulted in difficulties in accessing fuel and travelling far.

Picture 1 - On the way to fieldwork

In addition to these conditions, there were a lot of planning before any meeting. We had to find times that suited both us and our interview subjects. The planning of these

meetings often went through a third party, which increased the waiting time. Since we also needed a translator most of the time, the meetings had to fit their schedule as well. We had different translators throughout our research. During Iteration 1, we had a PhD student from Malawi, and a local CHW at one of the centres. During the second iteration the translator was usually a schooler from the University of Malawi.

3.2 Iteration 1

Our first expedition was to Kasungu, Malawi, in the Winter of 2022. The purpose of this trip was to find enough information to be able to start developing our application. It was important to first develop an understanding of the health service structure. Who was influential in a community, as well as establishing the different roles and their relation to each other. Then we could move on to determining the knowledge level regarding the use of statistics and various charts, and their available resources when it came to creating a digital solution. Did they have access to computers and internet? Which health topics did they find interesting? How would they use and share the reports with each other and other groups in the community? Our focus was on conducting interviews to collect information. This information was used to create an application to fit their needs.

Our stay began with a meeting regarding the iCHIS program, with people from the University of Malawi. Here we learned of possible groups we could continue interviewing, which led us to visit two different health centres where we spoke with CHWs and volunteers. They were presented with “Figure 4 - The first paper prototype” and “Figure 5 - The second paper prototype”, in addition to being interviewed. The places we visited are listed in “Table 4”.

Name of place	Date	Attended roles
iCHIS meeting	24.02.22	3 CHWs, Director of National Community Health Services at the Ministry of health.
Bua Health centre	25.02.22	1 CHW, 6 volunteers
Chidongo village clinic	01.03.22	5 volunteers, 1 Village Health Committee member
Bua Health centre	02.03.22	5 volunteers

Table 4 - Iteration 1, Malawi

3.3 Iteration 2

Iteration 2 began autumn 2022 and started with creating an application based on our findings in Iteration 1. The application was designed to be used by the CHWs to produce reports to the other roles. The content of the application will be explained in chapter “4 - The application”, before we account for our findings during both Iteration 1 and Iteration 2.

Our second fieldtrip began with 10 days in Ethiopia during November 2022. We experienced three different health centres, and spoke with CHWs, volunteers and one school leader. The purpose of this trip was to evaluate and improve our application, as well as keeping our initial research questions in mind to collect more data. It was important to still work out how the different roles in a community communicated with each other, and how their role was connected to public health. The places we visited are listed in “Table 5”.

Name of place	Date	Attended roles
Yesak Debir health post	03.11.22	10 volunteers
Kosoye health post	03.11.22	2 CHWs, 10 volunteers, 1 school leader
Chenchaye health post	10.11.22	2 CHWs, 10 volunteers

Table 5 - Iteration 2, Ethiopia

After Ethiopia, we went to Zomba, Malawi for 21 days. The purpose was the same as in Ethiopia, present our application and collect data. We began with meeting two senior CHWs at a health centre. They arranged for us to meet with many different religious leaders, as well as meet a school leader at a secondary school in the area. They were also responsible for arranging our visits to the village clinics and attending a Village Health Committee meeting. An overview of the places we visited are listed in “Table 6”.

Name of place	**Date**	**Attended roles**
Likangala Health centre	16.11.22	2 senior CHWs, 5 religious’ leaders
Umodzi Community Day Secondary School	16.11.22	1 school leader, 4 teachers
Matopa village clinic	17.11.22	3 CHWs, 2 volunteers
Village clinic in Likangala	17.11.22	2 CHWs, 2 volunteers
Village Health committee meeting in Likangala	29.11.22	1 care group, 1 chief, 2 senior CHWs

Table 6 - Iteration 2, Malawi

3.4 Data collection

The collection process was iterative and consisted of travelling to a health post/centre and conducting interviews with the different groups that were present. The interviews consisted of in-person discussions, either in groups or one-on-one. We had a structured interview style with a list of predetermined questions. In addition, we had created different prototypes of what a report could look like, which helped us determine their familiarity with reports, important health topics, and chart literacy. It also acted as a supplement to further help their understanding of our process and goal.

In Malawi, we still suspected that some interview subjects did not fully understand why we were present and, therefore, made their own assumptions about why we interviewed them. It could be that the interview subjects assumed that we were there to evaluate their work or do research specifically on them. This could have led them to claim that they know more than they actually do. After we discovered that this might be an issue,

we shifted from asking more simpler questions, like "How familiar are you with linear/pie-chart?" or "How comfortable are you with percentage?" to more specific questions where we asked them to account for different elements in the reports.

After we shifted the way we designed our questions, we discovered that the knowledge level was a bit lower than what our first interviews showed us. More specific questions made us avoid the possibility that people could claim they have more knowledge than they had. At the same time, we also tried to clarify and explain the purpose of the interview, which could have led to people being more relaxed and therefore being more honest in their answers.

In addition to changing the way we designed our questions, we changed our interview approach to a semi-structured style. The combination of predefined and open-ended questions created a more natural flow in the conversations and allowed us to gather more information along the way by asking follow-up questions. During Iteration 2, we were able to present the application, in addition to the reports in “Figure 3 - Sample reports”. This increased our list of questions, and the interviews now consisted of a demonstration that allowed a freer conversation.

Figure 3 - Sample reports

The interviewed groups can be divided into six different categories based on their profession. They are listed in “Table 7”.

Group	Relevance
Community Health Worker	Appeared as the most central role within health at the village level. Educated the volunteers, had communication with schools and religious leaders.
Volunteer	Informs and educates people in a village about different health issues.
School leaders	Health is educated at schools. Children are an important group, easily exposed to different diseases. The school leaders communicate with health workers.
Religious leaders	Important in the community and had a respected opinion. They sometimes preached about health issues in church to educate the people.
Traditional healers	Many people prefer them over CHWs, and they make up an important part of local health care and should be informed.
Chiefs	Managers of the community and should be aware of the health situation in their village.

Table 7 – Interviewed groups.

We chose to have no audio recording. Instead, we recorded the data by transcribing the interviews. One of us was in charge of the communication, while the other could focus on transcribing.

3.5 Data analysis

The thesis looks at how influential roles can use reports together with their influence in society to affect people's health behaviour. To answer this we constructed five research questions:

- **Application**: How should the app be designed and built?
- **Roles:** Which roles could benefit from receiving health reports?
- **Chart literacy:** How should the data be presented in the report?
- **Digital access:** What kind of resources do the different roles have?
- **Report content:** Which health topics do the different roles find relevant in a report?

These questions were the background for our interview questions. The result was used to alter the design of the application.

The research is dependent on the personal perspectives and opinions provided by the different groups we interviewed. To be able to draw a conclusion based on the gathered information, we needed to compare answers within each group and across groups. The goal was to find a general basis that we could use to determine the design of our application. In order to achieve this, we identified the similarities that occurred within each group. Then we considered the differences and how we best could adapt the application to the variation in knowledge, relevant health issues and digital access.

It was important to validate the experiences of single individuals and groups and explore why their answers differed. It could be because of the area they were in, a different knowledge level or just a difference in opinion. Some areas were prone to diseases because of climate, water resources or other differences. This led to a variation in the results, which is important to consider as this applies throughout the countries.

When it came to which health centres and posts we visited, we were not directly in charge of our destinations. They were often determined by people we travelled with, either from the University of Malawi, the University of Gondar or CHWs we met with. That is why it is important to be critical of the situation. There is a possibility that we were led to the best health facilities in each country and only were able to see the most

successful processes. This resulted in a convenience sample, where we collected the possible data from the resources available.

3.6 Data limits and possibilities

We experienced a lack of available health service data during our research. We wanted to present our interview subjects with health data from their area to increase credibility and understanding. In the beginning, we had no access to information other than what we found online, which resulted in creating dummy data for the purpose of presenting something close to reality.

In Iteration 1, we discovered that it was confusing for the participant that we did not show them real data. During Iteration 2, we, therefore, ensured that the application had access to actual data and that the data was applied to the area the interview objects belonged to. Since the application was just integrated with the Malawian health system, the testing in Ethiopia had a more proof-of-concept approach, where we did not have the opportunity to display real data. As a consequence, we had to explain to the participants that this is how the solution is in Malawi, but that an Ethiopian solution could have similarities if someone adopts it to the Ethiopian health information system.

We were able to represent data because we gained access to the iCHIS server in Malawi during Iteration 2. This opened our possibilities of presenting data to the different groups from their own district. The only issue we encountered was the lack of data within the server. The district we were in (Machinga) was in the starting phase of implementing iCHIS, which meant that few of the topics we deemed important had any data registered, and it became difficult to display charts with data in the application. This difficulty resulted in the use of existing data combined with dummy data.

3.7 Translation

During many of our field trips, we were dependent on someone who could translate between English and the local language (Amharic in Ethiopia and Chichewa in Malawi). This made it difficult to determine whether important information got lost in the

translation or not and if quotes really belonged to the person we wanted to speak with or the translator. There were times the translator seemed to add opinions of their own. We experienced that they even answered without translating to the interview subject. This was something we became more aware of as we conducted more interviews.

We can also question whether they managed to translate our questions correctly. There were times the answer did not align with the question we asked, and it is difficult to determine if this was caused by the lack of knowledge regarding the charts or the language barrier. Especially during Iteration 1, when we asked the volunteers in Malawi about their knowledge regarding the charts in the prototypes. They answered by explaining which health issues they were working with and which health issues were the CHWs' responsibility. It was difficult to get an understanding of their knowledge level when they never accounted for any of the elements in the prototype. This was avoided by asking more specific questions and explaining the purpose of our research to the translators. This way, they could easier explain the context and support our interview subjects.

3.8 Roles

Our initial thesis was to create reports for chiefs in the villages in order to include them more in health decisions. Earlier research has proven that the inclusion of chiefs has shown to be effective when it comes to improving sanitation. By providing chiefs with health reports, we wanted to find out if such inclusion also could be used to improve public health.

3.8.1 Iteration 1

We discovered during Iteration 1, that it was difficult to meet chiefs. This could be related to few contacts by the collaboration partner we had, or that chiefs for some reason did not want to meet us. On the other hand, the lack of chiefs enabled us to come in contact with other roles, for instance, CHWs and volunteers.

CHWs and volunteers were not a target group for receiving reports at this point, but we still wanted to hear their thoughts about the idea of serving the chief's health reports and help us understand the chief's role and daily tasks. These conservations gave us valuable information, but simultaneously we discovered that the CHWs and volunteers could find reports valuable to receive reports themselves. This made us consider if the scope for the report should be extended to include other roles as well. Public health seemed to be an important area which engaged many roles in the community.

3.8.2 Iteration 2

During Iteration 2 in Ethiopia, we met CHWs, volunteers and a school leader who showed interest in receiving health reports. There may be more roles in Ethiopia that could find reports relevant, but the short timespan we got did not allow us to research this further.

In Malawi, we managed to meet both religious leaders, school leaders and teachers. All these roles showed a strong interest in receiving health reports. This strengthens the idea to target more roles than just CHWs and volunteers.

Through an interview we had with a chief, and other role's thoughts about including them, it became clear that chiefs still should be included. We also got a description of what a traditional healer's daily tasks are and based on this, there was reason to believe that traditional healers should be a target group.

The list of target groups was:

- CHWs
- Volunteers
- Religious leaders
- Schools
- Traditional healers
- Chiefs

4 The application

We have developed an application with name “Health Reports” that allows CHWs to generate and share health reports based on data in Malawi’s Health Management Information System. This chapter goes through different phases in the development of this application and the application's technical documentation.

4.1 Paper prototypes

During the research, we developed two paper prototypes, where the second prototype was an improved version of the first. The prototype's purpose was to get answers to three different questions. First, how data in health reports should be presented (chart technics). Findings related to this are described in Chapter ***Feil! Fant ikke referansekilden.*** Chart literacy. Secondly, we wanted to find out what the report's content should be. Findings related to this is described in Chapter *8 Report content*. Thirdly, the conclusions of the paper prototypes formed the bases for the application’s functional requirements.

4.2 The first paper prototype

Our first paper prototype, see Figure 4, was made early during the first iteration. The report displayed different health issues with a variety of charts technics. As mentioned, our report was initially created for the chief in a village, but due to difficulties in meeting any, we spoke only with volunteers and CHWs. Since this prototype was made before we met with any of the CHWs and volunteers, we had little information to base the content of the report on. By using data from United Nations (FN, 2022) web pages regarding health statistics in a country, combined with advice from the locals, we were able to find some topics that might be relevant for the roles we would come in touch with. Based on this, the most relevant topics would be vaccinations, childbirth, children born with underage mothers and antenatal check-ups. The first prototype existed of four chart elements, where each element was associated with one of these health topics. We used dummy data in the report as we could not access any actual data at this point.

The first element, top left in Figure 4, was a vaccination chart displaying the number of vaccinations in the last 12 months. The chart's oblique line is a target line commonly used in Malawi to describe the planned progress for a vaccination program. The chart does not say what kind of vaccine, as it was more important to establish the knowledge level. Secondly, at the bottom left, we had a split bar chart comparing performance between three districts regarding their percentage of childbirths at clinics vs at home. Thirdly, the report at the top-right contains a column chart representing “Children born with underage mothers”, again with the last 12 months represented. Lastly, we had “Antenatal check-up” at the bottom-right, where we wanted to display the total number of check-ups each pregnant woman had completed.

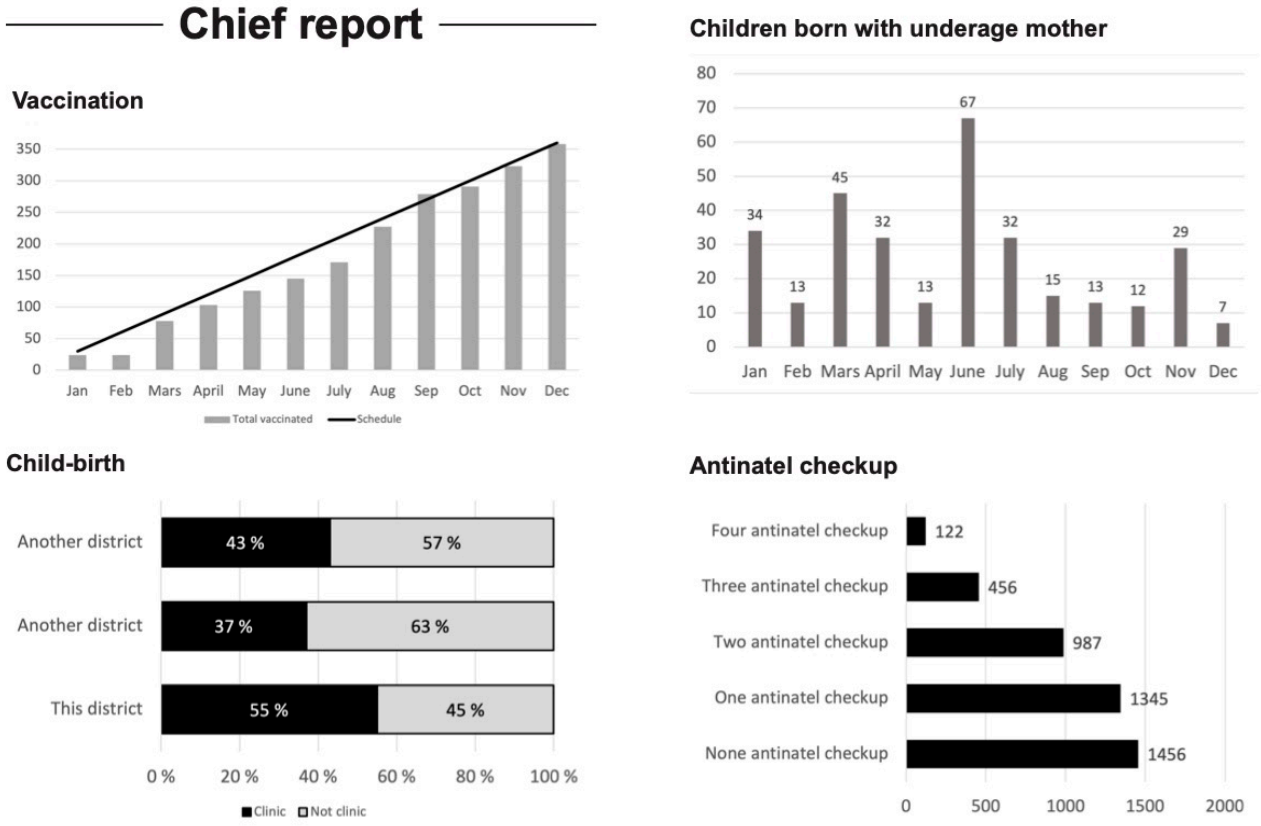


Figure 4 - The first paper prototype

Important questions to answer were to which extent people were able to understand what we were showing them and if the health topics we had chosen were relevant or

not. Questions we wanted answers to were, for instance, if we had chosen relevant sub-topics and if they could point out the target line in the vaccination chart and tell us what it describes. Were they able to understand that in some charts, large bars represent a bad value (Children born with underage mothers), and in others, a good value (Antenatal check-up)? Were some relevant health topics excluded? Are percentages a clear communication form, or are numeric numbers more suitable? These are some of the questions we tried to get answers to during the conversations we had with the CHWs and volunteers.

4.2.1 Findings from the first prototype related to the application

- Dummy data were confusing for many, as they did not understand why we showed them dummy data instead of real data.
- Some had more difficulty with understanding charts; for those, could other communication forms, such as text, be considered.
- Neither bar chart nor column chart with split bars, such as the chart at the bottom-right in Figure 4, are commonly used in Malawi and were therefore confusing for our participants.
- The reports need to be in the local language, not English.
- Using termination, such as “more”, “less”, “worse”, and “better”, is more understandable for many compared to using percentages.
- Determining good or bad values could be based on national standards.
- Several found comparing performance with other villages valuable.
- The total antenatal check-up for a woman is eight, not four as first believed.
- All four health topics seemed relevant in the field, but other more general health statistics could also be relevant for some.

4.3 The second paper prototype

Our second paper prototype was also developed during the first iteration. The prototype was based on the result of the first prototype. The report consists of both column charts and text phrases. By using text, we covered a larger variety of health issues with a shorter report, in addition to better including those with the poorest chart knowledge. The

focus remained on child health and vaccinations; some general health was also included (see “General statistics” in Figure 5). The data in the report were still not based on actual statistics since we did not have access to it.

After the first prototype, we discovered that percentages in charts could be difficult for many to understand. In the second prototype, we wanted to find out to which extent percentages could be a suitable format for presenting data as long as it is not used together with charts. Therefore, we added a textbox at the top of the report containing text phrases that describe a change in a health topic in percentages. Other text phrases were also added, where some described a change with numeric numbers, and others described a change with combining both numeric numbers and percentages. More focus on text also aligned with the idea that text phrases could be an appropriate way to include those with the poorest chart knowledge.

There was also an idea that comparing nearby districts could motivate CHWs to perform better and be used as an additional parameter to evaluate if their result was good or bad. To achieve this, we added text to compare statistics with nearby villages to find out if such information could be interesting.

There are two vaccination charts in Figure 5, which show a period of 12 months. The chart to the right starts with the turn of the years, and the chart to the left show data for the last 12 months. We made this choice to establish if they wanted the charts to begin in January or display the last year from the current month.

The charts were supported by text phrases to see if it made it easier for the reader to understand their meaning. To make it even more tricky, we created charts where the numbers in the text phrase did not match the representations below them; for instance, the vaccination chart to the left in Figure 5 says, “*171 new people were vaccinated in February*”, but the chart shows a value around 360 new people vaccinated. We used the mismatch to see whether people could detect the difference between the text phrase and the chart.

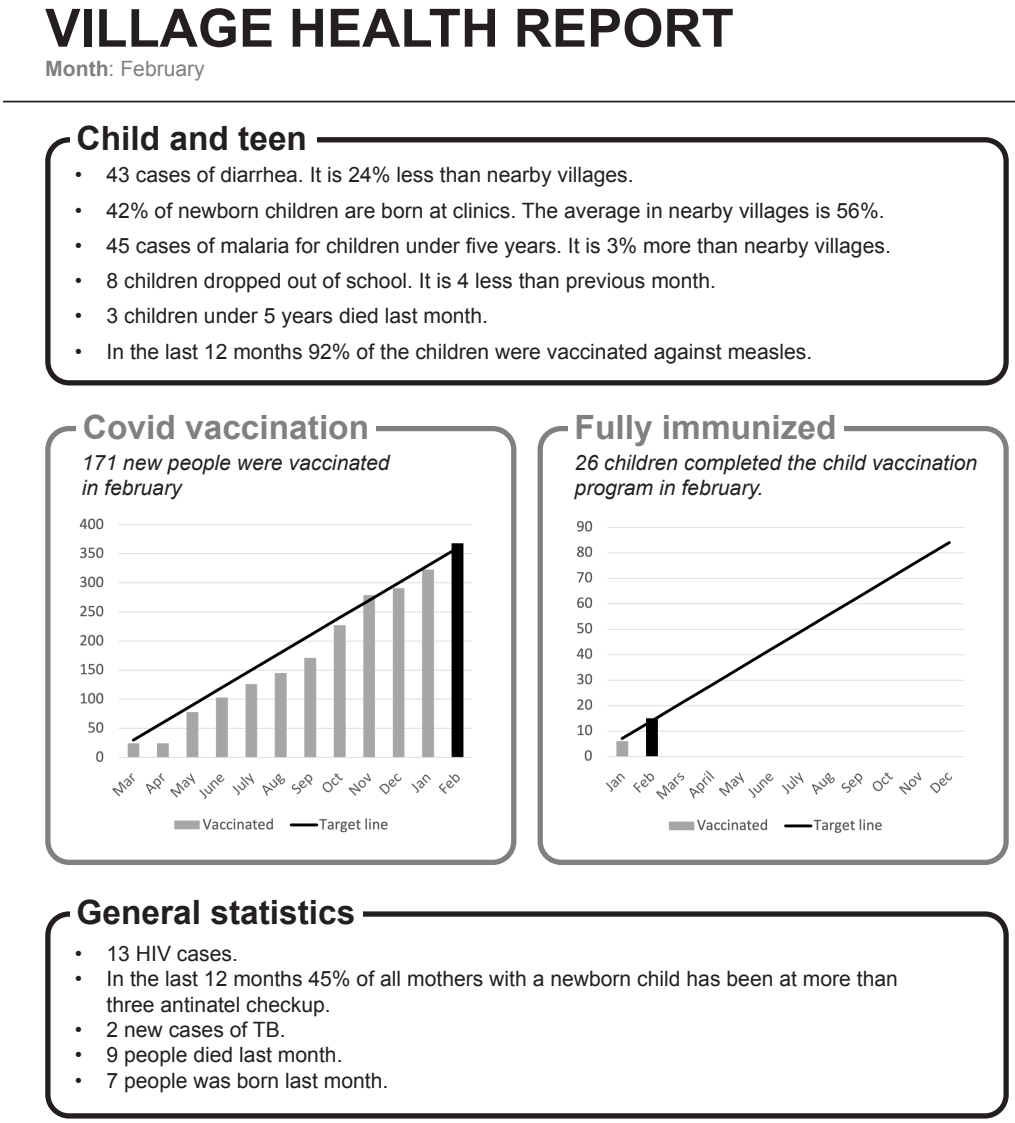


Figure 5 - The second paper prototype

4.3.1 Findings from the second prototype

- Simple text phrases with percentages were understandable for most people we were in touch with.
- The report needs to be for a specific area. People want to know the situation in their village or town, not an entire district.
- The CHWs said that they should be able to select among different chart methods, such as line chart, bar chart and column chart.
- A senior CHW wanted pie-chart

- The text was an appropriate way of communicating information that everyone was able to understand. Especially when the information was simple, such as “Five people got COVID-19 last month.”
- Using percentages and numeric numbers in combination with text phrases was confusing for many. We should stick to either numerals or percentages.
- When it comes to showing the progress of a vaccination program, our participants found it easier to understand the chart if it always started in January rather than showing the last 12 months.
- Few people noticed the mismatch between the values in the text that intended to support the chart and those in the chart.

4.4 The sample reports

In the second iteration, before we travelled to Ethiopia and Malawi, we were able to generate several sample reports with the application we had developed. The development process, decisions that were made and the application itself is described further in this chapter.

Based on the findings from the first and second prototypes, we decided to only use column and bar charts. Focusing on only two chart methods, allowed us to experiment more with which health topics to display, and for which time period. Since we created them before our departure, we could include colours as well.

We created three different reports regarding mother care, water-treated and COVID-19. The report regarding mother care, see Figure 6, contains “Number of antenatal check-ups for the last 12 months” and “Number of women who completed four or more antenatal check-ups in the last three years”. We used only column charts in this report and no text descriptions.

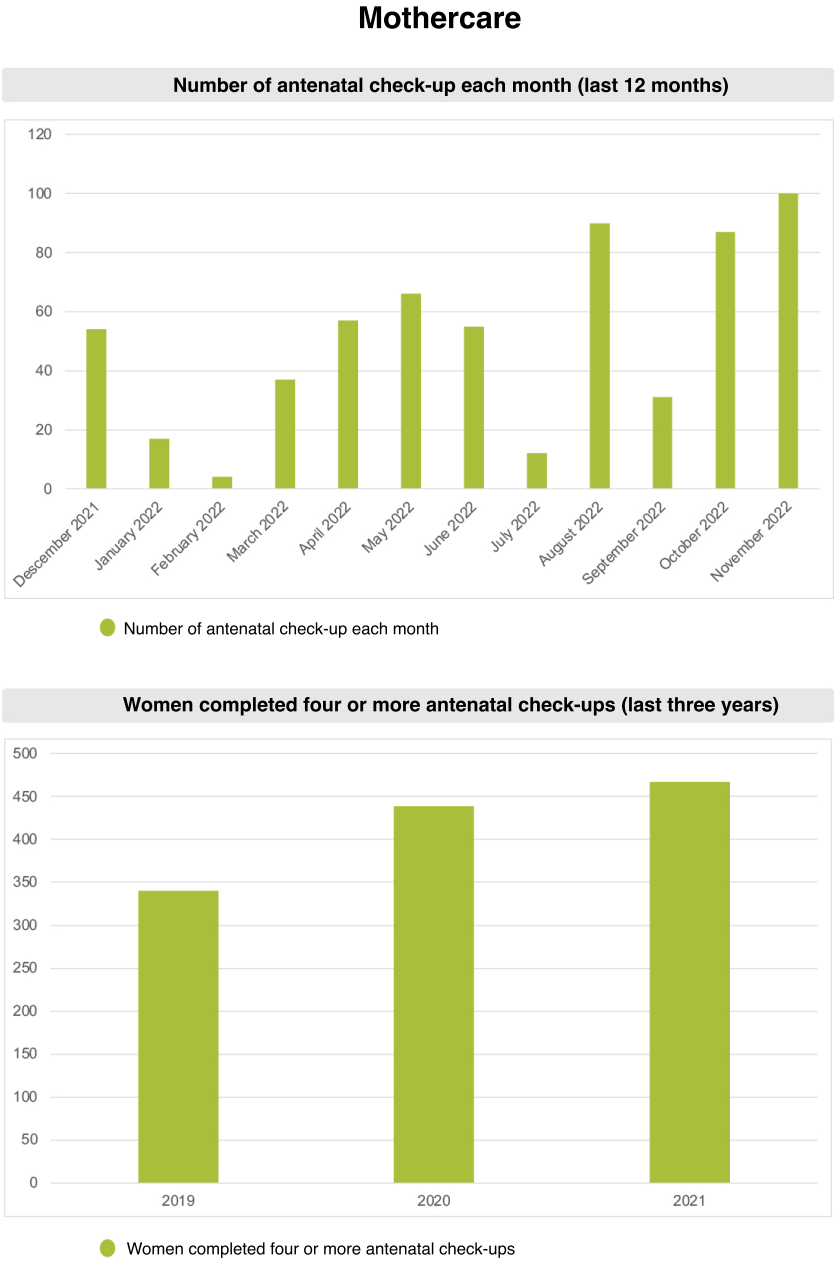


Figure 6 – Mother care report

The second report, see Figure 7, contained visualisations regarding water treated. This report was based on real data from Vigando in Kasungu. We combined the charts with a text description to provide an example of how text can help the understanding of the numbers. Due to a lack of data, the two charts contain the same issue, “HR percentage

of Households with water treated with 1% stock solution", which is why they display a different period and have different types of charts.

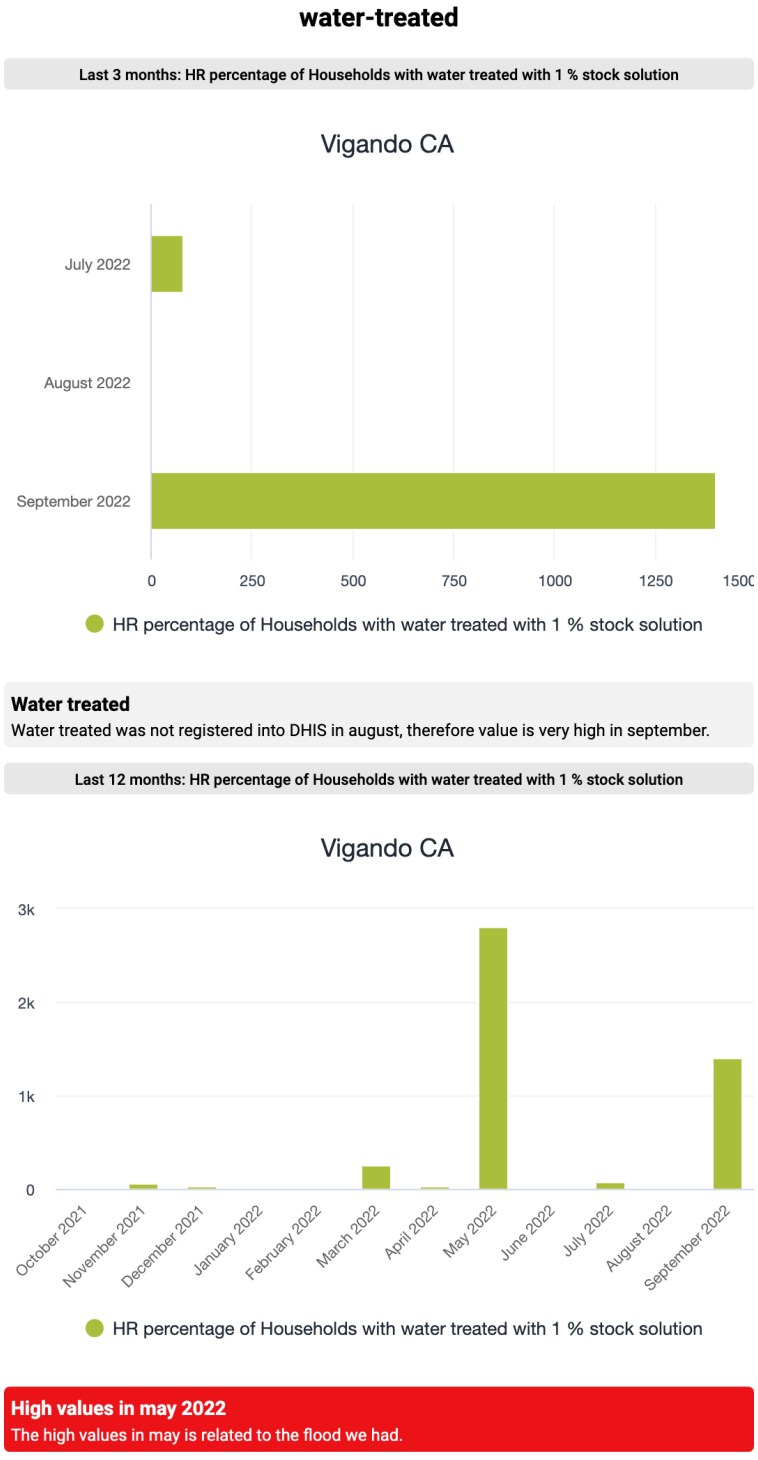


Figure 7 - Water-treated report

The last report, see Figure 8, contained two charts about the COVID-19 vaccination. The first is a bar chart regarding “COVID-19 first doses given per month for the last 12 months”, and the second is a column chart representing “COVID-19 people fully immunised per month (2 doses) the last four months”. This report is created with our application, but the name of the health topic and bars are edited in a photo editing software afterward, for making the reports more relevant.

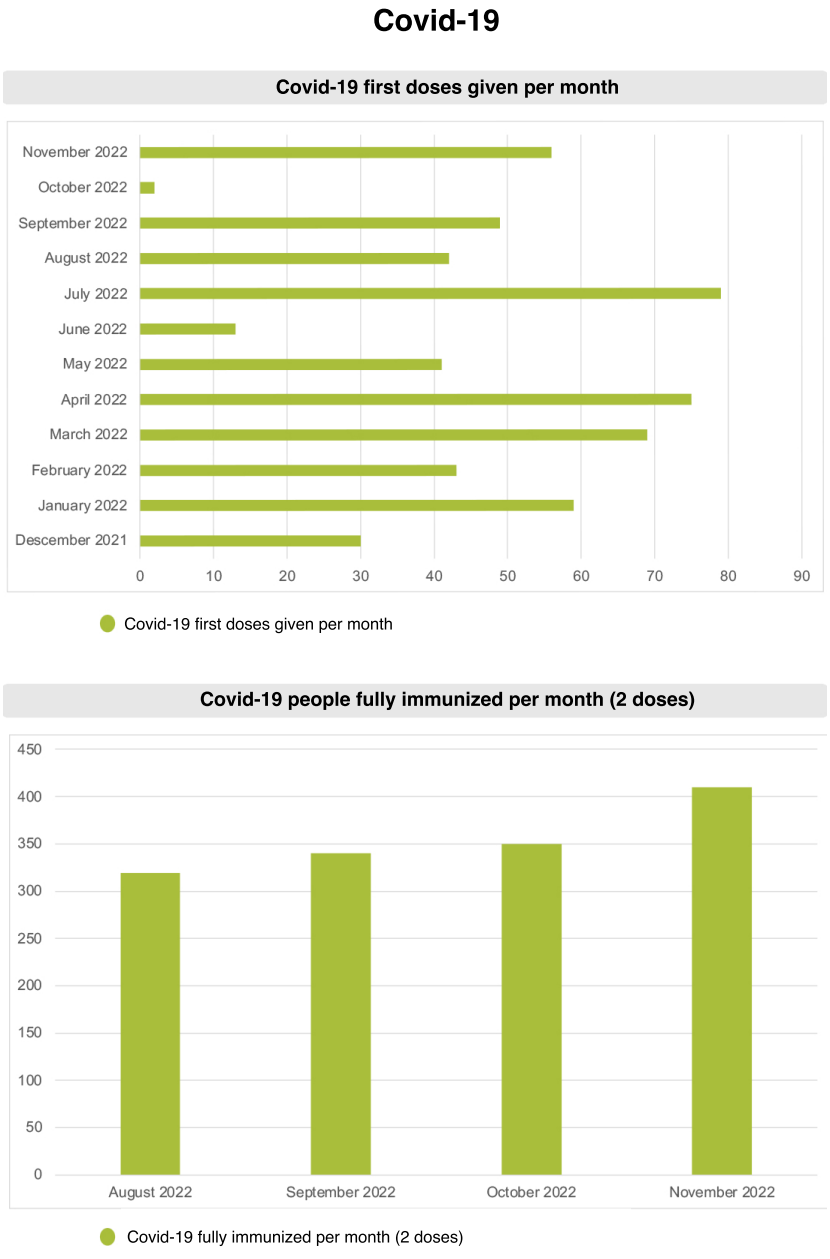


Figure 8 - COVID-19 report

4.5 Functional requirements

The functional requirements are based on the findings from the first and second versions of the prototype and discoveries done through conversations and interviews during the first iteration. New findings were also discovered during the second iteration in Ethiopia and Malawi, which led us to implement some changes in our application. The changes that were needed are described in “Chapter 4.10 User-testing".

It early became clear that the CHWs should be the distributors of information (Figure 9), as they have the latest image of the health situation and have access to a digital device. The findings also showed us that a lot of people have access to a smartphone, something that makes them able to receive a report in a digital format.

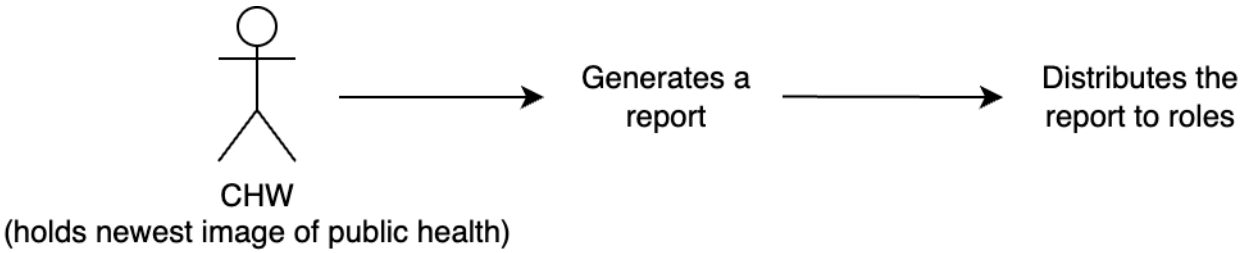


Figure 9 - How a CHW shares a report

4.5.1 Table of functional requirements

“Table 8” shows the functional requirements we designed and their priority. The level of priority is based on the impression of how important each requirement was for the CHWs and the different roles.

Functional requirement	Priority
CHWs could select visualisation methods for each chart in the report. A visualisation method is for instance bar chart, map, line diagram or pie chart.	High
CHWs could select for which area the data should be valid. For instance, select a district or a specific village. Such an area is referred to as an organisation unit.	High
CHWs could select the data element for each chart layer. A data element is for instance the number of malaria cases for adults, or the number of Penta doses given to children.	High
CHWs could select the time period for the chart layer. A time period could for instance be last month, last three months or last year.	High
CHWs could move layers up and down in the report	Low
CHWs could add custom text to the report	Medium
CHWs could share the report to other roles via a chat application	High
CHWs could print the report, if access to printer	High
CHWs could select from previous generated reports	Medium
CHWs could erase the report and start from the beginning	Medium
CHWs should be offered a guide for how to share a report	High
CHWs could compare data with nearby districts	Medium
CHWs could be able to select among different standard reports for different roles	Medium
CHWs could add target line to immunisation charts	Medium

Table 8 - Functional requirements

4.6 Environment

The application was built on top of Malawi's iCHIS, which is based on the open-source system DHIS2 (Kanjo et al., 2022). iCHIS is a health information system used on a community level by the CHWs. They use the system in their daily work, for instance, to do decision-making, registration of diseases and patient follow-up.

Since our application is built on top of Malawi's health information system, it was not possible to adopt it directly into the health information system used in Ethiopia. With some more configuration and development, it would likely be possible to adopt it, but this was not prioritised since Malawi was our primary focus.

4.7 Android vs web-solution

In the early stage of the application development process, we needed to define which technologies we wanted to use to develop our application. An early decision we made was whether the app should be built on top of the existing Android tracker app or be an add-on to the iCHIS web version. This decision was crucial, as the technologies used on each platform could be adapted to each other to a small extent. A more careful consideration between the two platforms was needed, as changing the platform later would require us to start the development process from the beginning.

4.7.1 Technologies in use today

The Android solution is based on implementing a new report feature in the existing Android mobile application that is in use in Malawi's district or will be rolled out to all districts soon. The web version is based on implementing a new report tool in a more comprehensive web version of iCHIS.

The main advantage of the Android solution is that the app is already or will soon be in use by all the CHWs. This is an advantage since introducing a new feature inside an already familiar app would likely require less training. The web version of the iCHIS is, according to the developers and what we saw in Malawi, in use by the CHWs to a much smaller extent. Introducing the report tool on the web version would require more from the CHWs, as they first need to learn this version of iCHIS, then, in addition, learn how the report application works. During fieldwork in Iteration 1, we discovered that many people needed help with internet browsers, such as understanding site navigation and selecting from a dropdown field. There was a clear sign that using web applications is

not widespread in Malawi and that introducing new digital tools would require training and practice.

4.7.2 Our knowledge with Android and web development

When choosing between the Android or web version, we considered our knowledge and familiarity with the two technologies. The time span for creating the application was short, so putting too much effort into learning new technologies would likely not be a good solution, as the time left for developing the application would be limited. Since neither of us has any experience with Android development, it would most likely require too much time to learn. Web technologies, such as React, HTML, JavaScript and CSS, used when developing new add-ons to the iCHIS web version, were more familiar to us.

4.7.3 Environment and documentation

The environment and documentation about how to extend the DHIS2 tracker application were very limited. It also required setting up a backend server running locally on the developer's computer. On the other hand, the web version was significantly better documented, seemed a lot easier to start with, and made it easier to publish add-ons. Creating add-ons to the web version is more common compared to extending the Android application; therefore, the development community around developing add-ons is better.

4.7.4 System requirement

To which extent the two different technologies could cover our functional requirement must also be considered. One of the requirements is to share the report using a chat application such as WhatsApp or Facebook Messenger. This interaction would probably have been more seamless with Android, as it likely would require fewer user actions. To determine how complicated the chart-sharing process was on the web solution, we developed a simple web application to test this out (see Figure 10). The simple web application was tested on several users, and all participants were able to share reports. This showed us that the process of sharing reports was user-friendly.

Since we saw that the sharing process in the web application worked fine, we did not test how the sharing process would have been in an Android application. Based on documentation and similar solutions, it seemed like the process of sharing images in an Android application would have been more seamless.

Figure 10 - The first digital prototype to see if it was possible to share an image from a browser to a chat application

4.7.5 Table over pros and cons with both solutions

Topics	Android-solution		HMIS web solution	
	Pros	Cons	Pros	Cons
In use today	Is already used by the CHWs.			In a small extent in use by the CHWs
Our knowledge and familiarity		Poor knowledge from both students, would require time to learn.	Familiar with the technologies that are in use. Would likely manage to develop more functionality.	
Environment and documentation		Poorer compared to web-solution.	Good development environment from DHIS2.	
System requirement	Would likely cover all needs.		Would likely cover all needs.	May not be seamless as it could have been with Android-solution.

Table 9 - Pros and cons with Android vs HMIS web solution

4.7.6 Conclusion

At first look, it seems most reasonable to extend the Android application since developing a web solution would require the CHWs to use an unfamiliar digital platform and require more training. On the other hand, Android development would most likely have been too comprehensive for us to learn. More time spent on learning technology would likely result in an application with fewer functionalities and less time to test and improve errors that occur. There was also a risk that extending the Android solution was not achievable in the time we had available. Choosing the web solutions turned out to be the best solution, even if it would require some training for the CHWs.

We also need to keep in mind that the main purpose of the solution was to investigate whether a digital solution could be used by the CHW to provide roles in the community with health reports. The availability, maintenance, and ease of use should, as we see it, be subordinated to this. With such a point-of-view on the application role, it makes it even more reasonable to choose a solution that is simplest to develop and gives us the best changes to implement most functionality.

4.8 Process

After deciding to develop a web-based application, we designed a prototype for the application with Figma (Figure 11), a digital tool for creating prototypes. The prototype consisted of three pages and accounted for all the functionalities listed in “4.5 Functional requirements”. It was an important tool to coordinate each other’s thoughts and ideas, during the development process and made it easier to divide the development into smaller tasks. The design of the final product has many similarities with the prototype.

We did not make a long-term plan for the development process, with goals for when each requirement should be finished. Instead, we had an approach where we prioritised which functionality that should be developed next based on which functionality that would likely give the most value. Using too much time for planning, would most likely not be optimal, as it were hard to determine many tasks, such as the Android vs web-

application consideration. Compared to a more commercial development project, we did not either have a product owner that was setting specific requirements for what we should develop. Therefore, the approach was more leaned on making as much value as possible, based on the time available.

During the development process, we spitted the task into several sub-tasks, where we developed mostly induvial and merged the work together with Github after each task was finished.

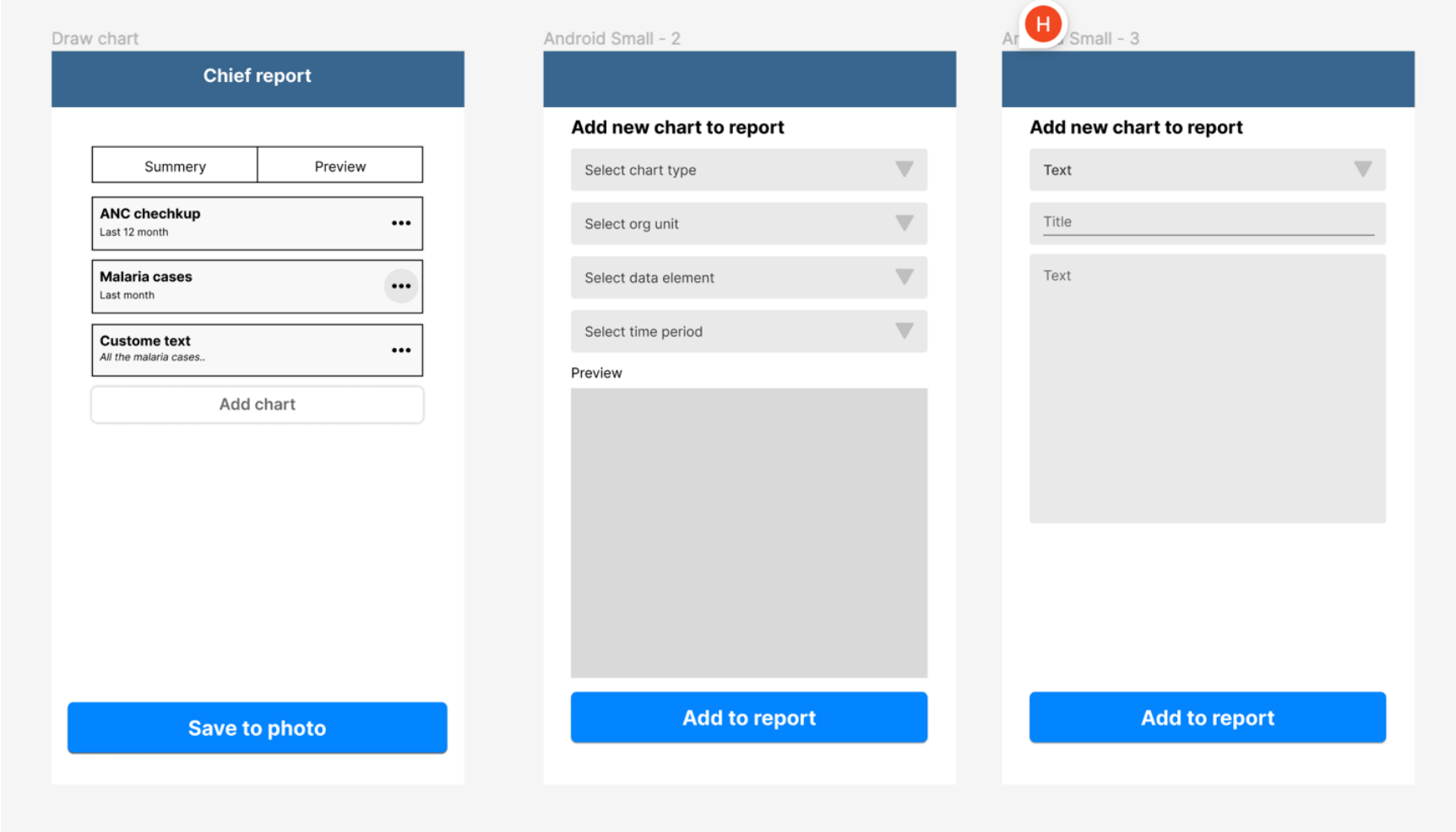


Figure 11 – The first digital prototype of the application. Left screenshot: the overview of the current report. Screenshot in the middle: adding a new chart layer. Right screenshot: adding new text layer.

4.9 Prioritisations

We managed to develop most of the requirements listed in “4.5.1 Table of functional requirements” before travelling in Iteration 2. Some functionalities were not implemented, mostly caused by lack of time, but some functionalities also turned out to be less valuable than we first thought.

4.9.1 Maps

Maps were not implemented since border data only existed for larger districts, and walking around Malawi with a GPS tracker to collect more border data was unfortunately not an option. We could implement functionality for comparing larger districts, but when comparing districts of that size, several other factors need to be accounted for, such as climate differences and different access to water sources. This makes such comparisons complicated, as it depends on CHWs having this background information. Maps were therefore not implemented.

4.9.2 Target lines

Using target lines, as shown in “Figure 4 - The first paper prototype” and “Figure 5 - The second paper prototype”, was familiar to many. The component to visualise charts in DHIS2 did not support such functionality; it was, therefore, not implemented in the application. We did not prioritise developing our own component that could support this since the benefit of supporting target lines was low compared to the time it would have required to develop it.

4.9.3 Compare nearby districts

Being able to compare a district with another nearby district was also not implemented. This could have been used as a second parameter in addition to national standards, to evaluate a district's performance. The main challenge with this functionality was related to how iCHIS is designed. Since every CHW only have access to data in their catchment area, implementing such a comparison functionality would also require all the CHWs to get extended access to nearby catchment areas. Giving CHWs extended access seemed for us as comprehensive work and would likely require some additional work

from the people that maintain iCHIS in Malawi. In addition, it was also pointed out by one CHW on the first trip to Malawi that such a comparison may also demotivate CHWs in catchment areas with poor results. This sounded reasonable, and we also thought that it might be better for the CHWs to only have attention to improving their catchment area rather than spend time comparing or being curious about other areas' performances.

4.9.4 Local language

Being able to have the report in the local language was also skipped. This was related to some technical challenges and a lack of time. After Iteration 1, we got feedback that the report needs to be in both English and the local language (Chichewa). Achieving this would have required the possibility of changing the language in the application on buttons and navigations. Implementing this functionality seemed comprehensive, so developing it would likely get at the expense of other functionalities; it was, therefore, less prioritised. Another challenge with translation was that the data element's name was being retrieved from a server where we had no guarantee that the names would stay the same. This means that creating fixed translations of the names of the data elements would have been a short-term solution and not sufficient to handle situations where new data elements are added, or names are changed. Doing machine translation with a REST-API would likely not be a good option either, as it would cause some wrong translation, cause cost and API-keys that needs to be maintained.

During Iteration 1, we were also witnessing a presentation of a new way of registering pregnant women for the CHWs where the language was English. This may indicate that the need for local language is mostly for some of the receivers with poorer English skills. As it was hard to translate the name of the data element directly, we rather introduced functionality for the CHW to change the entire chart label, for instance, change the auto-generated label "Last 3 months: number of malaria cases for children under five years" to whatever the CHW want. In addition, the CHW always has the ability to supplement the chart with text layers in the local language.

4.9.5 Auto-generated text phrases

A feature we also discussed was the possibility of implementing auto-generated text phrases explaining a change in a health topic, such as “It has been five more cholera cases this month compared to the same month the previous year.”. The idea was to make comprehending information easier for people with poor chart literacy and mathematics knowledge. The text phrases could have replaced the more comprehensive charts for certain groups, as they could deliver less but more specific and pointed information.

The feature was not implemented mostly due to lack of time. Creating text phrases that compare values from previous months would also take much work, as the data we got from Malawi only contained sporadic data points with few data elements. It could also be discussed if this functionality would have been redundant since we already had implemented a feature that let the CHWs add custom text phrases. The idea behind the custom text was to comment on charts and explain the health situation in more detail. Adding auto-generated text phrases does not add anything new to the application but may rather increase the complexity for the user and get at the expense of the user experience.

4.9.6 Report standards

We also discussed whether we should implement possibilities to choose from different report standards in the application. This would have made it possible to generate a new report with the latest data available, where each chart in the report has a predefined period, data element and visualisations method. The idea was to quickly generate reports that often are in use and help the CHWs decide which health elements are useful for the different target groups.

This functionality was not implemented due to lack of time. After Iteration 1, we also got the impression that the different roles mainly cared about the same health topics. If there was a lack of vaccination or an increase in disease occurrence, we got the impression

that these topics were on everybody's agenda. Therefore, we concluded that specific report content for each role was unnecessary. We also implemented functionality to generate a new report based on the content in one of the last three reports generated. (Figure 12) This functionality was, to some degree, a replacement for the functionality that standard reports could have offered.

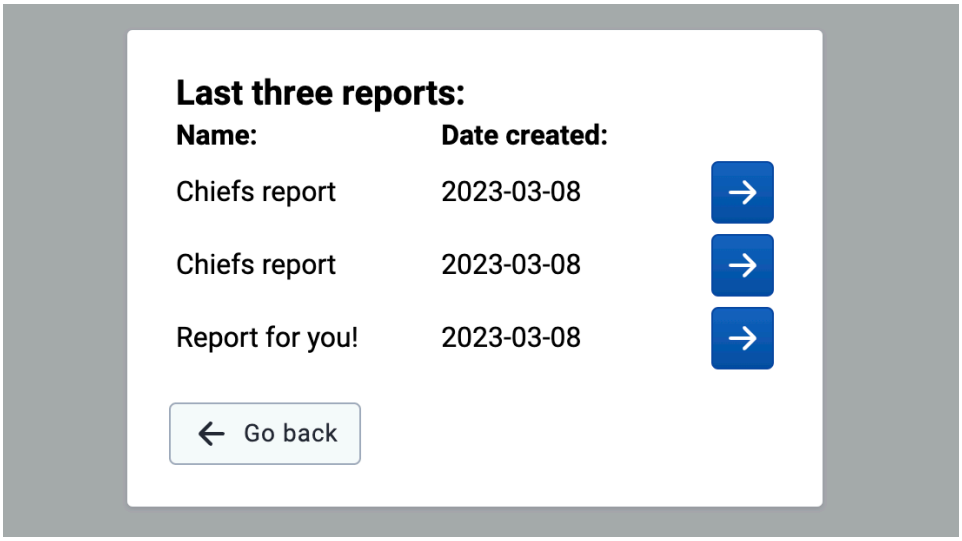


Figure 12 - Last three reports generated.

4.10 User-testing

Making a user-friendly user interface is essential to create a successful application. In developing the user interface, we followed the patterns in the DHIS2-design principles that included principles for colour, content, communication, forms, icons and spacing (*About DHIS2*, n.d.).

The people we were in touch with at fieldwork were often busy with other tasks, which limited how long we could occupy them. Asking questions related to our four main research questions was always our priority in fieldwork. The time left for user testing was therefore limited, and comprehensive user testing was not accomplished. The method for the user testing was instead more unsystematic and centred around asking the users questions about their overall impression of the application, such as "How easy was this application to use?" or "Could you come up with a part of the application that was hard to

find out how to use?". In scenarios where time allowed, the users were also asked to do special tasks, such as "generate a report that shows the number of malaria cases last month" or "add custom text phrases to the report". Based on the feedback we got, we considered if a change was needed or if the feedback was only associated with one user that did not achieve or understand something that everyone else could accomplish. "Picture 2" shows a user-testing conducted at fieldwork under a mango tree.

Picture 2 - user testing

4.10.1 Changed the way of displaying and editing charts

Our first version of the application was built with two tabs, as shown in Figure 13 and Figure 14. The "Summary"-tab displayed both the parameters chosen for each element in the report (*box 1* in Figure 13) and options to edit the chart (*box 2* in Figure 13). The "Preview"-page showed how the current report would look like when it got exported (Figure 14).

Summary

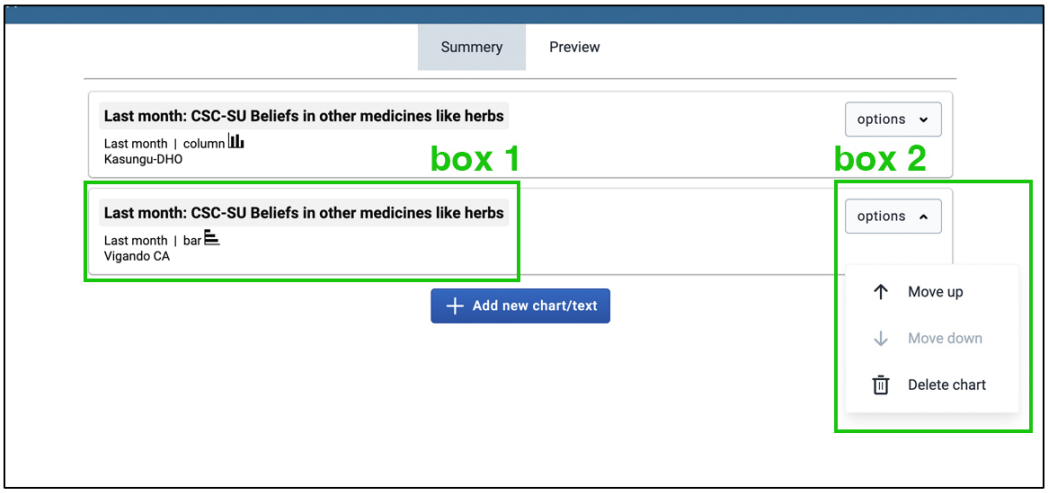


Figure 13 - Originally two-tab setup (Summary-tab)

Preview

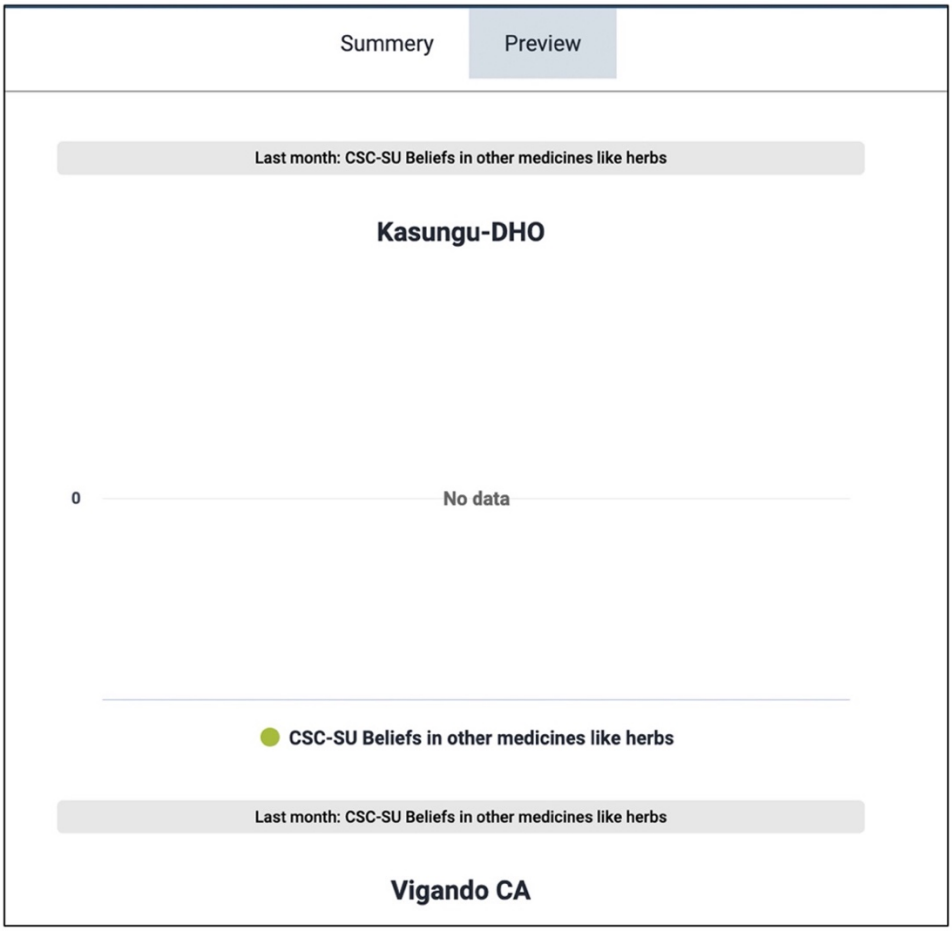


Figure 14 - Originally two-tab setup (Preview-tab)

During user testing in Ethiopia, we discovered that this setup needed to be clarified for someone. For some users, it was unclear which information was showing on each page, and someone also thought that changing tabs would affect or edit the current report in some way. To solve this issue, we looked at the possibility of merging the two tabs into one view. We also considered that some of the summarised information in *box 1* in Figure 13 needed to be revised, especially if we were able to show the user the different charts all the time. The result of the change is shown in Figure 15, where each chart is displayed on the left side, and edit buttons related to each chart are displayed on the right side.

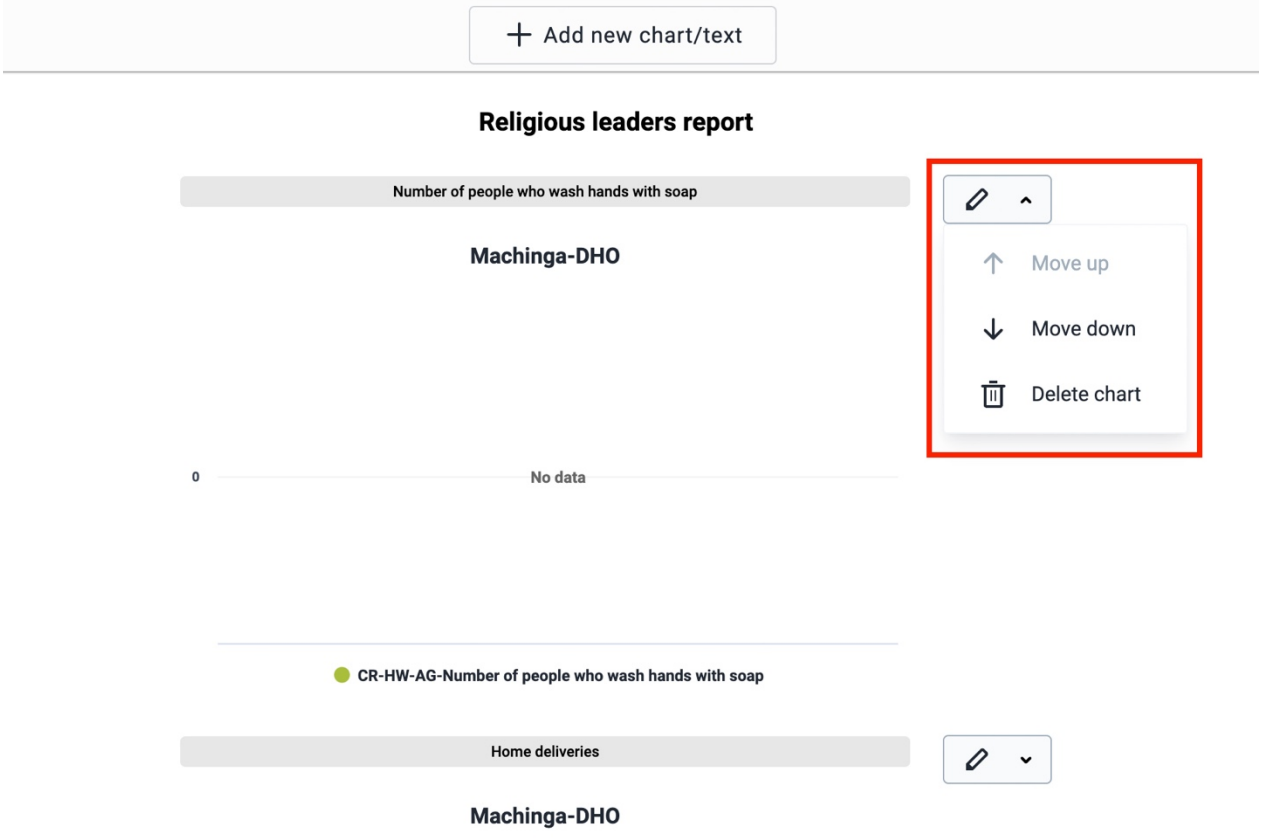


Figure 15 - New one-page setup

4.10.2 Dropdown fields in add new element-page

At a fieldwork early in Malawi during Iteration 2, we got feedback that the “Add new element to report-page” (Figure 16) existed of too many possible buttons and dropdown fields to choose from, something that it made it difficult for the user to understand where to start.

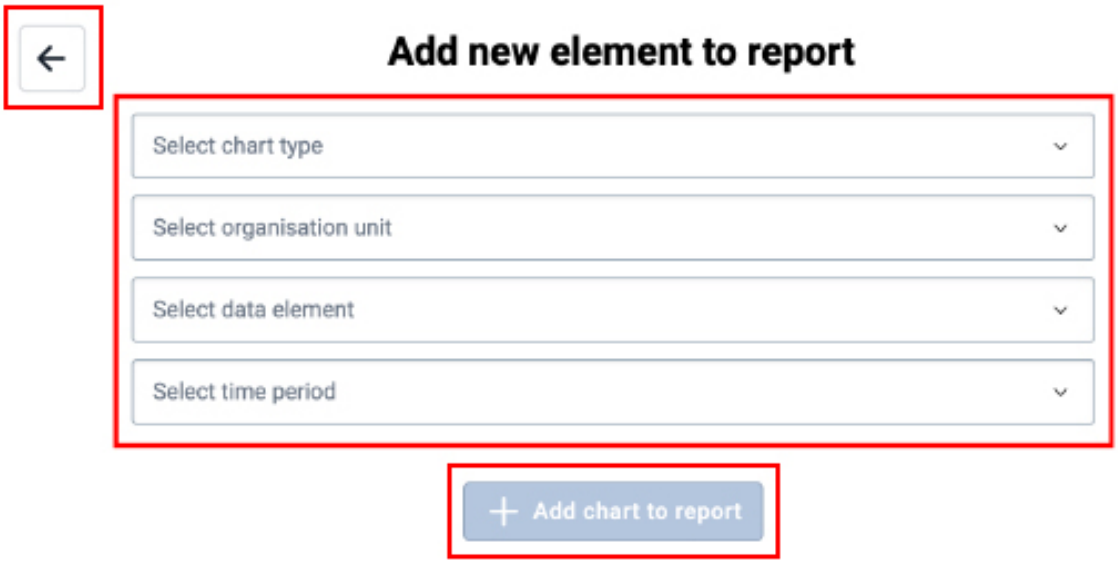


Figure 16 - Add a new element to the report (version 1).

In response to this feedback, we implemented version 2 (Figure 17) with functionality that only displayed the upper dropdown field first and then only showed the next dropdown field as long as the above dropdown field was set to a value. We implemented this change to limit the user's options when entering the page, only introducing one new dropdown field at once.

We tested version 2 in the field, but the effect of the change was different from what we had expected. Users we tested used a long time, as many did not notice that a new dropdown field had appeared. After seeing both versions in action, we concluded that the first version was the best.

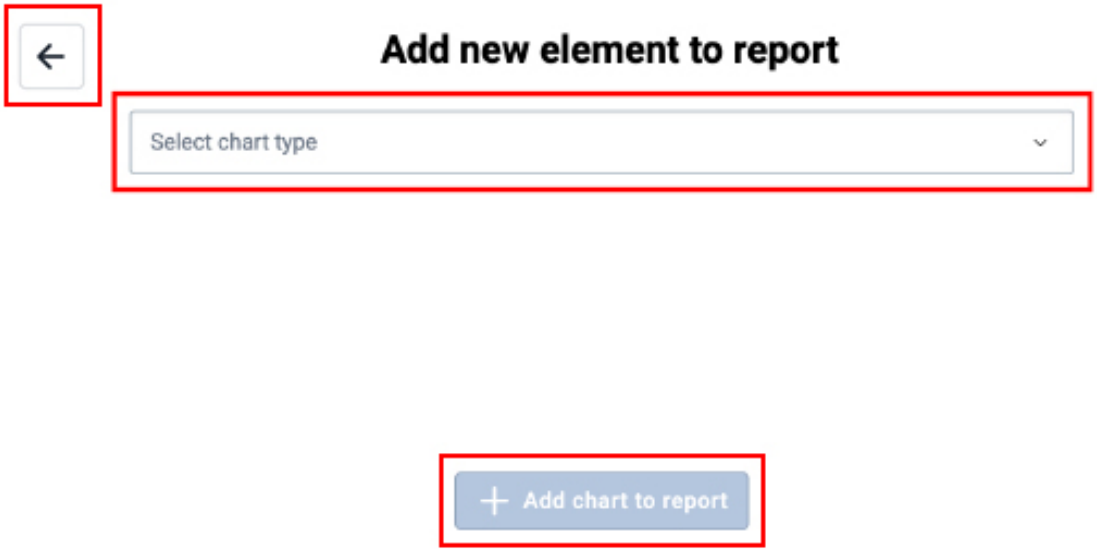


Figure 17 - Add new element to report (version 2).

4.10.3 Implemented report standards

Early during fieldwork in the second iteration, we discovered a larger variety of which health topics the different roles cared most about. In Ethiopia, we saw that the topics school leaders and teachers often discussed, such as hand washing and school drop-out, differed from what volunteers discussed, such as breastfeeding and immunisation coverage. The impression from Malawi during the first iteration, that the roles cared mostly about the same topics, was not aligned with what we discovered in the second iteration. In the second iteration, we discovered a broader variation in which health topics different roles cared about and that these topics often were related to their daily tasks.

Nevertheless, this finding from the second iteration caused us to consider whether the application should have a standard report functionality. In some of the first interviews we had in Malawi during the second iteration, we also got it confirmed from the interview subject that such functionality would be beneficial. With several clear signs that a

standard report tool would be valuable, we started to develop this functionality in Malawi and had it ready during the first week of our stay.

We adopted the different names of the roles as names for the standard, such as reports for volunteers became “Volunteers-reports”. The content in the standards was fitted to be as relevant as possible for each role based on accessible health data; for instance, a volunteer was provided with other charts than a chief. Some standards were also developed to cover general health topics, such as “Vaccinations-report”.

When clicking on the different standards, the application generates each chart in the selected standard. The charts would be displayed as a normal report, where the user further can customise and delete each element generated from the standard or add new charts to the report if needed. The result is shown in Figure 18, where the left menu shows the different standards available (no standard is selected in this screenshot).

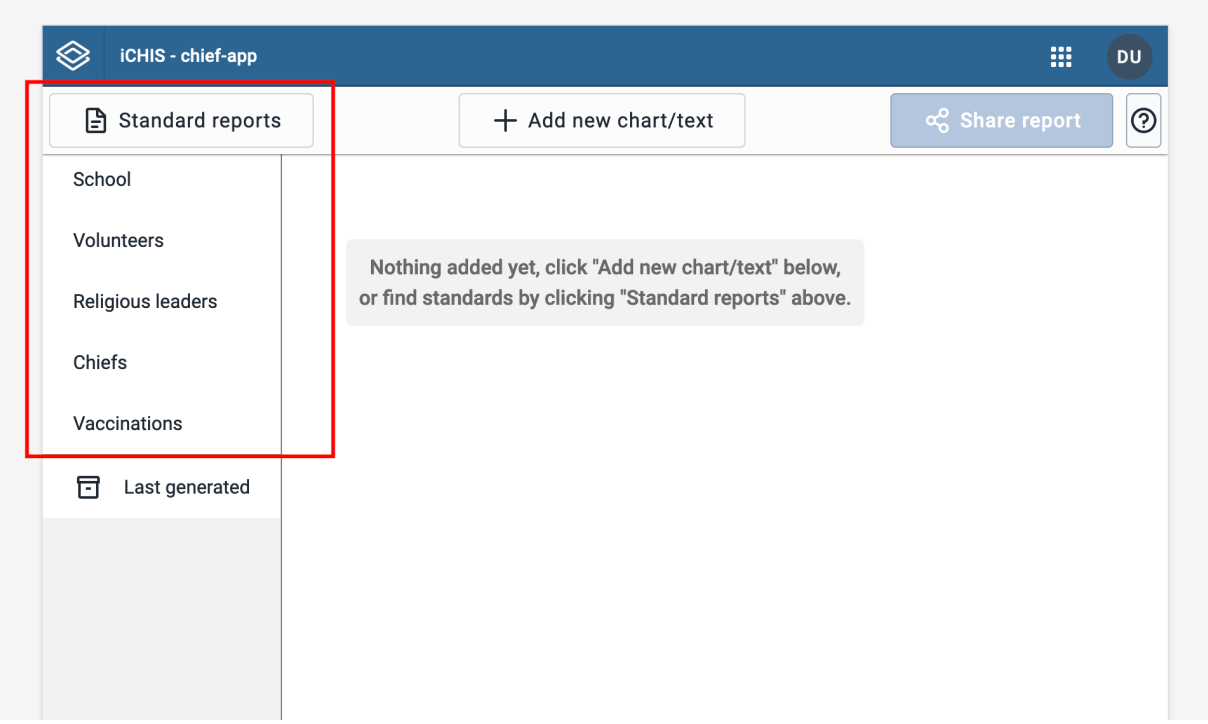


Figure 18 - Standard report implemented

4.10.4 Observations related to user-friendliness during fieldwork

In addition to direct feedback from our interview subject during user testing, we also made changes in the application in the areas where the user was struggling to improve user-friendliness. For instance, this was moving buttons, input fields, changing font size and adding icons to buttons. The list below lists several improvements we made based on observations during fieldwork.

Improvements based on observation:

- Removed the two visualisation methods, Area and Pie-chart. Area was unfamiliar to everyone we were in touch with. Pie-chart was removed since it required several organisation units to work. We concluded that introducing an option to select multiple organisation units would have considerably worsened user-friendliness, and it was not implemented.
- A pop-up box where the user needed to select either “Create new report” or “Create based on previous reports” was displayed when a user entered the application. This was removed as it seemed confusing when report standards were introduced.
- We added an image to the pop-up module that tells how the user could share the downloaded file on a tablet.
- A loading bar was added when waiting for the chart to display. When testing the application in Norway, the charts were displayed immediately since we had a high-speed internet connection. Internet speeds were slower in Ethiopia and Malawi, so it took some time before the charts were loaded. To improve the user experience, we added a loading bar to clarify that the user needs to wait for a server response.
- Navigation was moved to the top of the page, as this aligns more with the best practice about site navigation. Buttons in the navigation also got a larger font size.
- Added exit button on the export-pop-up module.

4.10.5 Overall impression of CHWs' experience with using the application

It could also be discussed how CHWs perform when using the application. Lack of knowledge of digital devices and potentially different ways of designing user interfaces in Malawi and Ethiopia could have made it difficult for the CHWs to use the application. The findings we got show that this was different. People seemed to be more used to digital devices compared to what we had expected. The CHWs we tested were able to use all functionalities we had implemented, such as navigating the application, adding charts, editing charts, choosing among standard reports, and sharing the report at the end. Some CHWs were completely self-going when using the application; for instance, a CHW in Likangala said, "This was easy" after using the application in under two minutes. Some other CHWs needed more help or tips, but overall, all CHWs could generate and share reports.

When the application was used by a group of people, we discovered that several CHWs performed particularly better when it came to an understanding of how the application should be used and what it could produce. Such groups made a suitable setting for CHWs with poorer digital skills to ask and learn from CHWs with better skills. This gives reason to believe that the CHWs with the poorest digital skills would be able to share reports, as they are learning from CHWs with more experience. There may be parts of the application that could be changed to improve user-friendliness. Still, the application satisfies a level of user-friendliness that is good enough to make it possible for every CHW to generate and share reports.

4.11 Customise report standards

The fact that the health topics roles considered as most important largely varied between areas, was a finding that was discovered after standard report functionality was implemented.

In today's solution, the content in each standard is based on a generalisation of which health topics the groups found relevant. Generated standard reports based on this

decision base would be sufficient in areas where the health topics align with the generalisation. On the other hand, the generalised report standards would not be sufficient in areas where the health situation is more unique, such as areas that are hardly attacked by a rare disease or hit by two or three diseases simultaneously. In these cases, today's generalised standards would not be sufficient, and the CHWs are instead required to create new reports from scratch each time the report should be updated.

The functionality where the user could choose among the last three generated reports could, to some degree, cover this need. At the same time, it would not be a fully sufficient replacement. A sufficient way to solve cases where the health situation is more complicated could be to offer the CHWs the ability to customise each report standard, create new standards or delete standards that are unnecessary. This would enable CHWs living in areas with rare health situations to adjust the pre-fixed standard to be relevant to their need. There was no time left for us to look into how such functionality could be implemented, and the implementation would have required more time than we had available. For people taking this application further, we would advise considering implementing such functionality into the application.

4.12 Technical documentation

The application is built with HTML, CSS, Typescript, and the JavaScript library React. Typescript is a superset of JavaScript that enables static typing and is designed for larger applications. The application is designed to be hosted on a DHIS2-server and use technologies that are broadly in use in the DHIS2-environment.

4.12.1 Source code

The applications source code is available at the following URL:
https://github.com/hermantretteteig/chief-app.git

4.12.2 Code structure

The application is structured into four main folders and shown in “Table 10”.

Folder	
src/pages	This folder consists of one root component named PageContainer.tsx that holds the two sites: “Overview” and “Add-chart”. The PageContainer.tsx also gives each component a route and stores the current charts as a context.
src/component	Inside this folder is most of the code that has been developed. The folder is further divided into several sub-folders that have names that correspond to different parts of the application.
src/contexts	This folder holds two contexts, one for layers and one for previously generated reports. Context is a React feature that lets you easily send data between different components. This makes it possible to add a layer from the AddChart-component and instantly update the Overview-component without sending states up and down components. Instead, it allows us to import a function that could update the value directly. After the value is updated, it would trigger all components that use this context and refresh the user interface with the newest state values.
src/interfaces	Interfaces are a feature in Typescript that lets us define rules for which entities our JavaScript-object should have. This helps us detect spelling mistakes for entities or missing entities in objects before we run the application.
public	This folder holds images that are being used in the help instruction. Content inside the folder is only public for signed-in users.

Table 10 – Code structure

4.12.3 Component hierarchy tree

The following figure 19 shows the relationship between different components in the React-application. The arrows show how data is sent from one component to another further down in the application.

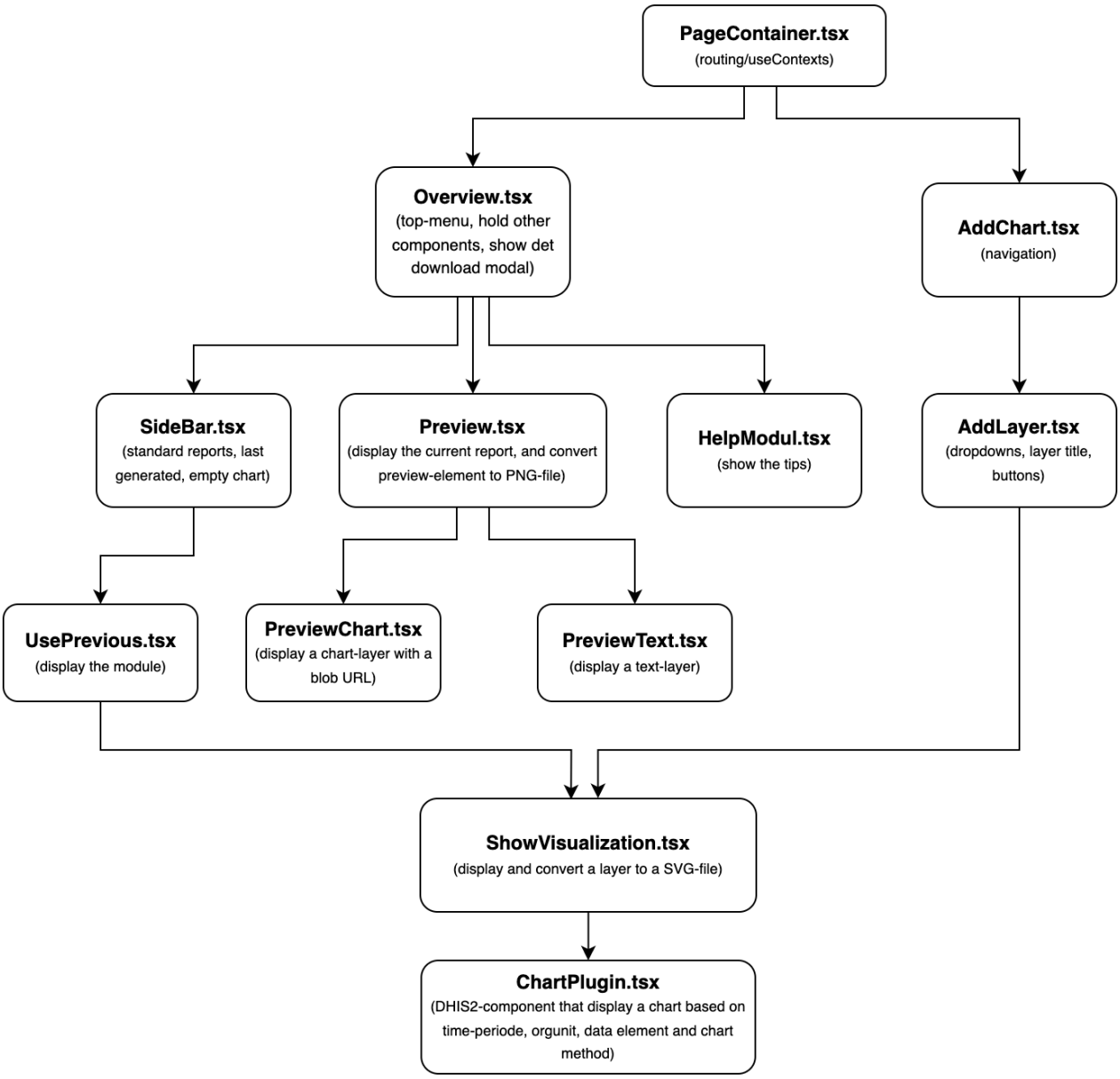


Figure 19 - Component tree

4.13 Final thoughts

We have developed an application that allows CHWs to create and share health reports based on data from Malawi's Health Management Information System. The application proves that it is possible to export information from the iCHIS and share it to different roles in the community formatted as a health report.

The design process of the reports could be done from scratch or based on a report standard. Report standards allow the CHWs to quickly generate reports that are adjusted to what each role finds relevant. Several weaknesses in the application were discovered through user testing and later improved. The user testing also showed that all CHWs were able to use the application to generate and share a report, although some struggled a bit more than others.

5 Roles

In this chapter, we will examine the various individuals we interacted with during our research. We will mainly focus on their everyday responsibilities regarding health and communication among roles. This will help us identify which roles would benefit from receiving reports. Furthermore, it is crucial to establish the communication process to determine who is most capable of creating and disseminating reports.

5.1 Ethiopia

As Chapter 2.1.1 mentions, the Ethiopian health structure consists of three levels: primary, secondary and tertiary. This thesis will focus on the health centres and health posts at the primary level. At these facilities, CHWs and volunteers provide public health. In addition, according to CHWs we spoke with, each “kebele” (the smallest administrative division in Ethiopia) often consists of around three primary schools, one health post and three mosques. These numbers can vary between kebeles but show that religious leaders and schools are essential to consider offering health reports. Further, we will look at the different roles we encountered during our fieldwork, focusing on their tasks in the community and their connection to each other.

5.1.1 Community Health Workers

The CHWs in Ethiopia are called Health Extension Workers and are a central part of the lower levels of health care. They undergo one or two years of training before they receive their certification. This makes them qualified to work at health posts, providing accessible health care to people living in that kebele. The work includes registration of households, vaccinations, antenatal care and postnatal care, and other issues that do not require instruments or lab work. In cases where they cannot provide the proper care, they refer people to the health centres. This could be for the first antenatal check-up or if a malaria test is inconclusive. They are paid employees in the health care system, and each Health Extension Worker has access to the national health information system through their tablets. The tablets are being used to register new households, newborns and pregnant women and to track who needs further care, like check-ups or

vaccinations. They also follow the Health Extension Program, which includes 18 health packages (Chapter 2.7.1). These packages work as guidelines for what they are going to educate the volunteers during their meetings.

The Health Extension Workers we spoke with informed us that they sometimes visit the schools to educate students, talk with religious leaders to help encourage certain behaviours, such as encouraging no home deliveries, and some even have contact with the administrative leader of the kebele to share health statistics. To simplify, we will refer to the Health Extension Workers as Community Health Workers (CHWs) throughout the thesis, as they have different names depending on the country.

5.1.2 Volunteers

Volunteers in Ethiopia are a part of the “Health Development Army”. Each Health Development Army usually consists of around ten women. The women are from “model households, " meaning they have adopted a certain set of healthy behaviours in their homes. We had the opportunity to look at a model household during our fieldwork. Some healthy behaviours they implemented were a latrine, separate rooms for animals and people to stay in, and agriculture.

The CHWs educate the Health Development Army on different topics from the Health Extension Package, like family planning, antenatal and postnatal care, breastfeeding, sanitation and nutrition. The education happens at meetings every two weeks. They have a guide for discussion, so they always know which topics to be brought up. The CHWs will then educate about specific topics, often displaying images to the Health Development Army and asking what it means to see if they understand. Then the volunteers' job is to inform and educate the people in the kebele, as well as bring children to the health post for vaccination, identify pregnant women and inform people of precautions in case of an outbreak. They report any health problem or situation back to the CHWs.

They also have 1-to-5 networking, where they group approximately 30 households together and one Health Development Army leader (Figure 20). Then these 30 households are further divided into groups of five, consisting of one leader from the Health Development Army and five households (1-to-5 networking group).

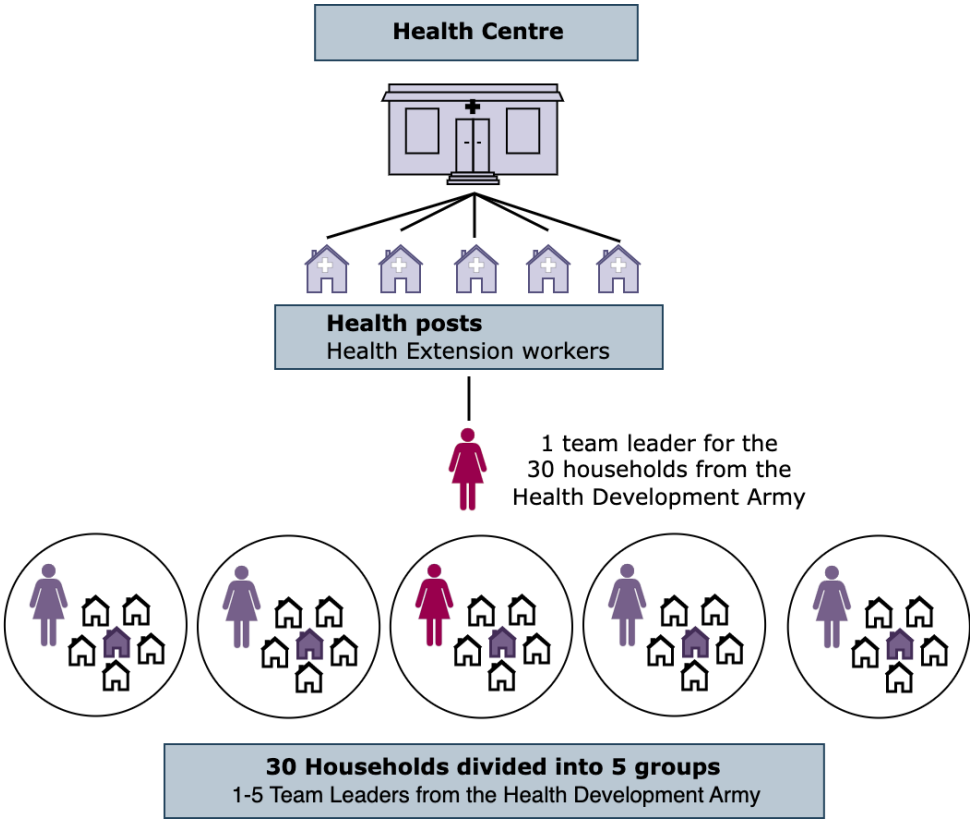


Figure 20 - Visualisation of the 1:5 networking

In these groups, they can discuss any health issues the people in the households might be experiencing, if any of them remains unvaccinated or reoccurring issues such as pregnant women missing their checkups. This is to follow up on health issues and extend health care to those not attending their meetings at the health post.

The Health Development Army is an important part of healthcare in the community. They told us they receive no special benefits or payments for their work other than the satisfaction of contributing to their community. They are, unlike the CHWs, not employed in the health care system, which is why they do not receive payment. Their only access

to health information is through the CHWs, which is why they have a strong connection. Throughout the thesis, they will be referred to as volunteers.

5.1.3 Religious leaders

We did not meet any religious leaders during our stay in Ethiopia. Therefore, how relevant religious leaders would find health reports is based on CHWs' thoughts. As there are cultural similarities between Ethiopia and Malawi, findings about including religious leaders in Malawi could likely be transferable to Ethiopia.

CHWs we were in touch with said religious leaders are involved in public health through them. According to the CHWs, they promote better health and educate on a topic in church every Sunday. One part of the education is to teach people about home deliveries' consequences and encourage pregnant women to travel to a health centre to give birth. They also bring up other important matters, depending on what health issues occur in their kebele. Religious leaders are influential roles in the community, according to the CHWs and are, for that reason, important people to offer health reports.

5.1.4 School leader

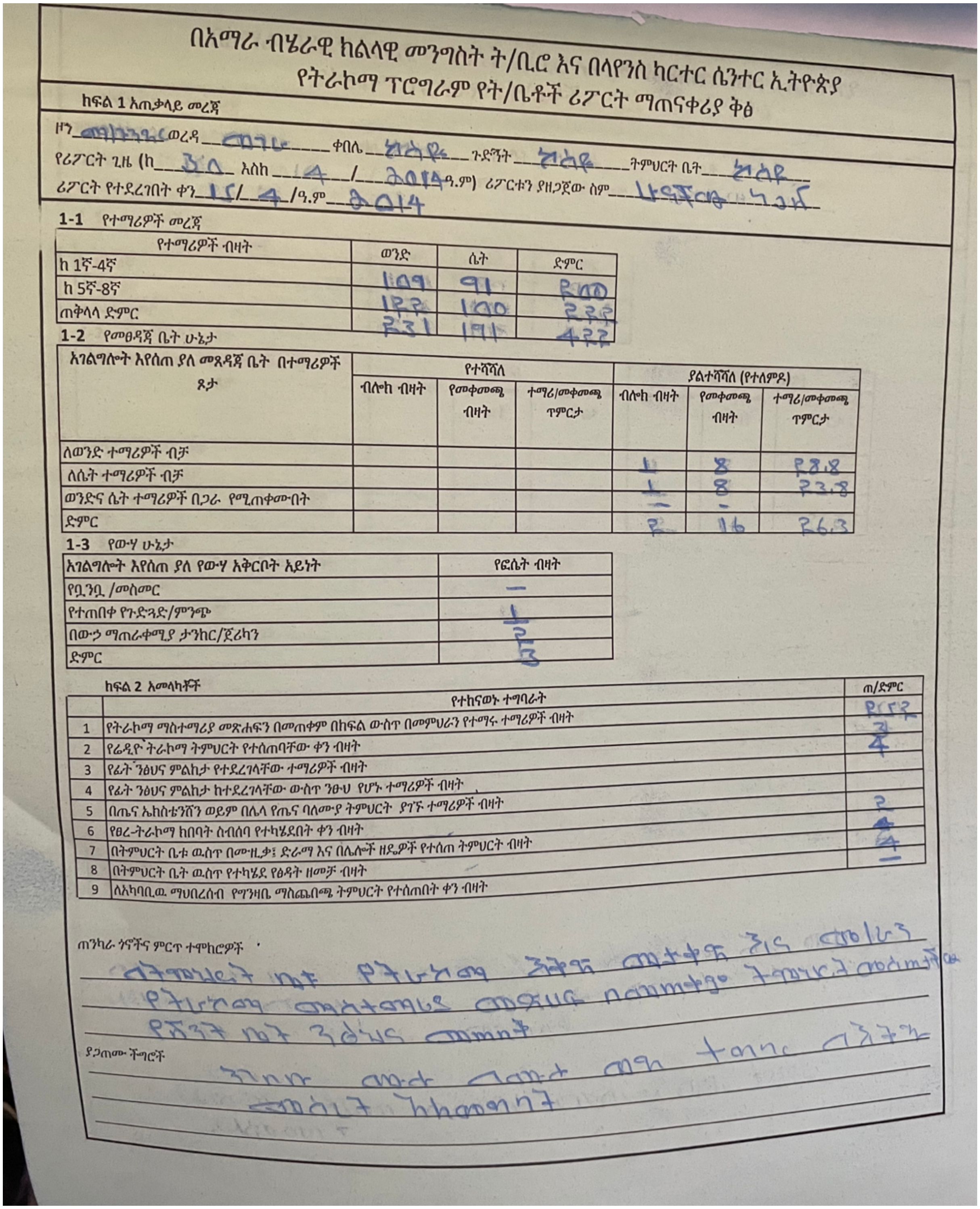
Health education is an important topic in primary school. Some of the health topics they learned about were food, sexual health, hygiene, and agriculture. The age group of 7-11 are educated about face and hand washing and has a weekly assessment where they accomplish it.

A CHW attended the school every week to provide health education, in addition to being available for additional visits if any unusual health issues occurred. The schools also notified each other if they detected anything unusual, and discussed actions needed in collaboration with the CHW.

The school we visited cared a great deal about reproductive health and how to avoid teenage pregnancies. A school leader we spoke with shared that they have a Reproductive Health Club, where the students can contact regarding any issues related

to preventive care, gender violence and other health-related topics. The schools are, in addition, focused on health awareness creation. For instance, by offering girls help and cleaning underwear and products during their menstrual period.

In the kebele we visited, there were four primary schools. All communication regarding health went through one of these schools, which was mentioned as the “leader school” and led by a school leader. The school leader receives health reports, shown “Figure 21” and “Figure 22”, from all four schools every month. The reports gave an overview of the different schools’ health status, such as the number of radio trachoma education, number of students who have had their facial hygiene checked, number of students who were clean from the facial examination, number of students who received education through health extension or other health professionals and number of aid campaigns conducted in the school. The data in the reports are being quality assured, through analysis based on a few percentages of the data. The school leader makes a summary from the reports and brings it to the “Performance meeting” every month, where they get supervision from the CHW. The school leader said their work was mainly preventive care, whereas the CHW took care of issues related to reactive care. It was also told that the school leader did not receive any updates on the performance based on the numbers in the reports, only regular discussions with the CHW at the “Performance meeting”.



በአማራ ብሄራዊ ክልላዊ መንግስት ት/ቢሮ እና በላየንስ ካርተር ሴንተር ኢትዮጵያ የትራኮማ ፕሮግራም የት/ቤቶች ሪፖርት ማጠናቀሪያ ቅፅ

ክፍል 1 አጠቃላይ መረጃ

ዞን [illegible] ወረዳ [illegible] ቀበሌ [illegible] ጉድኝት [illegible] ትምህርት ቤት [illegible]

የሪፖርት ጊዜ (ከ 3/1 እስከ 4 / 2014 ዓ.ም) ሪፖርቱን ያዘጋጀው ስም [illegible]

ሪፖርት የተደረገበት ቀን 15/ 4 /ዓ.ም 2014

1-1 የተማሪዎች መረጃ

የተማሪዎች ብዛት	ወንድ	ሴት	ድምር
ከ 1ኛ-4ኛ	109	91	200
ከ 5ኛ-8ኛ	122	100	222
ጠቅላላ ድምር	231	191	422

1-2 የመፀዳጃ ቤት ሁኔታ

አገልግሎት እየሰጠ ያለ መጸዳጃ ቤት በተማሪዎች ጾታ	የተሻሻለ			ያልተሻሻለ (የተለምዶ)		
	ብሎክ ብዛት	የመቀመጫ ብዛት	ተማሪ/መቀመጫ ጥምርታ	ብሎክ ብዛት	የመቀመጫ ብዛት	ተማሪ/መቀመጫ ጥምርታ
ለወንድ ተማሪዎች ብቻ				1	8	28.8
ለሴት ተማሪዎች ብቻ				1	8	23.8
ወንድና ሴት ተማሪዎች በጋራ የሚጠቀሙበት				-	-	
ድምር				2	16	26.3

1-3 የውሃ ሁኔታ

አገልግሎት እየሰጠ ያለ የውሃ አቅርቦት አይነት	የፎሴት ብዛት
የቧንቧ /መስመር	-
የተጠበቀ የጉድጓድ/ምንጭ	1
በውኃ ማጠራቀሚያ ታንከር/ጀሪካን	2
ድምር	3

ክፍል 2 አመላካቾች

	የተከናወኑ ተግባራት	ጠ/ድምር
		2552
1	የትራኮማ ማስተማሪያ መጽሐፍን በመጠቀም በከፍል ውስጥ በመምህራን የተማሩ ተማሪዎች ብዛት	3
2	የሬዲዮ ትራኮማ ትምህርት የተሰጠባቸው ቀን ብዛት	4
3	የፊት ንፅህና ምልከታ የተደረገላቸው ተማሪዎች ብዛት	
4	የፊት ንፅህና ምልከታ ከተደረገላቸው ውስጥ ንፁህ የሆኑ ተማሪዎች ብዛት	
5	በጤና ኤክስቴንሽን ወይም በሌላ የጤና ባለሙያ ትምህርት ያገኙ ተማሪዎች ብዛት	2
6	የፀረ-ትራኮማ ክበባት ስብሰባ የተካሄደበት ቀን ብዛት	4
7	በትምህርት ቤቱ ዉስጥ በሙዚቃ፤ ድራማ እና በሌሎች ዘዴዎች የተሰጠ ትምህርት ብዛት	4
8	በትምህርት ቤት ዉስጥ የተካሄደ የፅዳት ዘመቻ ብዛት	-
9	ለአካባቢዉ ማህበረሰብ የግንዛቤ ማስጨበጫ ትምህርት የተሰጠበት ቀን ብዛት	

ጠንካራ ጎኖችና ምርጥ ተሞክሮዎች ·

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ያጋጠሙ ችግሮች

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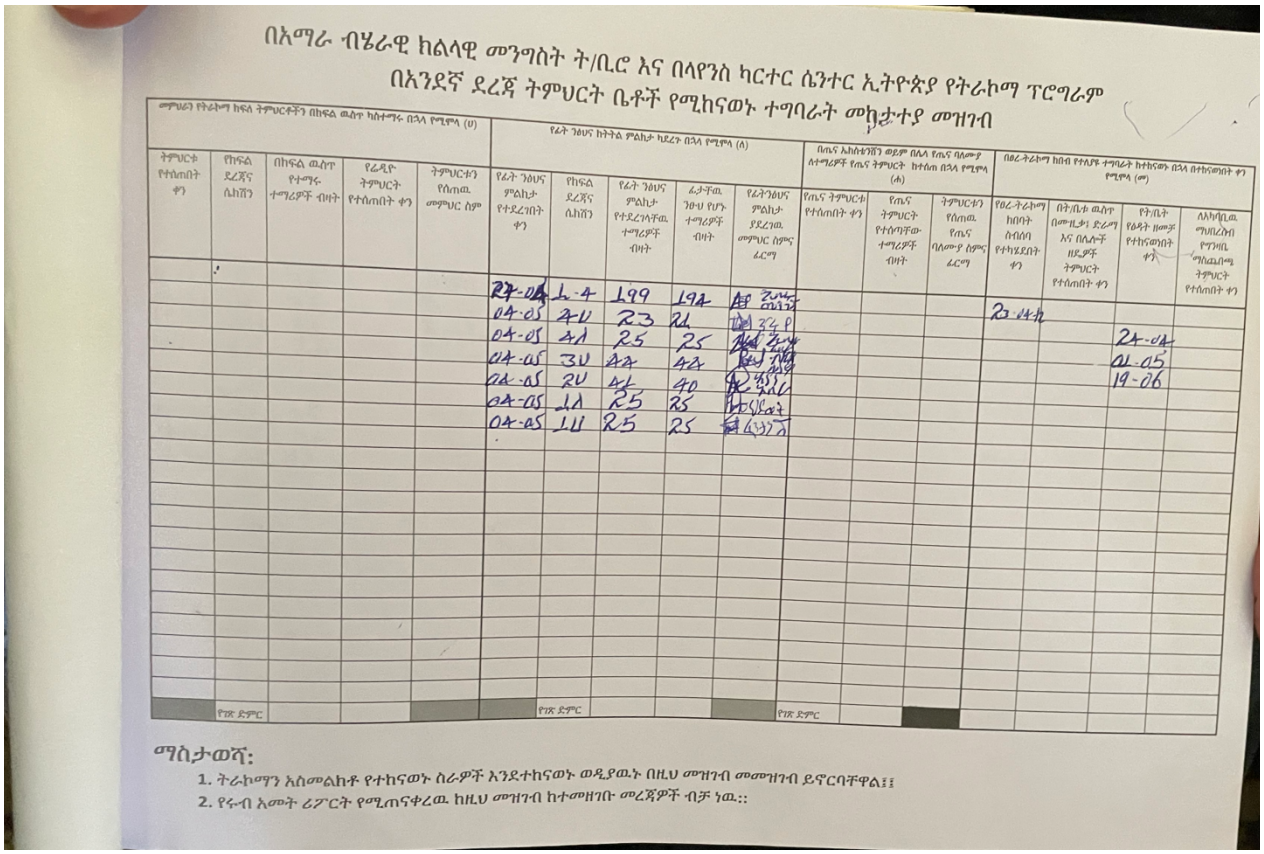
Figure 21 - Report to the school leader



በአማራ ብሄራዊ ክልላዊ መንግስት ት/ቢሮ እና በላየንስ ካርተር ሴንተር ኢትዮጵያ የትራኮማ ፕሮግራም

በአንደኛ ደረጃ ትምህርት ቤቶች የሚከናወኑ ተግባራት መከታተያ መዝገብ

ማስታወሻ:

1. ትራኮማን አስመልክቶ የተከናወኑ ስራዎች እንደተከናወኑ ወዲያዉኑ በዚህ መዝገብ መመዝገብ ይኖርባቸዋል፤፤
2. የሩብ አመት ሪፖርት የሚጠናቀረዉ ከዚህ መዝገብ ከተመዘገቡ መረጃዎች ብቻ ነዉ::

Figure 22 - Report to the school leader

5.1.5 Performance meeting

During a meeting every month, several different roles from the community discussed the village's performance. This meeting is called “Performance meeting”, where the last month's successes and challenges regarding health are discussed, in addition, to evaluating different health programs' progress. The performance meeting is not directly involved in outbreaks of diseases, but findings from these meetings could affect tasks the different roles have. If, for instance, it has been an outbreak of cholera, could different roles evaluate if there are actions under their responsibility that could be taken or changed to reduce further spread.

The different roles attend these meetings are:

- 1 professor in agriculture
- 1 school leader
- 1 administrative leader of the kebele

- 1 Community Health Worker
- 1 security
- 1 employee from the health centre (nurse, midwife)
- 1 volunteer

5.2 Malawi

The Malawian health structure shares many similarities with the Ethiopian. At the lower levels, we have health centres and village health clinics (health posts in Ethiopia). This is where the CHWs and volunteers work. A village health clinic also has a catchment area where CHWs and volunteers are responsible for providing people with primary health care. The collaboration between the health care system, schools, and churches is not as strong in Malawi as in Ethiopia. According to the CHWs we met, they communicate with schools, religious leaders, chiefs and traditional healers when needed.

5.2.1 Community Health Workers

The CHWs in Malawi are called Health Surveillance Assistants. They have undergone six weeks of training and are responsible for providing primary health care to the people in their catchment area. Some areas they focus on are immunisation, maternal health and nutrition. In addition, they follow up and educate volunteers. We experienced an information course they held for the volunteers, where they weighed children and informed them about breastfeeding and nutrition.

The Health Surveillance Assistants are employed in the health care system and usually work at a health centre or village health clinic. Some have access to tablets for registration, but that was only implemented in two districts in Malawi, so CHWs still register in books. The tablets have the iCHIS system, making registering patients and tracking individual- and populational health easier. Malawi also has Senior Health Surveillance Assistants, who are advisors to all the other Health Surveillance Assistants.

In addition to communicating and educating volunteers, the Health Surveillance Assistants have connections with chiefs, traditional healers, religious leaders and

schools. A Senior Health Surveillance Assistant explained that they meet with the religious leaders and school leaders when there is a need for it. This could be in the case of outbreaks. The Health Surveillance Assistants will further be referred to as Community Health Workers.

5.2.2 Volunteers

Volunteers are an essential part of the health care system in Malawi. One CHW said that "volunteers are the key". There are usually many of them, often around 6-8, but a village always has at least one. They travel around the village to check on patients. Their primary role while doing this is conducting household data, informing about family planning and nutrition to people in the community, and reporting suspected cases of tuberculosis to the CHWs. Further, they are involved when a patient is sent to a health facility because they are responsible for the follow-up. They are not employed in the health care system and receive no payment or benefits.

Volunteers work closely with the people in the community and the CHWs. They often have meetings with CHWs to discuss health challenges, pregnancies and antenatal care, but expressed that with health reports, the discussion would be based on them. The CHWs also offer the volunteers training in several health topics, such as breastfeeding and nutrition. Many volunteers are members of the "Village Health Committee".

5.2.3 Religious leaders

We met various religious leaders, such as leaders from 7-day Adventists, Jehovah's Witnesses, Good Samaritan, Baptist Convention and Partners in Harvest. The leader from 7-day Adventists said they meet weekly to discuss health challenges, and if they lack information, they ask the CHWs. The others did not mention how often they met and agreed that they did not want to preach health in church. Instead, they wanted the CHWs or other health personnel to show up and educate or give advice about health. They, as leaders, could support the information and keep encouraging the church members. One of the leaders said they had church service Wednesdays and Sundays,

where they often encourage people to seek medical attention if they are sick, but they never discuss health issues exclusively.

When we spoke to different CHWs, they all expressed some form of communication between them and the religious leaders. A Senior CHW at the Likangala health centre explained that most people respect the religious leaders' opinions and, therefore, might follow health advice to a broader extent if they also heard it from them. The CHW said that "This is why it is important to keep them informed". At the Matopa clinic, another CHW explained that they usually communicated with a middle leader of the church and that one topic often was vaccinations. According to the CHW, they passed the information on to church members, who passed it on to the religious leaders, who made announcements in church.

5.2.4 School leader

We visited a secondary school in Likangala with 12-21 years old students. The school did not receive education from the CHWs and had no specific health education class. They taught the students about HIV, aids, agriculture and cholera and stated that issues like hygiene were primary school issues, not secondary. The school leader wanted the CHWs to come and teach health to the students instead of the teachers, seeing as they were "not the professionals".

To receive health reports was a "welcome idea" among the teachers. They have parent-teacher association meetings at the school, where they discuss different topics, health being one of them. The health topics could be related to outbreaks, which at the time was cholera. The school leader said they "surely need health information" to be more aware.

The school we visited was not incorporated into public health to the same degree as in Ethiopia. They did not receive health reports or other health information from the CHWs. This could be because it was a secondary school and not a primary. Some CHWs we spoke with said they travel to primary schools to educate. Still, this shows a huge lack of

communication between the different partners, seeing that the school leader wanted the CHWs to educate at the school. The teachers at the school had access to power, printers, internet and smartphones, making them easy to access if they were to be provided with health reports.

5.2.5 Traditional healers

Traditional healers are people who practice healing in a spiritual or religious way, often by using herbs or without touching the patient. Most of them have either learned the trade from their parents or discovered their talents in a dream. No one wants to say exactly how they acquired their skills, but they often determine the right disease. Many people have faith in the healers and often prefer them to hospitals. We did not meet with any traditional healers, so our knowledge is limited to what the CHWs told us.

There are many traditional healers in the areas we visited, and according to the CHWs, they work hand in hand. This is because, as mentioned, many prefer them to hospitals and find them trustworthy, and they have shorter queues compared to formal health services. The healers are educated about symptoms from the CHWs, for example, how to recognise COVID-19 or tuberculosis. Knowing about symptoms and signs makes it easier to refer people to health centres or hospitals if needed. They are also informed to encourage people to deliver at a facility rather than at home.

5.2.6 Care groups and promoter

Each village clinic consists of one or more care groups. The care groups consist of 10 selected volunteers, one of whom is a health promoter. The health promoter receives information from the CHWs and gives regular training to the care group. Each group member is responsible for a cluster of 8-12 households located close together. Their responsibilities within this cluster are health, food, security and nutrition, and they educate and provide counselling on issues related to these topics.

The care group we met had a focus on child and maternal health. They are unpaid but see it as a benefit to “be able to know what is happening”. They expressed that they

really need the health reports, as they do not receive any health statistics from the CHWs or others. At the meeting, they engaged in songs and appeared to work closely together and collaborate. They face problems regarding travelling around to provide their care to the community. Seeing as they receive no benefits, they must use their own money for transport which can be difficult for many, and during rainy seasons they are not able to carry their register book with them, as it could be damaged by the rain.

5.2.7 Chiefs

The chiefs are the managers of the community and known as the main decision-makers. Their role includes handling misconduct and promoting proper health habits, such as hygiene. In case of a disease outbreak, they play a central role in handling the situation by trying to find the source of the problem and initiating necessary measures in order to limit further spreading.

Based on our conversation with the chief, the volunteers are the ones who provide him with health information. They keep him informed through the Village Health Committee meetings. Still, the chief we spoke with said he had many interactions with the religious leaders, both Muslim and Christian. According to him, they work hand in hand, and he has good interactions with both them and the teachers in the village. Sometimes they discuss health issues, for example, hygiene.

5.2.8 Village Health Committee

Every two weeks, there is a Village Health Committee meeting being held. A CHW leads the meeting, and the other participating roles are chiefs, care groups and volunteers. The purpose of the meeting is to discuss different problems or situations the people in the village are dealing with. This is usually related to different health issues they face but could also be the construction of important buildings or how to handle resources.

A Village Health Committee member we spoke with at the Chidongo clinic mentioned that their current issues were to reconstruct the village health clinic, reconstruct the CHW accommodation and that the number of patients was increasing beyond what they

had resources to provide for. Two of these issues were due to a cyclone causing destruction a few weeks earlier. In addition, they usually discussed child mortality and the dangers of teen pregnancies.

5.2.9 Information flow between the roles

Today's information flow

Figure 23 is drawn by a CHW and describes how information is sent between different roles and constitutions. Some information only gets exchanged with the nearest role or constitution, whereas other information goes several levels up or down. The figure shows the most common ways information is being shared, but as the CHW said, "information sometimes takes other routes", for instance, during the COVID-19 pandemic.

It is likely most convenient to make the application fitted to the existing information patterns, rather than introducing new patterns for sharing information. The application should therefore be adapted to the information flow as shown in Figure 23.

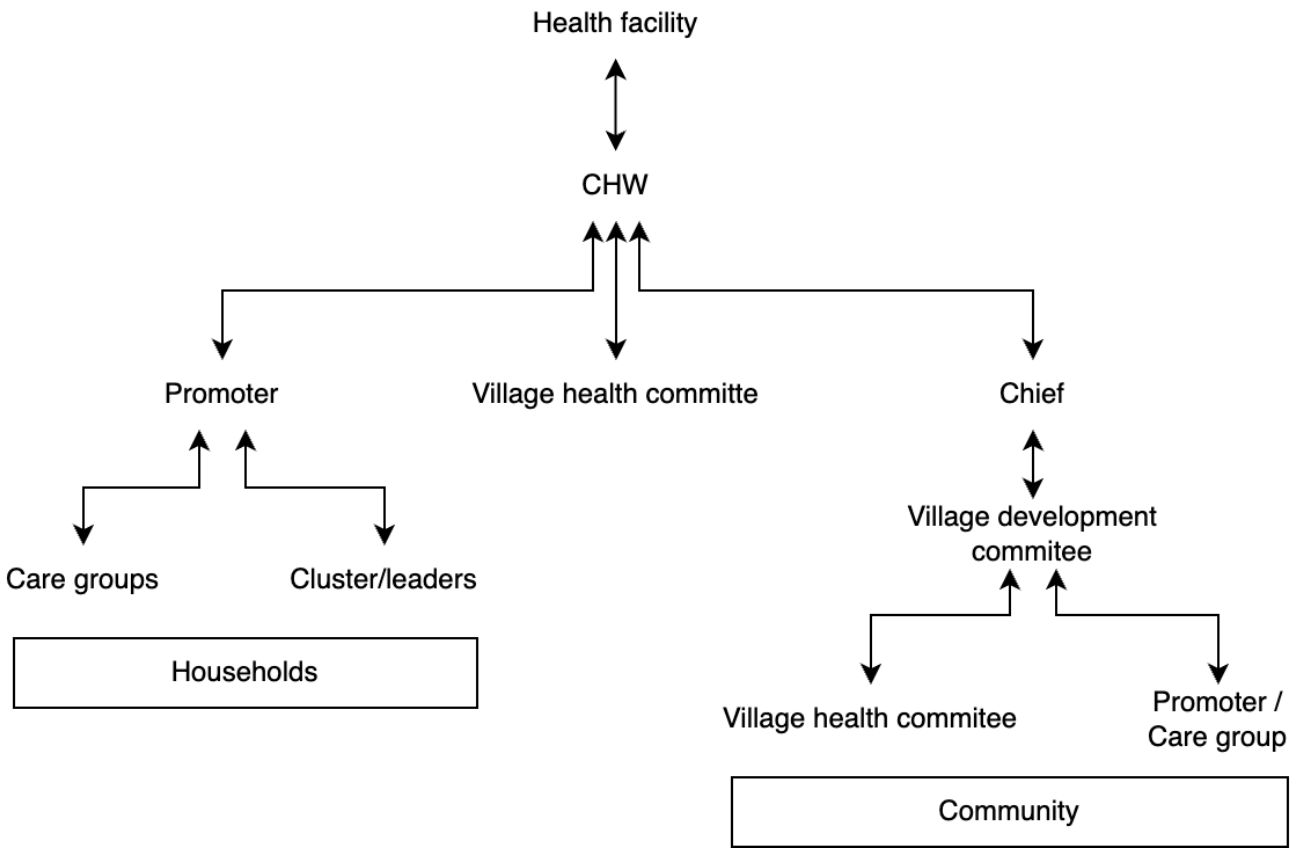


Figure 23 - Information flow between in the community.

Proposed information flow

The figure drawn by the CHW does not include school leaders, religious leaders, and traditional healers. Adopting the information flow into the application, creates a need to incorporate these roles into the flow as well. We propose that roles that are not a part of the health sector, such as school leaders, religious leaders, and traditional healers, could be included with a fourth connection from the CHW, as shown in Figure *24*. This would enable the CHW to have a direct link to these roles, where the CHW can quickly notify them about health situation changes. An information flow designed to share reports quickly could be valuable in critical situations.

Incorporating them under the chiefs could also have been a possibility, but it increased the likelihood that information got delayed or lost. This solution would also makes all chiefs without a smartphone, dependent on a printed version and require them to deliver

it by hand to the final receiver As incorporating the responsibility under chiefs may create unwanted side effects, and no other role points out as a suitable provider, the responsibility for providing reports to religious leaders, school leaders and traditional healers is therefore suggested to fall under CHW responsibility.

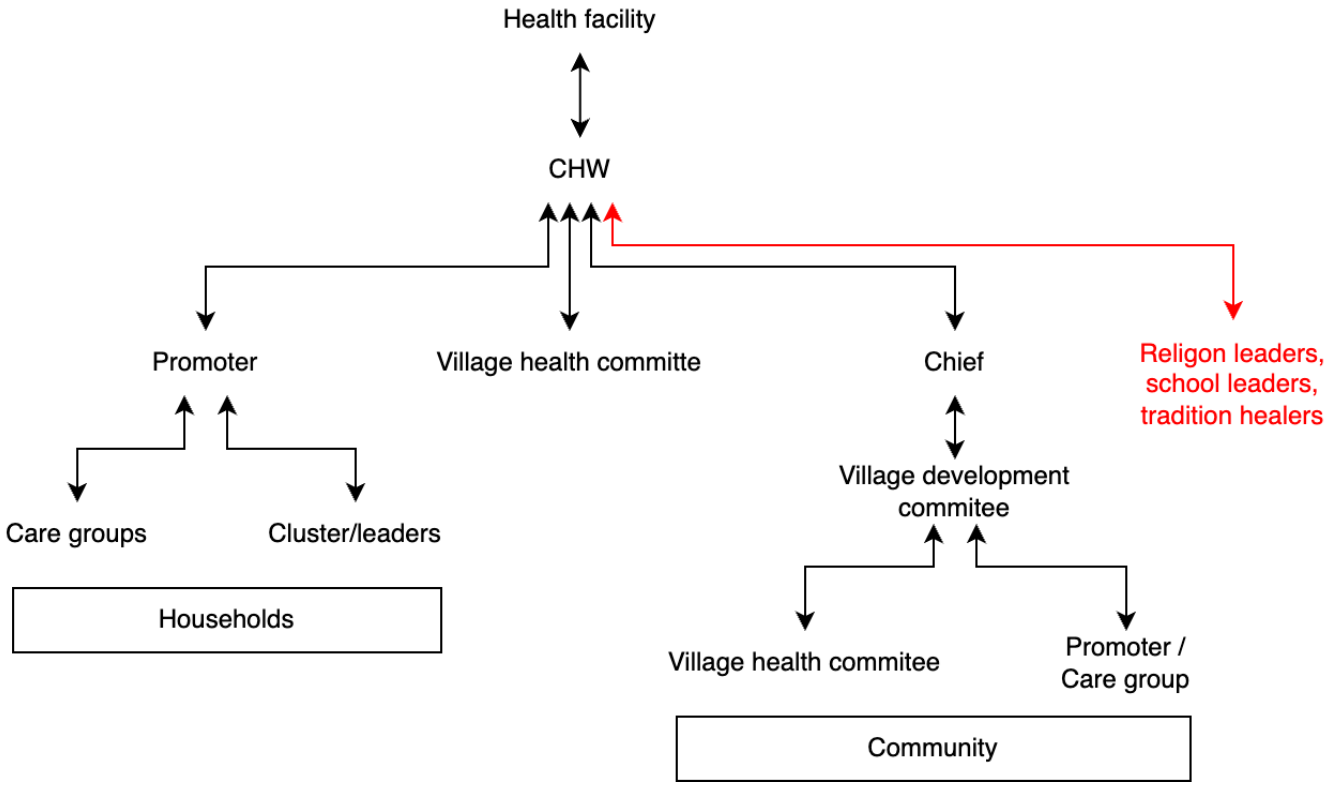


Figure 24 - Proposed information flow in Malawi health facility structure

6 Chart literacy

Understanding chart relies on several factors, including previous experience with statistics, interest in data, and relevant education. It is an important discovery to see where the level of knowledge lies and to what extent it varies between and within the different roles, as the chart need to be understandable for each user. In this chapter, we will look at the different role's chart literacy and whether variation in knowledge exists within and across groups.

6.1.1 Community Health Workers in Ethiopia

In Ethiopia, the CHWs seemed to have significant experience and understanding of different visualisation techniques. The walls in the health posts we visited were all filled with more complicated visualisations, such as maps, multi-series linear charts, histograms and linear diagrams with target lines for immunisations. The visualisations were regularly updated and were mainly drawn by hand, or lines drawn on pre-printed templates, as presented in "Figure 25", "Figure 26" and "Figure 27".

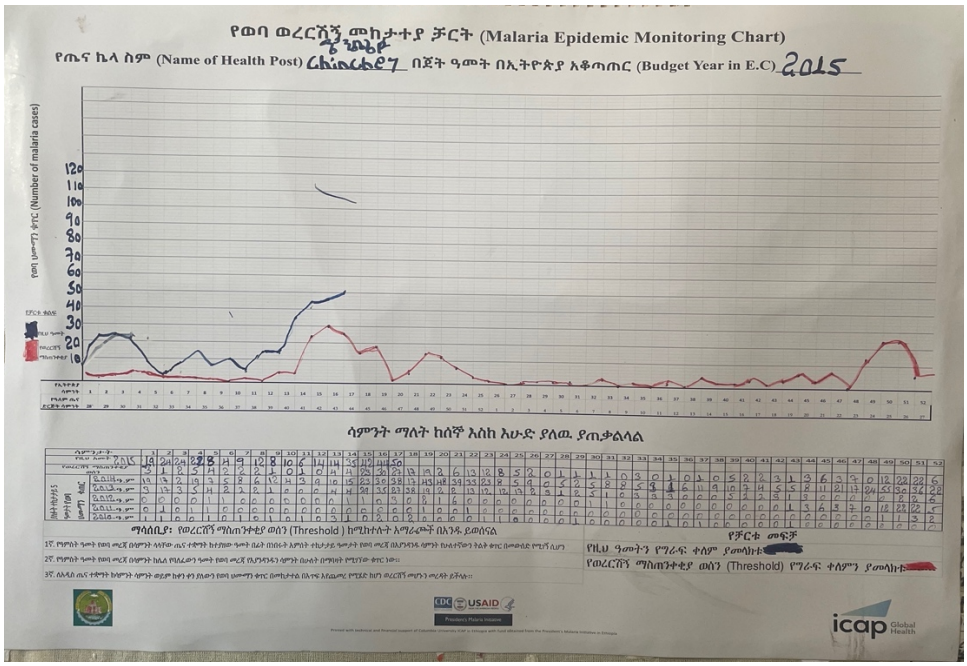


Figure 25 - Malaria Epidemic Monitoring Chart at Health post

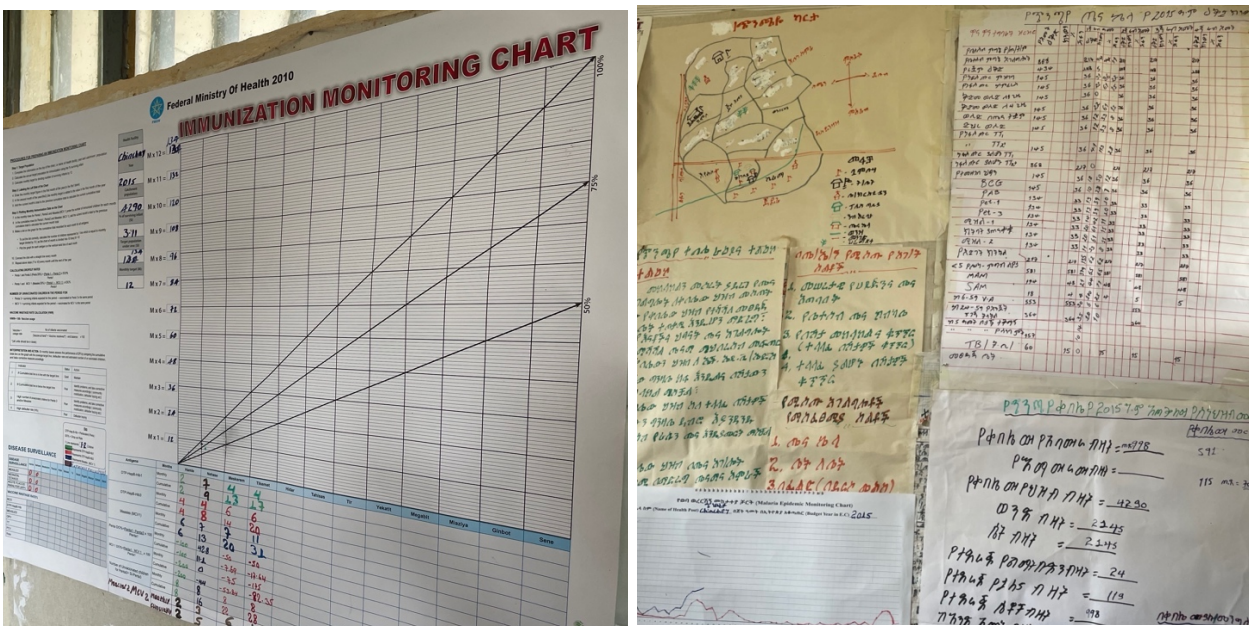


Figure 26 – Visualisations: Immunisation monitoring chart, map of the area and different registrations

This gave us the impression that the CHWs were used to visualisations and had an active approach to collecting data. They were handed the sample reports and seemed to have a general knowledge of every chart. They said the yearly comparison was good for the volunteers, as it was easy to show which year was shorter than the others. If the short one is positive or negative will depend on what the statistics represent, but the CHWs seemed to understand the correlation between the value and the data element and could help explain this to the volunteers.

Figure 27 - Visualisations at a Health post

6.1.2 Volunteers in Ethiopia

The volunteers in Ethiopia had a better understanding of different visualisations compared to the ones in Malawi. Still, when presented with the sample reports, some started explaining the meaning of the charts to the other group members, which indicated a variation in chart literacy. At the first health post we visited, a volunteer explained the different statistics on the wall. She understood the map and written statistics well but struggled with percentages and trends over time. Although she found the monitoring chart challenging, it could have been more complicated because it was in

English. However, she had better comprehension of the statistics presented to the right in “Figure 28” which was more relevant to the volunteers' work.

Understanding charts requires knowing whether low or high values inside a health topic represent a positive or negative result. In some charts could high bars convey negative results, like the number of COVID-19 cases, while in other cases, high bars could indicate positive outcomes, such as vaccination coverage. The volunteers often identified and commented on the high bars without expressing whether they represented good or bad results. This made it unclear if they understood the difference. This behaviour could be because they did not recognise the correlation between health topics and values. It's also possible that the confusion arose because they didn't receive a clear explanation of the charts presented in the report, which was written in English. This might have impacted their ability to determine whether the bars represented a positive or negative value.

At the Chenchaye health post, volunteers segregated the long and short bars but said they needed a translation to understand the context. They associated a short bar with a negative result and could tell that some months had higher bars than others, indicating that something had increased. A CHW said that “they will understand charts used with numbers", meaning a combination of charts using numeric numbers supported by text phrases might be a good solution. The volunteers understood that the charts were meant to show statistics related to various health topics. Many of the CHWs said the volunteers would need training in order to understand a full health report.

6.1.3 Community Health Workers in Malawi

During Iteration 1, we presented our first and second prototypes to the CHWs. We discovered that charts with target lines, bar charts and percentages were difficult to understand compared to column charts. Our second prototype had a sentence: "45 cases of malaria for children under five years. It is 3% more than nearby villages”. This was difficult to interpret for all our interview subjects. The number of malaria cases was understandable, but the percentage comparison led to confusion.

During the review of the first prototype, the CHW at Bua Health Centre suggested simplifying the last chart, which was a bar chart displaying the attendance of antenatal check-ups. They explained that the column chart about “Children born with underage mothers” was understandable and that we should continue using column charts in our reports. We later visited a remote CHW building in the area, where they had column charts and text representations on the walls, which explained why column charts were preferable. They used no other chart techniques or representations, which explains why some techniques used in our prototypes were unfamiliar.

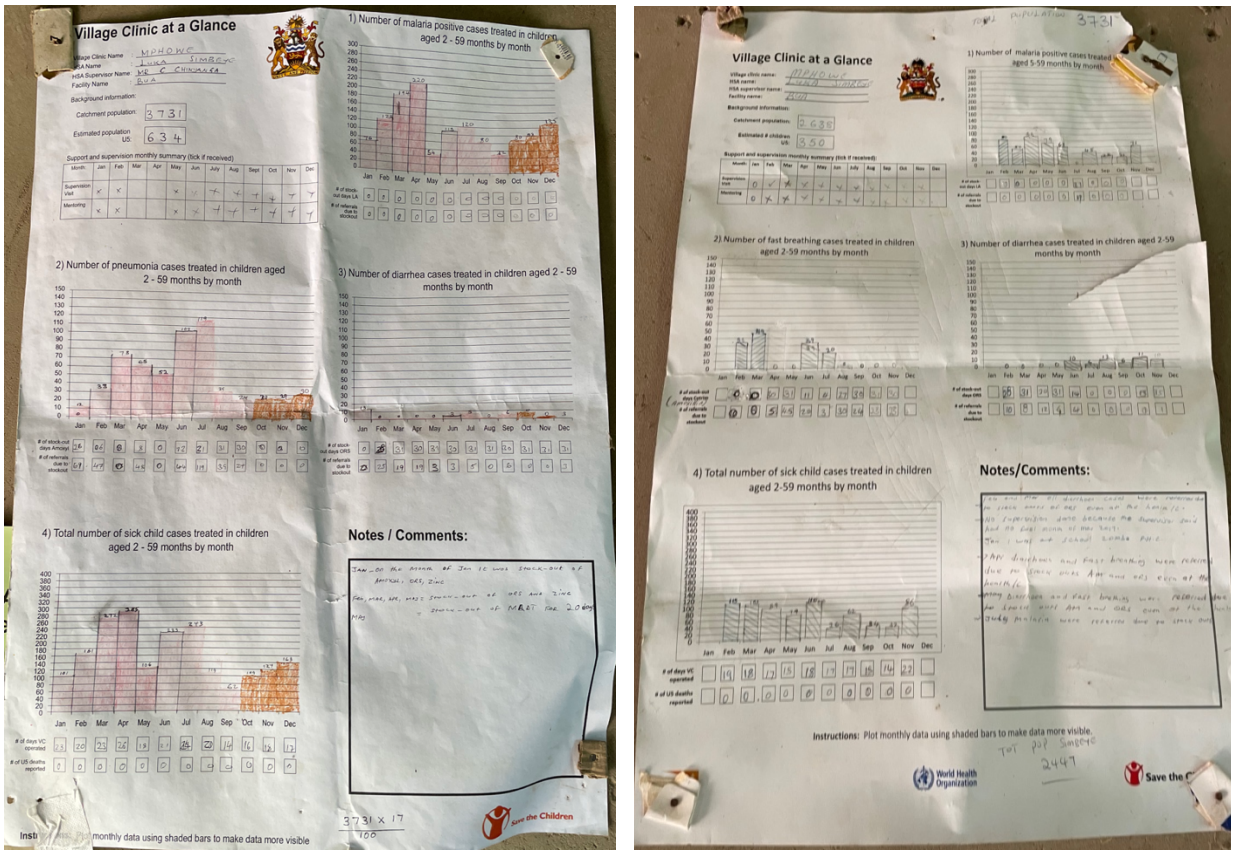


Figure 28 - Visualisations at CHW building

In Iteration 2, we presented the CHWs with the sample reports. These only included column and bar charts due to our discoveries during Iteration 1. The CHWs at Likangala Health Centre said the reports were easy to understand and even asked if it was possible to include a pie chart. These CHWs were Seniors, meaning advisors to all the other CHWs in the community. This could indicate they have more experience and skills

than the average CHW. They said the preferred chart type depended on the interpreter, but they thought most would choose a column chart if possible. Still, every CHW we spoke with understood the charts in the sample reports well, which indicates that column and bar charts are well-known to most CHWs.

Iteration 1 and Iteration 2 provided us with different results. One reason for this could be the prototypes. The prototypes during Iteration 1 had a large variation in charts, including percentages and target lines. They were much more complex than the sample reports used in Iteration 2. This could have affected the overall impression of the reports and made them seem even more difficult to interpret. Another reason could be a variation in chart literacy. It is possible that the CHWs we met during Iteration 2 had more knowledge of various visualisations.

6.1.4 Volunteers in Malawi

During Iteration 1, the volunteers were shown the first and second prototypes. They struggled with understanding the values within a chart and whether they represented a positive or negative number. They still pointed out errors, such as the number of antenatal checkups that needed to be corrected and that people were not born at clinics but at health centres. This indicated that it might have been the chart techniques in the first version of the prototype that made it hard for the volunteers to understand the charts, rather than the language. Percentages were the most difficult, mainly when they represented an increase or decrease based on numeric data, such as the text phrases in the second prototype saying, “43 cases of diarrhea. It is 24% less than nearby villages.”. More advanced visualisation techniques such as pie charts, bar charts, and area charts were also challenging. The CHWs we spoke with expressed that the volunteers would need orientation or training to understand the charts and that they could provide this.

The custom text phrases in the second prototype were introduced as an alternative to include people who have difficulties with understanding charts. They consisted of short sentences about specific health topics, such as a decrease in malaria cases or an

increase in the number of antenatal check-ups. They were more similar to verbal communication. The most straightforward text phrases were understandable for everyone who could read English. Text phrases where data were presented with numeric numbers seemed to be most understandable, such as “8 children dropped out of school. It is 4 less than the previous month.”. This discovery was aligned with the mathematical knowledge level we discovered when we tested out more advanced charts in the first prototype.

At the Matopa clinic, during Iteration 2, many volunteers needed an explanation to understand the sample reports. They began saying the long bars could represent more cases of a disease, but after getting an explanation from the CHWs and translators, they better understood the context and that this might vary between charts. This indicated difficulty in connecting the health topic to the corresponding values.

6.1.5 Chiefs in Malawi

The chief in Malawi showed a general knowledge regarding charts. He was presented with the sample reports, which contained only column and bar charts. He understood what each chart represented, mastered reading the language and even provided questions about the reports. He asked how he would receive the reports, if they contained one specific health topic or more, and if they would be received monthly or yearly. He said he was familiar with these charts and felt comfortable reading them. This was expressed when he thoroughly explained each chart in the report to the translator.

6.1.6 Religious leaders, schools and traditional healers

We had limited encounters with teachers, school leaders, traditional healers and religious leaders, which made determining their chart literacy difficult. There is reason to believe they at least shared the same level as volunteers based on having the same primary education.

Furthermore, teachers and school leaders have probably undergone extensive education and training to qualify for their school positions. In Ethiopia, the school leader

seemed familiar with using text phrases to present a number of cases in a report, but there were no indications as to whether he was familiar with charts. In Malawi, they only discussed the content of the reports, but their interest in receiving them suggests an understanding.

Becoming a traditional healer does not require any formal education, and the tasks they have accomplished have little or no relation to mathematics or other areas that could give them experience with charts. Based on this, it makes it reasonable to believe that traditional healers' chart literacy is similar to what we could expect from the volunteers.

It was unclear if it were common for religious leaders to accomplish any education, or if they were more self-learned. Still, we got the impression that they were well-informed people and the respect they have, to some degree, comes as a result of their knowledge. In addition, they asked few questions about the charts, and every religious leader seemed to find the report interesting. If the report is completely incomprehensible, it is unlikely that someone would find it interesting. Based on these impressions, there were few signs that their chart literacy was lower than volunteers, rather a little bit better, but as mentioned, this is more our impression than something we could say for sure.

6.1.7 Conclusion

Discovering to which extent different groups are familiar with visualisation techniques is essential to be able to make a tool that can be adjusted and aligned to everyone's chart literacy. We found that the CHWs, who are educated and employed in health care, had more experience and knowledge with different visualisations. In Malawi, they struggled with target lines, bar charts and percentages but understood column charts well. The Senior CHWs had a better understanding of the different representations than the other CHWs and would have liked pie charts to be represented.

We did not test the CHWs' knowledge of percentages in Ethiopia, but based on their statistics on the wall, they were at least comfortable with target lines. Furthermore, they seemed comfortable with any charts we showed them. The reports presented in Ethiopia

had less variety in charts than the ones we used during Iteration 1 in Malawi. Still, the posters at the health post indicated that they are using more statistics and have a general understanding. Their education is considerably longer than for the CHWs in Malawi, which explains the difference in skills.

The volunteers in each country struggled with connecting the values in each chart with the health topic. They did not understand if high bars were positive or negative but could clearly say that it indicated a change from the previous month. With help from the CHWs, they all agreed they would be able to understand the report content.

6.2 Table over different roles chart literacy

Roles / Visualisation method	**Line graph**	**Bar graph**	**Column graph**	**Pie chart**	**Percentages**
CHW in Ethiopia	Yes	Yes	Yes	Unknown	Unknown
CHW in Malawi	Unknown	No	Yes	Some	No
Volunteers in Ethiopia	Unknown	No	No	Unknown	Unknown
Volunteers in Malawi	Unknown	No	No	No	No
Chiefs in Malawi	Unknown	Yes	Yes	Unknown	Unknown

Table 11 - Chart literacy overview

7 Digital access

One important discovery is in which way the roles should receive the health reports. During our research, we have examined two formats: paper-based and digital. During Iteration 1, the focus was to create an application for CHWs to generate reports that can be printed at health facilities and delivered to receivers. This focus shifted after Iteration 1, as we found that few facilities have printers and that many facilities have large difficulties with electricity. This showed that a solution that only support printing, would have been unstable and unavailable for many CHWs. Therefore, we developed an application that, in addition to supporting printing, could share reports digitally to the receiver, via for instance WhatsApp or Mail.

Finding an absence of printers in Malawi does not necessarily mean that digital reports would be a better solution. A digital solution comes with several other requirements, such as access to digital devices and internet connectivity. Whereas it has some benefit, as it is faster to share, to a smaller extent rely on electricity and do not require access to paper or printers. In addition to the available resources, it also needs to be accounted for which format the different roles prefer. Reading a report on a small mobile phone would probably give another experience compared to having a sheet of paper in your hands. This chapter would account for the findings we found for each role.

7.1 Community Health Workers in Ethiopia

All the health posts we visited in Ethiopia had walls filled with different visualisations. They had, as mentioned, hand-drawn maps and tables containing statistics about households, children and immunisation. This indicates an interest in being able to present information on the walls and that a paper format would best fit this need. In addition, they gave the impression that paper reports were easier to present to the volunteers. They were familiar with using images from a book to aid during their meetings when discussing topics such as breastfeeding and family planning.

There was no access to printers or computers at the posts, but a CHW we spoke with said these resources most likely exist at a health centre. The health posts are often located in rural places, and most people rely on walking or bicycling to their destinations. The health centres are therefore in some cases far away and difficult to access. This makes printing out a weekly or monthly report a very challenging task. All the CHWs had access to tablets and were familiar with using digital devices. A digital format might be a more straightforward solution in this case.

7.2 Volunteers in Ethiopia

We spoke to multiple groups of volunteers, who all indicate they can benefit from receiving reports. So far, they have communicated verbally with the CHWs, and none of the meetings they have together includes using charts. A CHW stated that they only use numbers to explain health statistics to the volunteers and added that a report would help create a deeper understanding of the health situation. The CHWs have tablets, while the volunteers we spoke with only have basic phones, which gives them no opportunity to receive digital reports. At first, we thought of an SMS solution, where the CHWs sent the volunteers an update explaining the health situation for the last period. This would resemble the number representation they already have. The CHW explained that numbers could sometimes be challenging to interpret for the volunteers and that it creates an easier discussion when you have images.

7.3 Community Health Workers in Malawi

During Iteration 1, we saw a lack of statistical representation within health care. The only types we came across were the papers presented in “Figure 28 - Visualisations at CHW building” of two reports in the CHW building. Like in Ethiopia, they lack access to digital devices and prefer drawing charts by hand. The CHWs we spoke with at the Bua health centre preferred a paper version of the reports. They were only presented with the first and second prototypes and did not see a demonstration of the application. It is difficult to determine if the use of paper prototypes affected the answer.

At a village clinic during Iteration 2, we spoke with CHWs who had a different approach than our previous experiences. They said that if they received or created reports and could not share them further, digitally or by printing, they would use paper and draw the visualisations by hand. This made it possible to still display the statistics at the clinic, where volunteers and patients could see and interpret them. Some CHWs also mentioned having schoolteachers, religious leaders and even traditional healers' contact information on WhatsApp, making sharing digital reports easy. The only issue was that they would need internet to log into iCHIS and access the report, and internet connectivity was an issue in their area. The CHWs at the Likangala health centre said they preferred the digital format over the paper. They had three tablets available at the centre; one of them was for the senior CHW, as they were, which means they would be able to send out reports.

At another health post, the CHWs took pictures of their statistical posters and shared them with the chief by phone. The CHW we spoke with here stated that, in this case, a digital format could be a better option for sharing information since they are already communicating with smartphones.

7.4 Volunteers in Malawi

Volunteers were mostly interested in paper-based reports. The paper-based reports enabled them to sit in groups and discuss the different health topics. Most of the volunteers we met did not have smartphones, which could also affect why paper reports were preferable. They did not know how they would be able to receive them, only that a paper format would still be more accessible to them than a digital one.

7.5 Chiefs in Malawi

The chief we spoke with had access to a smartphone. If he received such a report, he wanted it to be either by phone or printed out by members of the Village Health Committee. He supported the statements regarding printers, that they were only

accessible at a health centre. He later said that his preferable format was digital because it could be “a problem to collect” the printed reports from the centres.

7.6 Schools in Malawi

At the school we visited, they had access to printers, power, internet, and smartphones. The teachers did not communicate with the CHWs regarding health issues, and no type of reports existed between them. Their easy access to supplies and power made them open to any format. They said a digital format would be easy to share, as everyone would be able to receive it, and it would save them the cost of using paper and ink.

7.7 Access to power and internet

The loss of power is an issue in Malawi and Ethiopia, contributing to why a digital reporting system could be challenging. Many places we visited are in rural areas with limited power supply. In both countries, we visited health posts and clinics without electricity. In a health post in Ethiopia, a solar panel on the roof gave them enough power to have lights, a refrigerator, and charge tablets. Otherwise, they had no computers, printers or larger electronic devices at these posts.

During Iteration 2 in Malawi, we visited a health centre where the CHWs said they had no electricity from the powerlines. One of the CHWs asked if they needed internet access to use the application. He stated that this might be an issue, as they do not have Wi-Fi at the centre and would need data on their phones. This might cost them money and prevent them from using the application.

7.8 Conclusion

In some ways, the lack of digital devices affects the process. There are often few computers, smartphones or printers available at the lower health system levels. This makes it challenging for the CHW to print out reports. If it depends on constant power and internet connectivity, it might not be accessible when they need it, and it will become impractical and rarely used.

Furthermore, many of the conversations and discoveries we made indicate that there is no clear answer to what the best format is. Different roles have different needs, and it is not possible to fulfil them in one report format. This means the best solution could be to allow them to choose the format. Most of the people we have spoken with seem to prefer a paper format, but none of them have an explanation on how they would be able to receive it. This leads back to the shortage of digital equipment, and the reports may have to come from a higher level, like the health centre.

8 Report content

To be able to create report content tailored to each role, it is essential to identify their areas of importance within public health. After conducting research, we have determined that three factors should be considered when deciding which health topics to include. First, the receivers' knowledge regarding public health should be considered when designing the reports. Secondly, the report should address the health areas that the receiver is most likely able to impact. Lastly, the health topics the receiver considers "most important" must also be accounted for.

Those receiving reports must know about correlations between causes and effects to accomplish effective decisions, such as the correlation between rain and malaria, poor hygiene and diarrhoea or that a higher antenatal check-up rate leads to lower maternal mortality. If they do not, their decisions to improve public health would, to a much greater extent, be based on guesses and assumptions.

Further, the report's content should also be determined by which health areas the receiver could influence. For example, teachers would probably find a report about children's hygiene more relevant than a report about the number of HIV cases among adults. They are in contact with children and can better influence their health. Another example could be the traditional healers wanting information on COVID-19 symptoms rather than the immunisation rate. COVID-19 cases affect the whole community, and they need to know when to refer people to hospitals. These two examples show the importance of adjusting report content to each role and that more than a single standardised report, in most cases, would be necessary to cover everyone's needs.

Lastly, we have the health topics that are most important to each role. Developing a generalised list of the most important health topics can be demanding. The answer would differ when we asked the roles what they deemed most important. People emphasise diseases differently, some areas in a country are prone to certain diseases, and experience and ethical perspectives affect their response.

8.1 Community Health Workers in Ethiopia

CHWs in Ethiopia are primarily responsible for healthcare in a kebele, which makes them interested in information from several different health areas. Some areas were more important than others, for instance, postnatal and antenatal care and nutrition. They also mentioned antenatal care, family planning, cancer, child nutrition and vaccination.

Regarding the current diseases, the problems in one of the areas we visited were tuberculosis, pneumonia, diarrhoea and malaria. Malaria was seasonal, but it was expected throughout the year. It was also considerable variation between villages when it came to malaria. During our visit to a health post, we observed that malaria posed a significant problem and caused the loss of many lives annually. However, it seems like it existed some local variation, as malaria was not a major concern in a nearby village. Additionally, local variations were also seen in home births, where some CHWs expressed concern about the number of home births, while in other areas, it was not a prominent issue.

At one health post, they were also concerned about a new cholera variant that was more severe than previous variants. The new variant was more deadly, and early symptoms were harder to discover, leading to people visiting a health facility later in the illness. The CHWs were interested in receiving information about this new cholera variant in terms of numbers and statistics. An example of a health report for the CHWs in Ethiopia is shown in Figure 29.

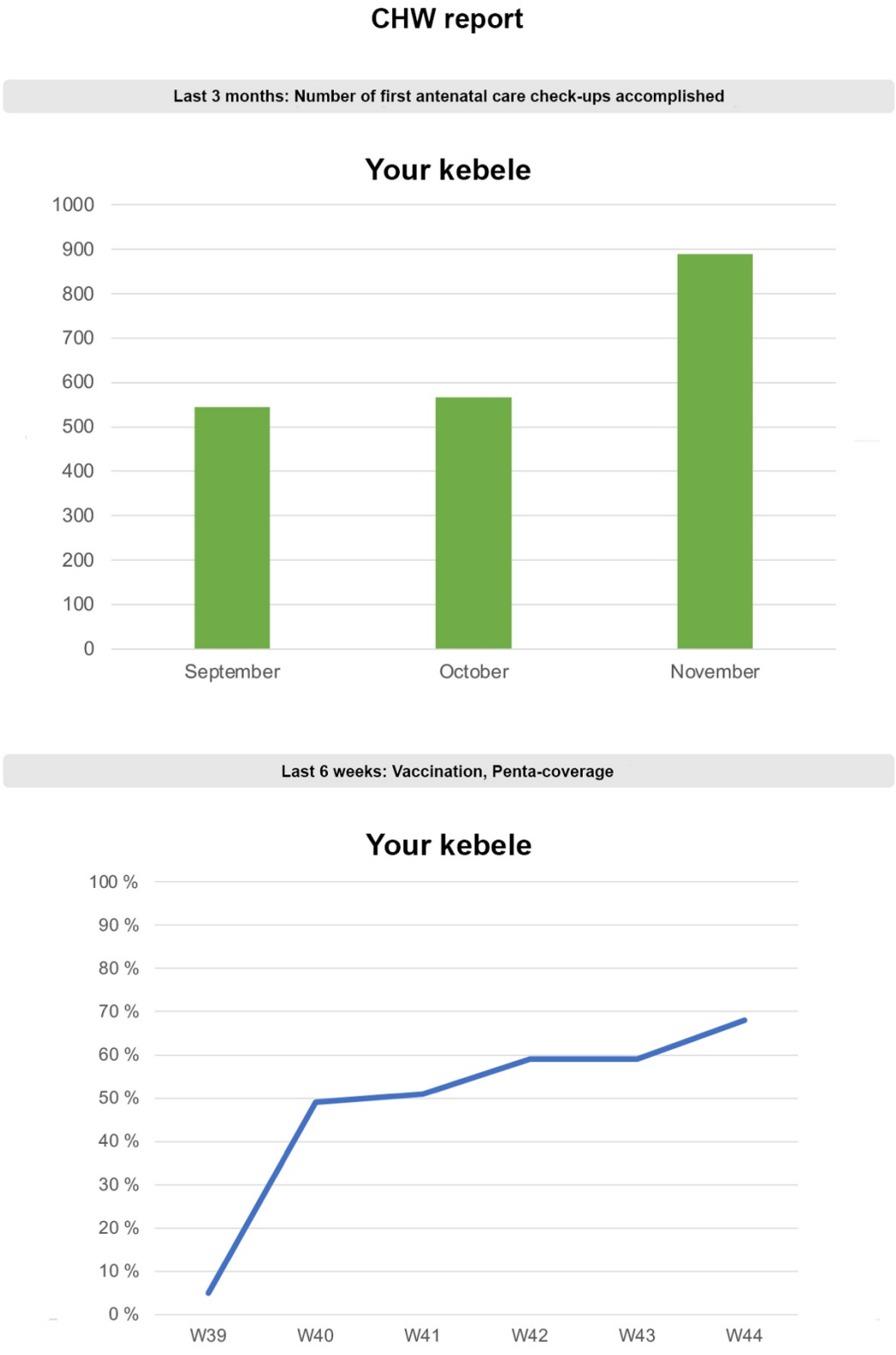


Figure 29 - Antenatal care and Penta-doses coverage sample report for CHWs in Ethiopia

8.2 Volunteers in Ethiopia

The topics the volunteers in Ethiopia cared most about were often similar to those of the CHWs. If a CHW were concerned about malaria or diarrhoea outbreak, this concern was often seen among the volunteers. Another example could be vaccination among children; if the CHWs were worried about low immunisation coverage, the volunteers were constantly engaged in this issue, monitoring the situation and increasing the coverage.

At the same time, the topics they cared most about were not exclusively pointed out by the CHWs. Regardless of the current health situation, the volunteers focused on maternal care and child health. Sub-topics inside maternal care that were considered important were breastfeeding and antenatal care. Essential sub-topics of child health were nutrition, measles and vaccination. When asking them about the relevance of receiving reports with charts regarding “Number of pregnant women” or “Number of Penta doses given”, the volunteers were clear that such information could have strong relevance to improving their daily work. In addition, the volunteers were also contributing to accomplishing family planning courses for their household, so data about number of families planning courses completed by themselves or as a volunteer group, could also be relevant to monitor, and could be used as motivation for further work.

We also discovered a pattern that health topics the volunteers care most about often were topics where cause and effect were easy to detect, for instance, malaria and diarrhoea. The more comprehensive issues were often laid over to the CHWs, as they are more educated and well-experienced. Therefore, the health topics in the volunteer report should be easy to understand and may exclude the more comprehensive health issues, such as diseases where symptoms are more complex. An example of a report for the volunteers is provided in Figure 30.

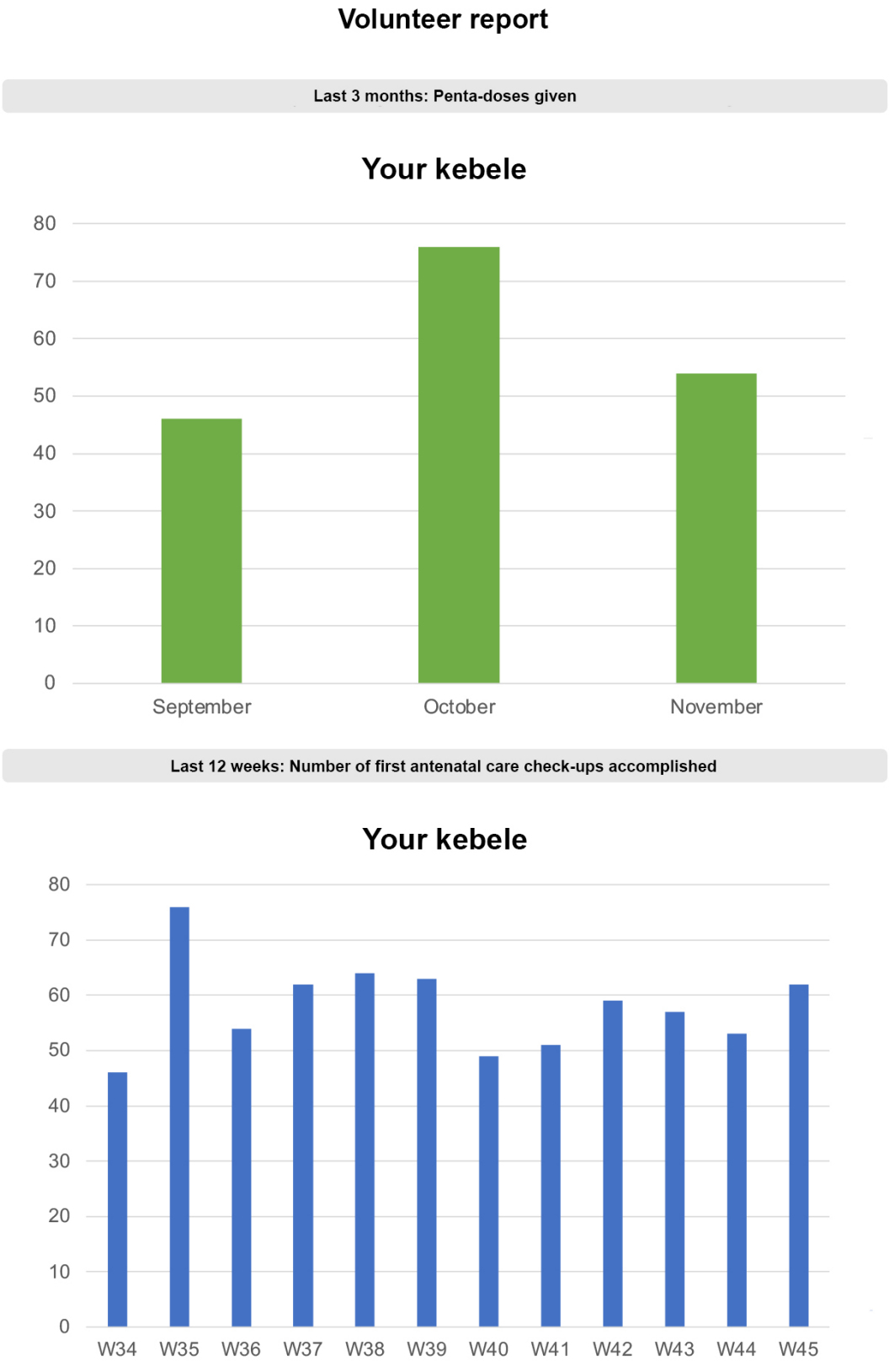


Figure 30 - Penta-doses given and antenatal care sample report for volunteers in Ethiopia

8.3 Schools in Ethiopia

We saw a strong link between the health post and the school leader in Ethiopia. As mentioned, the school receives weekly health education from a CHW, and the school leader provides the CHWs with a summarised health report from all the schools in the kebele every month.

The report contained information such as the number of face washes made and the number of children who had completed agriculture training. The leader said they focused on educating about hygiene, sexual health, and farming. He expressed that the main problem in their area was clean water, which made hygiene and face washing extremely important, and that a report about such health information would enable the school to be more aware of current health threats.

We only managed to visit one school in Ethiopia, and to what extent these topics are relevant for other schools could be hard to confirm. Still, out of our one visit, the school leader's opinion about important health topics seemed plausible with the impression we got about which daily activities the schools had in Ethiopia. As mentioned, local variation would always occur, and adjustment in the standards between each village is most likely needed in school reports. An example of a school report is provided in Figure 31.

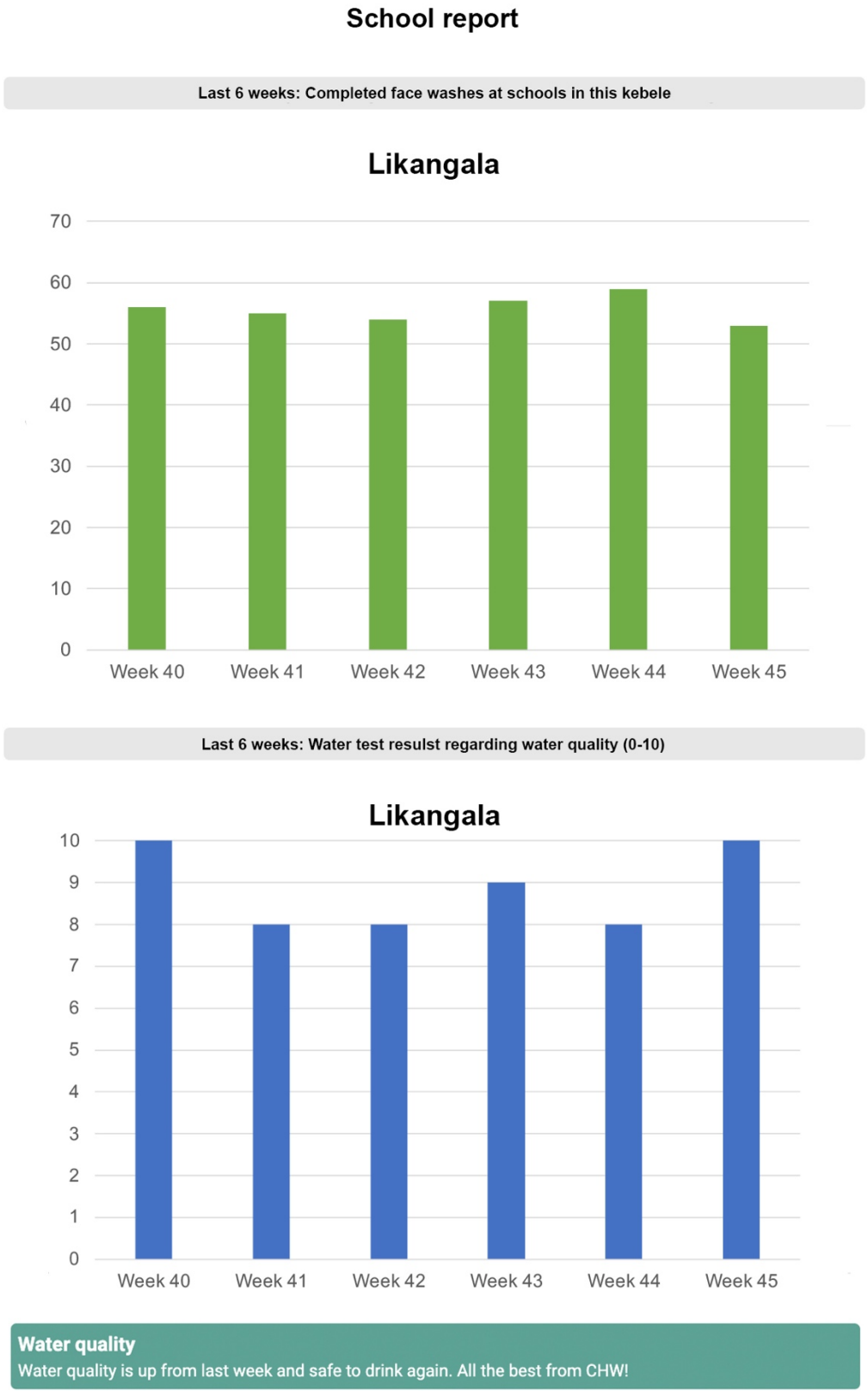


Figure 31 - Face washes and water quality sample report for schools in Ethiopia

8.4 Community Health Workers in Malawi

The two topics that attracted the most attention in Malawi were maternal and child health. Sub-topics of maternal care they focused on were antenatal care and breastfeeding. Within child health, the CHWs were most interested in children under five years and especially topics related to malaria, sanitation, nutrition, and immunisation.

In addition to these topics, the CHWs were also interested in health data about HIV and COVID-19. During Iteration 1, COVID-19 was a highly discussed topic among the CHWs. In Iteration 2, the Covid-situation was more under control and required less attention. It was informative to receive data about malaria cases' impact on adults. However, malaria remains most concerning for children, making it crucial to prioritise information about its effects on them.

Some CHWs were also clear about which timespan the chart should display. Some CHWs said that the report should be monthly to show the current situation, but also said that a three-month report could be valuable for making it easier to monitor and detect trends. The 12-month report, or even larger timespan, could also be interesting in some scenarios, for instance, to follow the progress of a vaccination program.

Regarding malaria, we were told that the number of cases largely depends on the season and that the current situation should be compared to the same month in previous years. Some Malaria reports should therefore show data from several years back to give a more in-depth image of the situation and give the ability to decide whether there is a seasonal variation or a deviation. A comparison was also made at a health clinic we visited, where they said they had malaria data as far as five years back.

The CHWs also pointed out that, in addition to evaluating the result toward national standards, it could be valuable to compare to other nearby districts in certain scenarios. A local comparison could give a more balanced point of view of the current health situation, as the national standard does not consider how climate variation between

different parts of Malawi or other predefined factors that are hard to change affects the health situation in a village.

During Iteration 1, we met with the Director of National Community Health Services at the Ministry of Health, who said that CHWs were important in the community and should be updated on trending issues. She thought they could benefit from receiving monthly reports presenting malaria cases and vaccination status. In addition, she pointed out that child health was important throughout the country and that diseases affecting children should be included. These topics were relevant for many of the CHWs we spoke with, which means they are probably an issue in many areas in Malawi.

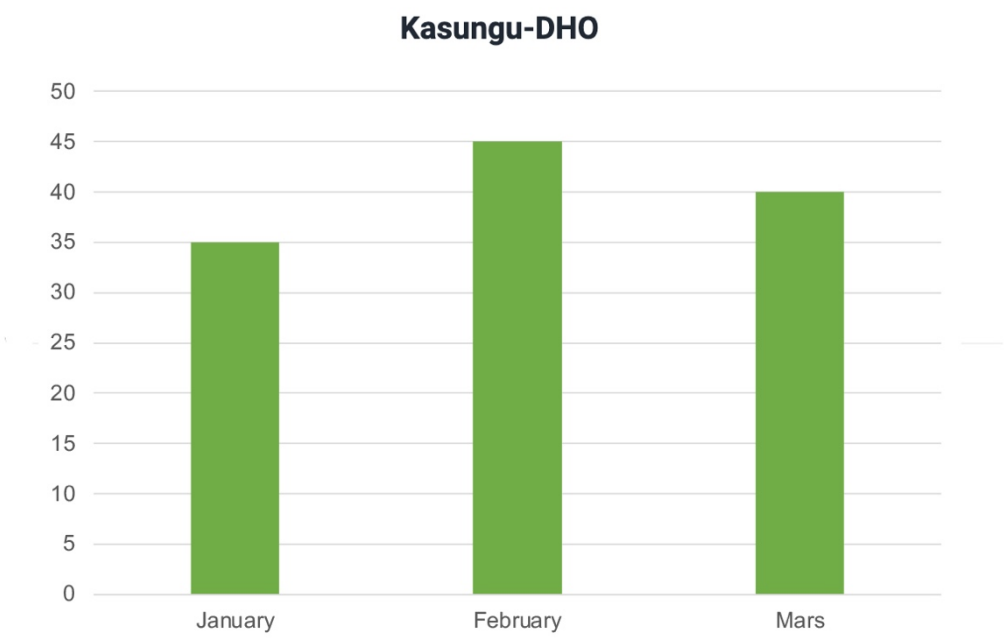
8.5 Volunteers in Malawi

During our visit to Kasungu in Iteration 1, we met a group of volunteers who expressed that their topics of interest regarding a report were immunisation and nutrition. This is because they are in charge of weighing the children and visiting each home to ensure people are vaccinated. They are also encouraging young women not to get pregnant and telling pregnant women to give birth at facilities, which means they could benefit from receiving this information as well. Another health issue that they deemed important was malaria.

Another group of volunteers in Kasungu mentioned diarrhoea, cough, and malaria as the main topics. This was primarily related to children and child mortality. They wanted the number of cases in that area in a monthly report for each topic. They mainly discussed preventive measures and how to reduce malaria cases at their Village Health Committee meetings rather than issues like water, sanitation or tuberculosis. A sample report for the volunteers is shown in Figure 32.

Immunisation and nutrition

Last 3 months: EPI - Expanded Programme on Immunization EPI_SP_IMM_Penta 3 given



Last 12 months: Number of children received nutrition package

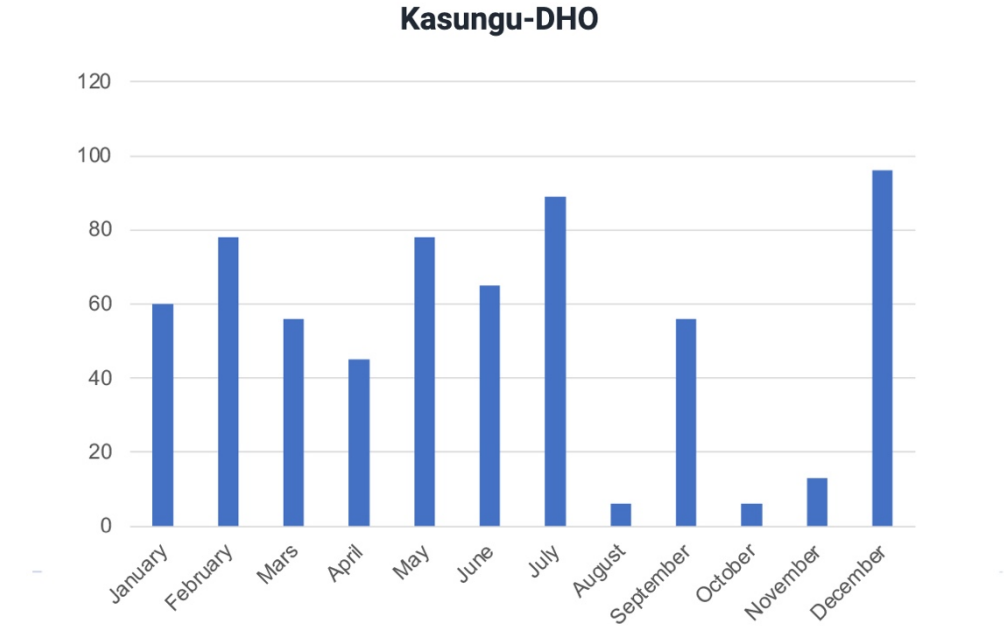
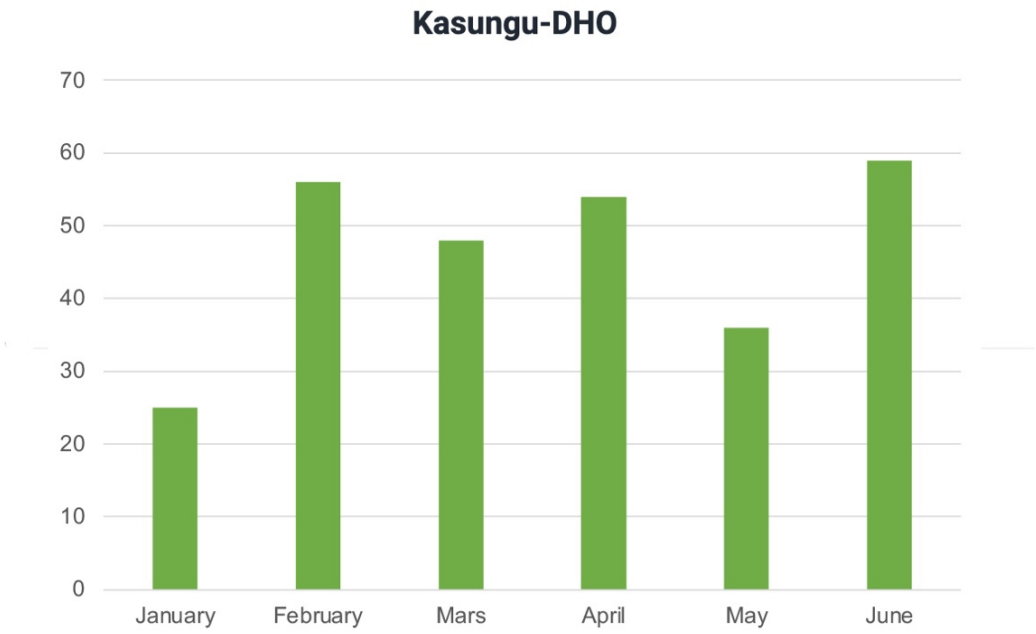


Figure 32 - Immunisation and nutrition sample report for volunteers in Malawi

Lastly, we spoke with a Village Health Committee member at the Chidongo Clinic during Iteration 1. He mentioned that the report should include the death and birth rates in the village, and if they had died of a disease, it was essential to learn which one. An example of a such report is shown in Figure 33. Furthermore, he said they discussed the risks associated with teenage pregnancies at the Village Health Committee meetings, but that the report should focus on information regarding teen pregnancies, rather than what it leads to. If the report focused on the number of teen pregnancies, they also said it needs to include whether the number was higher or lower compared to during covid. These issues were also mentioned by the Director of National Community Health Services, who said topics such as teen pregnancies, mortality rate amongst newborns and conditions like households with latrines and hygiene could be included in a report. She mentioned that the Village Health Committee should be updated on the current health situation because they need to see the result of their efforts in the community.

Deaths and births

Last 6 months: Deaths



Last 6 months: Births

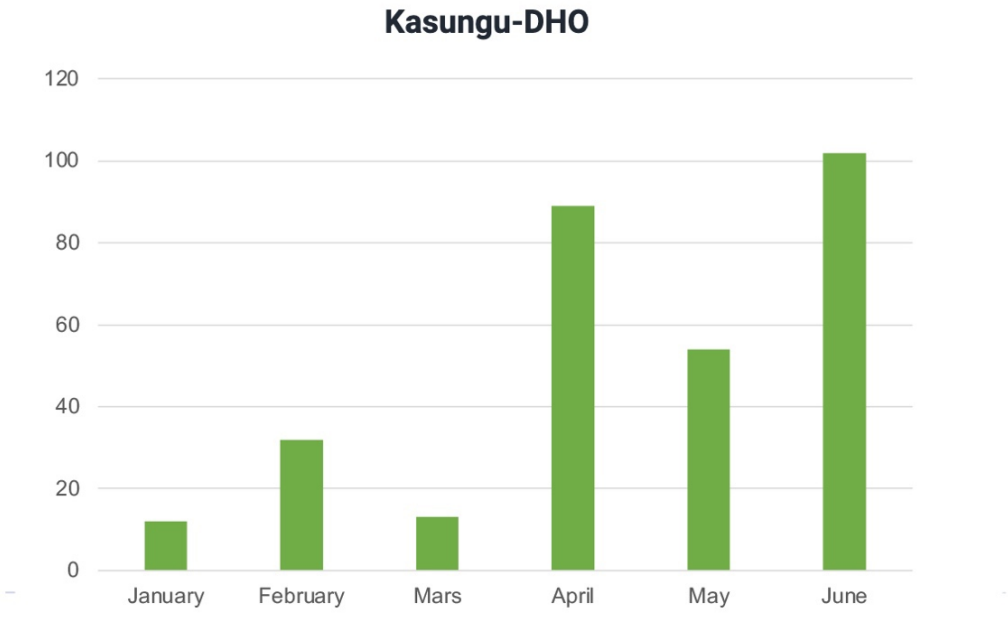


Figure 33 - Deaths and births sample report for volunteers in Malawi

During Iteration 2, we spoke with volunteers at the Matopa clinic in Zomba. They were responsible for conducting household data, educating on family planning and nutrition, and dealing with suspected cases of cholera or tuberculosis. The volunteers said they could benefit from receiving reports about nutrition, cholera, and tuberculosis. They also expressed interest in the number of teenage pregnancies and said, "Without the data, it is difficult to share the information". As the volunteers discuss current health situations in the Village Health Committee meeting and bring this information to the households, they expressed that the report must also contain the current issues of the village.

Further, they cared about the statistics of COVID-19 and how many were infected. They wanted to include the signs and symptoms of the disease in the report. They also pointed out that immunisation coverage among adults and children would help encourage unimmunised people to be vaccinated.

Antenatal care was also an important topic. They wanted to know if the pregnant woman showed up to her antenatal care meetings. Personal attending at an individual level would not be possible to include in a report. Still, it is possible to have the total number of women showing up for their care-ups. This could be important data to encourage other women to go to their visits and detect if many of them don't follow through.

8.6 Schools in Malawi

The school we visited in Malawi had no specific health education and said that they do not talk about the village's current health threats, except for COVID-19, when the teacher talked about how to avoid being infected and accomplished mandatory hand washes.

Even if the teachers were not educating about health issues, they were still interested in receiving reports and updates regarding the health situation. They said that reports would give them something to tell the children rather than assuming which health issues are currently concerning. The school leader we were in contact with said that they "surely need health information". The school leader and the teachers were interested in

topics such as HIV, cholera and other relevant diseases. They said that the information in the report needs to be specific for children of school age.

They were especially concerned about the rising threat of cholera in the area and wanted to receive an update every week if possible. This health issue affected them the most now, as they knew cholera would hit them soon and that they were in a prone area. They also experienced water issues, which made water and hygiene vital topics as well. The school leader said, "You can pass that information to us. The ones drinking water, are they treated, not treated". In addition, the teachers also stated that malaria was a problem in this part of Zomba throughout the year, making it an important topic to include in a report. An example for what a report for the school could contains is shown in Figure 34.

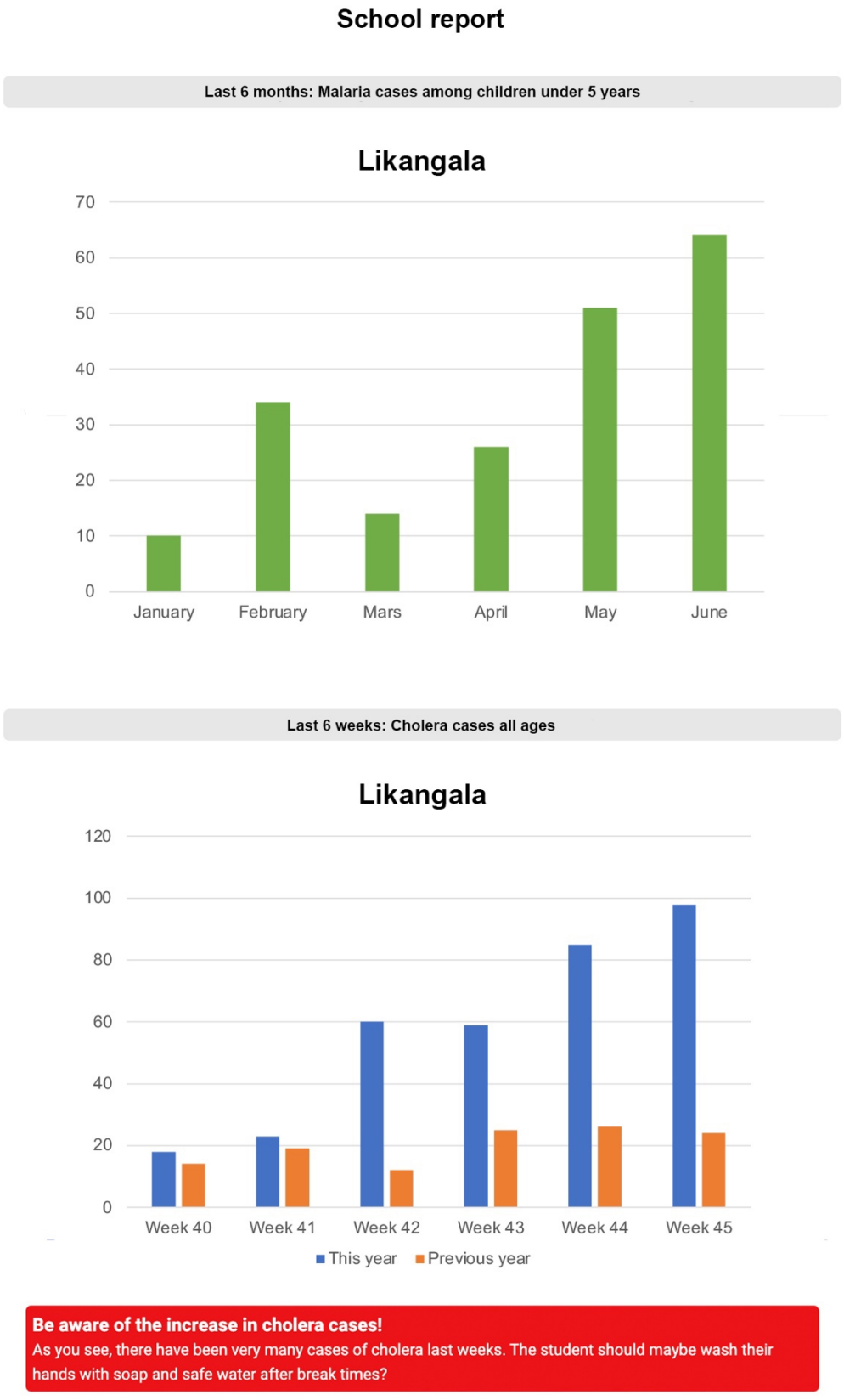


Figure 34 - Malaria and cholera sample report for schools in Malawi

Furthermore, they mentioned that they did not have an issue with teenage pregnancies, which seems to differ from other schools. During our meeting with the Director of National Community Health Services at the Ministry of Health in Iteration 1, she mentioned the issue of teenage pregnancies and how they struggle with teenage mothers dropping out of school. This seemed to be an overall issue in the district of Kasungu, which is why one can argue that it should still be included in a standard report. An example of a such report is shown in Figure 35.

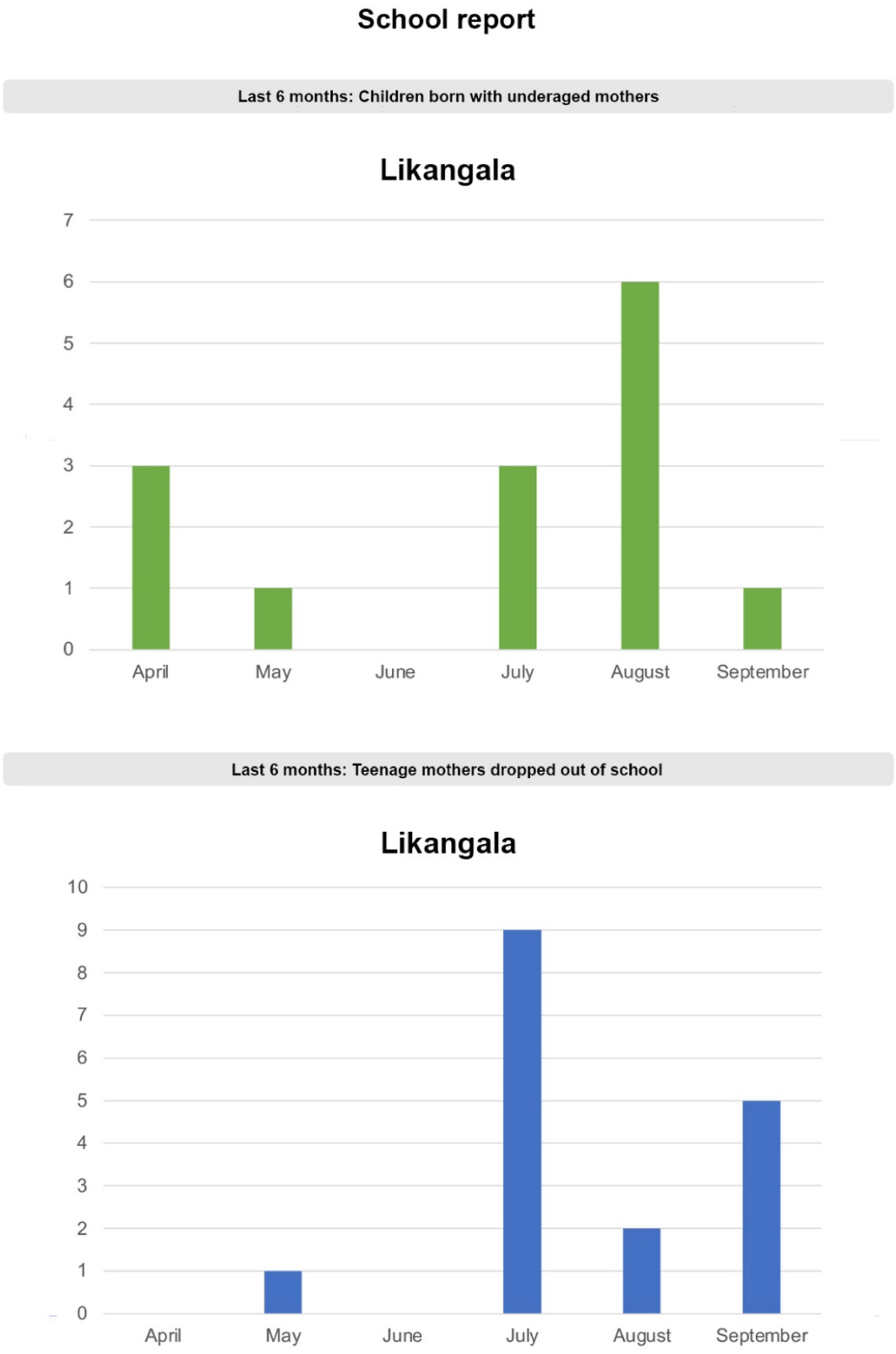


Figure 35 - Underaged mother and teenage dropout sample report for schools in Malawi

8.7 Religious leaders in Ethiopia and Malawi

We did not speak directly with any religious leaders in Ethiopia. Still, many CHWs seemed to communicate well with them and know what they cared about. The religious leaders were influential in the area. They said that “they discuss all the points” and mentioned maternal health as one of the main topics. The CHWs also said that the religious leader could travel to the areas where the number of home birth is high and try to explain why pregnant women should travel to a facility to give birth.

In Malawi, the religious leaders meant that the topics they would want to receive in a report should be directly relevant to the current health situation. If there is a cholera outbreak, it needs to be included because people should be aware of current health threats. Some did not care much about general hygiene and washing, but if we could narrow it down to handwashing in church, this would be interesting to them. Other religious leaders meant that water, hygiene, and nutrition were essential every year, every day, and therefore should also be included.

The religious leaders also expressed an interest in maternal- and childcare. They all seemed to agree that the information to the people still should come directly from the CHWs because they were the health personnel. Regarding understanding the information in a report, the religious leaders said that the CHWs could support them, so they could further encourage and motivate people to take action.

The CHWs also had an opinion about which health topics the religious leaders should receive. They mentioned that it could be valuable to have the religious leaders mention COVID-19 in church since it was a need for more information about how to prevent infections. In addition to saying how to prevent it, the CHWs said that the religious leaders could explain which symptoms often indicate COVID-19.

8.8 Traditional healers in Malawi

Since we did not meet with traditional healers, we based our conclusion on what they would like to receive in a report on our conversations with CHWs. According to them, they communicated with the traditional healers about COVID-19, tuberculosis symptoms, and HIV. If this were included in a report, the traditional healers could keep track of the numbers and realise the importance of their advice to people. They are also asked to encourage people to give birth at health centres instead of at home. Reports about the number of home births could be a parameter to decide whether such encouragement has succeeded and be used to motivate further work. An example of a health report for tradition healers is provided in Figure 36.

In addition, the traditional healer should be aware of the current situation. Are there any new diseases spreading, and if so, what are the symptoms? If they know this information, they can easier refer people to the health centres and prevent further spreading. This would require the CHWs to attach common signs and symptoms to the different diseases in the report, making it easier for non-health personnel to identify them.

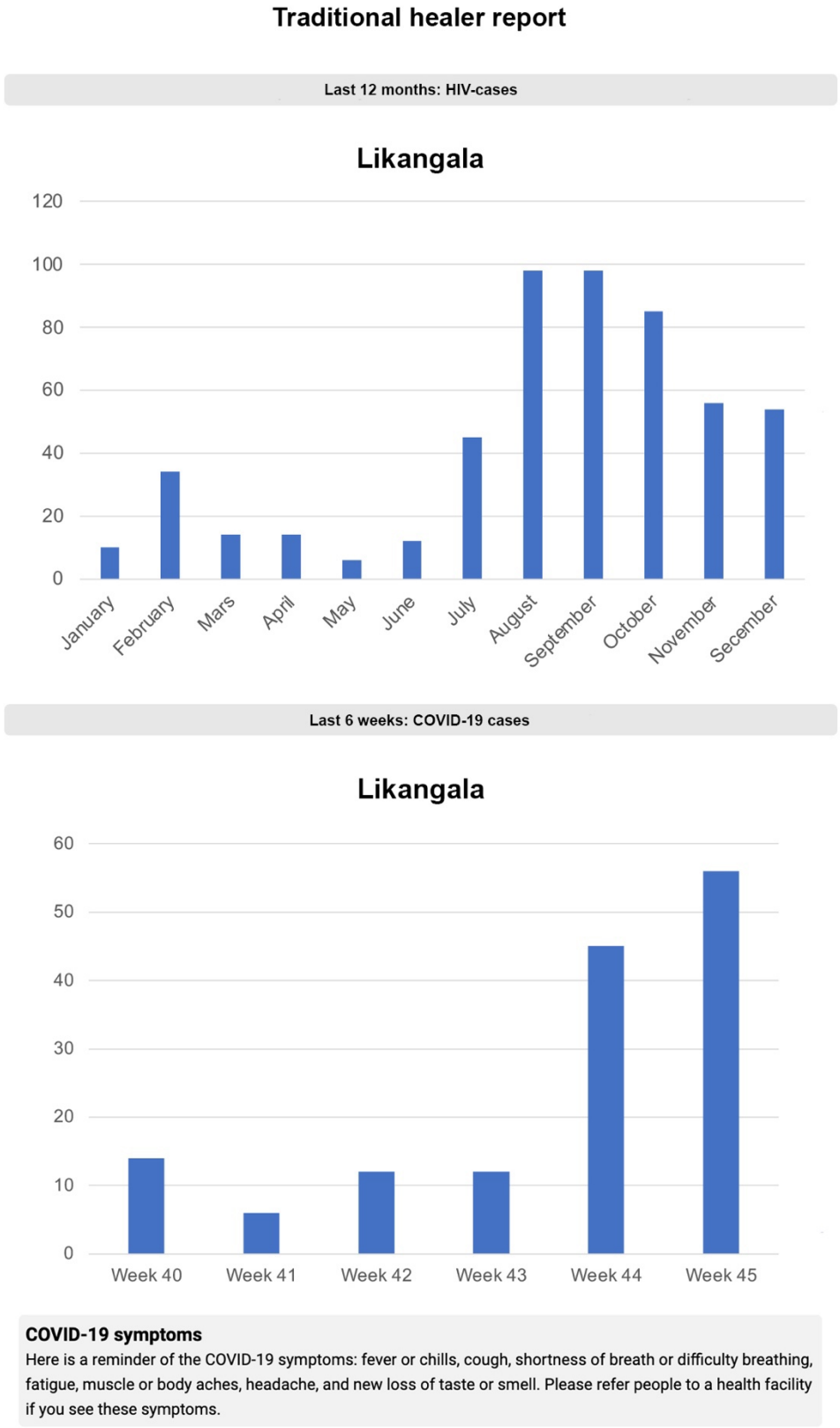


Figure 36 - HIV and COVID-19 sample report for tradition healers in Malawi.

8.9 Chiefs in Malawi

The chief we spoke with in Zomba mentioned the issues of COVID-19, malaria and the cholera outbreak as the most often discussed topics in their village. These topics are discussed at the Village Health Committee meetings, but the chief indicated that he also communicates with the schools and religious leaders. They work hand in hand and sometimes discuss health issues together, like the mentioned topics or hygiene. He would receive his report through the volunteers in the village, but his report does not necessarily need to be as detailed as the volunteers, seeing that he only deals with the most urgent issues.

8.10 Table over roles and health topics

	Healt topics									Diseases									
	Postnatal	Antenatal	Vaccination/ immunization Child under five years	Sanitation	Nutrition	Family planning	Home birth	Hygiene	HIV	Malaria	Covid-19	Tuberculosis	Cholera	Cough	Measles	Diarrhea	Cancer
CHW in Ethiopia	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes		Yes	Yes		
CHW in Malawi	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	
Volunteers in Ethiopia	Yes	Yes	Yes			Yes	Yes	Yes		Yes			Yes			Yes	Yes		
Volunteers in Malawi		Yes	Yes	Yes	Yes	Yes	Yes	Yes		Yes	Yes	Yes	Yes	Yes		Yes	Yes		
Teachers and school leader in Ethiopia					Yes			Yes											
Teachers and school leader in Malawi					Yes			Yes	Yes	Yes			Yes						
Religious leaders (both)	Yes	Yes		Yes		Yes		Yes	Yes		Yes		Yes						
Traditional healers in Malawi							Yes		Yes			Yes							
Chiefs in Malawi								Yes		Yes			Yes						

Table 12 - Table presenting which health topics and diseases different roles cared about

9 Discussion

This chapter will account for our first research question: application, before it takes the last four research questions: roles, chart literacy, digital access, and report content, and discusses whether they align with the literature that already exists within the research area.

9.1 Application

The application offers the possibility to share health reports out of the Malawian iCHIS-system. It is integrated into the iCHIS and takes advantage of many of the features DHIS2 offer. With configuration and minor development, there is likely that the application could be adapted to the Ethiopian HMIS system as well.

As mentioned in the background, the Ethiopian system already has a module for exporting health data elements presented in a table. Our application supplements this functionality, by providing a possibility to display data in charts as well as text phrases. The “Data visualizer” in iCHIS has some of the same features as our application, but is improper for creating reports, as it only allows creating one chart at once, does not support text and are much more complicated tool, that would require more training.

Due to the lack of knowledge with the iCHIS web solution probably makes our web-based application not the most optimal solution. If taking this application further, it needs to be considered if an Android application would be more sufficient to cover the need. Still, our application provided a valuable contribution to research, and discover several potentials for integrating report functionality into an HMIS system.

9.2 Roles

9.2.1 Community Health Workers

Our research has found that CHWs have important roles in providing health care services in the communities in both Malawi and Ethiopia. As shown in “Figure 23 - Information flow between in the community.”, they are at the centre of health information. In Ethiopia, they followed the Health Extension Programme to provide primary healthcare to their village, while in Malawi, they have a CHW guideline. As mentioned in “2: Background”, the CHWs arrange meetings and training with volunteers and meet with the Village Health Committee regularly, in addition to educating children at school (Ministry of Health, 2017). In our research, we have discovered that this cooperation exists and that they, in addition, communicate with chiefs, traditional healers and religious leaders. This confirms the central role of CHWs at the community level.

As we have seen through experiences and previous research, their areas of responsibility are many. This provides us with the question of whether they have time to be the distributors of reports or if they only want to receive them. Based on their response during our fieldwork, they thought including health reports would be beneficial, and they did not seem to mind being the creators. They valued the information and the possibility of spreading it to other roles. According to a previous study on the roles and tasks of CHWs, “One of the CHWs’ social functions is building trust with the community.” (Glenton et al., 2021, p. 4). Including health reports can help build trust and confirm the effectiveness of their work. It can also make their daily tasks easier. When more people have access to this information, they can take preventive measures on their own. Ultimately, this can result in fewer disease transmissions in the community.

There is little existing research regarding providing CHWs with health reports. Still, the feedback we received was that the need for reports was great. The article “Community health workers at the dawn of a new era: 5. Roles and tasks” discusses the issue of overloading the CHWs with tasks. Introducing them with a new application might require training, supervision and resources. They need to have sufficient knowledge regarding

how to fix technological issues as well as not spend too much time learning the system. Based on our user testing (Chapter 4.10: User-testing), there were little to no issues with learning how to use the application, which proves that this would at least require limited training.

9.2.2 Volunteers

A study on how volunteers in Ethiopia contribute to maternal and child health concludes that they play an essential role when it comes to sharing information from the CHWs with the community (Yitbarek et al., 2019). As one CHW from Malawi explained, “Volunteers are the key". An example is how the strong structure between the volunteers in Ethiopia resulted in the CHWs being able to refer more women to give birth in health facilities. One can discuss if more information regarding health issues can result in positive outcomes like this. The volunteers we spoke with expressed that they never receive statistical updates or reports, and they are not able to see the influence of their own work. Health reports could help change this by providing them with an image of the health situation.

As mentioned in Chapter 2, the volunteers deliver information between the CHWs and the households in a community. This aligned with our findings. In Malawi, the volunteers said they travelled around the village to check up on patients and then reported back to the CHWs. Their tasks consisted of conducting household data, informing of family planning and nutrition, in addition to reporting suspected cases of tuberculosis. This differs slightly from what we found in existing research. This may be due to different areas; some diseases could be a larger threat depending on the location, or the volunteers’ tasks could differ. In Ethiopia, the volunteers educated the people, as well as brought children to the health post for vaccination, identified pregnant women and informed people of precautions in case of an outbreak. They report any health problem or situation back to the CHWs. This aligns with the result of a study conducted in Ethiopia in 2019 (Yitbarek et al., 2019).

Further, volunteers in both countries received training and support from CHWs through meetings. In Ethiopia, they followed the Health Extension Programme, and the educated topics varied thereafter. The meetings we attended had a focus on family planning, antenatal and postnatal care, breastfeeding, sanitation and nutrition, but explained that they have a guide for discussion so the topics could change. Volunteers in Malawi collaborated with CHWs too, and said they always discuss health challenges, pregnancies and antenatal care during meetings. A study from Kenya explains that training and support are vital for those who are involved with changing other people's health-related behaviours, such as volunteers (Aseyo et al., 2018). Delivering support and training in Kenya, was in likeness to what we saw in Ethiopia and Malawi, done in meetings. The topics discussed at the meetings in Kenya were not explained, but the focus seemed to be on offering the volunteers general training and support.

At the meetings with CHWs, volunteers also have the possibility to receive training regarding the use and understanding of reports. As described earlier, our application opens the possibility to add own text phrases that could be helpful for those with lower chart literacy. These text phrases could be used to provide support in terms of adding more general information, such as listing COVID-19 symptoms or information about breastfeeding. The information in the reports could also strengthen volunteers' skills to assess behaviour change, with for instance adding information about symptoms and signs of different diseases in the report. By using this information during the meetings, the volunteers' chart literacy and knowledge level within health could increase, while also decreasing the possibility of misunderstandings regarding the information presented in the reports.

The health information delivered in a report can be directly relevant to the tasks of volunteers. They can get access to information such as the number of children immunised versus the total number of children. This would let them know the remaining number of unvaccinated children in their area. Volunteers would then be able to deliver more specific health services according to the community's needs. In addition, they would know which diseases are currently spreading and which health areas are the most

critical. This could lead to updated information being spread out to the community quicklier.

Previous studies have raised questions about whether volunteers should be paid for their work. The volunteers we spoke with told us that they receive no special benefits, other than the satisfaction of contributing to their community. In the study conducted in Kenya, the volunteers seemed to want some form of allowance from the government, so they could spend more time on their volunteer work. In Ethiopia, they have more than 990.000 groups of volunteers (Alula M. Teklu & Yibeltal K. Alemayehu, Girmay Medhin, et al, 2020). To pay them would require substantial means, and might reduce their number, and therefore affect their work and improvements.

9.2.3 Religious leaders

In our research, religious leaders have proved to be influential roles in a community. Their opinions are respected in the community and have the possibility to influence multiple health areas. This aligns with a study conducted in multiple Sub-Saharan countries in Africa, where religious entities are described as a significant and unique contribution to health services (Schmid et al., 2008). The study mentions that religious leaders have the potential to be powerful agents in the promotion of public health agendas. The inclusion of health reports could provide them with the right information, and keep them updated regarding currently spreading diseases and critical health issues. Even though some of the religious leaders we spoke with were not comfortable preaching health, it is important that those who are, have the right information. This is something the reports provide.

The religious leaders in Ethiopia preached health every Sunday and often educated about the consequences of home births. In Malawi, the ones who preached health usually encouraged people to seek medical attention if they were sick, and some promoted vaccinations. This does not correspond with existing research (Chapter 2.7.1). In a study conducted in multiple Sub-Saharan countries, religious leaders are mentioned to promote family planning, hygiene and HIV. Some faith-based groups also promoted

nutrition and immunisation (Schmid et al., 2008). The difference in topics could be caused by the different locations. We have seen how different topics of interest can vary between places and countries, which might give these results. In addition, it appears that there are varying levels of interest in health promotion among religious leaders. Some are willing to preach about it, while others feel they lack knowledge and avoid the more complex topics.

9.2.4 Schools

As mentioned in the background chapter, there is a strong connection between health and education recognised worldwide. In Ethiopia it was clear indicates that teachers knew that such correlation exists, as they were teaching about sexual health, reproductive health, teenage pregnancies and hygiene. The existing reproductive health club also witnessed that schools knew how they could affect students' health behaviour. In Malawi, signs indicated that knowing about a such correlation was less known, or they did not have the resources or knowledge to make health promotion as a part of the education.

The school we visited both in Malawi and Ethiopia were both interested in the reports, the school leader in Malawi said that they "surely need health information". This statement witness that people are known with the fact that evidence-based information is important, as also mentioned by (Mukamana & Johri, 2016) Ethiopia did practice evidence-based information, where we saw a school leader that gathered information about "number of students who were clean from the facial examination" or "number of students who received education through health extension" and delivered it the to CHW. We saw few signs of any use of evidence-based decisions related to health that were taken at schools in Malawi.

Seeing schools in Ethiopia already sharing health statistics may indicate that providing information between different instances in the society is common. It is likely that the likelihood of a successful introduction of health reports is higher when the purpose and potential of sharing them are already familiar. It appears that Ethiopian schools have a

great sense of organization. One example of this is the way they have established a system with a designated "leader school" that receives health-related data from three other schools. Observing this may indicate that schools are accustomed to completing routine tasks, such as submitting reports to school administrators. It is important to adopt this consistency in health reports, as schools are already familiar with regular tasks, they would likely understand it.

The systematic review of school-based interventions for health promotion and their impact in developing countries underscores the importunacy of making both students and parents active participants in health interventions. (Mukamana & Johri, 2016) We did not discover any such participation with parents in Ethiopia, but it seems like participation was taking place in Malawi, where health was being discussed at parent-teacher association meetings. The health reports could be used to support such meetings, in addition to creating a possibility for students and parents to track and follow the progress of different health issues. The reports could for instance be printed out as posters at schools or discussed at parent-teacher association meetings.

The systematic review also points out that the contribution between different agencies in the society is an important factor to succeed with health promotion in schools. There were strong signs that such collaboration already was taking place in Ethiopia, where the school leader said that they contact the CHW if they identify any problems among the students, as well as inform other schools. In addition to this, a CHW also attended to school every week to provide health education. Such a strong collaboration was not seen in Malawi, it was wanted by the teachers, that said that the CHW could come to school every week and teach about health to the students. The strong collaboration in Ethiopia could possibly be improved by being supported by a health report by a CHW. In Malawi, the situation differs, but any kind of support from the CHW would most likely benefit the schools, for instance, could support in terms of a health report be a starting point.

9.2.5 Traditional healers

Our experience with traditional healers was limited due to not meeting any. Based on what the CHWs explained in Malawi, they seemed to work hand in hand, because many people preferred the traditional healers to hospitals. This lines up with the research mentioned in chapter “2.4.5: Traditional healers”, where it is explained that the majority of adults in Malawi seek out the local traditional healer before the CHWs when experiencing health issues. This can further cause the formal healthcare system to not be able to identify cases in time (Joseph Wu et al., 2018). The inclusion of reports can be used as a preventive measure in this case, where the information between CHWs and traditional healers is shared more frequently. This was supported by the CHWs we spoke with, who wanted to share more information with the traditional healers in their community. In addition, by providing the traditional healers with reports, they would be aware of currently spreading diseases and perhaps their symptoms.

A study from 2010 showed the lack of communication between traditional healers and the hospitals in Addis Ababa (Birhan et al., 2011). One can discuss if the awareness created by receiving reports can help bridge this gap because traditional healers can have more reason to refer people further if they suspect certain diseases. Providing traditional healers with reports regarding the current health statistics might be a small, more affordable step when it comes to assuring their knowledge and bridging the gap between formal health care and traditional medicine.

9.2.6 Chiefs

Considering that chiefs are the administrators of a village, providing them with information can be significant to see results. As presented in the study from Zambia “Assessing the Impact of Leveraging Traditional Leadership on Access to Sanitation”, mentioned in Chapter 2, the involvement of chiefs led to an uptake in community-led total sanitation (Osbert et al., 2017). The chief we spoke with was involved in promoting proper health habits, such as hygiene, and disease outbreaks. If he was provided with information such as the spread of cholera or the hygiene level in the village, it could be argued that it would be easier for him to take action.

The chief is informed of health issues by attending Village Health Committee meetings. In addition to him receiving information from volunteers, these meetings can be used to discuss reports and plan further health promotion. This could correspond to the chief orientations performed in Zambia, where individual and group roles in the community were clarified, and information was shared between them (Osbert et al., 2017). At these orientations, the chief was presented with data, and they also compared sanitation access to neighbouring chiefdoms. With multiple stakeholders attending, it is easy to see the progress in the chiefdom and put pressure on the chief. This could be the effect of representing statistics in the Village Health Committee meetings as well.

9.3 Chart literacy

One of the most essential requirements in health reports is that the different roles understand the content. During our research, we found that chart literacy varied between different roles. CHWs, who are educated and employed within health care, had a better knowledge level regarding visualisations than volunteers. Still, in Malawi, they struggled with percentages, bar charts and target lines. The conclusion was that column charts worked best here. The CHWs in Ethiopia were familiar with many types of charts, including charts containing target lines, which they had presented at their health post. They showed a general understanding of statistics. Their education is considerably longer compared to CHWs' education in Malawi, which could be a reason for the difference in skills. These findings correspond to the study conducted in Germany and USA that found a correlation between people’s education level and their graph literacy level. They observed that a certain level of meta-knowledge about graphs acquired through formal education is required to understand graphs (Mirta Galesic, Rocio Garcia-Retamero, 2010).

In addition to a difference in education, the CHWs in each country received different representations of statistics. During Iteration 1, we presented the CHWs in Malawi with “Figure 4 - The first paper prototype” and “Figure 5 - The second paper prototype”, which contained multiple different charts, some more difficult than others. The CHWs in Ethiopia were presented mostly with column or bar charts, shown in “Figure 6”, “Figure

7” and “Figure 8”, during Iteration 2. This could be a reason for the contrast in chart literacy.

It seems that the volunteers in each country share the same level of chart literacy. To fully understand the reports, most of them would require help from the CHWs. Many did not understand the connection between the health topics and the values presented, which makes it difficult to determine if high values were positive or negative. Volunteers seemed to be at level 1 on the graph literacy scale accounted for in “Chapter **Feil! Fant ikke referansekilden.**: **Feil! Fant ikke referansekilden.**”. Level 1 is known as “being able to find specific information in a graph”. This could be for instance to identify the health topic in the chart or point of the highest bars.

The CHWs were at a higher level compared to the volunteer, and most of them were above level 2: “Reading between the data”. They understood the correlation between the health topic and the values presented. Still, the senior CHWs seemed to have the best control regarding chart literacy, at a level where they could use the presented information to see the spreading of diseases and understand the importance.

We had limited encounters with teachers, school leaders, traditional healers and religious leaders, which made determining their chart literacy difficult. The study from USA and Germany found a correlation between education and chart literacy (Mirta Galesic, Rocio Garcia-Retamero, 2010). Considering this correlation, there are reasons to believe that school leaders have better chart literacy compared to volunteers. As we did not learn whether religious leaders have received a formal education, it is difficult to determine their chart literacy based on this correlation. The impression we got regarding traditional healers was that they do not accomplish any education and are, therefore, likely at the same level as the volunteers.

The application considers the different levels of knowledge. As previously mentioned, the reports can be created from scratch in order to adapt to the receivers’ needs. They can choose to add explaining text phrases and a specific chart type. The CHWs should

know about each role chart literacy and adjust the use of different chart technics thereafter.

9.4 Digital access

There is an overall shortage of access to digital devices, reliable internet connections, and consistent power supply in both Ethiopia and Malawi. The situation seemed to be a bit better in Ethiopia, compared to Malawi, but most of the issues regarding digital access were found in both countries. The shortage affected the ability of printers at the health post and clinics, something that forced the CHWs to apply to other solutions, such as hand-drawn visualisations or tables. The lack of printers is also confirmed by the study from 2016 accounted for in the background chapter, which found that no computers and printers were available in health posts in Zomba, Malawi (Cunningham et al., 2016). Even though this study was conducted several years ago, it aligns with our experiences. Another major issue at the health posts was the limited access to stable electricity, which would be necessary if the CHWs should print the reports.

On the other hand, all the CHWs in Ethiopia had access to both tablets and the internet, which would make them able to create reports. This also applied to CHWs stationed in the two districts we visited in Malawi, and it will eventually be implemented in all districts throughout Malawi over the next years. It also seemed like almost all the CHWs in both countries had smartphones and were familiar with the use of WhatsApp. The one chief we talked with also said he had a smartphone. The situation seemed to be even better at schools in Malawi, where they had access to printers, power, internet, and smartphones. The volunteers turned out to be the group that had the lowest access to smartphones, so they preferred paper-based reports over digital ones.

Looking at global trends, there is clear evidence that the future will become more digitalised. According to an American research centre, newspapers produced every week in America got from 63.2 million in 1990 to 24.3 million in 2020, and seeing that people to a greater extent read news online as a cause (Adgate, 2021). Based on this trend, it could be more beneficial to focus on enhancing the digital version rather than

investing in printers and power supply. The digital trend also aligns with the GSMA report accounted for in the background, which finds that people using the internet, broadband coverage and mobile subscriptions have significantly increased in Sub-Saharan Africa since 2014. In addition, the fact that 40% of adults in Sub-Saharan Africa use mobile internet, should give clear signs that a digital solution not exclusively belongs to the future, but have the potential to be taken in use today.

We got the impression that the digital access we saw among people in Ethiopia and Malawi was a bit lower than the findings from the GSMA report. There could be several reasons for this. First of all, we visited mainly rural areas, which often have the poorest populations, and therefore often make it more difficult to obtain a smartphone. This correlation was for instance seen among the volunteers, as they appeared to be the poorest ones and the ones with the lowest digital access. A difference between findings from Malawi and the GSMA report could also be caused by the fact that Malawi is among the poorest countries the report applies to. This may explain why we saw lower access to digital devices than the GSMA report finds.

Under today's circumstances, in areas where there is a lack of access to smartphones or printers, it would become difficult to share reports. This can create a need to explore alternative solutions for distributing reports. One possible solution for volunteers is to display the reports on the CHWs tablet and circulate them during volunteer meetings. Some CHWs mentioned the possibility of drawing reports by hand based on the charts displayed on their tablets. Reports can also serve as a starting point for discussions or help CHWs determine what volunteers should pay attention to. In such scenarios, there is no need to print or forward the report to individual volunteers. For the groups that are less in touch with the CHWs, it becomes more difficult to share the report if neither printers nor smartphones exist. Still, the reports could be helping the CHWs decide what the other roles should be aware of, or which health topic they have improved. Sharing this information could be done face-to-face, by phone calls, SMS or other communication channels that already exist.

9.5 Report content

As shown in “Table 13 - Comparing health topics”, most of our findings regarding the content the different roles found interesting align with previous research, especially when it comes to volunteers and CHWs. The CHWs areas of importance consist of maternal and child health, current diseases as well as hygiene, immunisation, sanitation and general issues the communities struggle with. In Ethiopia, they implemented the Health Extension package in 2016. According to our findings, this appears to have been successful as the areas listed for CHWs mostly correspond with the list in “Table 1 - Health Extension Programme”. In Malawi, the CHWs had a guideline for their role in the community, which also explains why our findings align with existing research. The volunteer's interests seemed to be related to the CHWs' areas. This is reasonable as they work closely together in the community. In addition, they cared most about topics where cause and effect were easy to detect.

The Director of National Community Health Services at the Ministry of Health considered Malaria, child health and vaccination status as important topics for the CHWs. These are many of the same topics we found as most relevant for the CHWs and align with previous research. According to the director, the volunteers should obtain information regarding teenage pregnancies, infant mortality rates, and household conditions such as access to latrines and hygiene. This statement also aligns with our own research and previous findings.

The topics for schools in Ethiopia were consistent with existing research. Primary schools usually focused on hygiene and sanitation. These topics were extremely important in the area we visited because their main problem was access to clean water. In Malawi, on the other hand, the results differed. Malaria and cholera were two issues they struggled with in the area we visited, which explains why these are not mentioned in previous research, Further, we visited a secondary school where they explained that sanitation is a primary school issue, which is why they had not included it in their education.

Existing research mentions that religious leaders are influential when it comes to health promotion, and that many promote family planning, hygiene and HIV (Schmid et al., 2008). Many of the religious leaders we encountered did not want to preach health, because they were not health personnel. This could be the cause of why they avoided more complex issues like HIV, family planning and immunisation.

Our findings related to the traditional healers were exclusively based on CHWs' thoughts, something that may explain why the result differed. However, the issues we discovered for traditional healers during our research were consistent with the general health challenges faced by Malawi, such as HIV, home births and tuberculosis. It is important to note that the study on traditional healers that we compared within "Table 13 - Comparing health topics" was conducted in Ethiopia in 2009, which may be outdated. Additionally, we found that chiefs were primarily concerned with currently spreading diseases, like COVID-19 and cholera. It is reasonable to assume that chiefs would prioritise these topics, as they directly impact the community.

The overall similarity between our findings and existing research indicates that these health topics are important in many areas and may even be an issue throughout both countries. This creates a foundation for determining which topics should be included in reports provided to the different roles. In our application, we have created standard reports based on health topics, such as "Vaccination report", and standard reports that are created to fit each role's specific need (Figure 18 - Standard report implemented). These reports contain the highlighted areas that align with both previous research and our own findings about what interested each role. By taking this approach, we are able to increase the likelihood that the topics we cover in our reports are of interest and relevance to the recipient. Of course, it's important to keep in mind that various regions and areas may have their own unique preferences and priorities that must be taken into account.

"Table 12 - Table presenting which health topics and diseases different ", shows the combined result of our findings. The health topics varied greatly between areas. This

could be due to differences in climate, water resources or the prevalence of certain diseases, which made them higher priorities.

9.5.1 Table over roles and health topics

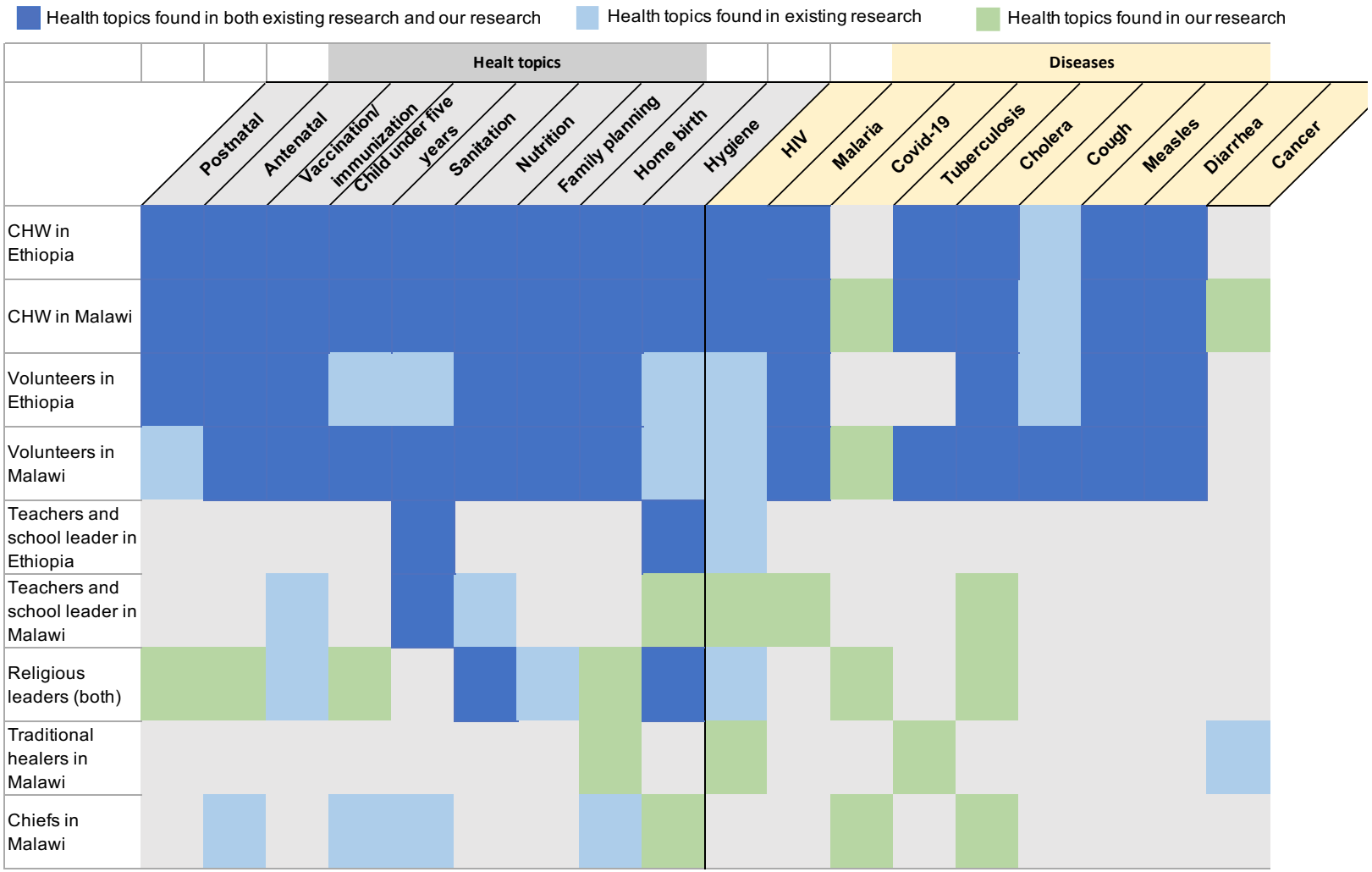


Table 13 - Comparing health topics

10 Conclusion

We have now looked at different roles with influence in society to affect public health behaviour, the chart literacy, digital access and report content. Findings from existing research, combined with our own findings have formed how the application “Health Reports” is designed. The application is a tool to share health information with different roles, where the content can be customised to fit each role’s needs. Further, this chapter will reach a conclusion for each of the research questions and provide suggestions for future work.

10.1 Application

We have developed an application that gives CHWs the opportunity to generate health reports with content and chart techniques that are adjusted to each role. The application proves that health information could be exported out of the Health Management Information System in at least Malawi. The standard reports functionality can be used to save time or get inspiration on which health topics each role could find interesting.

The prototypes' findings were crucial for identifying the functional requirements of the application and gathering information about the presentation format, digital access, and report content to answer research questions. In Chapter 4.5, the prototypes identified several functional requirements that the application meets. However, some requirements were not implemented due to either technical difficulties or lack of time.

Most of the CHWs we tested were able to take into use all the functionalities we had implemented. Using the application in groups, made an arena for CHWs with lower digital skills to learn from the CHWs who had more experience with using digital devices. The user testing shows that the application satisfies a level of user-friendliness that is good enough to make it possible for every CHW to generate and share reports.

10.2 Roles

This research identifies different influential roles in Malawi and Ethiopia. We have seen how these roles can affect public health behaviour through their daily tasks. Volunteers, religious leaders, chiefs, traditional healers and school leaders are roles that could benefit from receiving health reports. There might be roles that could affect public health behaviour that have not been discovered in our research.

The central role CHWs have in public health makes them the most suitable role to generate and share health reports, primarily for others but also for themselves. Volunteers work with health promotion and are a vital role when it comes to improving health in communities (Angwenyi et al., 2018). They are a group that would greatly benefit from receiving reports. The fact that they also act as the connection between public health and the CHWs puts them in a unique position when bringing health information from the CHWs to the community.

Religious leaders are relevant since they have authority in the community and can promote health behaviour during church services. School leaders would benefit from receiving health reports since they are in contact with many children and are in an environment that can play an essential role in improving the health and well-being of young people (Mukamana & Johri, 2016). In addition, the reports could be discussed at parent-teacher association meetings or printed out as posters at school to create awareness. Chiefs have the authority needed in the community to influence people's health behaviour and have the power to affect several social instances that can improve public health. Research from Zambia shows how presenting chiefs with data and including them in health decisions can improve public health (Osbert et al., 2017). Traditional healers operate independently from the national health system, relying on their own healing methods to treat various illnesses. However, by accessing health reports, they may become better informed about more serious diseases and be able to refer individuals to a CHW or healthcare facility.

10.3 Chart literacy

There was a large variation in people's chart literacy, where the volunteer was the role with the lowest literacy and CHWs were the ones with the highest. The chart literacy for the other roles was more unclear. It seemed like a column chart was understandable for everyone and was suitable for displaying many different health topics.

Both our findings and existing research show that charts are challenging. This is especially if we combine several data items in the same chart, shifting between percentages and numeric numbers, adding target lines, comparing too many elements or shifting between if a high bar means a positive or negative result. All this contributes to making the charts more comprehensive to read. The study about chart literacy in Germany and the USA also concludes that reading and understanding charts is a complicated task (Mirta Galesic, Rocio Garcia-Retamero, 2010).

Different roles chart literacy is an important finding for the CHWs that generate the reports. Awareness of each role's limitations and possibilities is vital for creating adjusted reports. Creating reports that are not entirely understandable could lead to misunderstandings that do not contribute to the most effective initiatives or, in the worst case, lead to a contribution that negatively affects already productive initiatives.

10.4 Digital access

This finding was vital for determining how the application should export health reports. There was a variation between the roles, whether they wanted a paper or digital format. Roles with limited resources preferred paper-based reports, due to their lack of smartphones. This applied to the volunteers. Roles with more resources, such as CHWs and schools, preferred to share and receive reports digitally. This variation is accounted for in the application, where the CHWs could choose the format.

There is an overall shortage of access to digital devices, reliable internet connections, and consistent power supply in both Ethiopia and Malawi. Neither a paper-based nor a digital format would be an ideal solution with today’s access to digital devices and

printers. Sub-Saharan Africa would have more internet users, better broadband coverage, and an increase in mobile subscriptions over the coming years (Delaporte, 2023). This would contribute to making the digital version more reliable. Based on this trend, it could be more beneficial to focus on enhancing the digital version rather than investing in printers and power supply.

With the shortage of digital access that exists today, there would be a need to find temporary solutions for sharing reports. A possible solution is to draw the charts on paper using the ones shown on the CHWs tablets or to display reports on the tablets and present them to various roles. If the reports are difficult to share, they could also be used as a starting point for a discussion or help the CHWs decide which health topics that are most concerning.

10.5 Report content

As mentioned in “Chapter 8: Report content”, we determined three factors that should be considered when deciding what content should be included in a report. First, it is important to take notice of the receivers’ knowledge regarding public health. The best knowledge was found among the CHWs, followed by the volunteers. Schools, religious leaders and chiefs had a lot of knowledge about public health and were aware of effective initiatives that could enhance various health concerns. Traditional healers’ knowledge of public health was not discovered, of the reason that we did not meet one.

Secondly, the report content should be determined by which health areas the roles most likely could impact. CHWs are in touch with all areas and should therefore receive all type of information. Considering that volunteers usually work in maternal and preventive care, they should receive information about topics like breastfeeding, immunisation coverage, antenatal and postnatal care. Further, schools could impact the students and should receive information about their current health. The religious leaders preach to people of all ages and could promote health issues that affect all, such as currently spreading diseases, sanitation and immunisation. The chiefs and traditional healers should be updated on current diseases. The chief has the power to initiate preventive

measures, while the traditional healer should know of symptoms and when to refer people to health facilities.

Lastly, it should include the topics each role considers “most important”. For CHWs and volunteers, it is difficult to determine which health topics were most important, as almost every topic drew their attention. For schools, chiefs, traditional healers and religious leaders, it seemed like the topics they found “most important” aligned with the health topics they had the best opportunities to impact.

Even though there are similarities within each role regarding the three mentioned factors, it is important to acknowledge the differences that have occurred. There is variation between roles and between the countries when it comes to areas of interest, health knowledge and areas of impact. The CHWs, who are at the centre of information flow, can adapt to this variation when generating reports for the different roles. They usually know what the receivers’ topics of interest could be. This, in addition to the standard reports, ensures that the different roles find the reports valuable.

10.6 Research contributions

There are strong signs that several roles in the community have the potential to improve public health if provided with the right information and format of presentation. During meetings, interviews and fieldwork, people have shown large engagement in our research. This engagement, together with findings confirming the potential for larger health collaboration between roles in the community and the CHWs, clearly demonstrates a need for a solution that could distribute health information better. Our application proves that this information could be exported out of the Health Management Information System in at least Malawi.

Osbert’s article proves how providing the chiefs with data during orientation meetings and including them more in health decisions could lead to an increased uptake in sanitation (Osbert et al., 2017). Compared to this, our research found that providing other roles in the community with information could be effective as well. Since we found

no other study on providing health data to other roles, all our findings represent novel knowledge.

10.7 Further work

There is still a need for further research, such as the effectiveness of the report. Would the reports lead to a larger engagement in public health, or do they draw attention from other, more important tasks? With the large engagement we saw under meetings, interviews, and user-testing we strongly believe that the reports would make a difference. Still, further research needs to confirm this. For instance, this could be done through interviews or to see if certain health topics improve. It also needs to be ensured that the reports are understandable for the receivers. More comprehensive research about Ethiopians' and Malawians' chart literacy would have been a valuable contribution.

The application could also be improved. As we know, were the CHW most used to the Android application, so integrating it as a part of this application would lower the threshold for taking the tool in use. Further, it could be valuable to investigate the effect of adding signs and symptoms of diseases into the report without having the CHWs do it. If the application could support linking saved symptoms to diseases when generating charts in a report, and provide an automatic explanation, it could be valuable in terms of saving time and energy when generating reports.

It would be worthwhile to explore other methods of distributing the reports. Printing reports and putting them up as posters, reading them on local radio or displaying them in newspapers could be additional ways to distribute the health reports. Health data that are accessible to everyone could promote transparency and create pressure on CHWs and the government to ensure good results. Moreover, it can increase people's interest in their own health, causing them to initiate better health behaviour to avoid different health threats.

If further research finds the reports effective when it comes to improving public health, the next step could be to add the application as a module in DHIS2-environment. This

would make it possible to easily adopt the application into other countries' Health Management Information Systems and could contribute to improving public health to a much larger extent.

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