D-Tree: Examining the efficacy of a Community Case Management mobile medical diagnostic tool

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COMPULSORY DECLARATION:
This work has not been previously submitted in whole, or in part, for the award of any degree. It is my own work. Each significant contribution to, and quotation in, this dissertation from the work, or works of other people has been attributed, cited and referenced.

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Executive Summary

This dissertation reports a formative evaluation on D-Tree International's Community Case Management programme. The Community Case Management programme intends to augment the poor quality of healthcare currently being provided by the Health Surveillance Assistant's (HSAs) in Malawi. D-tree International developed the electronic Community Case Management (eCCM), which is a decision support tool for use by HSAs in Malawi, for the care and treatment of acutely ill children under the age of five. This tool guides the HSAs through a clinical protocol to the correct diagnosis and subsequent treatment, thus providing the HSAs with a tool that can supplement lack of training, supervision, and/or experience.

The move to this decision-making tool also provides three further benefits for the HSAs. The tool includes a logistics tool, supervision tool, as well as a patient record form. The purpose of the logistics tool is to monitor the medicinal stock supply. The supervision tool alters the previously one-way information stream experienced by the HSAs to allow for feedback and quality checks of the healthcare provided by the HSAs. Lastly, the patient records are meant to enable the HSAs to provide a better follow-up.

The plausibility of the eCCM programme is dependent on two main determinants. Firstly, the application itself, and therefore its functions, were reviewed in comparison to Social Science literature to determine the utility of the eCCM application components. Secondly, the adequacy of the eCCM programme, specifically the mobile medium and the ecological context of Malawi was researched to determine the barriers and enablers of the eCCM application.

The present study is a formative evaluation aimed at the proximal outcomes of the D-Tree eCCM application. I used a post-test single group design to get feedback from the HSAs on their perspective of the application, based on the evaluation questions. In addition, secondary data that was collected through the eCCM application gives further insight into the efficacy of the eCCM programme.

The results revealed that the eCCM application is an effective method of providing support to the HSAs working in the secluded rural parts of Malawi. The benefits of the decision-making tool, supervision tool, logistics tool, and patient records were reflected in the secondary data, and were further supported by the opinions of the HSAs using the eCCM application. The efficacy of the eCCM application was however adversely affected by the ecological constraints in Malawi, which meant that the application was not able to demonstrate its full potential. Thus, I have made recommendations for the improvement of the eCCM application. These recommendations mainly address external factors that may influence the functioning of the eCCM application.

CHAPTER I: Introduction to the Field of mHealth and the Electronic Community Case Management (eCCM) Programme

Mobile Health Popularity in Developing Countries

There has been a wave of change in how quality healthcare in middle-to-low socioeconomic countries is conceptualised. The rapid evolution of mobile Health (mHealth) is one of the major contributors to this change (United States Agency International Development[USAID], 2015). In recent years, popularity for mobile health among researchers, practitioners, and policymakers has increased, as the use of information and communication technologies has grown (Labrique et al., 2013; Leslie, Sherrington, Dick, Gray, & Chang, 2011; USAID, 2015). J. G. Kahn, Yang, and J. S. Kahn (2010) found that the potential of mHealth was particularly pertinent in low resource settings. Real-time supervision of healthcare services improves the health infrastructure of an under-resourced health system. In this way, real-time supervision is beneficial to prospective patients (Ranck, 2011).

Although mHealth in developing countries is widely applied, there still seems to be a lack of literature within this field. In particular, there is a lack of literature demonstrating the efficacy of mHealth applications in middle-to-low socioeconomic contexts (Agarwal, Perry, Long, & Labrique, 2015; Chib, Van Velhoven, & Car, 2015; Källander et al., 2013; Tomlinson, Rotheram-Borus, Swartz, & Tsai, 2013; van Heerden, Tomlinson, & Swartz, 2012). The studies that have been conducted within this field support the notion that procedural changes caused by mobile devices improve healthcare service delivery (Mechael, et al., 2010). Such studies are also useful in that they establish lists of common aspects of implementation of technological features.

Extensive research has considered the utility of the medium of SMS/text messages for improving healthcare. Cole-Lewis and Kershaw (2010) reviewed a number of SMS-based interventions in developing countries and found that evidence of efficacy was largely lacking due to non-rigorous evaluations. However, this review did find some positive effects from the use of text messages as a means of health behaviour change. Chib et al. (2015), in their review of 63 articles on mHealth, found that there is predominantly a lack of underlying theory that mHealth, through its technological innovation, leads to measurable health outcomes. Källander, et al. (2013) found that reminder systems, providing learning materials, and distribution of clinical updates via mHealth applications could aid the performance of HSAs. Reminder systems and the provision of learning materials are of particular relevance to the present study, as these features form a part of the eCCM application. The eCCM application,

developed by D-Tree International, aims to improve health outcomes by aiding in the diagnosis and treatment of preventable diseases in Malawi.

Problem Statement: Evaluating the Efficacy of the eCCM Application, to Address Identified Social and Medical Need

D-Tree International designed the eCCM application to address the inadequacy of healthcare services provided for children under the age of five in Malawi. The high incidence of death caused by preventable diseases in this age group calls to question the quality of healthcare in Malawi as well as the access and demand for these services. For instance, the World Health Organization (WHO; 2010) reports that 23% of childhood deaths in Malawi can be attributed to pneumonia, 18% to diarrhoeal disease, and 14% to malaria.

Although the target population of the programme is the HSAs, the intended beneficiaries of the programme are children under the age of five. That is, D-Tree aims to improve the health outcomes of these children. The eCCM programme has two major paradigms that may lead to the success of eCCM as a moderator for positive health outcomes for its intended beneficiaries. Firstly, the functions of the application must be an asset that improve the quality of work provided by the HSAs. Secondly, the success of the eCCM application is largely dependent on the ecological constraints of the catchment area. The implementation and impacts of the programme hinge on the practicality of utilising a technological innovation in an under-resourced country.

The present study is an evaluation of D-Tree International's mobile CCM programme. The primary focus of this evaluative research is the utility of the mobile decision-making application within the ecological context of Malawi, a developing country. This study is an evaluation of the programme and the write-up of this document therefore does not follow the traditional structure of a conventional dissertation, but rather the format of an evaluative report. This study will therefore examine the following evaluation questions.

Evaluation Questions

1. Has the use of eCCM reduced the incidence of incorrect diagnosis of child illness under the age of five?
2. Has the integration of c-Stock into eCCM been beneficial for HSAs?
3. Has the use of Monitoring Information Systems improved the accessibility and utility of health records? Does this, in turn, mean that HSAs were able to provide a better follow-up?

4. Has the eCCM application increased the protocol adherence of HSAs?
5. To what extent has the use of the application improved the efficacy of HSAs' work? How does this improvement manifest itself, or how does the application fall short of such improvement?
6. Has the application been useful for the interaction between supervisor and HSA?

The rest of this chapter provides an overview of the organization that runs the eCCM programme, a description of the programme, and the theoretical background of how the programme is meant to cause change.

Overview of D-Tree International

D-Tree International is a non-governmental organization (NGO) that was founded in the United States in 2004 and was legally registered as an NGO in Tanzania in 2008 and in Malawi in 2010 (D-Tree, 2014a). D-Tree International carries out a variety of programmes with the involvement of various governmental subcontracts, the United Nations, and Foundation funds.

The organization's mission and vision. D-Tree International's mission is to develop and support electronic clinical protocols that enable health workers worldwide to deliver high quality care. They envision a world in which every person has access to high quality healthcare (D-Tree, 2014a). To achieve this overarching goal, D-Tree: (1) develops and validates clinical algorithms for use by health workers, (2) designs software for delivering these algorithms on mobile phones, and (3) attempts to enable the effective use of these algorithms on a scalable basis (D-Tree, 2014a).

A clinical algorithm, for the purpose of this evaluation, is a decision-tree approach to treating an illness. By logically summating the evident symptoms that suggest a type of treatment, the decision-tree approach is meant to decrease uncertainty in decision-making. A step-by-step procedure is designed to take the user all the way to the suggested diagnosis and treatment (Azar & El-Metwally, 2013).

The contextual background and problem faced by Malawi's Ministry of Health (MoH). Currently, Malawi is subject to a severe deprivation of human resources within their health sector (Muula, Mfutso-Bengo, Makoza, & Chatipwa, 2003). For every 100,000 people, Malawi has an average of 2.0 doctors and 36.8 nurses to meet the needs of the 15 million people

living in the country (WHO, 2010). The rural areas in Malawi are constrained by the lack of health facilities, clean water, and sanitation, but are home to 85% of the population. The average life expectancy is in the 50s and 53% of the population live below the poverty line (World Bank, 2010). To exacerbate the problems of the health sector in Malawi further, an average of 80 Health Surveillance Assistants (HSAs) are available for every 100,000 people. These HSAs are primarily deployed in the rural areas and thus are the primary means of care for 85% of the population (LeMay & Bocock, 2012). D-Tree International intends to address the lack of human capital within the health sector by providing the HSAs with a much needed support structure.

HSAs, the frontline health workers, are usually the only medical practitioners available in the rural parts of Malawi. HSAs are community health care workers that have been trained in integrated community case management of childhood diseases. The HSAs have undergone a 10-week course that covers basic treatment of preventable diseases, for which they are required to be literate and have a minimum of 2 years of secondary education. After completion of their training, they each become responsible for up to 1000 people (Gilroy et al., 2013). HSAs in under-resourced areas often lack competency training for their jobs, as well as up-to-date information on "best practices, clinical norms and procedures, implementation guidelines, materials for behaviour change communication, and drug dosage guidelines" (Lemay & Bocock, 2012, p. 65). Thus, the current health infrastructure in Malawi may not provide adequate supervision for HSAs who have not undergone competency assessments.

The problem D-Tree intends to address in Malawi coincides with the growing interest worldwide in the use of HSAs as a way to expand access to healthcare in low-income countries. D-Tree provides the HSAs with a medical diagnostic tool that is meant to be low cost and can provide high quality care, which in turn means that the HSAs can work more effectively in treating their patients. The diagnostic tool links to a referral network so that HSAs become part of the formal Malawian health system, rather than operating as independent agents. As HSAs in Malawi have limited training and lack supervision, such a diagnostic tool can potentially provide the support and oversight needed.

A 2010 study by the Malawian MoH found that 81% of the population in Malawi is residing up to 8-kilometres away from the nearest healthcare facility (African Health Observatory[AHO], 2015). This means that access for most is not feasible when travelling on foot with a sick child. The HSAs determine if the mother and/or father must travel with a sick child to the nearest healthcare facility or if home treatment is preferable. Introducing this step and providing the correct diagnosis and treatment at the first point of contact is essential for

the health of young patients. D-Tree International in Malawi has a team of six employees who facilitate and support the project that I am evaluating in the present study.

Organizational structure. D-Tree provides both the implementation and the support functions to run the eCCM programme, rather than outsourcing the roll out to another organization or government body. Figure 1 represents the organizational structure of D-Tree in Malawi (D-Tree, 2015). The project manager and his team of field implementers are the role-players that facilitate the eCCM programme. Their duties include the training of HSAs, as well as providing the first line of software and hardware technical support.

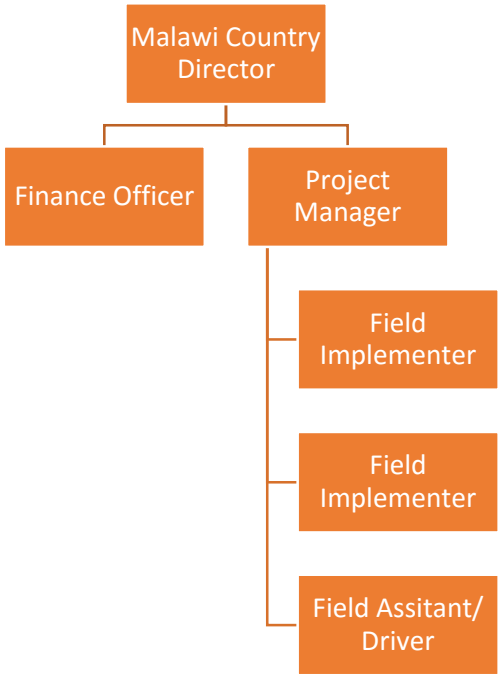


Figure 1. The organizational structure of D-Tree in Malawi.

Due to its success in designing the eCCM application for Tanzania, D-Tree International is now part of the Malawi RAcE 2015 consortium led by Save the Children. Malawi RAcE 2015 aims to reduce under-five mortality by reaching 160,000 children between 2013 and 2015 in four different districts in Malawi (Ntichisi, Dedza, Ntcheu, and Mzimba North; D-Tree, 2014a).

The possible influence of this programme, as well as stakeholder interest in the programme, suggests that organizations regard the eCCM application as a worthy and worthwhile intervention.

eCCM Application: The Intervention

D-tree developed the eCCM tool for use by HSAs in Malawi for the care and treatment of acutely ill children under the age of five (D-Tree, 2014b). This tool is a mobile-based version of the previously paper based form, and I will refer to it as eCCM in this evaluation. The eCCM application follows the clinical protocol outlined by the Sick Child Form (see Appendix I), and helps HSAs with decision-making by providing a diagnosis and treatment based on the entered symptoms. This function of the application leads the HSA through a systematic checklist of possible symptoms that the child may have, after which the application suggests an appropriate diagnosis and treatment (see Figures 2, 3, 4, and 5 for a visual presentation of eCCM). Figure 2 shows the step-by-step procedure of entering the symptoms present, which then results in a diagnosis and treatment suggestion, as shown in Figure 3.

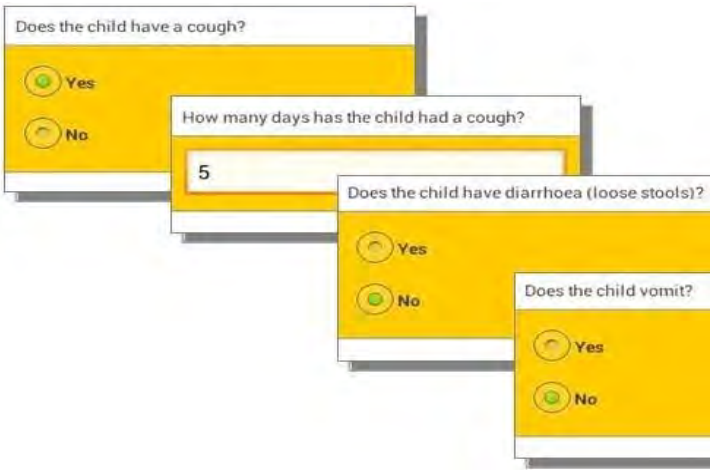


Figure 2. Step-by-step diagnostic procedure the HSAs undergo to make a diagnosis using eCCM.

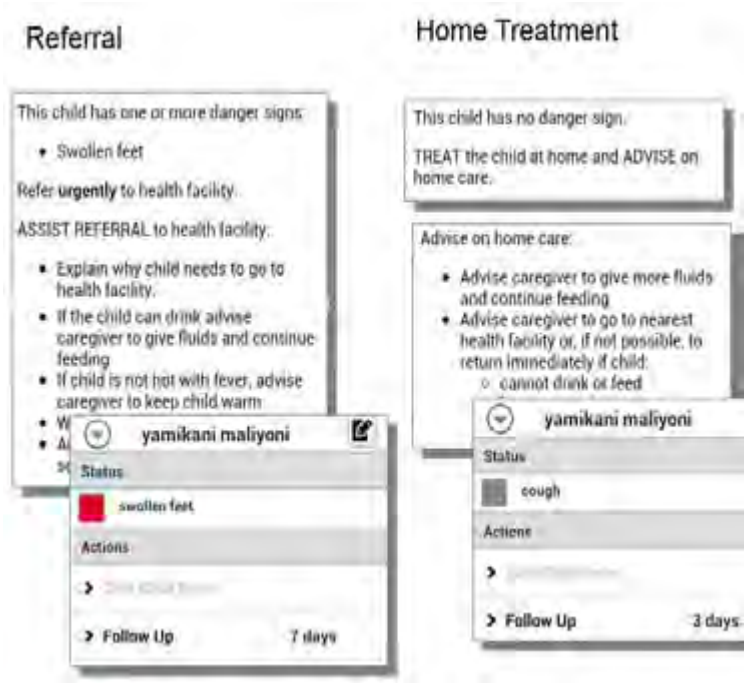


Figure 3. The diagnosis of the child will either suggest home treatment or refer the child to a medical facility if a danger sign is present. The application provides suggested steps the HSA must take as well as the reminder for follow-up (3 days after diagnosis).

eCCM was integrated with a logistics management tool, c-Stock, supported by John Snow Incorporated (JSI), and a supervisory tool supported by Save the Children (D-Tree, 2014b). The logistics management tool improves the availability of drugs for use by HSAs in rural areas. D-Tree integrated the logistics management tool into the eCCM application so that the stock order could be placed via the application rather than with a structured SMS (Figure 4).

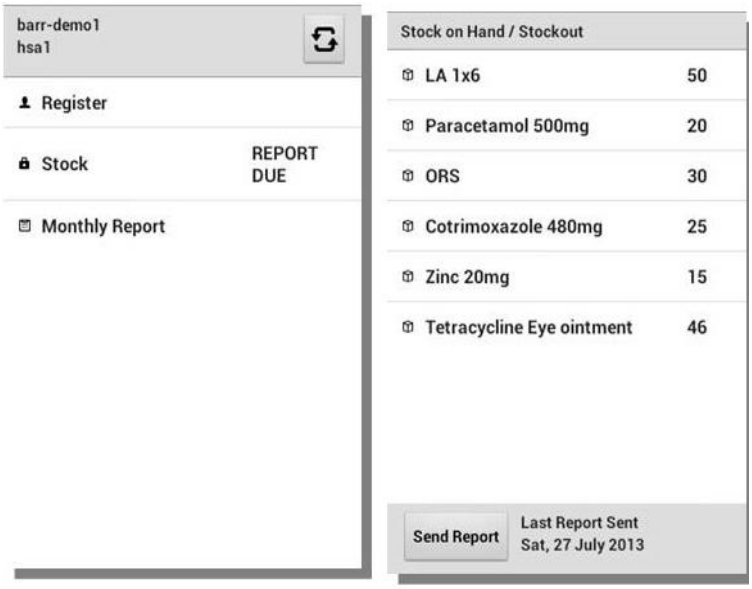


Figure 4. C-Stock overview. The c-Stock logistics overview maintains appropriate medicinal supply through HSAs' updates. Additionally, HSAs can use this screen to order new stock.

The supervisory tool is based on a checklist created by the MoH and Save the Children (see Appendix II). The supervision tool is comprised of a dashboard that captures data and provides primary data analysis. This enables supervisors to monitor the diagnosis and treatments made by the HSAs in the field. The supervision tool functions as a quality check for the work completed by HSAs, therefore assuring that the HSAs are adhering to the eCCM protocol (D-Tree, 2014a).

D-Tree has also created a patient record function for tracking patients' progress and other measures such as immunization status and weight (see Figure 5; D-Tree, 2014b). These patient records also provide the government with trend data for informed policy decisions.

Figure 5. Patient overview. This overview provides access to patient information and history, as well as vaccinations. The Sick Child Form opens a new case and will diagnose the child on symptoms.

In order to ensure that the entire application functions optimally, there are a number of different role-players involved. Each role-player provides a component needed to create the final android-based diagnostic tool.

eCCM as a collaboration between various role-players. D-Tree International works together with the Software Developers JSI, Save the Children, and the MoH to develop and support the eCCM application. eCCM, as a product of these role-players, is then presented to the HSAs in a training session organized by D-Tree Implementers, the respective SAFE project manager from Save the Children, and the IMCI Coordinator of the MoH of the respective district. The representatives from Save the Children and the IMCI Coordinator are present at the training to increase the capacity of the other role-players in the training of the application, as well as to assure quality of the programme. Additionally, these role-players represent their districts in terms of allocating resources for development of Malawi within the government and NGO sectors. Figure 6 shows the various role-players in the organization and shows how they interact to produce the eCCM application.

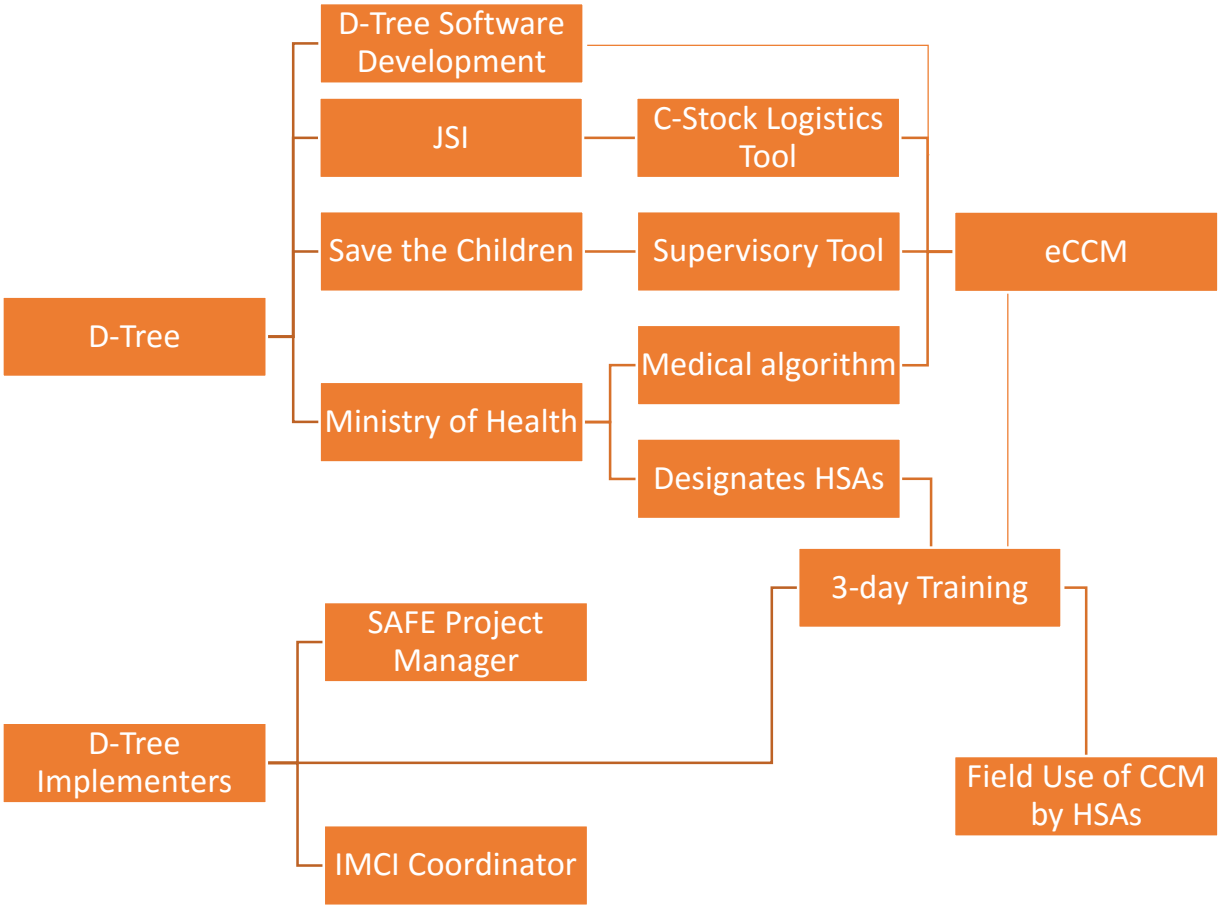


Figure 6. Services provided by eCCM role-players to facilitate the application.

The D-Tree intervention, as described in the 2014 Barr Evaluation Proposal, is supposed to lead to the following outcomes: (1) improved supervision of HSAs in the field, (2) accessible health records for HSAs, their supervisors and the MoH, (3) better follow-up for the patients by HSAs due to accessible health records, (4) improved drug availability, and (5) improved protocol adherence by HSAs. The goals that D-Tree hopes to achieve by creating these outcomes are consistent provision of quality healthcare, and solidifying the trust between the people and their healthcare system. The final impact D-Tree hopes to achieve is improved health outcomes (D-Tree, 2014b). I will discuss the details of the theory behind the eCCM intervention when I outline the logic model in Figure 10.

The most direct desired outcome is a decrease in incorrect diagnoses that may lead to child death (D-Tree, 2014b). Figure 7 represents the four main interventions of the eCCM application, which aim to address the gap in human capital created by the ecological context of Malawi's health infrastructure.

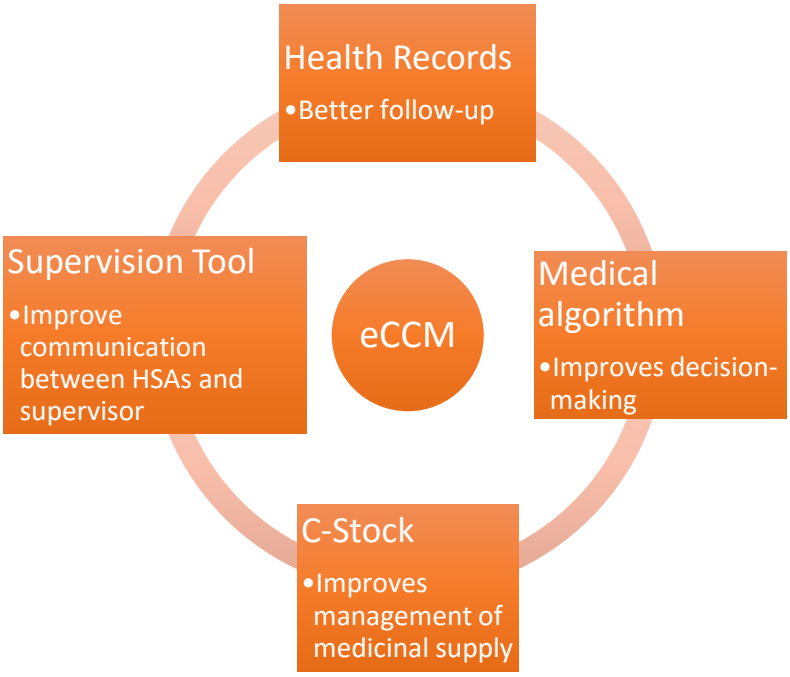


Figure 7. Activities of the eCCM application.

The eCCM service utilisation plan. The first step for D-Tree in determining a health need in Malawi is to determine a medical illness that requires attention; for this, the programme cooperated with the MoH. Once D-Tree and the MoH agreed upon a health need, D-Tree created the appropriate diagnostic tool, in this case eCCM, which they then ran as a pilot. Once D-Tree had sufficiently tested the application, they released it to the public. Figure 8 demonstrates the service utilisation of D-Tree's eCCM programme in collaboration with the MoH.

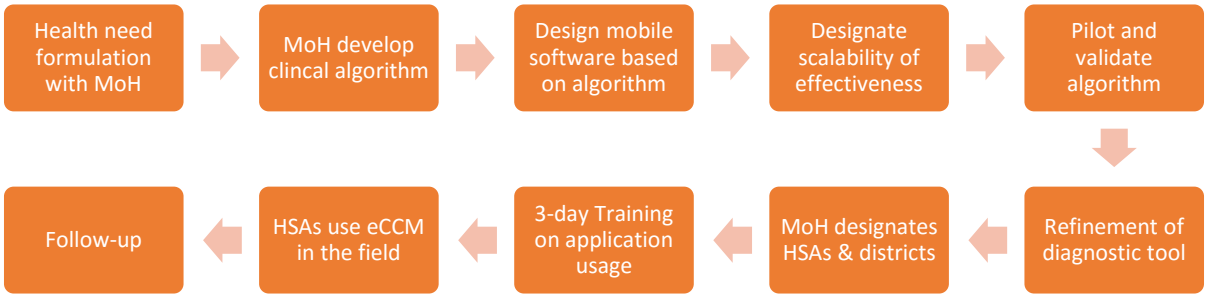


Figure 8. Service utilization plan of the eCCM programme (E. Safaro, personal communication, March 23, 2015)

The service utilization plan of the eCCM programme begins with the MoH formulating the health need, such as reducing the incident of child death by preventable illness, like fever. The MoH then creates a clinical algorithm that targets the health need. This breaks down into a summation of symptoms that lead to a diagnosis of a fever, as well as what treatment is suitable for the illness. D-Tree designs a version of the clinical algorithm on the android-based platform that replicates the process of the decision-tree equation. D-Tree then determines to what degree the mobile software-based algorithm is effective. Before implementation, the algorithm is tried, tested, and then refined. The MoH then determines the districts for implementation based on need and selects HSAs from these districts for the programme. D-Tree International implementers take the HSAs through a 3-day training course. After concluding their training, HSAs utilize the eCCM application in the field. D-Tree follows-up on the HSAs to determine if any problems have occurred post-implementation.

See Appendix III for the full programme plan for the period from 2014 to the end of 2016. The plan can be broken down into three primary components: increase coverage of eCCM, develop the support structures and tools needed by HSAs, and improve the capacity of the MoH.

Target population of the eCCM diagnostic tool. The primary beneficiaries of the programme are the 425 (136 in Ntchisi, 135 in Dedza, 45 in Mzimba, 79 in Ntcheu and around 30 in IMPACT districts) HSAs that are currently making use of the eCCM application, which provides support for their decisions in the field. The secondary beneficiaries are the children, who are potentially receiving improved quality healthcare from the 425 HSAs that are using eCCM.

Since eCCM implementation in 2013 until October 15th, 2015; HSAs have seen 158,861 children using the eCCM application for consultation. Districts like Ntichisi (89,964 children) and Dedza (54,125 children), which were the first districts to have full coverage of HSAs using the application, demonstrate the potential coverage of this application (D-Tree International, 2015).

Currently, D-Tree and the MoH have introduced the eCCM application to the following districts in Malawi: Lilongwe, Ntcheu, Zomba, Balaka, Machinga, Thyolo, Chikhwawa, Dedza, Ntchisi, Mzimba North, and Mulanje (see Figure 9). Under the USAID funded IMPACT programme, which introduced not only eCCM but also other programmes to these areas, the Catholic Relief Services distributed the application to HSAs via church catchment areas rather than medical facilities (D-Tree, 2014b).

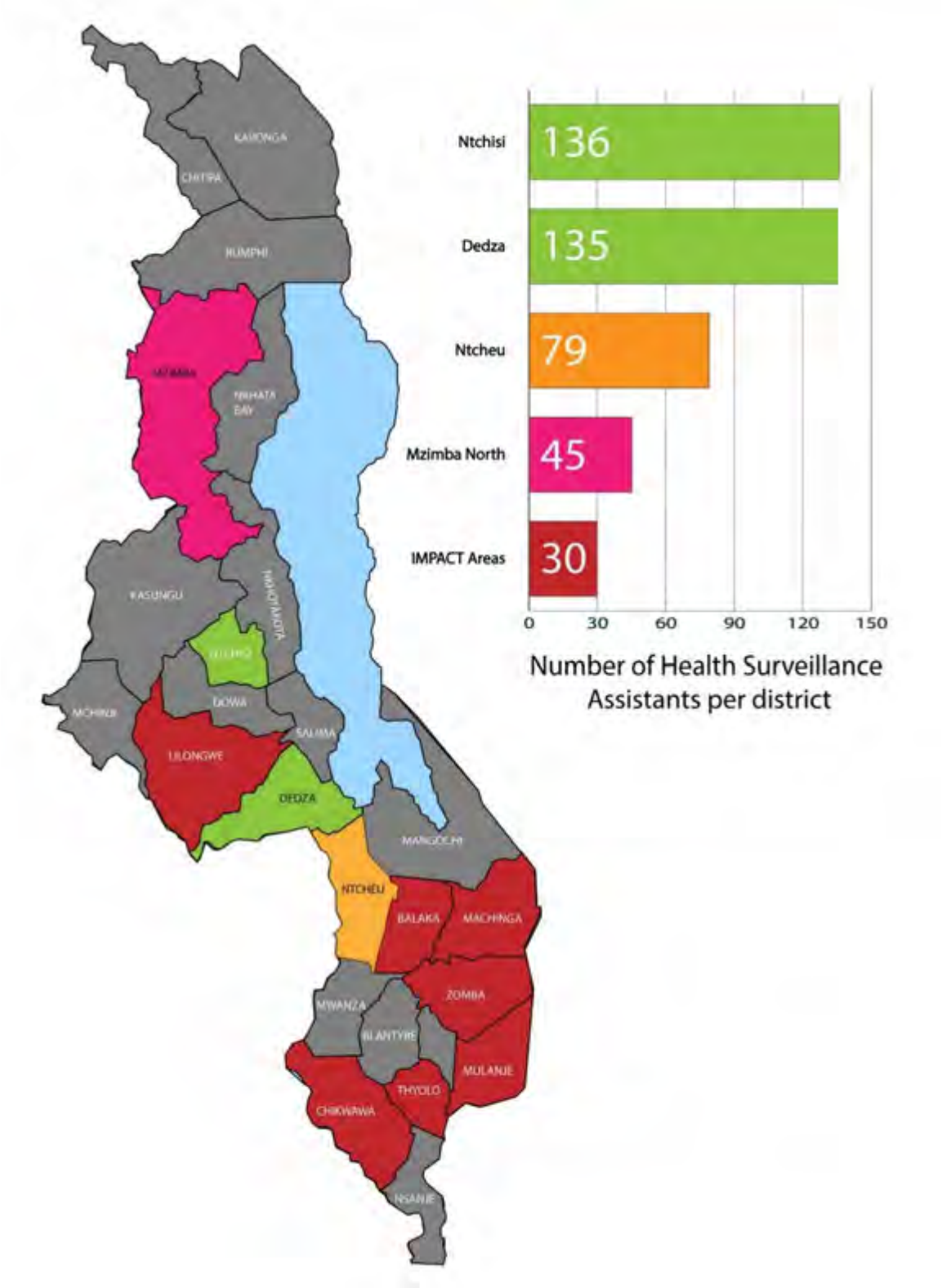


Figure 9. Map of Malawi with the districts where D-Tree and the MoH have introduced the eCCM highlighted.

Training of HSAs. An important part of the programme is to train the HSAs in the correct use of the application. See Appendix IV for a full outline of the training programme designed by D-Tree International for the HSAs.

The training programme provides information and practical experience on every component relevant to the application's use. On day 1, the HSAs learn how to operate the phone and download the application. Additionally, the HSAs learn about the eCCM application itself, including learning about its functions, like the Sick Child Form, follow-up, and reporting death or move away. On the second day, the HSAs register with c-Stock and get practical experience using the new interface. Furthermore, HSAs are shown how to handle basic technical support themselves. On the last day, the HSAs receive various text narratives with children presenting symptoms to practice using the application. Finally, HSAs receive their phones.

Budget. This eCCM programme has been possible through the annual support of the Barr Foundation, which has involved many other partners in Malawi including JSI, Save the Children, Johns Hopkins Program for International Education in Gynaecology and Obstetrics (Jhpiego), and the Meningitis Research Foundation. Although there are a number of organizations involved, they share a common goal: to reduce preventable maternal, infant, and child mortality in Malawi.

D-Tree international had an annual budget of US$1.6 million in 2014, and received grants and subcontracts from CDC, Pathfinder, PATH, CARE, CRS (private and USAID-funded), Bill & Melinda Gates Foundation, UN Foundation, Rockefeller Foundation, UNICEF, WHO, and others, in addition to the current grant from the Barr Foundation (D-Tree, 2014b). The 2015 budget was not available at the time that I requested it.

Programme Theory

A probable and workable model of how a programme should work is the key theoretical foundation. This provides a programme with fidelity (Bickman, 1987). A theoretical foundation supports the programme in that it provides a feasible reasoning as to why a type of intervention should bring about a certain kind of change. D-Tree provides innovative approaches to improving access and quality of healthcare in Malawi by means of delivering a decision-making tool to HSAs.

Figure 10 represents the logic model as outlined by the programme and as documented in the Grant Proposal for the Barr Foundation of 2014. This model shows a flow from the input or resources level, to the impact level. The input level is a compilation of the resources required

to implement the programme and the impact level is a long-term outcome representing the goal that the programme intends to achieve. D-Tree, at the input level, provides the hardware, software, and support structures necessary for the eCCM. This includes the provision of solar chargers for the Samsung Galaxy Y phones. The next step is there to clarify that the programme receives its participants from the MoH. At the activities level, the programme is only responsible for the training of the HSAs in the use of the application. However, D-Tree does provide technical support to HSAs if needed. After the training, the HSAs are then ready to use the eCCM application. The eCCM then leads to the following outputs, due the implementation of the application and through its various functions.

The main outputs of eCCM are therefore increased data usage (1.1), increased MoH capacity (1.2), a supervisory tool (1.3), and a logistics tool (1.4). The first three outputs contribute to the initial level outcome of improved supervision (2.1) of the HSAs by their respective supervisors. This in turn leads to improved protocol adherence (3.1), which leads to an increase in the quality of healthcare (4.1). The last output, the logistics tool (1.4), splits into a separate path and leads to improved drug availability (3.4) as an intermediate outcome. The availability of the medication should then reinforce trust in the healthcare system (4.2), as the healthcare system becomes better able to meet the medication needs of the districts.

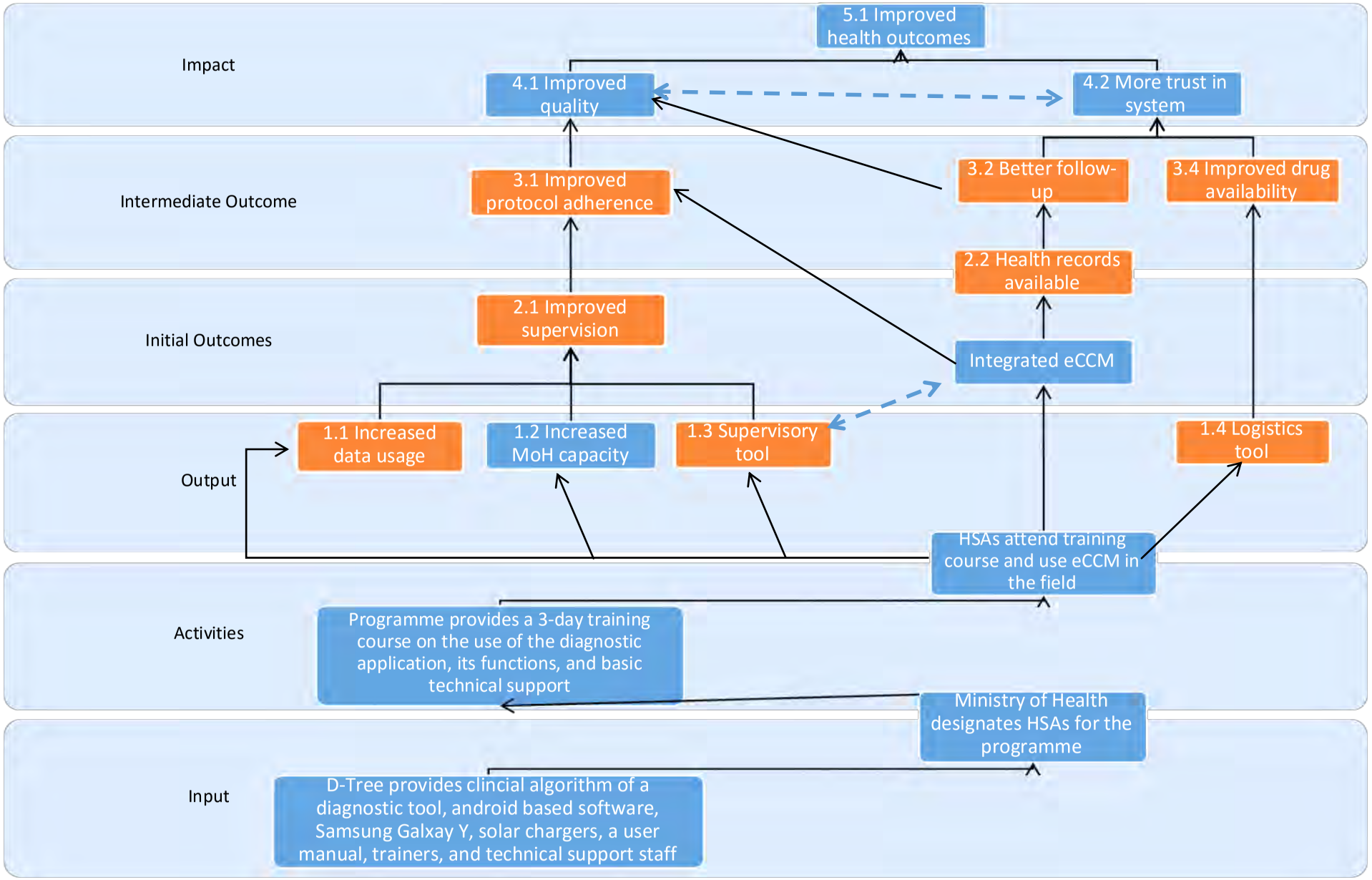


Figure 10. Logic Model of eCCM Programme as outlined by D-Tree International in their 2014 Barr Foundation Proposal.

The initial outcome of an integrated eCCM is currently in development as the supervision tool still functions separately from the eCCM application and is still in the process of integration. This integrated eCCM has two intermediate outcomes, firstly it supports protocol adherence (3.1) in that it will allow supervisors to more easily monitor the work of the HSAs. Secondly, this integrated eCCM will provide for the availability of health records (2.2). The availability of health records (2.2) will then enable better follow-up procedure (3.2) which will improve the quality of healthcare (4.1) and lead to beneficiaries placing more trust in the healthcare system.

Lastly, the improved quality of healthcare (4.1) and the increased trust in the healthcare system (4.2) will lead to improved health outcomes (5.1). The dashed line between the two distal outcomes indicates that there is a relationship between the two, in that each strengthens the other. Therefore, the quality of healthcare and the trust towards the healthcare system are not mutually exclusive. Similarly, there is a reinforcing relationship between the supervision tool and the integrated eCCM.

In order to understand this complex model fully, I would need to do comprehensive research into multiple domains, which would be not be feasible given the time constraints of this evaluation. Additionally, as the integrated eCCM was still in development during this evaluation, I could not evaluate this component of the programme. Therefore, I will focus specifically on the eCCM application and the feasibility and practicality of this mobile technology within the ecological context of Malawi. I have represented this by the orange highlighted blocks in Figure 10.

This chapter has described the D-Tree organization and its eCCM programme, as well as the programme theory. The next chapter will discuss the plausibility of the programme theory as outlined above, using Social Science knowledge and research.

CHAPTER II: Reflecting on the Plausibility of the eCCM Programme

Programme Plausibility

At the onset of this evaluation project, I researched decision-making applications as well as mobile tools to determine how such tools would work in low and middle income countries. As mentioned in the problem statement, I will examine two aspects of the eCCM application to determine the adequacy of the application. The first of these aspects is the medium of intervention, namely the mobile application, as a tool for HSAs. I will look specifically at the functions of the eCCM application as demonstrated in Figure 7. The eCCM application is an intervention that intends to bring about change in the current healthcare system by moving the assessment process onto a mobile platform. Therefore, the utility of a mobile platform is a quintessential foundation for the strength of the theory of change. The second aspect I will explore is the ecological context of Malawi. Specifically, I will present the outcomes of similar programmes and published articles.

The assessment of plausibility goes beyond assessing the adequacy of a programme by determining if confounding factors are contributing to the outcome of the programme. Therefore, the purpose of a plausibility assessment is to determine what effect the programme is generating when all other factors remain constant. Typically, an assessment of plausibility utilises a control group or a factor of time to regulate for confounding factors (Habicht, Victoria, & Vaughan, 1999). Constraints of this evaluation did not enable the use of a control group.

The eCCM programme is a plausible intervention with the aim of improving the functioning of HSAs in Malawi. The plausibility in Malawi, however, is constrained to the involvement of an external organization that can monitor and manage the support functions needed by the application. The most evident future concern in respect of achieving the impacts for the programme will be if the MoH in Malawi takes ultimate control of and accountability for the programme in Malawi. The costs and support functions are still running through D-Tree and a change in management could be detrimental to the success of the programme (D-Tree, 2014). This evaluation intends to determine the functionality and practicality of the eCCM application.

The utility of mobile applications. Gabriel (2004, as cited in Basole, 2005, p. 1935) found that mobile applications could improve “operational performance, asset utilization, sales effectiveness, and customer service”, while also providing “faster access to critical data at the

point of work, accelerated communications, and improved decision-making." Malawi's health sector infrastructure lacks resources for information accessibility and sharing. The rationale for the technological innovation is therefore plausible, as long as an external body monitors and maintains the programme until the MoH has the capacity to take over the programme.

Decision-tree improvement. The main benefit of the eCCM application, but also one of its drawbacks, is the removal of the subjective element in a diagnosis. The high error rates in diagnosis are often associated with fatigue, incompetence, and lack of training (Azar & El-Metwally, 2013). To remove the subjective error rate, HSAs can use decision-making tools to complement a diagnosis and add precision. These tools make use of a data mining technique, which detects patterns and relationships between an extensive number of variables, compares these patterns to pre-existing data, and predicts disease outcomes (Azar & El-Metwally, 2013). A decision-making tool of this nature is aptly called a decision-tree. Haffey, Brady, and Maxwell (2014) found a decision-tree application could be particularly beneficial for junior doctors that are responsible for most prescriptions and feel unprepared for this responsibility. The application would provide reassurance and decrease the error rate for wrongful prescriptions. Research estimates that this error rate is approximately 10% (Haffey et al., 2014).

The decision-tree improves the healthcare system by improving diagnostic accuracy. A well-programmed decision-tree can be especially beneficial in situations where medical professionals need to consider complex situations with fine lines between outcome decisions. For instance, in terms of following the protocol of eCCM, a child must have had diarrhoea for 14 days or more for the health professional to give a referral. However, without the strict guidelines of the eCCM application, an HSA may send the patient for referral before this cut-off at his/her own discretion.

Azar and El-Metwally (2013) investigated the accuracy, specificity, and sensitivity of decision-tree algorithms. They analysed, the single decision tree (SDT), boosted decision-tree (BDT) and decision-tree forest (DTF). Their results showed that the BDT performed better than the SDT on all counts: accuracy (SDT = 97.01%; BDT = 98.83%), sensitivity (SDT = 96.62%; BDT = 98.42%), and specificity (SDT = 97.91; BDT = 99.58%) in the testing phase. The validation phase showed that the DTF (97.51%) performed the best in terms of these three variables in comparison to the SDT (95.75%) and BDT (97.07%). It is important to note that all three decision-tree methods have high accuracy, specificity, and sensitivity.

Azar and El-Metwally (2013) also noted that SDT and BDT fall short of DTF because of a high variance. The SDT method can lead to adverse results if the health professional makes an input mistake during the first few entries. This error can lead to a false diagnosis branch due

to the hierarchical nature of the SDT. The DTF can better cope with this problem, as it contains multiple classification methods for one classifier. This type of algorithm can therefore greatly increase the accuracy of a diagnosis and reduce human error. I have relied heavily on the study done by Azar and El-Metwally (2013) in this section, because there is a limited amount of published literature comparing the accuracy, specificity, and sensitivity of decision-tree methods.

A study of nurses found that 16% admitted they would have made a mistake in their clinical treatment if they had not used mobile equipment (West, 2012). Not only does this add to the process theory, but it is also the foundation for the causal mechanism in terms of impact theory.

Florez-Arango, Dunn, Iyengar, and Zhang (2011) evaluated protocol compliance and error rates of an mHealth application comparing a control and treatment group of healthcare workers (n = 1394). They found that the mHealth application increased adherence to the protocol by 30.18%, and reduced error rates by 33.15%. Similarly, DeRenzi et al. (2008) investigated the electronic Integrated Management of Childhood Illness (e-IMCI) protocols, which, like the eCCM, uses a step-by-step approach to lead the health worker to the correct treatment. The authors found that when using the e-IMCI programme, the healthcare workers adhered to the required IMCI examinations more than with previous practices, which increased adherence from 61% to 84.7%.

Logistics, supervision, and accessibility as mediums for quality healthcare. In this section I will discuss the logistics tool, supervision tool, and health records function in relation to the availability and accessibility thereof. The basic claim is that these tools will improve healthcare; however, the success of these tools is intrinsically linked to the success of mobile health. Providing accessible health records seems to be the simplest way to improve healthcare, but most under-resourced countries are still constrained, using paper-filing systems and usually only having access to an electronic database at healthcare facilities. HSAs, however, do not work near healthcare facilities, but rather in the secluded villages, and therefore do not have access to the electronic databases.

Johnston and Bowen (2005), in a review of electronic records management, found that there is no clear-cut method to solve information management problems. However, they found that there are real benefits and possibilities for return on capital for investing in improving information management. A Kenyan study on antiretroviral treatment found that the implementation of a mobile records system reduced the average time it took to deliver reports to KEMSA from eight hours to five minutes. This was in part because healthcare professionals

were completing 70% of reports only when healthcare facilities were dispensing the antiretroviral drugs (West, 2012).

Braun, Catalani, Wimbush, and Israelski (2013) found that the most common improvement caused by mHealth was in terms of process improvement. The mHeatlh services used by HSAs demonstrated less data loss (Tomlinson et al., 2009) and had fewer errors (Bernabe-Oritz et al., 2008). The move to mobile-based healthcare thus improves three elements of concern for HSAs, namely time, cost, and accuracy. There is no longer a need to meet face-to-face with your supervisor to show the supervisor your patient's records and get feedback. Neither is it necessary to take the reports to the nearest medical facility to process the claims for the medical supply agency.

A review by Braun et al., (2013) demonstrated that mobile tools could increase the capacity for programme monitoring, increase the efficiency of services, as well as improve on the quality of healthcare that community healthcare workers provided. For instance, an evaluation of the performance of 75 HSAs in Malawi over a 6-month period determined that FrontlineSMS reduced the cost of operations by $2,750 and reduced the hours the HSAs worked by 2,048. This meant that the FrontlineSMS method enabled each HSA to see twice the amount of patients.

A study by White and Winstanley (2010) focused on the difference that supervision can make on patient outcomes. The authors investigated the positive relationship between supervision, quality healthcare, and patient outcomes, specifically looking at patient satisfaction levels in terms of their overall care. Importantly, the eCCM intervention targets the same two goals of improving supervision and circumventing the lack of training HSAs have to improve patient outcomes. White and Winstanley (2010) did not find a positive relationship between these variables, except in one private hospital. Fenton, Jerant, Bertakis, and Franks, (2012) did find a positive relationship between patient satisfaction and both increased quality healthcare and drug expenditures. The literature therefore substantiates the eCCM application's approaches to improving quality healthcare.

The ecological context of Malawi influencing mobile integration. After considering the utility of a mobile platform, the second aspect pivotal to the success of the eCCM application is the ecological enablers and barriers for the implementation and the success of eCCM. Before discussing this in more detail, I will outline a few barriers faced by D-Tree in terms of implementation of eCCM that are specifically related to the programme. D-Tree International highlighted these barriers in their Grant Proposal for the Barr Foundation (D-

Tree, 2014a). The first barrier is at the district level. The programme's various funders have prioritised certain districts, which means a few districts like Ntchisi, Dedza, and Ntcheu have a significant number of HSAs using eCCM, while other districts have just a few. The programme would need to address this disparity. Secondly, although the MoH is supportive of the programme, the MoH currently still lacks the capacity to take over the programme. Specifically, they lack the technological expertise to maintain the program on a day-to-day basis. The last obstacle is the possibility of overworking the HSAs, as there is an increased demand for HSAs to cover more health services. Currently, for instance, the HSAs are required to complete both the Sick Child Form and the paper-based version, which only expends more time. The ecological context of Malawi further compounds these specific problems for D-Tree.

Barriers for eCCM efficacy. The first barrier that prevents the sharing and access to health information is that information dissemination is slow-paced and HSAs usually prefer oral methods of communication (LeMay & Bocock, 2012). Information passed on via radio, face-to-face meetings, and mobile phone calls leaves the HSAs with little reference material to look back to (LeMay & Bocock, 2012). The eCCM application can circumvent some of these dissemination difficulties by updating health information straight to the phones. The phones themselves also provide a means of communication.

Health staff, even those in rural areas, have mobile phones; however, the cost of airtime and network reliability issues hinder the use of mobile phones as a means of dissemination of health information (Mechael, et al. 2010). A further problem for dissemination is the integration of the data retrieved from the mobile phones with the health sector data banks. The data rights would be in question and thus the parties that have access to the data may not be the ones that need it the most (Mechael, et al. 2010)

Although the introduction of the eCCM application would save on a multitude of other costs (e.g., paper, meetings, and well-being of patients), the original implementation is costly and the maintenance costs of the phones can be expensive. A further cost would be the need for solar panelled charging devices for the phones, as many rural areas have no access to electricity (Barteit et al., 2015).

The sustainability of eCCM is problematic, as Malawi currently does not have the capacity in its healthcare system to manage and maintain such a programme (LeMay & Bocock, 2012; Mechael, et al. 2010). The only possibility for the continued implementation of a diagnostic tool would lie in the collaboration with an organization that has the capacity to maintain, manage, and update the protocols. Ngabo et al. (2012) found that the replacement and maintenance of the phones used for their innovative SMS-based alert system was one of

their major challenges. If managing organizations do not continually maintain the eCCM tool and test it for reliability, it could adversely lead HSAs to make false diagnoses and further damage the healthcare system of this under-resourced country.

Enablers for eCCM efficacy. The enablers for the use of mobile phones to disseminate information are that they are widely used and fairly stable Internet connections are available in Malawi (LeMay & Bocock, 2012). Moreover, the mobile decision-making tool is useful in its ability to complement the diagnostic process and educate HSAs in the process of diagnosing patients (Barteit et al., 2015). The mobility, flexibility, and dissemination capabilities of mobile devices make them suitable for HSAs located in rural settings with little means for receiving updated health information. A diagnostic protocol with real-time updates could drastically enhance the quality of healthcare the HSAs are able to provide. Furthermore, the tool can alleviate the human error in healthcare, and provide a diagnosis based on pre-existing data.

The tool could enable the possibility of collecting demographic and health data that the MoH could then use to explore trends within the population (Barteit et al., 2015). These trends may aid in the further development of the diagnostic tool. The tool can also use a feedback system to provide communication between the HSAs and their supervisors. An example would be the feedback system used by the non-profit organization, JSI, which developed a drugs logistics application that allowed for improved drug availability. This application has made great strides to improve the monitoring of drug availability at the community level (Barteit et al., 2015). The impact of this tool would be derived from alleviating the severe stock-outs of essential medicines. In 2012 an Oxfam study found that only 54 of 585 had all the essential drugs listed in the Essential Health Package. Mueller, Lungu, Acharya, and Palmer (2011) based on report by the health facility mangers of Malawi concluded that: 60% considered their facility to have insufficient stock of cotrimoxazole (used to treat infections), 13 % were out of stock, and only 27% reported they had sufficient stock.

Ngabo et al. (2012) implemented an SMS-based alert system (RapidSMS-MCH) that aimed to improve maternal and child health in Rwanda. The authors noted a 27% increase in births that were facility-based from the start to the end of the one-year pilot study. The authors attributed much of the success of their programme to the commitment of the community health workers and the organizational skills of the district health team. A critical enabler for the pilot study was therefore a well-organized community health structure, as well as a high commitment level from the various stakeholders, especially considering the low-resource setting of the programme.

The social science literature largely supports moving from the paper-based CCM to a mobile platform. However, there does seem to be an ecological constraint placed on the efficacy of the eCCM application.

Chapter III: Method of the Evaluation

Design

This evaluation followed a three-tiered approach to answering the evaluation questions. The first tier involves observational data that I collected in Malawi. The second tier of the evaluation involves a post-test single group design, in the form of a questionnaire. The third tier involves secondary data that D-Tree collected via their Management Information System (MIS). The data that I analysed pertained to the Ntchisi district as it is was the first location to have full coverage. That is, all HSAs in the Ntchisi district used the eCCM application. It was necessary to look at data collected in a district with full coverage, because it was essential for the HSAs to have a level of familiarity with eCCM.

Observational data. I gathered observational data during a research trip to Malawi in July 2015. I collected the observational data during a 3-day training programme held in Ntcheu by D-Tree International from 15 to 17 July 2015. I paid particular attention to how the training was conducted, by whom it was conducted, and in what format it took place. This observational information was useful to understand the ecological context of the eCCM programme better. It is important to note that I made these observations in Ntcheu, thus they may not generalise to the district of Ntchisi. However, my primary focus for this observational data was to glean an understanding of the eCCM application in general. Thus, observing the ecological context of the district was not as important as observing the context of the training programme.

Secondary data. The online Zenji Dashboard captured the data in real-time and performed some preliminary demographic analyses. The data available on the dashboard was descriptive, in that the dashboard only captured data for monitoring the eCCM application.

Questionnaire data. I used a post-test single group design to gather data on the HSAs' perspectives on the eCCM application's efficacy and efficiency. Firstly, this method was useful in providing some qualitative support for the descriptions and relationships found from the secondary data. Secondly, the focus was on the initial outcomes to which the HSAs could provide feedback, as the project has not been running long enough for the programme to show distal outcome effects. The unit of analysis was at the district level.

Data Providers

I gathered data from multiple sources, as shown in Table 1. I broke down the secondary data from the Zenji dashboard into a sub-sample, which I then used to determine the accuracy of diagnosis and treatment, as well as adherence to the eCCM application. A sub-sample was necessary due to the quantity of data points and the time constraints of cleaning data. I used the population samples for the death, follow-up, and referral reports as this data provides an overview of the demographic trends of the district.

Additionally, I collected data from the HSAs on their perspective of the eCCM application. I collected this data using a questionnaire that used purposive sampling to include all HSAs of the Ntchisi district. Districts may have varied in ecological context, which could have proven difficult to analyse with a small sample. Men dominate the HSA population in Ntchisi.

Table 1. *The breakdown of data providers*.

Data provider	Medium	Aim
Sub-sample of the every 25th Ntchisi district patient (n = 2,461)	Zenji dashboard: -eCCM Ntchisi database report	Determine accuracy of diagnosis and treatment
Population sample of Ntchisi district patients (n = 93,805)	Zenji Dashboard: -Death report -Follow-up report -Referrals	Demographic description of the Ntchisi district
HSAs from the Ntchisi district (n = 50)	Questionnaire	HSA perspective on the utility, mobility, and sustainability of the eCCM application

Measures

Secondary data. The measure for the secondary data was the eCCM application itself. I used the programme records of the MIS to evaluate the tool. The programme collects data each time the HSAs use the eCCM application to diagnose a child. MIS can be used to answer

questions on demographics, drug availability and accessibility, health records, follow-up procedures, reason for attrition from the programme, and supervision.

Questionnaire data. The second measure was a paper-based questionnaire that I developed (see Appendix V). I used this questionnaire to ask the HSAs about their experience using the eCCM application in comparison to the previous paper-based CCM. I made two changes to the questionnaire upon discussion with the programme staff during the research trip in July 2015. Firstly, the original questionnaire did not explicitly distinguish between the mobile eCCM and the paper-based CCM. Additionally, the chat function described in the D-Tree documents provided was not yet active and the HSAs were using WhatsApp instead. I applied these changes. I then handed the questionnaires over to programme staff for dissemination in the Ntchisi district, which occurred in August 2015. I received the questionnaires back from D-Tree via DHL postage on 5 October 2015.

The main topics of the questionnaire focused on: mobility, flexibility, dissemination, utility, and sustainability of the eCCM application. In terms of mobility, the questionnaire asked how mobile the application is and what factors may constrain its mobility. Flexibility questions focused on how user-friendly the eCCM is and if its functions have a variety of different uses. Dissemination questions targeted the supervisor/HSA relationship in terms of ease of communication and time of feedback. Utility indicated whether eCCM had made the work of the HSAs easier and given them reassurance in their assessment. Lastly, sustainability questions targeted the HSAs' beliefs on adhering to the application usage and diagnostic suggestions.

I used a 5-point Likert scale for questions 1 to 34. The Likert scale measured the HSAs' agreement with the question ranging from 1-5 (Strongly Disagree = 1, Disagree = 2, Not sure = 3, Agree = 4, Strongly Disagree = 5). Questions 35 and 36 were ordinal-polytomous questions that provided ranges to determine the amount of exposure the HSAs had with the mobile versus paper-based method of CCM. Question 37, 38, and 39 were nominal-polytomous questions that permitted more than one answer.

Table 2 provides a breakdown of which measures answered which evaluation question. The measures have several indicators that I used to answer the respective evaluation questions.

1. The first evaluation question made use of the death file available on the Zenji dashboard to determine incidence of child death as well as important factors like location and cause. Additionally, I used the sub-sample to demonstrate the accuracy of the eCCM diagnosis and treatment. I used the follow-up file as a proxy for

children's wellbeing after treatment. Lastly, I used HSAs' responses that focused on diagnosis, treatment, and care to give further credibility to the secondary data.

2. The second evaluation question focused on the benefit of the c-Stock integration. For this question, the sub-sample demonstrated the doses provided by the HSAs and the possible shortfalls of stock. The HSAs also reported on how they felt about c-Stock within the eCCM application.
3. The third evaluation question looked at the MIS system more holistically to determine how the system can influence follow-ups of HSAs. I used the number of children seen and referral files to describe how the data may benefit HSAs. I did this by reviewing the captured data on the MIS and examining how it could aid the HSAs. Lastly, I used the more direct interactional experience of the HSAs to determine if their follow-ups had benefitted from eCCM.
4. The fourth evaluation question utilized the sub-sample data to determine protocol adherence. Additionally, the HSAs reported on several questions that related to protocol adherence.
5. The fifth evaluation question used the sub-sample data to determine how well the HSAs were performing through child health outcomes and referrals. The HSAs reported on the utility, mobility, and flexibility of the medium.
6. The sixth evaluation question utilized reports of the HSAs to determine improvements in communication between supervisors and HSAs.

Table 2. *An overview of the pertinent data to answer the specific evaluation questions.*

Evaluation question	Measure			Indicator
	Sub-sample	Zenji dashboard	Questionnaire	
1. Has the use of eCCM reduced the incidence of incorrect diagnosis of child illness under the age of five?	-eCCM data file	-Death report file -Children seen report	19, 20,21, & 29	-Confidence, accuracy, learning effects, better care, correct diagnosis, correct treatment, incidence of death
2. Has the integration of c-Stock into eCCM been beneficial for HSAs?	-eCCM data file		1, 18, 23	-Availability, missing stock, and easier to use
3. Has the use of Monitoring Information Systems improved the accessibility and utility of health records? Does this, in turn, mean that HSAs were able to provide a better follow-up?		-Non-referral report -Referral report -Children seen	2,3,4,5, 6, 32	-Accessibility, utility, coverage, usage, ease of follow-ups
4. Has the eCCM application increased the protocol adherence of HSAs?	-eCCM data file		7,8,9,10,12,14,33	-Diagnosis/treatment adherence, eCCM vs. experience,
5. To what extent has the use of the application improved the efficacy of HSAs work? How does this improvement manifest itself, or fall short of such improvement?	-eCCM data file		16,17, 26, 28, 29,30, 31, 36, 38	-Easier, faster, medicinal availability, better care, health records
6. Has the application been useful for the interaction between supervisor and HSA?			15, 22, 28, 34	-Frequency of communication, medium, travel, feedback

Procedures

Observational data. Involved parties were in the United States and Malawi in this multi-country intervention. I, the evaluator, am based in South Africa and I had access to the data located on an online database. To engage with the programme I used electronic data provided by D-Tree International. The Director of D-Tree in Malawi and the Project Manager provided additional clarity through a number of Skype sessions and e-mail communications.

In order to collect observational data, I took a research trip to Malawi from 10 to 19 July 2015. During this time, I visited the programme's offices and programme sites.

Five pertinent observations made during the research trip:

1. The HSAs are currently required to use both the paper-based and the eCCM application. eCCM is used after the paper-based version.
2. D-Tree staff led the training sessions. However, both the districts IMCI Coordinator representing the MoH and the SAFE Project Manager representing the interests of the NGOs were present and involved in the training of the HSAs. The research trip helped to provide clarity on the extent to which these outside organizations are involved in the eCCM programme.
3. D-Tree staff hold the training sessions in the most common native language, Chichewa. D-Tree staff only speak English when referring to the phone or the application.
4. Some HSAs were visibly struggling with the training. It took HSAs surprisingly long to adjust to the software, despite the fact that it is based on a protocol that the HSAs all know.
5. A fault on the software can be detrimental. D-Tree staff discovered a software issue during the training, which was problematic, as the HSAs need to take their phones with them the next day. The software designer needed to fix the technical fault. However, the software designer lives in Germany, which further compounded the problem. The technical fault was fixed, but at the expense of extra time and additional costs to the programme.

Although the 9-day trip to Malawi only allowed for 5 days of exposure to the programme and there was not enough time to get a full understanding of the programme, it did decrease misunderstandings that may have made this evaluation less useful for the programme staff.

Secondary data. To obtain the data from the Zenji dashboard, I performed a series of downloads. The data was fairly difficult to access at times. The two determinable reasons that prevented access to the data were that either the server was down or the data file was too large and the server timed out before the download was complete. I downloaded the required data on 13 July 2015. This first download indicated which data I could use for the final analyses. I performed a more recent download on 5 November 2015. The downloads were specific to the Ntchisi district. I downloaded data files as excel files and then exported them to Statistical Package for the Social Sciences (SPSS), version 22.0, as required. The Director in Malawi provided two large data files which featured the death and follow-up reports.

I downloaded the eCCM file on a monthly basis. A single download of data from the past three years was not possible due to the size of the file. I cleaned the data by matching the months between August 2014 and August 2015 to the variables that were represented in the most recent month of October 2015. The variables seemed to change over time with the development of the application and only the most consistent variables were retained (See Appendix VI). The data sample was limited to date back only to August 2014 as the malaria rapid diagnostic test (mRDT) variable and the child status variables were not included before this date.

Questionnaire data. I asked the D-Tree implementers to distribute the questionnaire to the Ntchisi medical facility. This was the most practical choice for quickly distributing the questionnaires to a spread-out sample. The D-Tree implementers then asked the staff of the Ntchisi medical facility to hand the questionnaire out to the HSAs upon their monthly return to the district facility. Data collection of questionnaire data began after I had returned to South Africa. I captured this data into SPSS.

Ethics

The Commerce Faculty Ethics in Research Committee at the University of Cape Town granted ethical clearance for this evaluation. I consulted the programme director of Malawi and his team in the development of the evaluation questions. Through their input, the formative evaluation was better able to assist them in future planning efforts as well as give them an impression of their proximal outcomes. The questionnaire data for the post-test design required a cover letter (See Appendix VII). The cover letter informed the participants of the research's purpose, that participation was voluntary, and that the questionnaire was anonymous.

Data Analysis

Observational data. I recorded observations made during the research trip in Malawi as notes. Issues discussed with the team in Malawi were then discussed with the academic supervisor on return. Observations and discussion helped contextualize the results found in the other two tiers of data analysis.

Referral accuracy. I carried out the statistical analyses with the SPSS package. I based the primary analysis on a sub-sample of the Ntchisi district patients to assess the accuracy and specificity of the application. This analysis focussed on the procedure of the eCCM application to verify protocol adherence. For example, if a danger sign was determined to be present in the child's symptomology then the HSA should have referred the child to a healthcare facility. Additionally, for that specific danger sign, the child should receive the appropriate initial treatment. Similarly, if there was no danger sign but the child was ill, home treatment should have occurred. This establishes a symptom, diagnosis, and treatment causal chain. The analysis can then determine at what stage this causal chain was broken and for what reason. For instance, the correct medicine may not have been available.

I analysed the sub-sample using frequency counts of two different protocol checks. Firstly, I recreated the protocol of the CCM Sick Child Form to verify that the HSAs followed the correct protocol for referral. To establish this, I matched variables that indicated that the HSA should have referred the patient with instances that the system captured referral of patients. Referral was meant to occur when danger signs were present, medicine was not available, and in the case that an illness or symptom was present that the HSAs could not treat. Appendix VIII holds the details of the 'if, then' statements used to confirm protocol. Below I have given an example of 'if, then' statements:

- If the child has diarrhoea for more than 14 days, then the HSA refers the child.
- If the child has diarrhoea for less than 14 days, then the child receives home treatment.

Treatment accuracy. I used a similar method to confirm that the correct treatment was given, based on the symptoms of diarrhoea as a case example. The protocol-based treatment of diarrhoea is zinc supplements and oral rehydrate salt (ors) solution. I performed this analysis by creating split-files in SPSS based on referral or home treatment of patients. I also split the

sample by the appropriate age groups. I used the frequency of drug dosage as well as the strength of dosage to determine whether the HSAs gave the correct dosage as stipulated in the protocol. If the HSA did not adhere to the treatment protocol, I was able to see how their treatment recommendations differed from the protocol.

Incidence of death. I used the complete population data of the Ntchisi district from 2013 to 2015 to determine the incidence of child death. This is important because a key aim of the eCCM application is to reduce the incidence of death by preventable diseases. I used the follow-up by HSAs as a proxy to inform the incidence of death. The follow-up determines how well the child is doing after treatment. Therefore, the well-being of the child at the time of follow-up is a reflection of the child's likelihood of dying after treatment. Although these data are only proxies for child death actually occurring due to the illness, these proxies may help determine if the success rate of eCCM correlates to a decreasing incidence of child death. This assumption holds because an improvement of healthcare is likely the underlying cause of decreasing child mortality.

MIS descriptive data. A descriptive analysis of the data available on the Zenji dashboard was used to show trends in medication usage and the type of illness. I then used this data to assess the efficacy of the logistics tool in terms of making stock available. Firstly, I used the non-referral report to show trends in illness as well as the most common types of illness that need attention. Secondly, in the same respect, the referral report provided similar information. This report also ascertained in what areas HSAs might require additional training. Additionally, the report indicated how the eCCM application can be improved to increase capacity to no longer have these types of referrals. Lastly, I compared the active HSA report for Ntchisi to the number of children seen a month to determine, on average, how many children can be seen with the number of active HSAs. I drew a further comparison between number of patients seen each month for the Ntchisi district and the number of follow-ups that occurred. This can show the increase in coverage and how well the programme is doing in meeting the needs of the population of the catchment area.

Questionnaire data. I analysed the HSAs' perceptions to strengthen the claims of the descriptive data. I analysed the questionnaire with frequency counts towards the questions in the questionnaire. These results give an indication of the efficacy of the eCCM tool.

CHAPTER IV: Findings of the Evaluation

Results

The results section is broken down into three parts to answer the evaluation questions. I have structured this section around the type of data rather than the evaluation questions, as some of the data provide results for more than one evaluation question. Thus, I will use the number of the evaluation question/s as an indicator of which question/s each analysis answers (refer to page 8). The first section demonstrates the overview data from the Zenji dashboard (Q1 & Q3). The second section analyses the eCCM data collected from the sub-sample to determine protocol adherence and medicine availability (Q1, Q2, & Q4). The last section delves into the questionnaire data (Q1-Q6). This analysis presents the results of the data on perceptions of the HSAs about the eCCM application, which compliments the data found in the previous two sections.

Section 1 - Description of the available monitoring data from the Ntchisi district. The purpose of this section is to demonstrate the type of data that is available on the Zenji dashboard. This section mainly provides an overview of how the eCCM programme is performing through D-Tree International's MIS. Therefore, this data will demonstrate the strengths and gaps in the MIS (Q1 & Q3).

Coverage and accessibility (Q1 & Q3). The following data are a composition of the Zenji dashboard data. These data are a representation of the monitoring data of all eCCM variables. From July 2013 until the end of October 2015, HSAs using the eCCM programme have seen 93,805 children. In July 2013, three medical facilities started with the programme (Chinthembwe, Malomo, and Mkhuzi). By the end of the year, another two catchment areas started to use the programme (see Figure 11). The programme was not yet rolled out to the remaining districts.

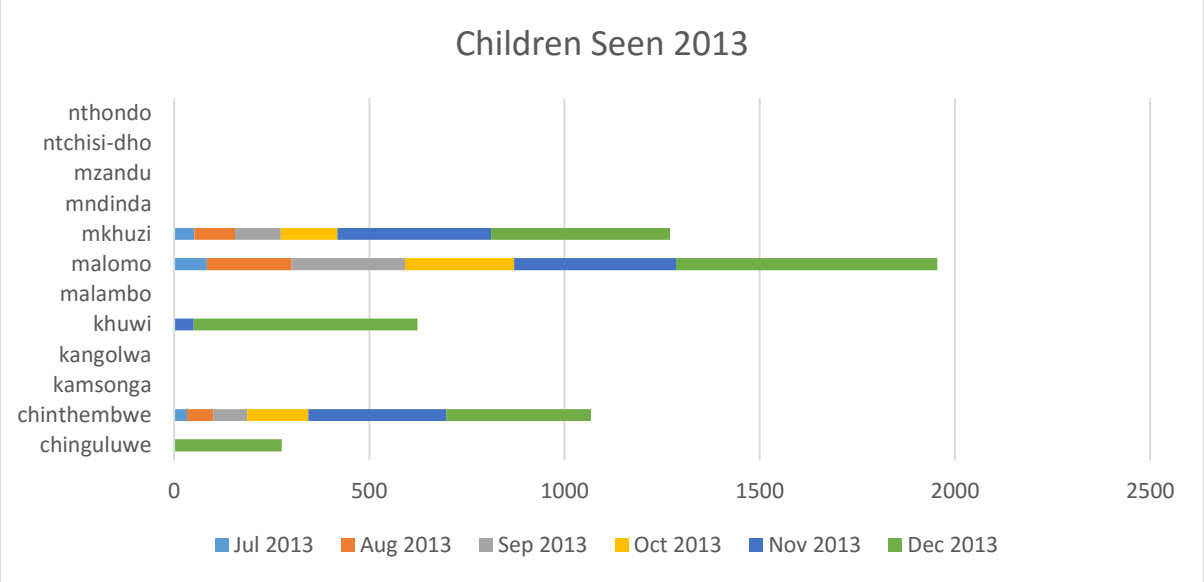


Figure 11. Stacked bar graph of children who visited HSAs for a consultation in 2013.

By May 2014, every medical facility in Ntchisi had their HSAs trained in using the eCCM application (Figure 12).

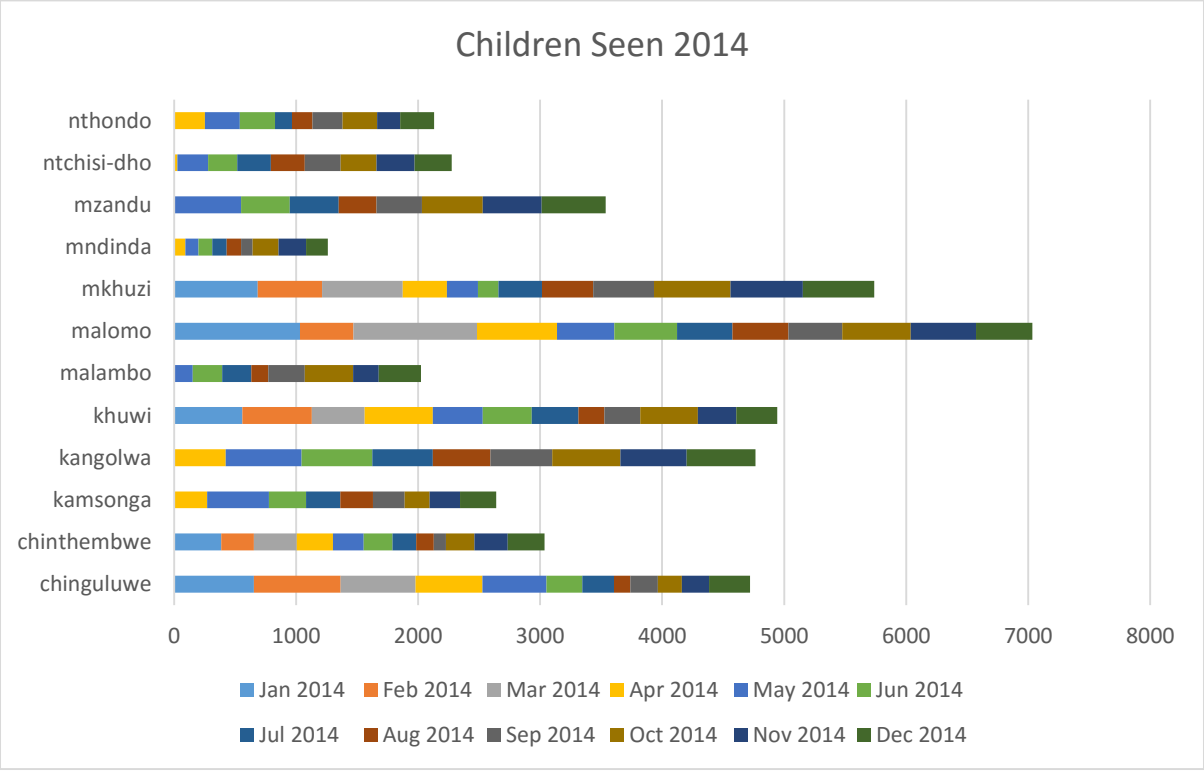


Figure 12. Stacked bar graph of children who visited HSAs for a consultation in 2014.

The 2015 data looks similar to the 2014 data and would not add any more information than the above graphic comparison already has. The HSAs in the district of Ntchisi have, on

average, been seeing 4808 (*SD* = 654.98) children every month for the period from October 2014 to October 2015. A more detailed breakdown of this information is available in Figure 13.

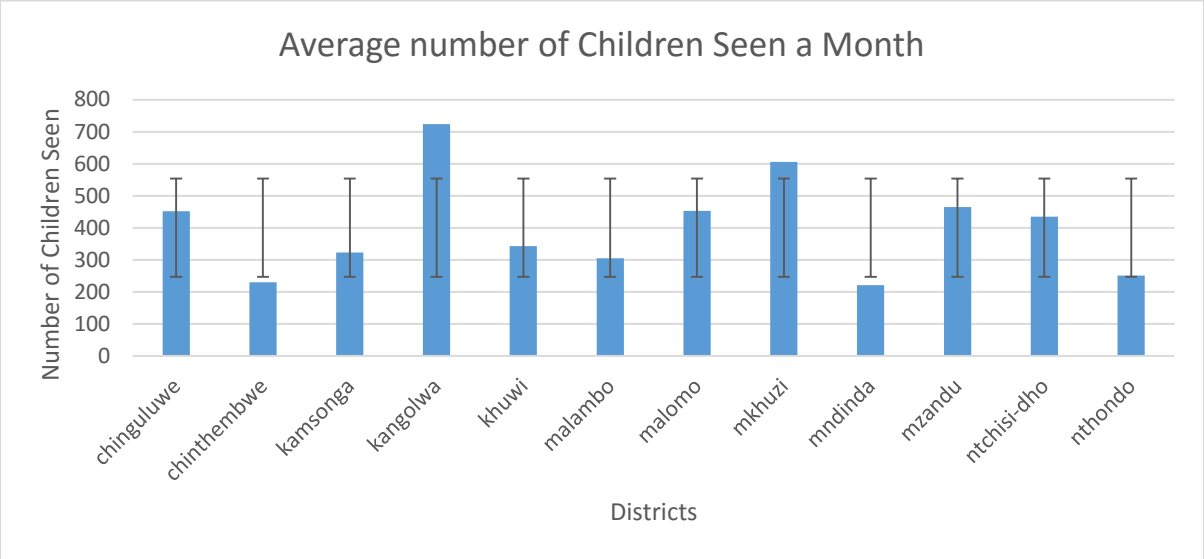


Figure 13. The number of children seen monthly per medical facility from October 2014 to October 2015.

The maximum number of active HSAs assigned to this district in this period was 103. This means that one HSA was attending to roughly 47 patients every month. Figure 14 represents the number of HSAs that were available during the past three months. According to the general HSA to child ratio, the number of HSAs for each health facility is a reflection of the average number of children seen a month. The only medical health facility that deviates from the general HSA to child ratio is the Kangolwa facility, where there are less HSAs attending to more children. From August to October 2015, the Kangolwa facility saw an average of 952 patients a month (*SD* = 30.51).

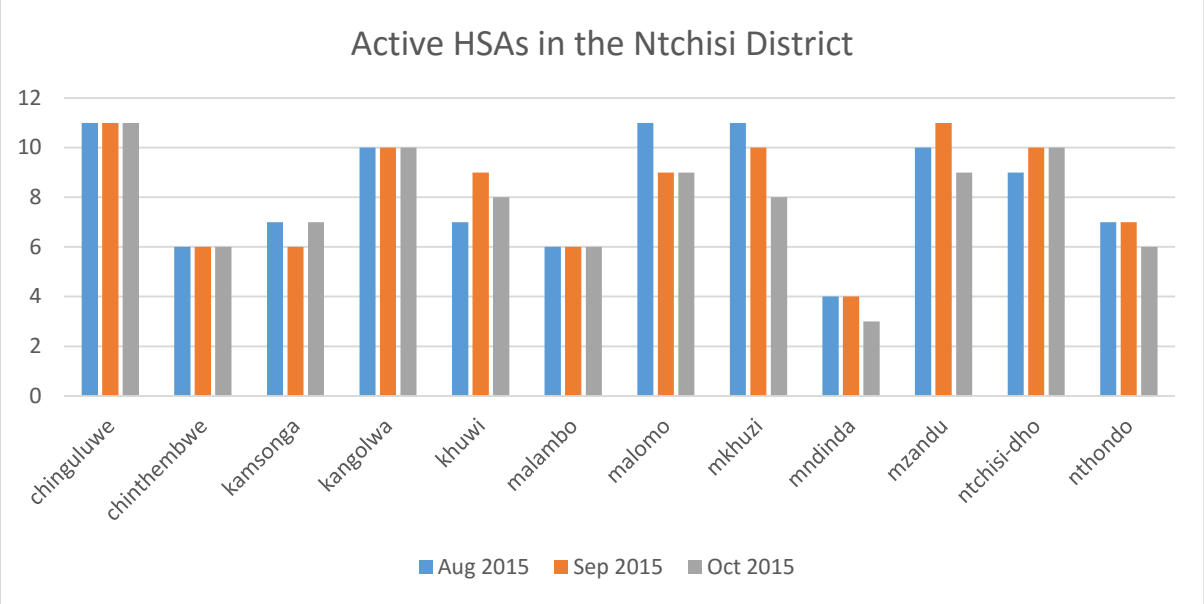


Figure 14. Active HSAs in the district of Ntchisi.

The utility of non-referrals and referrals by HSAs (Q3). The MIS system establishes utility of the classification of symptomology and illness. The most common symptom that HSAs are able to treat themselves is a fever, followed by coughing and fast breathing (see Figure 15). Breaking down the non-referral cases by symptomology can help to inform the quantity and proportions of medical stock required for cases of home treatment. A breakdown of referrals and non-referrals by medical facility demonstrates seasonal patterns in symptomology and illness. Additionally, I can break down the cases of referral by the symptoms present.

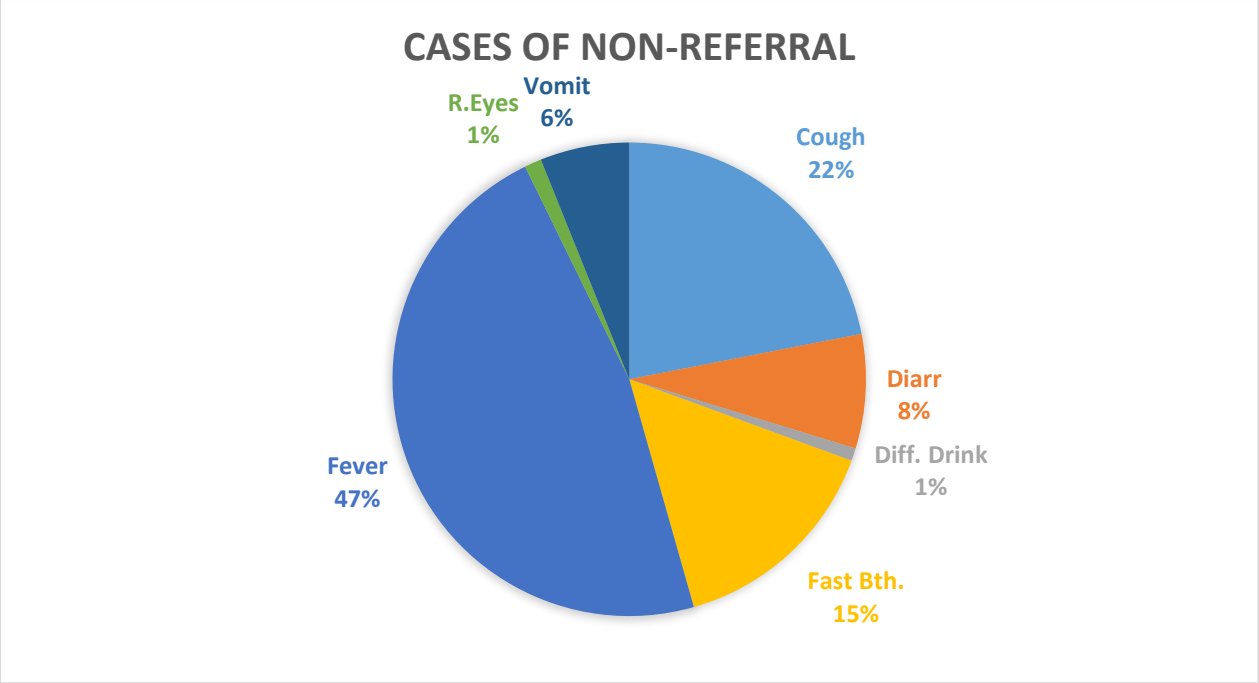


Figure 15. Demonstration of home treatment cases from October 2014 to October 2015 broken down by symptoms.

Figure 16 represents the incidences in which the HSAs have referred patients during the period from October 2014 to October 2015. In total, HSAs have referred patients for 2002 symptoms that required referral. In contrast, HSAs have suggested home treatment for 106,410 symptoms. Fever for children under the age of five months is the most prevalent symptom that has led to referral.

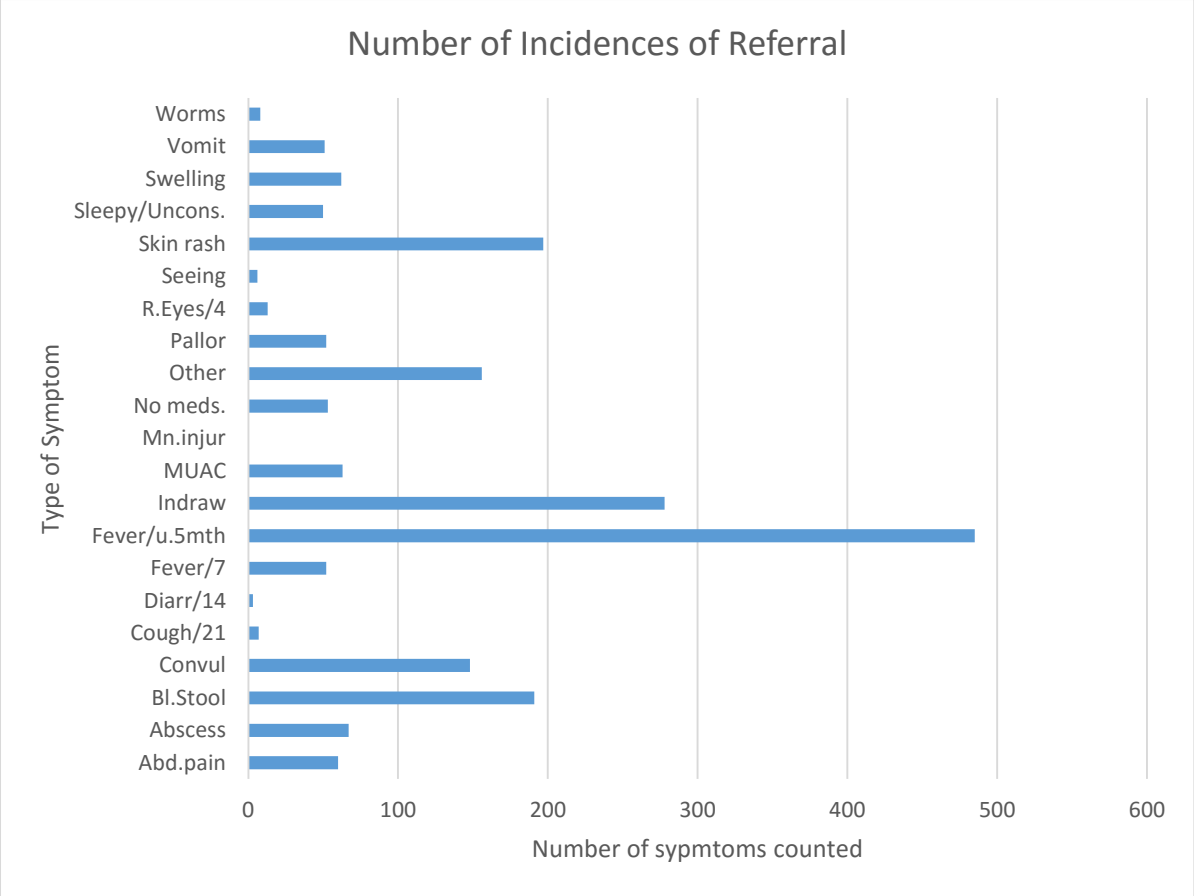


Figure 16. Symptoms and illnesses that have led HSAs to refer patients to a medical facility from October 2014 to October 2015. Patients are able to be referred for more than one symptom and/or illness.

Provision of follow-ups by HSAs (Q1, Q3 & Q5). From October 2014 to October 2015, the HSAs followed up on 33,501 patients. The HSAs followed up on 58% of children seen each month. This excludes patients that did not require follow-ups, for instance, cases when the child had no symptoms at the first consultation. Additionally, the data demonstrates a decrease in the percentage of follow-ups over time. A comparison of the first 6 months to the last 6 months of the specified time period (October 2014 to October 2015) shows that while the average number of patients seen remains the same (October 2014-March 2015: $M = 4464.7$, $SD = 482.7$; May 2015-October 2014: $M = 4459.7$, $SD = 916.5$), the number of follow-ups on average decreases from 3078.3 ($SD = 399.2$) in the first six months to 1986.3 ($SD = 262.8$) in the last six months. Thus the follow-up rate decreases from 69% in the first 6 months to 44% in the last 6 months (see Figure 17).

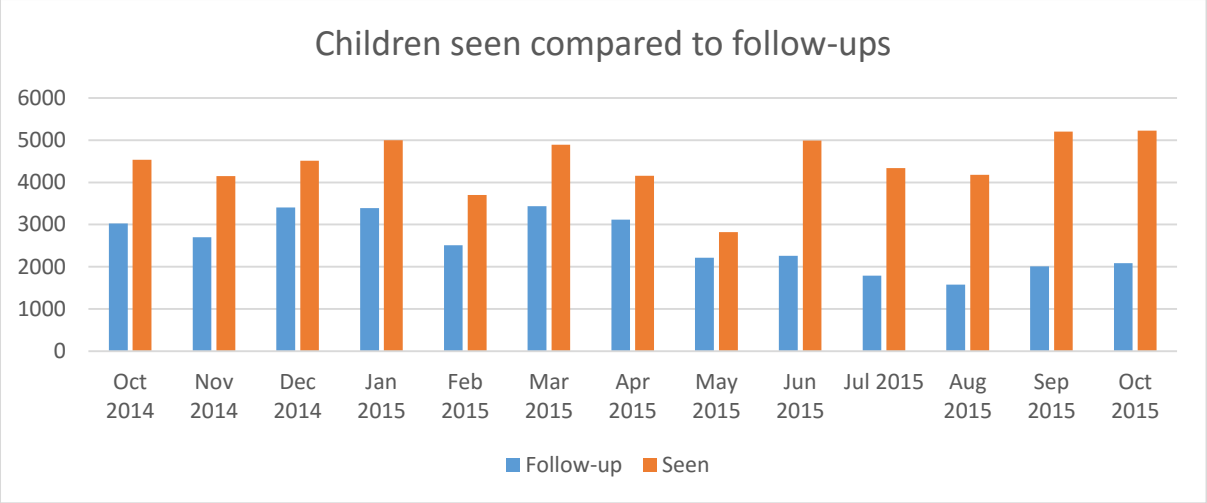
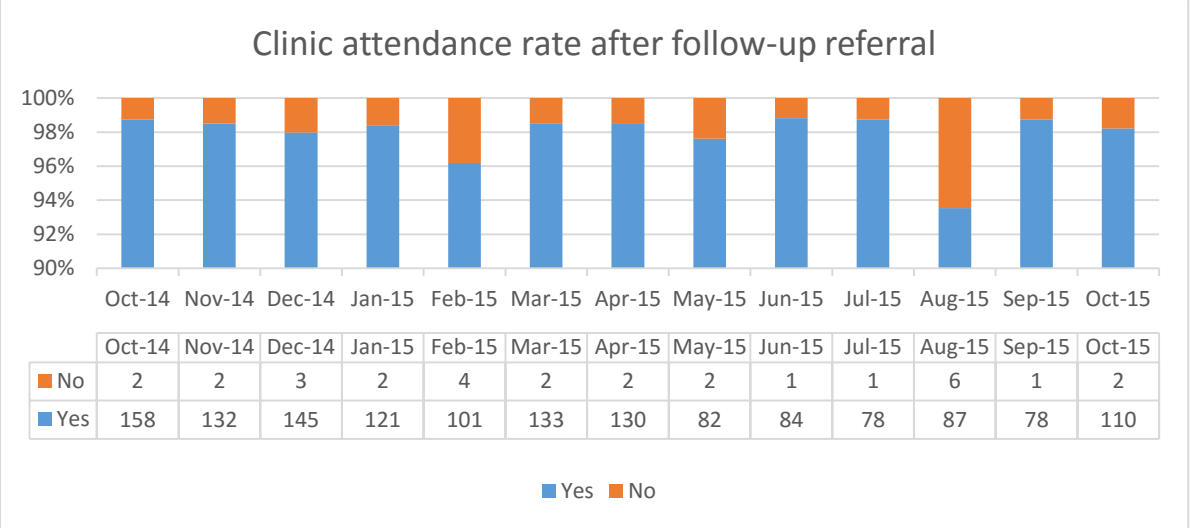


Figure 17. The number of children seen compared the number of follow-ups on patients.

Figure 18 demonstrates a complication for follow-ups. Specifically, not all patients that HSAs refer to medical facilities comply with this recommendation (Q3). These patients form a small portion of the referrals; however, it is important to consider the reasons behind this non-compliance. From the sample of patients who did not seek help at medical facilities as recommended, the HSAs reported the following:

- Three cases were because the family did not give permission for the patient to visit the health facility.
- Five cases were because of transport/distance-related issues.
- One case was because the caregivers of the patient had a negative impression of the health facility.
- One case was because the caregivers of the patient sought help from a traditional healer.
- 20 cases were because there was no need to attend the clinic, as the child was already improving.



	Oct-14	Nov-14	Dec-14	Jan-15	Feb-15	Mar-15	Apr-15	May-15	Jun-15	Jul-15	Aug-15	Sep-15	Oct-15
No	2	2	3	2	4	2	2	2	1	1	6	1	2
Yes	158	132	145	121	101	133	130	82	84	78	87	78	110

Figure 18. Clinic attendance rate after follow-up referral from October 2014 to October 2015.

Table 3 represents the child's well-being at follow-up, which is a proxy for child mortality (Q1). The table shows that at follow-up, on average, 96% of children are healthy again after treatment during the period from October 2014 to October 2015. The unknown category represents unsuccessful follow-ups by the HSAs.

Table 3. *Designation of child's well-being at follow-up.*

Month	Child's well-being at follow-up					% of children well after treatment	Total
	Child is better	Child has a danger sign	Child is improving	Child is not improving	Unknown		
Oct-14	2804	2	45	14	160	92.7%	3025
Nov-14	2568	2	58	23	51	95.0%	2702
Dec-14	3243	6	97	9	48	95.3%	3403
Jan-15	3185	6	66	10	123	94.0%	3390
Feb-15	2442	3	17	8	42	97.2%	2512
Mar-15	3347	0	15	18	58	97.4%	3438
Apr-15	3013	1	6	4	89	96.8%	3113
May-15	2190	0	6	4	11	99.1%	2211
Jun-15	2187	2	17	11	39	96.9%	2256
Jul-15	1758	2	12	5	7	98.5%	1784
Aug-15	1518	1	13	7	34	96.5%	1573
Sep-15	1962	0	14	5	28	97.7%	2009
Oct-15	2014	0	7	9	55	96.6%	2085
Total	32231	25	373	127	745	96%	33501

Incidence of child death in Ntchisi (Q1). This data analyses the utility of the manner in which the Zenji dashboard currently captures child death. Since the eCCM application has been implemented, the HSAs from the Ntchisi district have recorded 1936 deaths through the Zenji dashboard. These incidences of child death average at 87 (SD = 35.63) deaths per month for the period from October 2014 to October 2015 (see Figure 19).

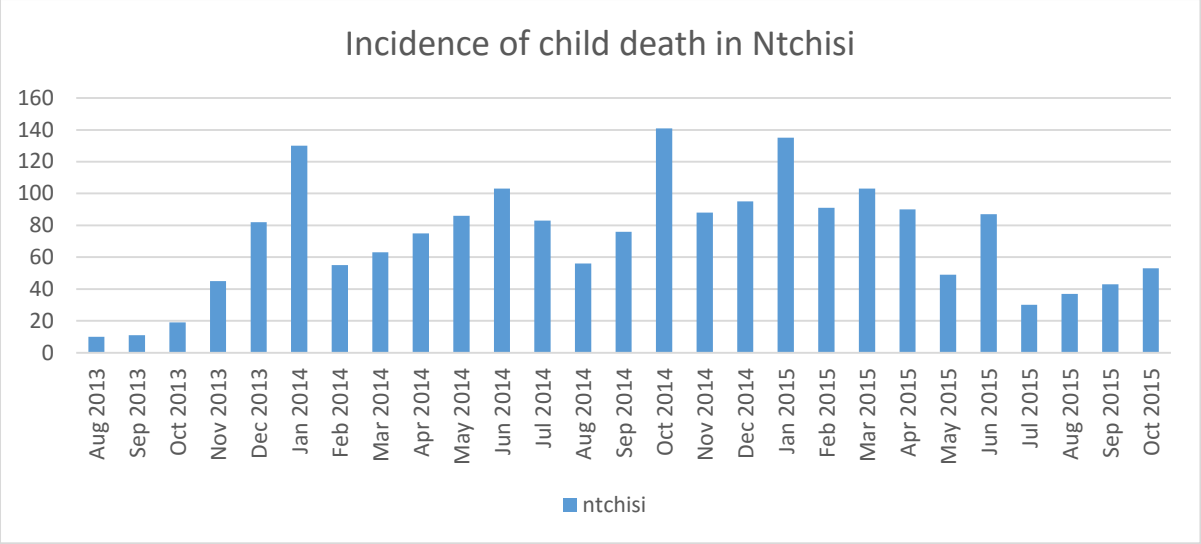


Figure 19. The number of children classified as having died since the implementation of eCCM.

A closer look at this data file demonstrates that incidence of child death is counted by the system as an addition of two variables, *died* and *moved away*. The sample of Ntchisi had a total of 1920 cases of child mortality. However, upon closer inspection of this statistic, the HSA classified the child as dead in only 106 cases, while the HSA classified the child as having moved away in 1812 cases. Cross-tabulation was used in SPSS to split up the incidences of death compared to the child having moved away. This is more representative of the sample, as the cross-tabulation distinguishes between children who have died and those who have moved away (see Figure 20).

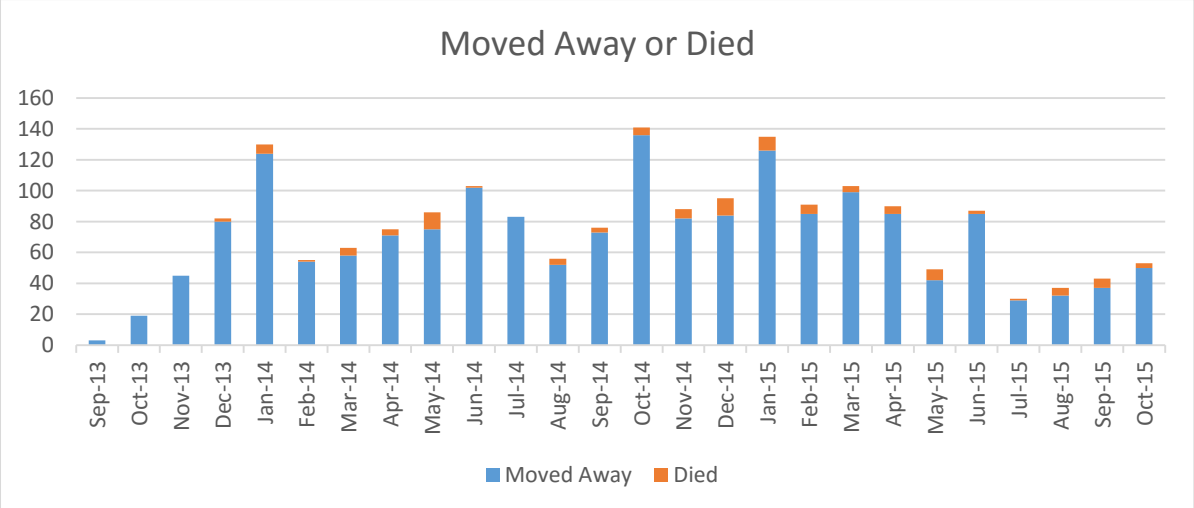


Figure 20. Comparison of the recorded child mortality to the moved away variable on the Zenji dashboard.

In the cases where the HSA classified the child as dead, I was able to determine the location of death. Figure 21 shows where the children passed away, of which 45% died at home and 45% died at a medical facility.

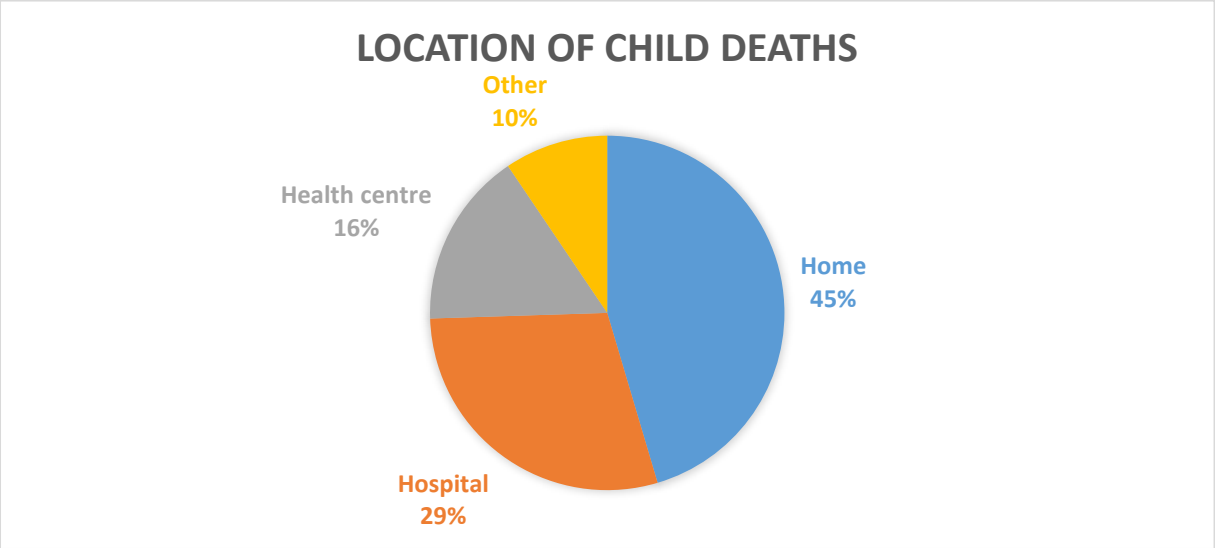


Figure 21. Demonstration of the location where the children passed away (n = 106).

A count of the actual causes of death for these patients is represented in Figure 22. Here we see the dominant symptoms that caused the death of the children. The most common cause was Malaria, followed by fever, although these are not necessarily mutually exclusive. The most common causes of death are existing diagnoses in the eCCM application (Q5). However, certain less common diagnoses, such as malnutrition, drug overdose, and oedema, are not yet included in the eCCM application.

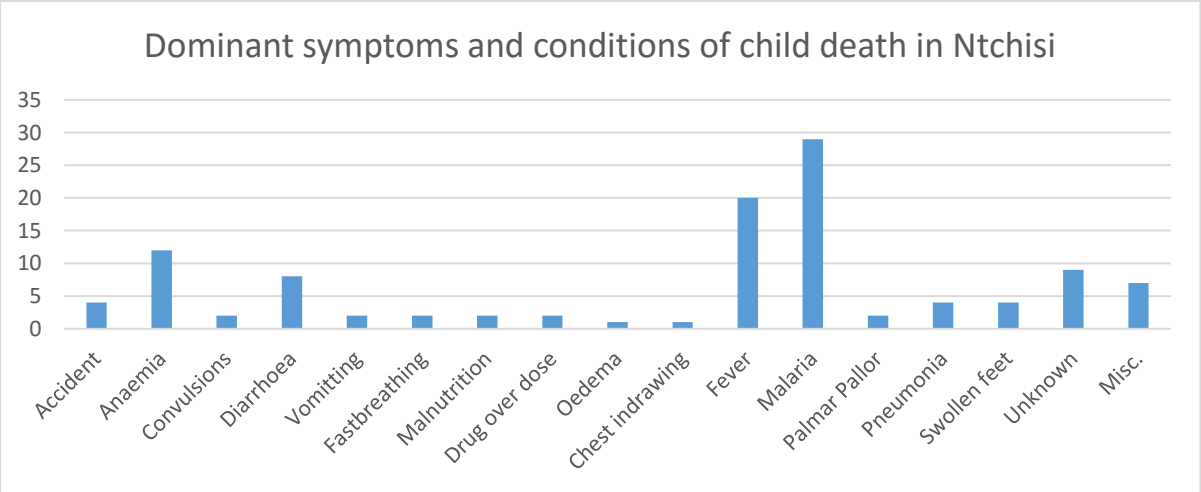


Figure 22. The conditions and symptoms that caused death for children in Ntchisi (n = 106).

Section 2 - Sub-sample of Ntchisi eCCM data. The sub-sample from Ntchisi is comprised of 2461 patients seen using the eCCM application from September 2014 to October 2015. From this sample 517 patients ($M = 7.58$, $SD = 2.44$) were aged 2 to 11 months and 1944 patients ($M = 33.25$, $SD = 13.70$) were aged 12 to 60 months. Table 4 provides an overview of the child's status after diagnosis, but prior to the recommended treatment. This table indicates that, of the sample, HSAs classified 284 children as sick and, of these sick children, HSAs referred 13 to a medical facility.

Table 4. *Frequency count of status for different age groups.*

	Frequency	
	2-11 months	12-60 months
Refer	5	8
Well	363	1282
Paused	80	309
Sick	35	249
Total	483	1848
Missing	34	96
n	517	1944

I compared the status counts to the symptom counts in Table 5 to confirm the accuracy of the status description counts from Table 4. Table 5 demonstrates all the symptoms and conditions, which by far outnumber the status variable above. Thus, this verifies that there is a mismatch in the HSAs' coding of status and their coding of symptoms. The status variable represents the child's well-being after diagnosis, but before treatment. Symptomology does not directly relate to the diagnosis due to the possibility of multiple symptoms. This is evident in Table 5, as 167 danger signs were present: however, from the sample of 2461 patients, HSAs referred only 92 patients. There is, however, a mismatch in the counts.

Table 5. *Sub-sample overview of present symptomology before treatment.*

	2-11 months		12-60 months	
	Yes	No	Yes	No
Cough	283		763	
Cough > 14 days*	1		0	
Swollen feet*	0		2	
Chest in drawing*	5		10	
Sleepy or unconscious*	1		3	
Fast breathing***	206		494	
Fever	379		1737	
Palmar pallor*	1		0	
Red eyes & seeing problem*	0		0	
Red eyes	7		43	
Red eyes > 4 days*	0		0	
Seeing problem	0		0	
Vomiting	70		213	
Vomiting everything*	2	68	5	
Unable to drink & eat	6		37	
Unable to drink & eat anything*	0	6	0	37
Convulsions*	1		5	
Diarrhoea	124		247	
Diarrhoea > 14 days*	0		0	
Blood in stool*	3		6	
mRDT 1 & fever*	27		66	
Muac colour*	0		1	
Refer medicine*	0		3	
Other problem*	9		16	
Danger signs count**	50		117	

**Causes for referral, **the total number of danger signs present in the sample, ***more than 50 heartbeats per minute for children under one/more than 40 beats per minute for children over one.*

Using protocol checks, I analysed if the danger signs led to a referral. That is, I checked that in every instance that there was a danger sign, a patient was referred (Q4). The eCCM application had a 100% accuracy rate when referring a child presenting with a danger sign. It was not the case however, that only danger signs led to referrals. HSAs referred 27.2% of patients without any danger signs. Although these 25 cases did represent sick children, they did not present with the danger signs that would have necessitated a referral. I found that the age of the patient influenced this statistic of incorrect referral. This was the only trend that I identified within these cases.

Table 6. *Referrals based on CCM Sick Child Form protocol.*

Referrals of patients		Frequency	Percent
Valid	Incorrect*	25	27.2
	Correct	67	72.8
	Total	92	100.0
Non-referrals when danger sign present		Frequency	Percent
Valid	Missing referrals	0	0.0
	Correct	2461	100.0
	Total	2461	

*Correct = the number of cases where protocol was adhered to, Incorrect = the number of cases where protocol was not adhered to, *excludes referral of a double invalid on the mRDT*

The age of the patient is the only strong predictor of referring a child without a danger sign. A split file of the age groups showed a difference between the two age groups on referral accuracy. Table 7 shows that while the system referral for children from 12 to 60 months had 10% more cases of referral than the protocol, the children referred by the system from 5 to 11 months of age had 47.6% more cases of referral than the protocol. Therefore, protocol adherence decreases when the child falls within the 5 to 11 months' age range.

Table 7. *Comparison of system versus protocol referrals between children aged 5-11 months and 12-60 months of age.*

	System referral		Protocol referral	
	Frequency	Percent	Frequency	Percent
5-11 months	42	45.7%	22	32.8%
12-60 months	50	54.3%	45	67.2%
Total	92	100.0%	67	100.0%

Correct medicine distribution (Q1, Q3, Q4, & Q5). The next step was to determine if the HSAs distributed the correct medicine based on the symptom present. The example used was diarrhoea and the recommended treatment of the illness is ors solution and zinc supplement tablets.

Table 8 shows the two treatment conditions, referral and home treatment. I split these treatment conditions by age group to determine whether the treatment given was age appropriate. The first lines confirm the numbers of patients who did and did not have diarrhoea for the specific age groups. The next lines show if the HSAs gave the correct treatment, no treatment, or the incorrect treatment, based on the guideline of the CCM Sick Child Form protocol (See Appendix I). In the referral condition, HSAs are required to give one ors solution to the child before they send the child to a medical facility. As an example, for the age group of 2 to 11 months, children received one ors solution in nine cases of referral for diarrhoea. Of the children who did not have diarrhoea, none received treatment for diarrhoea. In two referral cases, the HSA gave the child the incorrect amount of medication. In these instances, children were given three ors solutions instead of one ors solution. For the 12 to 60 month group, there were similar discrepancies and, in two instances, the HSA gave no ors solution, despite the protocol recommending this treatment. Of the patients within the age range of 5 to 11 months in the home treatment group, the HSA gave one dose of ors solution for one case and two doses of ors solution for nine cases.

Table 8. *Correct treatment of diarrhoea with oral rehydrate salt solution.*

Oral rehydrate salt solution as treatment for diarrhoea						
Refer	Age 2-11 months			12-60 months		
(*Give ors solution immediately*)	Yes	No	Total	Yes	No	Total
	9	33	42	10	40	50
	Correct	Not given	Incorrect	Correct	Not given	Incorrect
	7	33	2	7	42	1
	1 ORS	-	3 ORS	1 ORS		3 ORS

Home treatment	Age 2-11 months			12-60 months		
(*Give 3 ors solutions*)	Yes	No	Total	Yes	No	Total
	115	360	475	237	1657	1894
	Correct	Not given	Incorrect	Correct	Not given	Incorrect
	92	373	10	188	1691	15
	3 ORS	1	1 ORS	3 ORS	3	1 ORS
		9	2 ORS		12	2 ORS

To complete the treatment suggested by the CCM Sick Child Form, I analysed data for the treatment of diarrhoea with zinc supplements. For this, I adjusted the age groups according to the different age appropriate zinc supplement dosages. For the referral patients, The HSAs were not meant to give zinc supplements. This condition did well; however, there are three cases of referral where the HSAs gave the patients zinc supplements. In these instances, the HSAs gave the patients the age appropriate dosage for home treatment rather than the dosage for referral. In the home treatment condition, although HSAs gave 20 out of 21 patients zinc supplement, for 10 of these cases, HSAs gave a double dose of zinc supplement. For the age group of 7 to 60 months, 49 patients did not receive the medicine when needed and eight received an incorrect dosage. Of these eight cases of incorrect dose, four patients received five tablets and one patient only received one tablet. Overall, however, the number of patients who received incorrect treatment is rather small with an overwhelming amount of patients receiving the correct medication. Similar results can be seen in the treatment of diarrhoea with zinc supplements in Table 9.

Table 9. *Correct treatment of diarrhoea with zinc supplement tablets.*

Zinc supplement tablets for treatment of diarrhoea						
Refer	Age 2-6 months			7-60 months		
(*None -no recommendation to do so*)	Yes	No	Total	Yes	No	Total
	3	21	24	16	52	68
	Correct	Not given	Incorrect	Correct	Not given	Incorrect
	0	22	2	0	67	1
		-	5 tabs			10 tabs
Home treatment	Age 2-6 months			7-60 months		
(Age 2-6months = 5 tablets &	Yes	No	Total	Yes	No	Total
age > 6 months = 10 tablets)	21	121	142	331	1896	2227
	Correct	Not given	Incorrect	Correct	Not given	Incorrect
	10	122	10	274	1945	8
	5 tabs		10 tabs	10 tabs	4	5 tabs
					4	1 tabs

Section 3 - Questionnaire output (Q1-Q6). I have grouped the data in this section based on the evaluation question/s that they address. Some of the data provide answers to more than one question. The target population of the questionnaire was the 136 HSAs in the district of Ntchisi. The data gathered came from a sample of 50 participants: these participants were from Malambo (n = 7), Mkhuzi (n = 7), Malomo (n = 11), Nthondo (n = 10), Mndinda (n = 4), and Mzandu (n = 11). The participants had worked with the paper-based version of CCM for at least as long as they had worked with the eCCM. Of the participants, all had already had a minimum of 6 months experience with eCCM (Table 10).

Table 10. *HSA familiarity with CCM and eCCM methods*

	Number of HSAs				
Time	< 1 year	1-3 years	4-6 years	7-10 years	10 years+
Paper-based	4	32	13	1	0
Time	< 6 months	6-12 months	1-2 years	3-4 years	4 years+
Mobile-based	0	18	26	4	2

**Time frames are different as paper-based version has been around longer than eCCM.*

Table 11 presents the results of the Likert scale questions from the questionnaire. For ease of reading, I have changed the questions into a short description of what they are meant to indicate. The question numbers are the same as on the actual questionnaire and can be used as a comparison (See Appendix V). The colour range gives an indication of how many HSAs chose a specific response. The colour *green* means that a large number of HSAs gave that answer. The colour *red* shows that not many HSAs gave that answer. *Orange* and *yellow* signify that the answers were more spread out, and this makes it easier to see where the HSAs disagreed the most. Table 11 gives a summary of the results of the questionnaire.

Table 11. *Indicators of the questionnaire*

Q	Indicators	*n*	*M*	*SD*	S. Disagree	Disagree	Not sure	Agree	S. Agree
1	Availability of medicine has improved	49	4.35	0.72	0	2	1	24	22
2	Accessibility of health records has improved (easier)	48	4.46	0.5	0	0	0	26	22
3	Health records are more useful	49	4.53	0.5	0	0	0	23	26
4	All required health information is covered	49	4.37	0.81	0	3	1	20	25
5	Frequency of accessing health records has increased	50	4.26	0.85	0	4	1	23	22
6	Mobile health records make follow-ups easier	49	4.51	0.51	0	0	0	24	25
7	Adherence to the step-by-step procedure	49	4.55	0.61	0	1	0	19	29
8	Compliance to treatment suggestions	49	4.46	0.54	0	0	1	24	24
9	Utilizing the eCCM diagnosis	50	4.54	0.65	0	1	1	18	30
10	Decision-making	46	2.28	1.28	15	18	0	11	2
11	Mobility problem(battery runs out)	48	3.08	1.16	2	19	5	17	5
12	Future use-sustainability	47	2.21	1.23	16	17	5	6	3
13	Repetitive protocol-(boredom)	50	2.2	3.04	24	18	4	2	2
14	Non-adherence to application usability	48	1.38	0.61	33	12	3	0	0
15	Frequency of communication with supervisor	48	3.65	1.36	5	8	1	19	15
16	Has made work easier	49	4.47	0.71	0	2	0	20	27
17	Faster than previous method	49	4.49	0.54	0	0	1	23	25
18	Loss of medicine	50	1.68	0.79	24	20	4	2	0
19	Learning from the application	50	4.38	0.92	2	1	0	20	27
20	Improved confidence in decision-making	50	4.56	0.61	0	1	0	19	30
21	Perceived accuracy	49	4.51	0.82	1	1	1	15	31
22	Preference for verbal communication	49	3.37	1.18	2	14	5	20	8
23	C-Stock is easier to use	49	4.57	0.5	0	0	0	21	28
24	C-Stock helps me get my stock on time.	50	4.48	0.54	0	0	1	24	25
25	C-Stock gives me an accurate count of my available stock.	50	4.42	0.78	0	3	0	20	27
26	C-Stock makes me less likely to run out of medical supplies.	48	4.04	0.92	0	5	4	23	16
27	Dissemination of health records	49	4.29	0.67	0	1	3	26	19
28	Decrease in travel time	47	3.89	1.15	2	5	6	17	17
29	Improved care of patients	49	4.23	0.58	0	0	2	24	23
30	Availability of medicine	48	4.29	0.71	0	2	1	26	19
31	Easy to call up patient records	48	4.33	0.78	0	3	0	23	22
32	Loss of health records	49	3.94	1.25	4	5	0	21	19
33	Improper utilization of the phones functions	47	2.31	1.04	9	24	5	8	1
34	Fast feedback	49	3.69	1.33	3	11	1	17	17

Q = question number referring to the HSA questionnaire, n = sample, M = mean, SD = standard deviation

Decision-making (Q1). The mobile application demonstrates that the HSAs agreed that eCCM has improved decision-making. 98% of the HSAs gained confidence in decision-making from using the eCCM application. 93.8 % of the HSAs believed that the eCCM application was more accurate than their own decision-making. 94% of HSAs believed that the application had shown them how to better diagnose their patients. Lastly, a majority of 95.9% agreed that the use of the eCCM had enabled them to provide better care for their patients.

c-Stock integration (Q2). The HSAs agreed that the integration of c-Stock into the eCCM application had improved the availability of stock (93.9%) and all the HSAs agreed that c-Stock had become easier to use through the eCCM application. 88% of HSAs thought that no medicine had gone missing, while four HSAs were uncertain, and two HSAs believed medicine had gone amiss. The HSAs also believed that c-Stock enabled a more timeous delivery of medicinal stock (98%), provided an accurate count of their available stock (94%), and made them less likely to run out of medicinal stock (81.2%). However, some HSAs seemed to feel that they were still running out of stock.

Electronic health records (Q3). The electronic health records component of eCCM provides HSAs with the necessary patient history (91.8%), although three HSAs believed that there was still some information about their patients that they were lacking. All HSAs agreed that the mobile health records were easier to access than previous paper-based methods. Furthermore, HSAs utilized health records more since they started using eCCM (90%) and the availability of mobile health records made follow-ups easier for all HSAs. HSAs also reported that they were less likely to lose patient information since they started using eCCM (81.6%); however, nine HSAs disagreed with this.

Supervision (Q6). 70.8% of the HSAs frequently utilized WhatsApp as a medium to communicate with their supervisors. 13 HSAs reported to not often use the WhatsApp chat function to communicate with their supervisors. HSAs were divided in their preference for calling their supervisor instead of communicating via WhatsApp. 32.7% of HSAs preferred using WhatsApp, while 57.1% of HSAs preferred to call their respective supervisors. 72.2% of the HSAs reported that they travel less since using eCCM and 91.8% of HSAs reported that providing health records to supervisors had become easier. Lastly, the majority of HSAs (69.4%) reported that they received timeous feedback from their supervisors via WhatsApp, although 28.5% reported that they received slow feedback.

Protocol adherence (Q4). 98% of the HSAs reported that they followed the step-by-step procedure of the application and claimed to follow the treatment suggestions of eCCM.

96% of HSAs said that they always use the eCCM diagnosis to treat their patients. HSAs diverge in reporting on if they rely on their own experience to make decisions about treating their patients. 28.3% relied on their own experience when treating their patients, while 71.7% reported that they did not rely on their own experience. 93.8% of HSAs agreed that they only used eCCM for children under the age of five.

Utility, mobility, and sustainability (Q5). 95.9% of the HSAs reported that the eCCM application had made their work easier. Furthermore, 98% of the HSAs reported that the mobile application is faster than the paper-based version. The patient records were easy to call up for 93.8% of the HSAs. 45.8% of the HSAs reported that their phones had run out of battery life while seeing patients and 43.8% reported that this had not happened to them. 70.2% of HSAs planned on using the application in the future, however nine HSAs reported that they would not use the application in future. Most HSAs (84%) did not experience boredom while using the eCCM diagnostic tool. Some HSAs (19.1%) reported that they were using some of the phone's functions differently to how D-Tree had intended HSAs to use these functions, while 70.2% utilized the phones functions as they were meant to.

Figure 23 outlines the most common problems that these 50 participants experienced in using the eCCM diagnostic tool (Q1 & Q3). Please note that participants were able to select more than one option from the list provided. The most severe problem experienced by the HSAs was an insufficient quota of airtime. 27 reported that they did not have enough airtime to utilize the application and 14 reported problems with the internet. 21 HSAs reported that they had experienced a problem with the phone itself. However, not a single HSA reported that the eCCM application had provided them with and incorrect treatment or diagnosis.

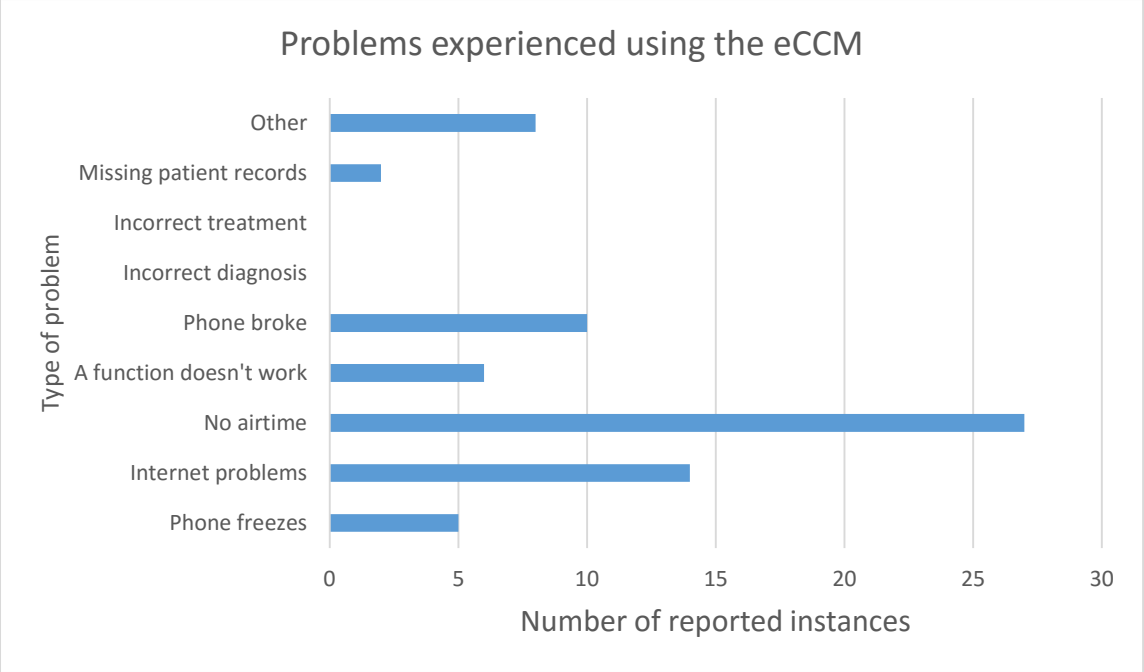


Figure 23. *Common problems HSAs experienced using the eCCM diagnostic tool.*

Lastly, for Question 38, which asked the HSAs what difficulties they experienced with eCCM that prevented them from using the application (Q5), 22 HSAs reported that they had no electricity available with which to charge their phones. Six reported that their phone battery had died. Nine reported that they had something else that kept them from using the phone. No HSAs reported that the application was difficult to use, that their phone had been stolen, that their patients did not like them using eCCM, or that they had forgotten their phones somewhere.

Discussion

For this formative evaluation, I decided to work as closely as possible with the secondary data provided by D-Tree to attempt to answer the evaluation questions. The questionnaire data, therefore, augments the secondary data findings that were heavily reliant on proxies for the variable in question. This section is broken down into the evaluation questions and presents recommendations with regard to these evaluation questions. These recommendations appear in italics throughout the chapter.

Has the use of eCCM reduced the incidence of incorrect diagnosis of child illness under the age of five? From the results, I can deduce that the diagnosis and treatment procedure of the eCCM application is effective at treating patients and thus is effective for improving the health

outcomes of patients. Based on the available data it is difficult to offer a definitive answer to this question. Therefore, this section aims to make recommendations that would help substantiate this question in future research as well as highlight the data that does show promise of the eCCM reducing the incidence of incorrect diagnosis.

Exit mechanism of eCCM. Figure 20 (p. 49) shows that the child death variable is comprised of actual incidence of child mortality and a variable called *moved away*. The latter variable is inflating the actual number of recorded child deaths quite drastically, as the HSA assigns the child to the *moved away* category whenever s/he does not know the outcome of the child. Additionally, the HSA uses this method to delete the child from the system. The current eCCM application captures only a small number of confirmed death by the HSAs.

I recommend that D-Tree considers reworking the exit mechanism for the eCCM application to include cases where the child is exiting the system for reasons other than death. For instance, it would be useful to know if the child is exiting the system because s/he has died or if s/he has simply turned six years old. It may also be useful for D-Tree to include a method for case deletion so that HSAs can delete the cases with an unknown outcome. Although the system allows the reason of exiting to be captured, it does not force the HSAs to enter data at this point. Encouraging the HSAs to provide an answer at this point would determine the reason for deleting the child from the system and would thus provide more detail on these cases. Importantly, if the application forced HSAs to give a reason for case deletion, they would classify fewer cases incorrectly in the moved away category.

Only 106 of 1812 cases were cases of confirmed death since D-Tree implemented the application in 2013. Although it is difficult to form firm conclusions because application coverage was still increasing during this period, there were very few confirmed deaths when compared to the number of patients seen. Specifically, out of 89,964 patients consulted since August 2013, 106 patients died. The results provide some evidence in support of the proposition that the application is contributing to improved healthcare, but as no base line is available one needs to be tentative in one's conclusions.

Point of treatment. A closer analysis of the 106 cases of confirmed death indicates that half of the children were at a medical facility at the time that they passed away. This shows that the eCCM protocol, which is at the pre-referral stage of diagnosis and treatment, was effective for these children. That is, using the eCCM application, HSAs were able to recognise the severity of these cases and refer the patients to a medical facility (Figure 21, p. 50). The clinic attendance rate shows that not all referred patients went to medical facilities. Therefore, although the eCCM application is providing the correct diagnosis and treatment, caregivers of the patients not adhering to the suggested treatment may affect the success of the application

in reducing child mortality. It would be useful to understand what barriers to compliance are in this context and this may be an avenue for future research. The simplest example of this is the comparison between the number of children that came to HSAs for a consultation and the number of follow-ups that occurred. The caregivers are ultimately responsible for bringing their children back to the clinic for a follow-up. If the parents do not come back because the treatment the children received has worked, then the HSAs are unable to complete their follow-ups.

A recommendation for improving the follow-up would be to send reminders to parents about follow-up consultations. This reminder could be an automated SMS that the system sends on the day the follow-up is due. The efficacy of this method would still be limited in Malawi, as only 30 people had mobile cellular subscriptions for every 100 people in 2014 (The World Bank, 2015). A further recommendation would be to pilot a free application for the caregivers of the patients, which would allow them to schedule appointments with the HSAs and set reminders for treatment as an integration with the eCCM. This kind of a patient application has been developed by Shimba Technologies Ltd in Kenya, a programme called MEDAfrica.

Increasing stringency. Another competency of the eCCM application is that it captures the causes of mortality for the children from Ntchisi (Figure 22, p. 50). The application already includes the majority of symptoms and conditions that have caused the death of the children in this sample. Fever and malaria are responsible for the most deaths.

A further recommendation here would be that the application designers consider increasing the stringency of the clinical protocol for fever and malaria. Therefore, it is critical that the clinical protocol has fever included as a danger sign. The mRDT clinical protocol has been improved in the last year. In particular, it includes two tests and the HSA should refer the patient if s/he fails both of these tests. The mRDT is not a perfect test for Malaria and the number of deaths due to Malaria can be an artefact of false positives rather than a problem with the eCCM accuracy. The eCCM application is dependent on the accuracy of the mRDT, which has low sensitivity and specificity, especially at the community level. Llombe et al. (2014) found a 40% overestimation of Malaria at the community level due to false-positive mRDT results, which is an example of how the accuracy of the eCCM diagnosis can be adversely affected by its components. The mRDT is dependent on levels of parsitaemia in the area as well as the humidity of the area, which can lead to inaccuracies as both bias the mRDT (WHO, 2004). *I would recommend a more cautious approach using eCCM for children from 2 to 11 months of age. Although treatment was adjusted to consider the age of the child, the clinical protocol does not include a difference in diagnosis for younger children.*

Accuracy of the diagnosis. The last component to discuss is the accuracy of the diagnosis, to determine the incidence of incorrect diagnosis of child illness. For the Ntchisi

sub-sample, the data suggests that, in all cases that a danger sign was present, the HSA made a referral (Table 6, p. 53). This signals a great success for the application, as the HSA should be referring patients when s/he does not have the capacity to handle the illness or condition. Gilroy et al. (2013) found that, for the paper-based version of the application, the HSAs only correctly referred 55% of children with a danger sign. This is an indication that the eCCM may perform better than the paper-based CCM when it comes the accuracy of the diagnosis to reducing child mortality.

When I compared the referrals captured by the MIS to the referrals suggested by the Sick Child Form, I found that the MIS was suggesting more referrals than the Sick Child Form protocol (Table 6, p. 53). Table 6 shows that there are 67 referrals made based on the sick child form and 92 patients had actually been referred. Specifically, the HSAs were more likely to refer the 2 to 11 month old children based on the MIS (Table 7, p. 54). This was not of particular concern for the accuracy of the diagnosis. That is, referring this age group is preferable, as they are at higher-risk than the older children. As this is a discussion about the quality of the care, the HSAs are doing what is in the best interest of the children and assuring that these children receive age appropriate care.

The last piece of evidence to support this section comes from the questionnaire. The HSAs unanimously reported that the eCCM application never gave them an incorrect diagnosis or treatment (Figure 23, p. 61). Additionally, the HSAs believed that their confidence and decision-making improved by using the application. This reaffirms the results of West (2012) and Haffey, Brady, and Maxwell (2014) who found that applications could reassure HSAs and reduce error rates.

Has the integration of c-Stock into eCCM been beneficial for HSAs? I conclude from the questionnaire results about c-Stock that the eCCM integration of c-Stock has been beneficial for the HSAs (Table 11, p. 58). The HSAs reported that c-Stock had become easier to use with its integration into eCCM. The self-report data additionally indicated that the HSAs did not believe that they were experiencing loss of medication. The HSAs also reported that the availability of medicine had improved since they started using eCCM. This speaks to a simplification of the c-Stock SMS system. Prior to the integration of c-Stock into the eCCM application, it was an entirely SMS-based feature requiring specific text to place orders for medication. eCCM has simplified this process by creating the SMS for the HSAs through an order form in the application.

It is clear from the results that the c-Stock logistics tool has helped HSAs get their medicine on time as well as having provided an accurate count of their available stock. The HSAs also seem convinced that they are less likely to run out of medical supplies by using c-Stock, although there was some disagreement around this (Question 26, Table 11, p. 58). This means that c-Stock is not meeting the medicinal supply needs for all of the HSAs.

In focusing on at the Ntchisi sub-sample is again beneficial as it sheds some light on how c-Stock is actually performing. In three cases, the HSA referred the patient because the HSA had insufficient medicine. This is promising because this is a very small proportion of the sample (3 out of 2461 patients seen).

One area where the eCCM application is not meeting the drug availability needs is for diarrhoea treatment (see Tables 8 and 9, pp. 55-56). Drug availability for the sub-sample in the case of diarrhoea shows there to be an insufficient supply. Although, these numbers need to be considered in relation to the patients in need of treatment (n = 371), which would mean the ors solution treatment was provided to 83% of the patients. Another 7% of patients received a smaller dose of ors solution than suggested and 10% did not receive medicine. In comparison, an evaluation by Gilroy et al. (2013) found that, when using the paper-based version of CCM, only 69% of the children with diarrhoea received the ors solution. The eCCM application therefore outperforms the paper-based version. This issue speaks to protocol adherence which is discussed in more detail later.

In summation, although the c-Stock integration has simplified the stock order procedure for the HSAs and gives them more control over their stock take, there is still a lack of medicine available for the HSAs to give to the patients. In relation to the patients in need of medicine, c-Stock is making medicine available for the majority of patients. The c-Stock integration is also beneficial as it can assess the shortfalls in the eCCM system and D-Tree can then address these shortfalls. Therefore, the c-Stock integration was beneficial, but in order to mediate shortfalls in supply, some consideration of budgetary constraints in this district will need to be considered.

Has the use of Monitoring Information Systems improved the accessibility and utility of health records? Did this, in turn, mean that HSAs were able to provide a better follow-up? The Ntchisi district attained full coverage of the eCCM application in 2014 (Figure 12, p. 41). Because the HSAs had already gained some experience with the paper-based CCM protocol, training them in the use of the eCCM application was fairly easy. This partly explains the rapid growth of eCCM in this district. Additionally, the programme is coordinated in

congruence with key role-players who support the uptake of this programme, namely the IMCI Coordinator and the Safe Project Manager. With the increase of coverage comes the increase of accessibility to the benefits the eCCM application can present in terms of health records.

The HSAs in Ntchisi are, on average, seeing 47 patients on a monthly basis (Figure 13, p. 42). Thus, a fair amount of children has had access to healthcare through the eCCM application, particularly when considering that the beneficiaries of the application are limited to children under the age of five. The village clinic of Kangolwa is able to provide healthcare for approximately twice the amount of patients than other clinics. This suggests that, when using the eCCM application, HSAs are able to consult with a large amount of patients, if necessary. The other clinics may hence have a lower demand for healthcare than the Kangolwa clinic.

Additionally, the HSAs received a health record from their referral and non-referral of patients. Although the HSAs do not directly access this health information, the role-players can utilise this information to keep the medicine in stock in the correct proportion. Thus, this information can indirectly aid the HSAs for their future consultations. Referrals identify gaps in the application and HSAs are then able to address these gaps.

The number of children seen by the HSAs exceeds the number of follow-ups for HSAs by 42%. This means a large number of patients are not coming back to the HSAs for a follow-up. Although a portion of this number would be children whom the HSAs have diagnosed as having no symptoms, this number is likely to be minute, as even a slight cough would count as a symptom. *A possible recommendation would be to create pivot tables on the Zenji dashboard to include specific indicators. Data could be restructured and broken down by district and then by the indicators for more practical comparisons. If this were done then it would be possible to create a comparison between the children who consulted with the HSAs, those who received follow-ups, and those who were determined to be healthy.* As I have already mentioned, it seems natural that not all parents would come back to the facility if the treatment was successful. However, the drop in follow-ups in the second half of the period analysed is a cause for concern. The number of patients seen seems to have remained consistent, but the follow-ups have decreased (Figure 17, p. 46). In Tanzania an SMS-based reminder system, called CommCare, which focused on patients that required chronic care, reduced the average number of days that patients were overdue to consult with a healthcare professional from 9.7 days to 1.4 days (DeRenzi et al., 2012). Additionally, the authors found that forwarding the reminder for the monthly home visits to the supervisor was vital to increasing the performance of the

HSAs. *Although the HSAs receive reminders for follow-ups, forwarding the reminders to the supervisors could curb the lack of follow-ups seen in the second half of the period.*

The results show that the HSAs perceive the eCCM as encapsulating all the health records they require (Table 11, p. 58). The health records have also become easier to access, which may have contributed to the fact that the HSAs seem to be more frequently referring to the health records. The health records are also more useful than the previous records HSAs kept. Both the utility and the accessibility of the health records gives credibility to the HSAs unanimously agreeing that having mobile health records has made their follow-ups easier (Question 6, Table 11, p. 58). However, there is still a decision that HSAs need to make about the child's well-being at the stage of follow-up, which HSAs base on their expertise. Although the HSAs classify the child's well-being quite accurately, there are times when the HSAs are not able to determine whether or not the child has improved at follow-up (Table 3, p. 48). This may suggest that, although the health records are available to the HSAs, they are not necessarily sufficient for making a comparative decision about a child's well-being at follow-up.

Has the eCCM application increased the protocol adherence of HSAs? The increase of protocol adherence was not determinable due to the lack of available baseline data and a host of potential variables, which is a reality of research in this complex domain. The eCCM application does, however, exemplify a protocol that is well adhered to by the HSAs. The sub-sample of Ntchisi demonstrates that, for the most part, HSAs did comply with the protocol; however, there were some deviations from the protocol. The eCCM application led to a referral for all patients who needed a referral, but there was a group of referred patients who should have received home treatment instead (Table 6, p. 53). This autonomy in decision-making or deviation from the protocol is beneficial for the children's health outcomes. The HSAs seem to be taking it upon themselves to refer patients even if the symptoms or conditions do not necessitate the referral. This counter-protocol referral occurred more frequently in the age group from 5 to 11 months. In terms of the protocol, this may be a deviation from the decision-making tool; however, the tool is only meant to aid HSAs and they should have autonomy to refer a child if they think it is necessary (Table 7, p. 54). A child who is a couple of months old should not have to present with diarrhoea for 14 days to receive a referral. This, again, is a reiteration of the previous recommendation to discern age appropriate danger signs.

The HSAs are possibly also taking some autonomy in the distribution of medicine doses. This appears to be the case for the example of diarrhoea treatment. Although it cannot be accurately determined if HSAs gave the incorrect dosage due to lack of stock or due to the

HSA not following the protocol, there are some instances that were more suggestive to the provision of an incorrect dosage. For instance, for the referral due to diarrhoea, the protocol does not suggest zinc supplements as part of the treatment. Table 9 (p. 56) showed that some children were still receiving zinc supplement treatment. The dosage was correct for the age of the children; however, this is a deviation from the clinical protocol. In the case of referral, this may occur if the caregivers cannot take the child directly to the medical facility or if there is another reason that the child will not be going to the medical facility. The HSA may be making the decision to provide some treatment that the child may not receive fast enough from a medical facility. I was not able to understand why the data shows that there is a deviation, since the eCCM application tells the HSA what the recommended treatment is.

The home treatment condition for zinc supplements also demonstrates a potential problem. Some of the children received the medication recommended for a different age group (Table 9, p. 56). This incorrect dosage may be because, in the CCM Sick Child Form, the 6-month cut off point is not specific. Therefore, the children receiving incorrect dosages should belong to the older age category. The protocol may not be clear at this point and this may cause the HSAs to misinterpret the procedure. *A possible recommendation would be to adjust the treatment to cater to the child's physical weight, rather than the age. This would require each HSA to have access to a scale to determine the child weight. This would be dependent on if the HSAs would have access to scales. D-Tree could then add a drug dosage calculator to eCCM. Thus treatment dosages could be based on the weight of the child. This is especially relevant in a country with a high degree of childhood stunting, because age may not necessarily reflect the size of the child accurately.*

Based on the HSAs responses on the questionnaire (Table 11, p. 58), the HSAs agree that they adhere to the step-by-step procedure of the eCCM application and comply with the treatment suggestions. The HSAs also indicate that they uniformly utilise the eCCM diagnosis for the treatment of their patients. However, only two of the HSAs did disagree, which confirms that there are situations when the HSA may not follow the guidelines of the eCCM application. Interestingly, HSAs reported that they both do and do not use their own experience for the treatment of their patients (Question 10, Table 11, p. 58). This divergence could explain why their medicine dosages do not adhere to the protocol. It may also explain why some patients are being referred when they do not exhibit any danger signs. The HSAs indicate that they only use the application for children under the age of five; however, some HSAs reported that they were unsure, which could mean that the exact age of the child may not have been known.

To what extent has the use of the application improved the efficacy of HSAs work? How does this improvement manifest itself, or how does the application fall short of such improvement? The eCCM application does an excellent job of improving the efficacy of the HSAs' work by making their work easier, faster, and providing decision-making support. The efficacy of the HSAs is however adversely affect by some ecological constraints that make the eCCM application more difficult to use. Factors that constrain the HSAs from utilizing the application are poor internet connectivity, lack of sufficient airtime, and insufficient means of charging the mobile devices.

To support this the HSAs themselves reported that the eCCM application is making their work easier; this can be due to the approaches of the application. The supervision, mobile health records, logistics tool integration, and decision-making procedure are all competent aids at achieving just this. The HSAs are reporting this even though they currently still have to use the paper-based CCM method at the same time. This means that even though the eCCM application is additional work for the HSAs, it has still managed to make their work easier.

The HSAs are also reporting that the application is faster than the paper-based version. This may be partly due to the decision-making aspect of the application. The eCCM application removes the time it takes to make the decision about the diagnosis, referral, and treatment. However, this may be based on subjective experience, as the HSAs are required to complete the paper-based CCM form first and then after complete the same procedure on the eCCM application. This would make completing the electronic portion of the CCM go considerably faster, as the HSA simply needs to re-enter the input from the paper-based CCM. *This dual-process may no longer be necessary as the eCCM application does present a promising alternative. A possible recommendation would be to test using only the eCCM application in one of the initial catchment areas in Ntchisi where the HSAs have more experience with the application.*

The self-report data suggests that the application makes the HSAs more effective, in that although they are only capable of treating the most basic conditions, it allows them to be the first line of healthcare and this puts less strain on the medical facilities. Similarly, the HSAs find it easy to call up the patient records using the eCCM application. This means that HSAs can access the health records of patients quickly. The eCCM application has also resulted in less travel time for the HSAs; therefore, HSAs should have more time available to consult with patients. The reason that travel time has been reduced is that, prior to the availability of the phone, the HSAs were reliant on face-to-face communication with their supervisors.

Figure 23 (p. 60) demonstrates the most pressing difficulties experienced by HSAs when using the eCCM application. These problems are a reflection of the contextual factors presenting as barriers in Malawi. The HSAs reported both internet problems as well as an insufficient amount of airtime. Although D-Tree International provides an airtime quota, it may not be enough due to the expensive rates of airtime. *A recommendation for addressing the high cost of airtime would be to work closely with the mobile providers in Malawi just as the RapidSMS programme has done. RapidSMS has achieved an agreement to lower the operational costs of its text messages* (UNICEF, 2015). Alternatively, HSAs may be using the airtime provided for personal use. A few HSAs also reported that their phone broke or that the phone was freezing. Thus, it may be necessary to consider providing the HSAs with more stable mobile phones to run the eCCM application.

Question 38 of the questionnaire showed that 22 HSAs had no electricity to charge their phones and six HSAs reported that the phone's battery died while they were using the eCCM application. D-Tree provides the HSAs with solar chargers and yet a number of HSAs are still reporting that they do not have enough power for their phones. *I would recommend that D-Tree provide all HSAs with a second battery, so that while one battery is in use, HSAs can charge the other battery. An extra battery, at the price of R149 each, would cost R20,264 to cover the Ntchisi district.* Considering, the number of patients seen by the HSAs a month, it is apparent that the HSAs are using the phone for other purposes and not strictly for the eCCM application (Figure 13, p. 42).

Has the application been useful for the interaction between supervisor and HSA?

The mobile phone has enabled a faster method of communication between the HSAs and their supervisors. HSAs are using the WhatsApp application to communicate with their supervisors. The HSAs report that they often communicate with their supervisors via WhatsApp, although not all HSAs report that they use WhatsApp frequently. This could mean that some HSAs are better equipped than others are to deal with problems on their own. From the data, it is clear that some HSAs prefer this method of communication while others do not. However, regardless of the reasoning, the provision of mobile phones has caused an increase in the amount of interaction between the supervisors and the HSAs. However, most HSAs seem to prefer calling their supervisors instead of using WhatsApp. The preference for calling their supervisors could be an explanation of why the HSAs are running out of airtime, as WhatsApp costs significantly less than phone calls. The eCCM application is improving the speed and quality of the information between the supervisors and HSAs, thus providing a similar benefit to the

RapidSMS system in Malawi, which identifies malnutrition among rural children. This programme enabled information transfer time to improve from two months to two minutes (UNICEF, 2015).

The travel time of HSAs has decreased since the HSAs have started using the application. Having a means of communicating with their supervisor, which they may not have had before, could have decreased travel time to see the supervisors in person. HSAs differ in the reported speed of feedback they receive from their supervisors. This could be due to a lack of airtime or to the supervisors not all being as active on WhatsApp. *D-Tree originally intended to install a supervisor chat function into the eCCM application. If D-Tree were to integrate this chat function into the eCCM application, a priority message function could help HSAs to receive timeous responses from their supervisors for urgent queries.* However, a notable benefit of the increased interaction between the supervisor and HSA is that the interactions are moving away from a one-way flow of information. Field-based HSAs were accustomed to seldom receiving feedback for their work. This resulted in a decreased sense of ownership (UNICEF, 2015).

The results therefore show that a contribution of the eCCM application for the HSA and supervisor interaction has been the medium used for the application, i.e., the mobile phone. The mobile phone has increased the frequency of conversation between the involved parties as well as sped up the communication between them. The eCCM application has thus been useful by providing this link in communication.

Limitations of the evaluation. The first limitation for this evaluation was that I am based far from where the programme is being implemented. Thus, I did not have much direct exposure to the programme activities and context of Malawi.

A second limitation is that the evaluation does not have a control group for comparison. I would have been able to make a direct comparison between the paper-based CCM and the eCCM if I had had access to a control group from another district in Malawi that has only had the paper-based version of CCM. However, due to time constraints and limitations in the scope of this study, this was not possible.

Additionally, proxies had to be used to determine if the eCCM application is decreasing incidence of child mortality. The way that the eCCM application captures child death allows for error and makes it difficult to make claims about the trends of child mortality. The confirmed numbers of child death were too low to show an actual decrease with a timeline.

As the eCCM application is continually being updated to meet the needs of the patients, the data files have suffered. That is, the variables do not always match up from month to month. The sample I used had missing data, as certain months did not have certain variables. Another problem was that the Zenji dashboard created a coding variable instead of a variable giving the reason for referral, i.e., the diagnosis. The medicines given by HSAs were thus used as a proxy for correct treatment based on symptoms.

The Zenji dashboard data that holds the CCM, death, and follow-up information is broken into different datasets. This makes a combined analysis of these datasets difficult. It may be more practical for the application to store each full patient record in one data file so that it is easy to follow the progress of each patient.

The questionnaire was in English and although the vernacular was simplified, the HSAs may have had difficulties understanding the questions. A questionnaire in Chichewa may have provided results that were more accurate, as this would decrease possible misunderstandings.

Conclusion. This formative evaluation concludes that the provisional findings above suggest that the eCCM application is bringing about change by means of the activities of the application; namely the medical algorithm, supervision tool, logistics tool, and health records. The eCCM application provides an alternative to the paper-based medium currently used in Malawi. The eCCM application, although a reflection of the Sick Child form, surpasses it by supporting the HSAs by providing a decision-making aid that accurately gives diagnosis and treatment suggestions. The c-Stock software has been successfully integrated into the eCCM application, and thus provides the HSAs with logistical support to make sure they have the needed medication to help their patients. The improved communication between the supervisors and HSAs was an artefact of the provision of mobile phones for the application. In future, this increased communication will reintegrate the HSAs into the health system by providing needed feedback for the HSAs. The main finding of my evaluation is that, while the eCCM application is fulfilling the intended goals of the application outlined by D-Tree, the adequacy of the ecological context of Malawi is preventing the application from reaching its full potential. As Donner (2008) points out, cultural, ecological, societal, and economic factors are all integral in the functioning of mHealth technology.

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APPENDIX I

Sick Child Recording Form

(for community-based treatment of child age 2 months up to 5 years)

Date:_____/_____/____ **HSA:**_____

(Day / Month / Year)

Child's First Name: _____ **Surname** _____ **Age:** __Years/__Months **Boy / Girl**

Caregiver's name: _____ Relationship: Mother / Father / Other: _____

Physical Address: _____ **Village /TA:** _____

1. Identify problems

	ASK and LOOK	Any DANGER SIGN?	SICK but NO Danger Sign?
	ASK: What are the child's problems? If not reported, then ask to be sure: ..... YES, sign present → Tick ☑ NO sign → Circle ■		
☐	■ Cough? If yes, for how long? _____ days	☐ Cough for 14 days or more	
☐	■ Diarrhoea (loose stools)? IF YES, for how long? _____days.	☐ Diarrhoea for 14 days or more	☐ DDiarrhoea (less than 14 days AND no blood in stool)
☐	■ Blood in stool?	☐ Blood in stool	
☐	■ Fever (reported or now)? If yes, started ___ days ago		
☐	■ Convulsions?	☐ Convulsions	
☐	■ Difficulty drinking or feeding? IF YES, not able to drink or feed anything? ☐ ■	☐ Not able to drink or feed anything	
☐	■ Vomiting? If yes, vomits everything? ☐ ■	☐ Vomits everything	
☐	■ Red eyes? If yes, for how long _____days.	☐ Red eye for 4 days or more	☐ Red eye (less than 4 days)
☐	■ Difficulty in seeing? If Yes for how long _____days	☐ Red eye with visual problem	
☐	■ Any other problem I cannot treat (E.g. problem in breast feeding, injury)? See 5 **If any OTHER PROBLEMS, refer.**	☐ Other problem to refer:	
	LOOK:		
☐	■ Chest indrawing? (FOR ALL CHILDREN)	☐ Chest indrawing	
☐	**IF COUGH, count breaths in 1 minute:** _____breaths per minute (bpm) ■ Fast breathing: Age 2 months up to 12 months: 50 bpm or more Age 12 months up to 5 years: 40 bpm or more		☐ Fast breathing
☐	■ Very sleepy or unconscious?	☐ Very sleepy or unconscious	☐ **Yellow on MUAC**
☐	■ Palmar pallor	☐ Palmar pallor	
	For child 6 months up to 5 years, MUAC tape colour: _____	☐ Red on MUAC tape	
☐	■ Swelling of both feet?	☐ Swelling of both feet	
☐	■ If fever(without any danger sign) **Do mRDT**	☐ Negative mRDT	☐ Positive mRDT
☐		☐	☐

2. Decide: Refer or treat child
(tick decision)

☐ **If ANY Danger Sign, refer to**

☐ **If NO Danger Sign, treat at home and advise careaiver**

GO TO PAGE 2 →

Child's name: _____ **Age:**_____

3. Refer or treat child (tick treatments given and other actions)

☐ If ANY Danger Sign, refer to health facility

☐ If NO Danger Sign, treat at home and advise caregiver

If any danger sign, REFER URGENTLY to health facility:	
ASSIST REFERRAL to health facility: ☐Explain why child needs to go to health facility. ☐FOR SICK CHILD WHO CAN DRINK, BEGIN TREATMENT:	
☐ If Diarrhoea	☐Begin giving ORS solution immediately.
☐ If Fever and Convulsions Very sleepy or unconscious Not able to drink or feed anything ☐ If fever AND mRDT negative, no danger sign other than the 3 above	☐ Give rectal artesunate suppository ☐ Age 2 months up to 3 years 1 suppository ☐ Age 3 yrs up to 5 yrs 2 suppository ☐ Refer --- ☐ Refer
☐ If Chest indrawing, or ☐ Fast breathing and danger sign	☐Give first dose of oral antibiotic (cotrimoxazole adult tablet—80/400) ☐Age 2 months up to 12 months— ½ tablet ☐Age 12 months up to 5 years— 1 tablet
If red eye for 4 days or more	☐ Apply antibiotic eye ointment
☐For any sick child who can drink, advise to give fluids and continue feeding. ☐Advise to keep child warm, if child is NOT hot with fever. ☐Write a referral note. ☐Arrange transportation, and help solve other difficulties in referral. →FOLLOW UP child on return at least once a week until child is well.	

If no danger sign, TREAT at home and ADVISE on home care:	
☐ If Diarrhoea	☐Give ORS. Help caregiver give child ORS solution in front of you until child is no longer thirsty. ☐Give caregiver 2 ORS packets to take home. Advise to give as much as child wants, but at least ½ cup ORS solution after each loose stool. ☐Give zinc supplement. Give 1 dose daily for 10 days: ☐Age 2 months up to 6 months – ½ tablet (total 5 tabs) ☐Age 6 months up to 5 years—1 tablet (total 10 tabs) Help caregiver to give first dose now.
☐ If Fever	☐ mRDT is positive, Give LA ☐Age up to 5 months—Not recommended ☐Age 5 months up to 3 years—1 tablet (total 6 tabs) ☐Age 3 years up to 5 years—2 tablets (total 12 tabs) Help caregiver give first dose now and 2nd dose after 8 hours. Then give dose twice daily for 2 more days. ☐Advise caregiver on use of a ITN ☐Give Paracetamol. Give 4 times a day for 3 days ☐ Age 2months up to 3 years - ½ tablet (total 3 tabs) ☐ Age 3 years up to 5 years – ¾ tablet (total 6 tabs)
☐ If Fast breathing	☐Give oral antibiotic (cotrimoxazole adult tablet—80/400). Give twice daily for 5 days: ☐Age 2 months up to 12 months— ½ tablet (total 5 tabs) ☐Age 12 months up to 5 years—1 tablet (total 10 tabs) Help caregiver give first dose now.
☐ If red eye	☐ Apply antibiotic eye ointment. Squeeze the size of a grain of rice on each of the inner lower eyelids, three times a day for 3 days.
☐ For ALL children treated at home, advise on home care	☐Advise caregiver to give more fluids and continue feeding. ☐Advise on when to return. Go to nearest health facility or, if not possible, return immediately if child ☐ Cannot drink or feed ☐ Becomes sicker ☐ Has blood in the stool ☐Follow up child in 3 days (schedule appointment in item 6 below).

4. CHECK VACCINES RECEIVED (tick ☑ vaccines completed, circle ■ vaccines missed)

Age	Vaccine		→ Advise caregiver, if needed: WHEN is the next vaccine to be given? WHERE?
Birth	☐ ■ BCG	☐ ■ OPV-0	
6 weeks*	☐ ■ DPT—Hib + HepB 1	☐ ■ OPV-1	
10 weeks*	☐ ■ DPT—Hib + HepB 2	☐ ■ OPV-2	
14 weeks*	☐ ■ DPT—Hib + HepB 3	☐ ■ OPV-3	
9 months	☐ ■ Measles		

*Keep an interval of 4 weeks between DPT Hib + HepB and OPV doses. Do not give OPV 0 if the child is 14 days or more.

5. If any OTHER PROBLEM or condition I cannot treat, refer child to health facility, write referral note.
(If diarrhoea, give ORS. Do not give antibiotic or antimalarial.)

Describe problem:

6. When to return for FOLLOW UP (circle): Monday Tuesday Wednesday Thursday Friday Weekend

7. Note on follow up: ☐ Child better continue to treat at home. Day of next follow up:_____
☐ Child is not better—refer URGENTLY to health facility.
☐ Child has danger sign—refer URGENTLY to health facility.

July 2008

APPENDIX II

COMMUNITY CASE MANAGEMENT H.S.A SUPERVISION CHECKLIST

Supervisor Name:	**Date:**
HSA name:	**District:**
Name of village clinic :	**Health facility:**

#	Item	Yes	No	NA	Comment
A. CASE MANAGEMENT (Observe the HSA managing a sick child, or use a case scenario from your supervision materials. **TICK** if you observed a **sick child** ___ or if you used a **case scenario** ___.)					
1	Takes child's identification (name AND age AND sex)?				
2	Assesses for all danger signs correctly				
2b	Identifies danger sign(s) correctly				
3	Counts respiratory rate correctly (+/- 2 breaths)				
4	Decides to treat or refer child's illness correctly				
5	Perfom mRDT correctly				
6	Gives correct treatment				
7	Demonstrates how to administer treatment correctly				
8	Counsels (correct messages on feeding, increased fluids and when to return)				
9	Explains how to administer drugs correctly				
10	Asks mother to repeat back how to administer				
11	Asks caregiver to return for follow-up visit				
12	Refers if child has danger sign or condition he/she cannot treat				
13	Facilitates referral (provides referral slip AND first dose)				
	OVERALL SUMMARY (''Yes'' for 2, 4,5,6 and 8)				
B. INFORMATION-DECISION-TREATMENT CONSISTENCY (Review the 5 most recent cases in the Register.)					
14	Case 1: consistent information, decision and treatment				

15	Case 2: consistent information, decision and treatment				
16	Case 3: consistent information, decision and treatment				
17	Case 4: consistent information, decision and treatment				
18	Case 5: consistent information, decision and treatment				
	OVERALL SUMMARY (4/5 or 5/5 cases correct)				
C. DATA QUALITY					
19	Village Clinic Register filled completely (all blanks filled and all boxes appropriately circled or ticked) for last full sheet (= 2 pages)				
20	Page summaries done correctly for last full sheet (= 2 pages)				
21	Copies of at least previous 3 Monthly Reports kept at clinic				
22	CCM Monthly Report submitted to health facility last month? (Ask for a copy to verify)				
23	Did you report on cStock last month				
	OVERALL SUMMARY ("Yes" for items 19, 20,22 and 23)				
D. LOGISTICS (Observe drug box, mRDT and medicines)					
24	Medicines and other medical supplies stored in a 2 lock system drug box				
25	All Medicines and other medical supplies are unexpired.				
26	Observe FEFO				
	OVERALL SUMMARY ("Yes" for 24,25 and 26)				
E. AVAILABILITY OF MEDICINES AND OTHER MEDICAL SUPPLIES (Check medicines and ask about availability.)					
27	Amoxicillin (approximately 100 tablets=10 blister packs)				
28	Did you have Amoxicillin everyday last month? If no, for about how many days were you without Amoxicillin ?.....				
29	Rectal Artesunate (At least 12 suppositories)				
30	Did you have Artesunate everyday last month? If no, for how many days were you without Artesunate?.....				
31	LA 1X6 (At least 36 tablets = 6 blister packs)				
32	LA 2X6 (At least 48 tablets = 4 blister packs)				

33	Did you have LA everyday last month? If no, for about how many days were you without LA last month?……				
34	mRDT (at least 10 tests)				
35	Did you have mRDT everyday last month? If no, for how many days were you without mRDT?……				
36	ORS (At least 12 Sachets)				
37	Did you have ORS everyday last month? If no, for about how many days were you without ORS last month?……				
38	Zinc (Approximately 60 tablets)				
39	Paracetamol (Approximately 36 tablets)				
40	Eye ointment (At least 6 tubes)				
41	Did you have a continuous supply of LA, mRDT,RA, Amoxicillin , and ORS for the last 3 months without any stock-out of those products?				
42	Did you have a timer and a continuous supply of LA, mRDT,RA,Amoxicillin , ORS and zinc for the last 3 months without stock-out of any for 7 or more days?				
	OVERALL SUMMARY ("Yes" for 27,29,31,32,34 and 36)				
F. AVAILIBILITY OF SUPPLIES (Ask HSA to show you the following.)					
43	Appropriate timer (measures seconds and minutes) available and functioning				
44	Blank Monthly Report forms (at least 2)				
45	Village Clinic Register with blank pages (for at least 10 cases)				
46	Do you have a cellphone				
47	Laminated Sick Child Recording Form in color				
48	Blank referral slips (at least 3)				
49	Supervision Log Book				
50	MUAC tape				
51	Plastic pail				
52	Basin				

53	Spoons (at least 2)				
54	Cups (at least 2)				
55	Disposable gloves				
56	Swabs (cotton and spirit)				
57	Disposable Aprons				
58	Sharps containers				
59	Biohazard bags				
	OVERALL SUMMARY ("Yes" for items 43,44,46,48,50,55,56 and 58)				
G. COMMUNITY INVOLVEMENT					
60	VHC helps monitor drug availability? (available during clinic OR sign drug order form OR witness re-supply)				
61	VHC member keeps drug box key				
62	VHC held child health mobilization or education session in the last quarter				
	OVERALL SUMMARY ("Yes" for 61 and 62)				
H. WATER and SANITATION at the CLINIC (Observe for…)					
63	Latrine (mud or brick) with drop-hole cover				
64	Pit latrine for throwing in sharps materials				
65	Rabish pit for burning no sharps materials				
66	Hand washing (running water) available at latrine				
67	Safe, protected source of water at the clinic (for first dose)				
	OVERALL SUMMARY ("Yes" for 63 and 67)				

68	What were the HSA's most important concerns (and your responses)? Number by priority.
69	**Observations and recommendations? Also record in Supervision Log Book at Village Clinic**

APPENDIX III

Activity	Month Start	Month End	Milestones
1. Expand and consolidate coverage of CCM tool			
1.1 Meet with district and MOH to identify key districts for support	M1	M1	Districts selected
1.2 Orientation meetings in selected districts and HSA selection	M2	M2	Orientation meetings held
1.3 Training of additional HSAs	M3	M9	Additional HSAs trained
1.4 Systems support and supportive supervision	M3	M24	
2. Develop comprehensive HSA support tool and support structures			
2.1 Meet with nutrition unit at MOH and other stakeholders	M1	M2	
2.2 Selection of candidate sites for pilot	M2	M2	
2.3 Development and validation of 0-2 month and malnutrition algorithms	M2	M4	Algorithms approved by MOH
2.4 Develop integrated application	M5	M7	Prototype application developed ready for field testing
2.5 Field-test and refine the software	M7	M8	Stable, easy to use tool available for wide-scale use
2.6 Develop, test and refine training packages	M6	M8	Training packages developed and tested
2.7 Train HSAs in one district	M8	M9	~50 HSAs trained
2.8 Provide technical support and quarterly supervision	M8	M24	Comprehensive tool functioning in field with

			minimal technical support required
2.9 Training for MOH trainers on systems support and data analysis	M2	M3	Existing MOH trainers trained
2.10 Continue to co-Chair the mHealth Community of Practice	M1	M24	Community of Practice meeting regularly (quarterly)
2.11 District trainings on Data Usage and Analysis	M3	M6	Districts trained
2.12 Quarterly District Data Review Meetings	M4	M24	Quarterly meetings held
2.13 Recruitment and secondment of HSA mHealth coordinator at MOH	M1	M3	HSA mHealth Coordinator placed
3 D-tree Capacity improvements			
3.1 Recruiting of Communications Officer and Data Analyst	M1	M3	Communications Officer and Data Analyst hired
3.2 Outreach activities	M4	M24	Newsletters, campaigns, routine Twitter, Facebook, website updates are produced
3.3 Documentation	M4	M24	Project videos, blog posts, success stories produced
3.4 General Operating Support raised (via foundations and individuals)	M4	M24	Increase # of new donors by 500% and secure 2 – 3 new unrestricted grants from private foundations

APPENDIX IV

Table 2. *HSA training schedule as outlined by D-Tree's 2015 training agenda for Mzimba.*

Time	**Activities on Day 1**
8:00-08:30	Introduction – get to know each other
08:30-9:00	Introduction about D-Tree Remarks form IMCI Coordinator
9:00-10:00	Introduction to phones: The external features of the phone and their uses Switching on phone Menu and applications – tap, swipe, unlock/lock screen etc. Setting date and time (Ensuring correct date settings) Applications (How to find apps and how to create a shortcut on home screen) Open application and log in Phone settings
10:00-10:15	Morning break
10:15-12:00	Introduction to eCCM application: Registration, Sick Child Form and mRDT, vaccinations, follow-up, patient history, report death or move, syncing, edit patient details, search patient, sort children names. Monthly report Chat Detailed discussion and practice with eCCM application.
12:00-13:00	Lunch
13:00-15:00	Practice: Registration, history taking, follow-up, patient history, monthly report, vaccinations, report death or move a child
15:00-15:15	Break
15:15-16:00	Feedback about practicals
16:00-16:30	Introduction to android c-Stock – familiarisation with interface
16:30-17:00	Recap of the day
Time	**Activities on Day 2**
08:00-08-30	Recap of day 1

08:30-9:30	c-Stock: Registration, adding products, reporting stock on hand, transfer to other HSA, receipt from health centre, emergency order, receipt from other source, leave c-Stock
9:30-10:00	Practice with c-Stock: Registration, adding products, reporting stock on hand, transfer to other HSA, receipt from health Centre, emergency order, receipt from other source, leave c-Stock
10:00-10:15	Break
10:15-11:00	Practice with c-Stock
11:00-12:00	Feedback session and discussion about eCCM and c-Stock in general and testing of solar panel chargers
12:00-13:00	Lunch
13:00-15:00	Practice c-Stock and eCCM
15:00-15:15	Break
15:15-15:45	Discussion about common problems in eCCM and their management: Syncing, battery charging and consumption, using phone first and village register later, check, application missing reports, family info, patient history, synching, What's app
15:45-16:15	Discussion about common problems in c-Stock and their management: Lost phone/stolen phone
16:15-16:45	Recap for the day
Time	**Activities on Day 3**
08:00-09-00	Handover of phones and initialization
9:00-10:00	Migration to c-Stock
10:00-10:15	Break
10:15-11:00	Transport Reimbursements
11:00-11:15	Closing remarks – end of training

APPENDIX V

For the following please circle how much you agree with the statement.

1	**Medicine is more available since I started using the CCM mobile application.**				
	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
2	**Health records are easier to access with the CCM mobile application.**				
	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
3	**Health records on the CCM mobile application are useful.**				
	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
4	**CCM mobile application health records cover all the information I need to know about a patient.**				
	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
5	**I use health records more often since I started using the CCM mobile application.**				
	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
6	**My follow ups have become easier with the availability of mobile CCM application health records.**				
	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
7	**I follow the step-by-step procedure of the CCM mobile application every time.**				
	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
8	**I always follow the treatment suggestions of the CCM mobile application.**				
	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
9	**I always use the CCM mobile application diagnosis for the treatment of my patients.**				
	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
10	**I rely on my own experience to make decisions about treating my patients.**				
	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
11	**My phone's battery life runs out while seeing patients.**				
	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
12	**I do not plan on using the CCM mobile application in the near future.**				
	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
13	**I feel bored when using the CCM mobile application.**				
	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
14	**I have used the CCM mobile application for children older than 5 years of age.**				
	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
15	**I often use the WhatsApp chat function to communicate with my supervisor.**				
	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
16	**The CCM mobile application has made my work easier.**				
	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
17	**It is faster to use the CCM mobile application than paper records.**				
	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
18	**Medication has gone missing since I started using the CCM mobile application.**				
	Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree
19	**The CCM mobile application has taught me how to better diagnose my patients.**				

Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree

20 I feel more confident in my decision making since I have started using the CCM mobile application.

Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree

21 I find the CCM mobile application diagnosis to be more accurate than my own.

Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree

22 I prefer to call my supervisor instead of using WhatsApp.

Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree

23 C-Stock is easier to use with the CCM mobile application.

Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree

24 C-Stock helps me get my stock on time.

Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree

25 C-Stock gives me an accurate count of my available stock.

Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree

26 C-Stock makes me less likely to run out of medical supplies.

Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree

27 It is easier to get health records to my supervisor since I started using the CCM mobile application.

Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree

28 I travel less since I started using the CCM mobile application.

Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree

29 I am able to provide better care to my patients since using the CCM mobile application.

Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree

30 I have the necessary medicine available for treatment since using the CCM mobile application.

Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree

31 I find it easy to call up patient records using the CCM mobile application.

Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree

32 I am less likely to lose patients health records since using the CCM mobile application.

Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree

33 I use some of the phones functions differently than I am supposed to.

Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree

34 I receive fast feedback from my supervisor via WhatsApp.

Strongly Disagree	Disagree	Not sure	Agree	Strongly Agree

Tick every option of the list that applies to you.

35 How long have you worked with the paper based CCM?

less than 1 year	
1 to 3 years	
4 to 6 years	
7 to 10 years	
more than 10 years	

36 How long have you worked with the mobile based CCM?

less than 6 months	
6 months to 1 year	
1 to 2 years	
3 to 4 years	
more than 4 years	

36 What problems do you experience using the CCM mobile application?

Phone freezes	
Internet problems	
No airtime	
A function doesn't work	
Phone broke	
Incorrect diagnosis	
Incorrect treatment	
Missing patient records	
Other	

37 Which clinic do you work for?

Ntichisi-dho	
Malambo	
Mkhuzi	
Chinthembwe	
Malomo	
Nthondo	
Mndinda	
Khuwi	
Mzandu	
Chinguluwe	
Kangolwa	
Kamsonga	

38 What prevents you from using the CCM mobile application?

Forgot my phone	
My phone was stolen	
My battery died	
My patient doesn't like me using CCM	
A technological problem	
No electricity to charge my phone	
It's difficult to use	
Other	

APPENDIX VI

Variables retained for Analysis as per Zenji Dashboard availability
Time
Patient Id
unlisted-other-problem
child-has-swollen-feet
refer
child-has-chest-indrawing
child-has-sleepy-or-unconscious
child-has-fast-breathing-1-5-years
no-ors-reason-other
reason-given-no-eye-ointment
given-cotrimoxazole-tablets
mrdt2
mrdt
mrdt1
child-has-which-other-problem
sick
days-with-red-eyes
breaths-per-minute
refer-medicine
child-has-fever
child-has-palmar-pallor
child-has-difficulty-seeing
given-ors-sachets
child-has-cough
given-eye-ointment-tubes
given-la-tablets
child-has-muac-colour
reason-no-paracetamol-given
pause
child-has-unable-to-drink-feed
child-has-vomitting
itn-advice
child-has-other-problem
status
days-with-diarrhoea
days-with-fever
persistent-diarrhoea
given-zinc-tablets
given-amoxicillin-tablets
reason-other-no-la-given
child-has-red-eyes
reason-given-no-ors
child-has-fast-breathing-2-11-months
child-has-blood-in-stool
days-with-cough
child-has-vomitting-everything
child-has-unable-to-drink-feed-anything
child-has-convulsions
child-has-diarrhoea
given-paracetamol-tablets
Patient Uuid
reasons-for-referral
months
reason-given-no-la

APPENDIX VII

The following is a request from a Master's student from South Africa:

I am currently doing my Master's degree in Programme Evaluation at the University of Cape Town and as part of the requirement for my degree I am working together with D-Tree to have a look at their Community Case Management application.

The purpose of this evaluation is to provide D-Tree with some valuable feedback on the CCM application that has become part of your daily routine. The questions I am asking will hopefully shed some light on your experience of the CCM application and how it has affected your daily work. This feedback together with the data that D-Tree has captured could then provide D-Tree with the necessary insight into the programme and if they are achieving what they set out to do.

I humbly ask that you answer the following questionnaire. You will not be requested to supply any identifiable information, ensuring anonymity of your responses. Your participation in this research is voluntary. You can choose to withdraw from the research at any time.

The questionnaire will take approximately 10-15 minutes to complete.

This research has been approved by the Commerce Faculty Ethics in Research Committee.

If you have any questions about my research, you may feel free to contact me via e-mail.
kaitschramm@live.co.za

I would like to thank you in advance for helping me with my research.

Kind Regards,

Kai Schramm

APPENDIX VIII

The code used below was the check for the correct referral based on SPSS coding. This emulates the sick child form (See Appendix I). The reverse of this was used to confirm that no presenting danger signs resulted in home treatment.

Referral Check:

child_has_other_problem = 1 & refer = 1 OR child_has_muac_colour = 3 & refer = 1 OR child_has_swollen_feet = 1 & refer = 1 OR child_has_blood_in_stool = 1 & refer = 1 OR child_has_chest_indrawing = 1 & refer = 1 OR child_has_sleepy_or_unconcious = 1 & refer = 1 OR child_has_convulsions = 1 & refer = 1 OR child_has_palmar_pallor = 1 & refer = 1 OR Redeyes_Seeing = 1 & refer = 1 OR days_with_red_eyes >= 4 & refer = 1 OR child_has_vomitting_everything = 1 & refer = 1 OR child_has_unable_to_drink_feed_anything = 1 & refer = 1 OR Fever_Mrdt1 = 1 & refer = 1 OR days_with_cough >= 14 & refer = 1 OR days_with_diarrhoea >= 14 & refer = 1 OR refer_medecine = 1 & refer = 1