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Mobile Based Design for Strengthening Traditional Birth Attendant Health Care Systems in Low Resource Settings: The Case of Migori County, Kenya

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Abstract

Mobile health applications are established tools for healthcare management, patient education, and capacity building of healthcare providers. However, their use for strengthening Traditional Birth Attendant (TBA) health care systems is surprisingly limited in low resource settings where geographic, social, or economic barriers render the World Health Organization (WHO) policy of facility births untenable. The work presents a blueprint for implementing a mobile-health intervention for strengthening TBA health care systems in low resource settings. The objectives were to establish existing TBA structures, their challenges, TBA user requirements, and to develop and test a prototypical implementation. A mixed methods study facilitated the collection of quantitative and qualitative data from a population of pregnant mothers seeking care within public hospitals in Migori County, TBA & skilled birth attendants (SBAs). A survey instrument administered to 20 patients, 20 skilled birth attendants, and 20 traditional birth attendants was used in establishing challenges of existing structures, eliciting user requirements, and for the design and testing of the prototype mobile based design. Snowballing sampling enabled the researchers reach patients and TBAs who had visited the four public facilities in Rongo Sub County in the second quarter of the year. The focus group discussions method led to refined user requirements, while review of documents on maternal and newborn care protocols enabled the research to determine desired system functionalities for the new roles envisaged by the World Health Organization (WHO) for TBAs in low resource settings. Findings showed that TBA health Care systems were manual with weak links to the formal health care system. Users required a system that could support secure collaboration between TBAs and SBAs, address the problem of scarce SBAs and facilities, improve the convenience, cost and quality of care suitable for their social economic status. Figma was used as a user interface design tool to rapidly prototype the design. The prototypical design was implemented in MySQL and Java. The resulting mobile based design provided users with functionality to register and log into the system, capture, and avail patient data, access global maternal and child health protocols and offer telemedicine sessions between patients, TBA and SBAs. The prototypical TBA app was tested during a focus group session for performance, usability, and utility. The TBA app offers a convenient, cost effective and quality system while addressing the key challenges of manual TBA health care systems in low-income settings. Findings offer valuable design insights for implementing a mobile based initiative to address the challenge of reducing maternal mortality in low resource settings in Kenya and beyond.

Keywords: *Mobile Based Design, Skilled Birth Attendants, Low Resource Settings, Traditional Birth Attendant Health Care Systems*

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1.0 Background

Mobile health (mHealth) applications are proven digital platforms for healthcare administration, patient education, and capacity building for healthcare staff. However, the application of mhealth by traditional birth attendants (TBAs) is scant despite the vast possibilities in solving challenges of care seekers in low resource settings. Proof of concept, design and development, a pilot test were the frequently documented stages of related mHealth interventions (Aboye, Walle and Aerts, 2023). In such contexts, patients in remote and hard-to-reach areas and are often unable to access skilled birth attendants (SBAs). Traditional birth attendants are key to providing maternal and new born health care (MNHC) within these communities. TBAs is an elderly woman with skills to assist during childbirth acquired by delivering babies herself or through apprenticeship to other TBAs. They are often older women and are generally illiterate (WHO, 2016).

The persistence of traditional birth attendants in low resource setting has been a subject of recent focus by the World Health Organization (WHO). In particular, it has been suggested that a need exists to rethink the suitability of the current global maternal health policy. Once promoted as part of the solution to reducing maternal mortality, the training and integration of TBAs into formal healthcare systems in the global south was deemed a failure and side-lined in the late 1990s in favor of ensuring a skilled attendant at every birth (Starrs, 1997). The shift in policy was a matter of some debate. In fact, the question of whether and how to effectively to engage TBAs has been one of the core policy debates in the history of the global maternal health movement and TBAs continue to be regarded with deep ambivalence by many researchers and policymakers at the national and global levels, not to mention front-line healthcare providers (Campbell et al., 2016; Prata et al., 2011).

In the wake of the policy shift, TBAs did not go away, though the programmes to train and support them often did. Non- Governmental Organizations (NGOs) and National Health Systems focused their efforts elsewhere as funding dried up for such projects and research. And so began an era of policy retreat with regard to TBAs at the global level, which continues in large part today. In major statements and position papers, the training and formal integration of TBAs in the past appears as a policy that did not produce (Starrs, 1997; WHO, 2005). Yet TBAs continue to practice and participate in maternal health projects in many countries with varying degrees of inclusion within formal healthcare systems. The persistence of TBAs in low resource setting suggests that the global policy on facility births may be unsuitable in the global south. Some of the challenges of enforcing a global policy that favors facility birth include inadequate emergency obstetric facilities, few trained birth attendants, and poverty. Mobile technologies are acknowledged as having the potential to address these long-standing issues in provision of maternal and newborn care in low resource settings. In such settings, design of a mobile based health care system can strengthen existing manual systems by improving access, lowering costs and increases patient control of health care provision. While traditional birth attendance remains an attractive option in low resource settings in the global south, current manual structures remain inadequate in supporting the new roles of traditional birth attendants.

This study argues for a mobile based design that can facilitate the implementation of a mobile design for strengthening TBA health care systems, especially in the global south.

The current global policy on maternal and newborn care assigns TBAs the role of encouraging of pregnant mothers to deliver in health care facilities. Unfortunately, in most low resource settings the problems of distance, inadequate facilities and healthcare personnel have made TBAs a preferred option. It is often impractical in such settings to apply the global policy that discourages traditional birth attendant's involvement during delivery in preference for facility births. As the practice is not practical in low health resource settings, it may be argued that a need exists to rethink the roles of TBAs. Central to the argument that a need exists to redesign TBA health care systems is emerging evidence that Mobile health (mhealth) interventions have enormous potential in the global south. Mobile health technology has become more and more widely available and used in the global south. The emergence of mhealth apps that focus on Maternal and Newborn Child Health (MNCH) offers a great opportunity for the design of a comprehensive mobile based traditional birth attendant health care system. Mobile device usage and scarcity of health care resources are arguably at the center of initiatives aimed at strengthening TBA health care systems using mobile based designs.

Thus, it can be argued that a mobile based TBA health care system can strengthen the role of TBAs in provision of clinical services to underserved populations in the global south, such as Kenya and Sub-Saharan Africa where mobile technologies continue to penetrate. Recent data on mobile phone penetration in Sub-Saharan Africa (SSA) shows that 51% of residents own a mobile device (Paw Research Center, 2021). By the end of 2020, 495 million people or 46% of the population had mobile service subscriptions in Sub-Saharan Africa. Fifty percent of the population, or 619 million people, are projected to subscribe to mobile services by the end of 2025. The number of internet users in SSA is currently 303 million (28%) and is projected to reach 474 million by the end of 2025. (39%) (Aboye et. al, 2023). Sub-Saharan African nations are adopting mHealth as a way to increase accessibility to high-quality, egalitarian healthcare, particularly for underprivileged and vulnerable people in low health care resource settings (Scott & Mars, 2015). The evidence that most mothers in low health care resource settings prefer to be attended by traditional birth attendants' points to the need to rethink the roles of TBAs. The problem is that despite increased penetration of mobile technologies and persistence of TBAs, its use amongst traditional birth attendants is limited.

For instance, the work by Dwivedi et al (2024) was limited to exploring the needs and bottlenecks of developing an interactive mobile application for maternal and infant care for tribal birth attendants. The scope of the study did not include the development of a mobile based design research for strengthening TBA health care systems. It was a qualitative study based on in-depth interviews with seekers of Maternal and infant services, and furthermore was conducted in tribal and rural locations in the district Sirohi, Rajasthan in India. The current study also builds on lessons learnt from three decades of confusion on strengthening traditional birth attendant's roles in the Global South. It builds on earlier studies in Malawi and Tanzania on the use of mHealth interventions aimed at providing MNCH services to underserved populations in Sub Saharan Africa. The current study addresses the research gap by developing and testing a prototype of a mobile based design for strengthening traditional birth attendant health care systems in low health care resource settings. It is acknowledged that TBAs are indispensable in provision of MNCH care in low resource settings.

However, there is little research on how mobile technologies can be deployed to strengthen existing manual TBA health care systems in SSA. The lack of clarity on how to strengthen TBA health care systems is arguably a key challenge in automating TBA health care provision

in resource limited settings. The earliest attempts to incorporate TBAs in the 1770s failed to redefine their roles using ICTs perhaps because the technology wasn't widely available. The approach during this decade involved the inclusion of TBAs as part of the international response to maternal mortality (Neumann, Ampofo & Nicholas, 1974). The interventions during the 1970s focused largely on training of TBAs. Unfortunately, despite efforts in this and subsequent decade to train TBAs, evidence gathered shows little reduction in maternal mortality ratio. The failure of training as a strategy for strengthening TBAs ability to provide MNCH care led to a shift in policy toward promoting birth with skilled birth attendants (SBAs) in facilities. The approach has been to improve the ability of TBAs to work in close partnership with SBAs in provision of MNCH care services (Freedman et.al, 2007).

By the end of the 30 years of interventions designed to skill up TBAs and encourage facility births it become apparent that a rethink of the role of TBAs was needed. In particular, the advent of mhealth provided a platform for striving to attain the MCH goals set in the MDGs. To be able to play their newly established roles, use of mobile health technologies to strengthen TBA health care is suggested (PWC, 2012). Mobile health (mHealth) is gaining momentum as a tool to advance the provision and promotion of Maternal and Newborn Child Health (MNCH) in underserved areas (Tamrat and Kachnowski 2011, mHealth Alliance 2012). With increased use of mobile phones in low-income countries, it is increasingly seen as a strategy to address barriers to accessing MNCH information and care (Free et al. 2013).

It is expected that deploying mobile technologies to strengthen TBA health care systems the potential of accelerating the achievement of maternal health targets in many countries (WHO, 2010a). Worldwide, mobile technology and its promise have moved up the healthcare agenda (PWC, 2012). The enhanced research interest in the use of mobile technologies is attributable to its increasingly ubiquitous and potential to address long-standing issues in healthcare provision characteristic of low resource settings. The problem is that such a system must be carefully designed bearing in mind the emerging role of TBAs as per current global policy on maternal and newborn health care.

To address the research gap, we develop and test a prototypical implementation of a mobile based design for strengthening TBA health care suitable for low health resource settings. The objectives are to establish the current structures and their limitations for strengthening TBA health care systems, establish its user requirements, and then design and test its prototypical implementation. Recent research on ways of reducing maternal mortality, has shown that being able to strengthen the TBA health systems using mobile based applications holds the promise to attaining global maternal health targets. Most studies found that mobile phone technology is highly appreciable in improving several Maternal and new health (MNH) indicators, in low resource settings (De & Pradhan, 2023). Mobile based designs have the potential of solving the long-standing problems of distance, inadequate facilities, and SBAs. A mobile based design is particularly envisioned as an ideal solution to the problem faced by traditional birth attendants.

Such as design answers the need for telecommunications technology as a medium for the provision of medical services to sites that are at a distance from the provider (WHO, 2010b). However, telemedicine is still an unpopular and emerging technology in Kenya. Hospital visits is the most common practice. But with the dramatic expansion of mobile technology, delivery and quality of health care is bound to change. For remotely located patients, a well-designed application can strengthen TBA ability to handle patients with the help of remotely located and often scarce skilled birth attendants. With a tele-medical application, a doctor can access real-time images of patients and provide care through the TBA on location. The aim of this research is to provide a prototype model of a mobile based application for strengthening the role of

TBAs in line with renewed calls for a rethink of the roles of TBAs. In particular, it seeks to provide an empirically derived model for a mobile based tele-medical application suited for low resource settings. Such as system can allow the provision of real-time support to TBAs by SBAs based in distant health facilities. An analysis of existing interventions aimed at strengthening the role of TBAs have tended to focus on their training and limiting their roles to referrals to health facilities. The existing structures seem to make this approach little workable in light of challenges in low resource settings. A systematic review of evidence suggests that attendance at health facilities is often avoided for lack of quality and timely care.

2. Literature Review

A review of literature on Global maternal health policy points at its global nature and lack of clarity on the role to be played by TBAs. The literature suggests that an all-sizes fit policy may not work where resource limitations make it preferable to be attended by a TBA. The problem is that global policies are often crafted in developed country contexts and hardly realistic in the context of low resource countries. For instance, current the current global maternal and child health policy requires that the global roles of TBAs be limited to referring patients to health facilities. Such a policy is crafted in the Global North may not be wholly applicable to countries in the global south. Research suggests that determinants of in uptake of SBA's birth attendance services are region-specific, whereas poverty, maternal education, and urbanization have become less predictive for the uptake of SBA over time (Priebe et al., 2024).

The elusive goal of improving maternal health appears to have led to renewed calls for better programming in recent times. In settings with poorly functioning health systems and limited infrastructure, a comprehensive approach is essential. Integration mechanisms may be the same as for strong health systems; however, their application will differ. In weak health systems, universal access is an unreasonable expectation: priority must be given to women at high risk of complications and obstetric emergencies, with integrated TBAs occupying more pronounced, long-term roles.

The evidence is overwhelmingly context-related; thus, TBA integration must be based on situation analysis to ensure selection of the most appropriate integration mechanisms and complementary activities. Applied in this way, strengthening TBA capacity through platforms to virtualize care, well designed mobile based systems have the potential to enhance real-time remote skilled birth attendance and, thereby, contribute to safer motherhood. The present study reviews existing structures for strengthening TBA health systems, their challenges and TBAs mobile based application systems design requirements.

The literature on strengthening TBA health systems cites multiple mechanisms for TBA strengthening. The often-cited approaches include training and supervision of TBAs; collaboration skills for health workers; facility-based integration; communication systems; and role definition. Unfortunately, current structures for strengthening TBAs role seems to bear little fruits in the face of weak health care systems in low resource settings. It has been suggested that successful strengthening of TBA health care systems may involve more than just applying mobile technologies. Success is dependent on the ability to create an enabling environment: first, to support TBAs to link women with formal health workers, and second to remove barriers to women's access to SBAs. For TBAs, direct support from community members and health workers is crucial; however, their inclusion in the formal health system is also likely to require policy, strategy, and legislation changes (Byrne & Morgan, 2011). The current study investigates the design of a TBA health system aimed at addressing gaps in current conceptualization of their roles. It proposes an intervention that has the potential of involvement of TBAs by increasing coverage of skilled birth attendance coverage, setting up

formal heath care structures with potential of strengthening the connections between TBAs and the health system.

In this way, TBAs can make a profound contribution to safer motherhood. While there is renewed interest in TBAs it is surprising that current structures are yet to effectively incorporate them into a health system-oriented approach to safe motherhood programming. This is unexpected as mobile based health care systems can strengthen TBAs ability to play the new role envisioned for them by the WHO. The current WHO global policy on maternal and newborn child health care (MNCH) requires TBAs to promote facility births. Insufficient human resources (doctors, nurses), poor health resource allocation, lack of access to healthcare and high disease burden has hampered the implementation of the WHO policy on MNCH. For instance, emerging evidence from recent studies in Kenya suggest that the effect of the change in global policy on facility birth on maternal deaths is inconclusive. Findings suggest that changes in maternal natality is also influenced by the context of the study, with urban areas showing less deaths than rural areas. As evidence isn't conclusive a need exists to investigate the problem of TBA to fill the contextual gaps. This study aims at investigating the use of mobile technologies in mainstreaming involvement of TBA in rural settings in a developing country context, such as Kenya.

A review of studies conducted in low resource settings point at five existing structures for strengthening the role of TBAs that can be automated by use of mobile based systems. According to Byrne & Morgan (2011) existing research has only tended to focus on means of TBA integration, commonly applied complementary activities, and change in coverage of skilled birth attendance. Existing mechanisms for TBA integration are often limited to training and supervision of TBAs; collaboration skills for health workers; inclusion of TBAs in facility-based activities; systems for communication between TBAs and SBAs; and defining roles for TBAs and SBAs. Further, complementary activities were commonly employed in conjunction with TBA integration included specific selection of TBAs; community participation; accessibility changes; health system development; and improved affordability, including scrapping of maternity fees as is the case in Kenya. The impact of existing structures for strengthening TBA health café systems within resource scares contexts has not been impressive. However, it may be argued that design of a mobile based system has the potential to actualize the intention of current policy for strengthening the global role envisaged for TBAs, given the current maternal policy.

From previous studies, structures with the potential to strengthen TBA health care systems included regular training, supervision and collaboration. The current study is premised on the possibility of a mobile based design for building relationships among SBAs, TBAs, and community members. Its operationalization would strengthen care as TBAs will be formally included in facilities. A noteworthy eventuality is that at implementation, TBAs would be included as partners in low resource settings with their roles re-defined beyond recommending facility births. As currently envisioned, TBAs role in the period before, during and after childbirth is premised on global measures of skilled birth attendance. The paradox is that TBAs still handle most of the deliveries at home despite the global policy of promotion of facility delivery. It may then be argued that it makes sense to consider mobile based designs that can strengthen TBA health care services while addressing barriers to facility births in low resource settings.

Conclusions from previous research that major barriers to skilled birth attendance are transport, cost, distance (Lee et. al., 2009;), and health worker shortages (Prata et. al., 2009). Others include the lack of female health workers (Islam & Malik, 2001; Gloyd et. al., 2001), poor

quality of care and communication by health workers (O'Rourke, 1995), and an unwillingness or inability for women to leave the home (Koblinsky et. al., 2006). As suggested by Byrne & Morgan (2011), an initial assessment of the low resource setting, health system capacity, and barriers may lead to appropriate application of TBA integration and increased skilled birth attendance. Recent work tends to favor models of strengthening TBA healthcare systems that deploy self-management technologies. The current WHO recommendations that banned TBAs from offering delivery services and limits their role to promoting SBA at facilities requires a rethink of strategies for strengthening the roles of TBAs.

With increased availability and use of mobile phones in low-income countries, it is increasingly seen as a strategy to address barriers to accessing MNCH information and care (Free et al. 2013). It can be argued that in the context of low resource settings, such as Migori County in Kenya, there is a need to rethink MNCH care provision by deploying mobile based platforms of care. In particular, for such contexts a new health care delivery models that deploys mobile based health care systems can strengthen self-management and improve quality of compliance and monitoring of prescriptions.

The biggest advantages of using mobile phones to strengthen health care are that these devices are personal, intelligent, connected, and always with people (Whittaker, 2012) These systems can serve patients in everyday life, during hospitalization, rehabilitation and on emergencies. The pervasive high speed wireless networks and powerful mobile devices, there is no doubt it is going to transform health care delivered (Byrne & Morgan, 2011). Recent surveys of mobile health applications in healthcare shows advancement of mobile technologies have had a great impact on healthcare systems. Sub-Saharan African nations are adopting mobile based health care as a way to increase accessibility to high-quality, egalitarian healthcare, particularly for underprivileged and vulnerable people, in order to take advantage of the aforementioned potential (Scott & Mars, 2015). In terms of type of mobile based designs, they are categorized as SMS based, App-based, Telemedicine-based, wearable-based, and mixed mHealth approaches.

SMS based mobile designs consist of applications that use text messaging as a means of delivering healthcare interventions or services through mobile devices. App-based designs use mobile applications (apps) to deliver healthcare interventions, services, or support through smartphones or other mobile devices. Telemedicine based designs use mobile devices to facilitate virtual consultations between healthcare providers and patients. Wearable-based designs involve the integration of sensor-based wearable devices with mobile applications or online platforms. Finally, mixed mobile designs utilize a combination of one or more of these mobile designs.

Ali, E., Chew & Yap (2015) note that the purpose served by mHealth interventions are health promotion and disease prevention, diagnosis, treatment, monitoring, and health services support. mHealth applications encourage healthy behaviors by providing support for patient tracking and feedback, goal setting and social influence (Klasnja, Predrag, and Wanda, 2014). Current evidence suggests that the use of mobile technology can improve diagnosis and compliance with treatment guidelines, as well as patient information, and can increase administrative efficiency (Sherry & Ratzan, 2012). Other ways are strengthening surveillance, health information, acquisition and analysis of primary health data, supporting community health worker, teleconsultation, tele-education, research, and patient management (Osei et al, 2021). Despite potential of mobile based designs for strengthening TBA health care systems, no study reports the design of a mobiles-based app for strengthening TBA health care systems. Indeed, despite popularity of mHealth for MNCH, mobile designs for strengthening home-

based care and reducing the burden on the health system are not yet widespread (mHealth Alliance 2012). In fact, mHealth apps have tended to support health care seekers, and offer little supporting for the roles of TBAs, particularly in low health resource settings.

Notable exceptions, include the Health Center by Phone in rural Malawi, designed to bridge the divide between communities and life-saving health information and services. The app provides pregnant women and caregivers with new, timely, and reliable MNCH information. In Tanzania, the Wired Mothers app, has shown positive impact on maternal health outcomes (mHealth Alliance 2012). It is designed to strengthen communication between caretakers and primary health care units. Like other interventions, the Wired Mothers mhealth interventions deploys voice and text message reminders for awareness and knowledge building (mHealth Alliance, 2012). These apps weren't intended for strengthening TBA health care systems. The current research builds on these earlier interventions by focusing on a mobile based design for strengthening TBA health care systems in low health care resource settings. The current study addresses this conceptual gap by developing a mobile based design of a prototypical app for strengthening TBA health care systems. The aim is to provide a blueprint for implementing a mobile-health interventions targeting the work of TBAs in settings where facility birth isn't a viable option, owing to geographic, social, or economic barriers.

Though the mHealth field is still in its infant stages, its potential to transform health delivery in developing countries it enormous. Projects throughout the developing world are demonstrating concrete benefits. The first, is strengthening of collaboration with facilities to increase access to healthcare by hard-to-reach populations. Second, is strengthening diagnosis and tracking of diseases in the whole continuum of MNCH care. Third, is strengthening the provision of timelier and more actionable public health information. Fourth, the TBA the mobile based health care system will strengthen TBA's ability by enabling them to obtain continuing medical education and training together with other health workers in facilities. Fifth, the mobile based design will strengthen TBA healthcare systems by improving patients-health care facility interaction and lowering the cost of care by SBA. The potential for actualizing the design can be actualized if the design is based on user needs and targets rethinking of care provision in situations where health care resources and personnel are limited.

For the mobile based design to actualize its purpose of strengthening TBA health care it must be based on user needs. Software engineering approaches were used to study the current system and base the systems design on analysis of user information needs. An analysis of challenges of the existing system enabled the researchers to generate user's functional requirements. Nonfunctional requirements relating to security and ease of use were also specified to ensure the optimal design is secure, easy to use system and upholds data privacy. It is expected that the strengthened TBA health care system will make patients more responsible in preserving their health. Further, a strengthened TBA health patients is likely to provide patients with incentives to improve eating and exercise habits, so as to achieve normal delivery at term. By providing information on the devastating consequences of poor care, the mobile based design may promote prevention and address the challenges of maternal health in low resource settings. Further, the functionality to capture patient data would provide medical specialist with valuable input for offering accurate tele-consultations. will be availed to the medical specialists at remote health facilities. Also, the health facility can monitor the short-term and long-term course of the pregnancy, develop a complete treatment plan, and assess in detail the performance of a specific intervention.

3. Methods

In this study a mixed methods research design was adopted. A survey research design proved adequate for establishing the existing structures and their challenges in strengthening TBA health care systems. A participatory action research strategy was appropriate in the agile phase of prototyping, while the traditional systems development life cycle approach provided the overall software engineering framework. During systems analysis, the researchers carried out a survey and focus group discussion to derive functional and non-functional user requirements specification for use in the systems design stage. Rapid application prototyping methodology was useful in the design and prototype development activities. The population of interest consisted of all pregnant mothers accompanied by TBAs for delivery at health care facilities and the SBAs who attended them in the second quarter of the year, ending June 2024. To obtain a representative sample access was requested to obtain contacts of TBAs that had accompanied expectant mothers to the Rongo sub county hospital. From the initial list of five patients, the snowball technique was used to contact more TBAs and patients who had been served by SBAs in the cut off period of April, May and June of 2024. Figure 1 presents the steps in development and testing of the mobile based design for strengthening TBA health care systems.

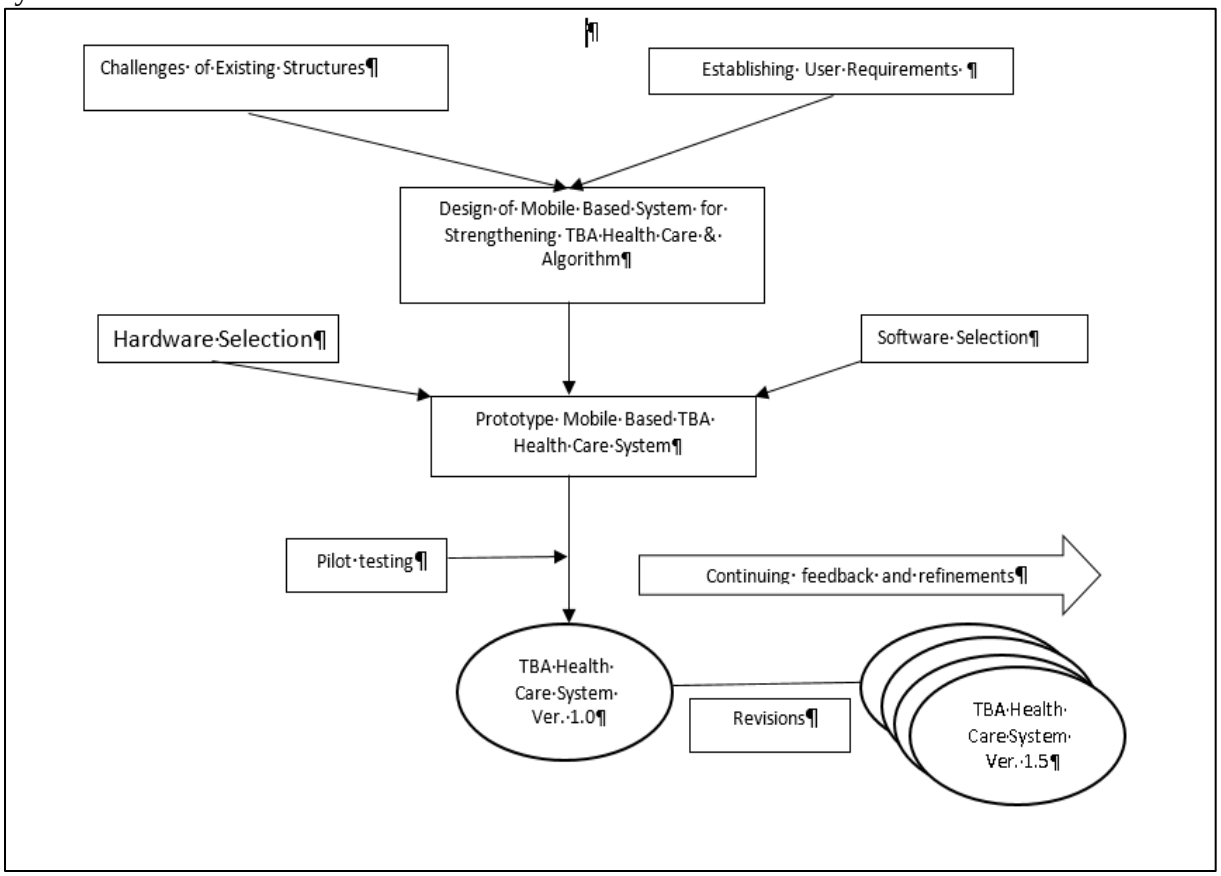

Fig. 1: Steps in design and testing of the mobile based application for strengthening TBA health care systems

The design was developed following the systems development life cycle methodology. The first phase involved a survey of study participants to determine the challenges of strengthening TBA health care systems using existing structures. The current TBA health care system was largely manual and ineffective in strengthening the role of TBAs in line with current global programming on MNCH. Establishing user requirements involved surveying the opinions of

respondents on suitability of common features of mobile health apps for strengthening TBA health care systems, in low resource settings. The results of functional and non-functional user requirements were then refined into a document specifying the user requirements for each of the user groups, namely the SBAs, TBAs and pregnant mothers. Based on the user requirement specifications and armed with the problems of the current manual TBA healthcare system it was possible to design the proposed system.

The resulting mobile based system for strengthening TBA health care consisted of a user interface (UI) and user experience (UX) design elements, a database design as well as the algorithms for its main functional modules. Following the systems specification, it was then possible to select hardware and software for implementing the prototype mobile based system for strengthening TBA health care. The UI/UX requirements provided the input into the design platform known as Figma. The user interfaces were prototypes and users involved in the iterative process of refining the designs. Having made the designs based on the user requirements, it was possible to begin the systems implementation as illustrated in Figure 1. The implementation begun with selection of hardware and software components for the first prototype of the automated TBA health care system. Pilot testing and continued refinements were made to version 1.0 of the TBA Health Care System.

3.1 Phase 1: Establishing TBA User requirements

This phase of the systems development involved an analysis of requirements of SBAs, TBAs and patients. The use of semi-structured questionnaire enables the researchers to elicit functional user requirements from the respondents. Better insight into the requirements of the three groups of users was obtained from direct interview with facility in-charges in the four hospitals within Rongo. During the engagements, the researchers used the snowball sampling technique to identify 20 patients, 20 TBAs and 20 SBAs, which formed the sample of 60 respondents. The population consisted of all TBAs, SBAs and Pregnant women who had been attending MCH clinics in Rongo Sub County Hospital the last 3 months of the second quarter of 2024. The results of systems analysis were the TBA user system requirements document s. This was used as the basis for the systems specification in the systems design phase. The document consisted of both functional and non-functional requirements that were to form the basis of TBA health care systems architecture, database, functionalities, hardware and operating specifications.

3.2 Phase 2: Design and Prototype development

The user interface and algorithms for systems functionalities required in developing the prototype were designed using Figma and Fig jam. The mobile based design of the user interface and user experience was accomplished using the spiral and rapid prototyping methodologies. This involved an iterative design approach in which the researcher provided two SBAs with access to the design platform through a link.

The SBA was trained on how to make comments about any design changes that they required. The first version of the prototype TBA health care system was shared with a focus group consisting of 5 SBAs and 5 TBAs and 5 patients. Their comments were then used to refine the mobile based design before being presented with the new version for their input. After 5 refinements, the prototype version 5.0 was then uploaded in play store after creating a developer account. The participants in the final focus group discussion consisting of 15 participants were then asked to download and install the TBA health care app on their smart phones.

Special training was conducted for half a day to help the focus group users to access the app and explore its key features. The training entailed use of the app to register on to the database, resetting the password in case a user forgot it and navigating the various screens to access the apps functionalities. The purpose of the training was to ensure that the users were ready to evaluate the app for user experience during the focus group discussions in the afternoon. The research on user experience involved getting users to use the app for the month of July before the final focus group discussion session to evaluate the final version of the TBA health care prototype system. During the month TBAs and SBAs were expected to use the medical equipment for capturing the vitals of patients. Where necessary, SBAs and TBAs assisted patient to enter their data using the birth plan builder interface. Using the system a SBA could examine the history of the patient and immediately responded or provided feedback in form of general health tips, change of medication recommendations or an appointment request. After the use of the app for the one month, researchers convened a final focus group discussion session to evaluate the prototype TBA health care app.

The mobile based app was evaluated on the basis of four measures of performance, data transmission, usability and usefulness. The first metric was meant to capture the performance of the mobile based app for strengthening TBA health care systems. The key measures included the apps uptime, downtime, MTBF, reliability, response time and availability. The second metric focused on the apps ability to transmit and retrieve data to and from remote database. The third metric was designed to capture the SBAs, TBAs and patients' perceptions on the usability of the mobile based design for strengthening TBA health care system. The metric for assessing usability was a Systems Usability (SUS) questionnaire administered during the final session of the focus group discussion. The fourth metric used focused on users' perceptions of its usefulness. The metric was based on a tailor-made questionnaire administered to all participants during the last 30 minutes of the focus group discussion session.

4. Results

4.1 Requirements of TBA health care system users

The systems analysis phase of the study generated the functional and non-functional user requirements for the mobile based design. The user's requirements were categorized as patient, TBA and SBA user requirements. Specifications by patient included three key functional requirements. First, they desired a mobile based TBA health care system for strengthening the ability for SBAs to be able to provide MNCH services remotely. In particular, the system should have the ability to remotely access MNCH services without having to travel to the nearest facility, except where emergency obstetric care is required during delivery. Second, they required a TBA health care system that could support self-care at home with or without the aid of a TBA or SBA.

A key feature they wanted to include was push notifications that sends targeted educational messages and reminders to pregnant women based on pregnancy stage. The third requirement of TBAs was a system that could facilitate planning for their birth and handling of emergencies that may occur. In particular, the system ought to be able to provide a map showing the nearby health care facilities as well as the contact numbers of the ambulance drivers and emergency medical personnel at the casualty desks.

The fourth was a feature to enable them to record basic information about pregnant women receiving care. In particular, they required forms for capturing vital signs, pregnancy progress,

and any relevant observations. Further, the system should be able to allow a TBA to access patient data for purposes of planning safe delivery.

On the other hand, the SBAs requirements, though similar to those of traditional attendants also incorporated additional functionalities. A key requirement was for a system that facilitates collaboration with traditional birth attendants. In particular, in planning delivery, patient referral, training of traditional birth attendants and patient clinics. The other SBA requirement was for a system that enabled then obtain data on Traditional birth attendants, provide a forum for culturally appropriate content respectful of local childbirth traditions. Finally, the system should enable SBAs to provide TBAs with a forum for sharing experiences and oversee roles of TBAs. These requirements formed the basis of the systems design, beginning with the architecture, user interface and user experience designs, database and algorithms for key system modules.

4.2 System Architecture

The mobile based design for strengthening TBA health care system consists of three units, namely: - data collection unit, data storage unit and an alerting and reporting unit. The design of the data collection unit consists of vital monitoring gadgets and an android mobile phone. The TBAs, SBAs and patients would use the kits to take the readings of vitals, such as pressure, weight, and age of pregnancy. The mobile phone then transmits the vital data to a cloud based Firebase database. The SBAs, TBAs and patients can access this history whenever need arises. The data collected from patients via the mobile application is sent to the Firebase database server. The cloud based server then processes the collected data and stores it to the database server. The alerting and reporting unit sends a push notifications on important issues during the pregnancy. The SBAs can retrieve the pregnant women's data from the firebase server which also holds educational materials. The output of the server is then displayed on the mobile device in form of videos, audios, tables and lists. From the data fed and requests for tele-consultation, a Skilled Birth Attendant is able to review the history of a patient and provide appropriate feedback to the care seeker and traditional birth attendant.

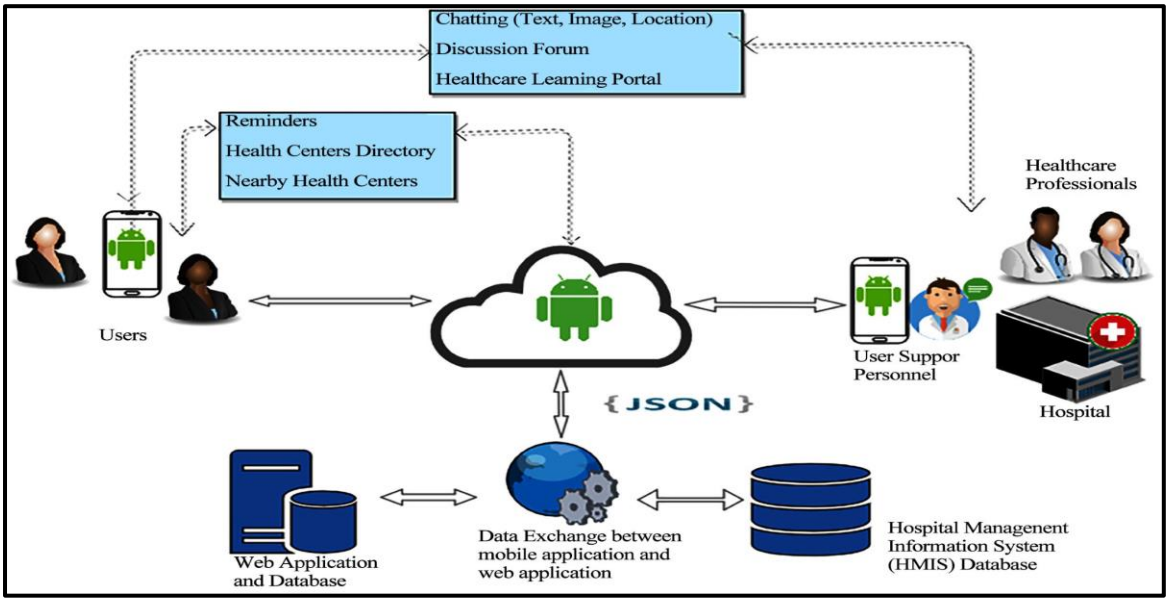

Figure 1: System architecture of the mobile design

Figure 1 presents the systems architecture of the mobile based design for strengthening TBA health care systems.

4.2 Phase Two – System Design, development and performance testing

This phase involved the actual design, development and performance testing of the prototype mobile based design for strengthening TBA health care system. Sample mock up screens for the registration, SBA, TBA and Patient User Interface are presented in Figure 2 to 5.

Figure 2: Welcome Screens

As shown in the sample in Figure 2 a user is welcomed to the system and can either sign up or log in. Existing users can log in using the mock up screen in Figure 3.

Figure 3: Log in screen

In Figure 3, a forgotten password button is included for purposes of resetting their passwords.

A user can still go back to the sign up screen in case they mistakenly choose to log in as existing users but had not signed up into the TBA HealthCare system. The user is authenticated using an email address and password as shown in Figure 4.

Figure 4: User authentication

Once logged in, the system present a user with an appropriate home screen based on response to prompts on category of user. The UI design for the pregnant mother should consists of four quick access buttons with clear icons and labels as captured by the screen mock up in Figure 5.

Figure 5: Home screen for pregnant women

Figure 5 shows four buttons users can click for information on pregnancy stage, danger signs, nearby care and building a birth plan.

Users can use the navigation keys to go back, find care or build a birth plan. Figure 6 presents the Traditional Birth Attendant Home screen.

Figure 6: TBA Home screen

The TBA home screen in Figure 6 has buttons for accessing safe delivery practices, educational resources, telehealth consultation and patient data. Figure 7 shows SBA home screen

Figure 7 SBA Home screen

The home screen in Figure 7 enables a SBA to manage appointments with TBAs, handle referrals, access birth management guidelines and access patient data.

4.2.1 Performance, Usability and Utility Results

This phase involved collecting user's perceptions about the performance, usability and utility of the prototypical implementation of the mobile based design. A total of 20 patients, 20 TBAs and 20 SBAs were surveyed in a focus group session. The prototypical implementation had patient data entry function as well as educational content uploading and access. In the two week testing period, TBAs were provided with gadgets for collecting and entering patient data remotely. SBAs uploaded educational content on the system for access of TBAs and Patients.

The performance tests were conducted over a 5 days period. Performance measures included prototype Uptime, Downtime, MTBF, Reliability, Response Time, and Availability. The 5 days test results are presented in Table 1.

Table 1

System performance results

	Day 1	**Day 2**	**Day 3**	**Day 4**	**Day 5**	**Total**
Test Duration (hrs.)	5	5	5	5	5	**25**

	Day 1	Day 2	Day 3	Day 4	Day 5	Total
Operational Time (min)	253	236	285	278	333	**1385**
Downtime (min)	1	2	3	2	0	**8**
Number of failures	1	0	0	1	1	**3**
Time to Repair (min)	1	0	1	2	0	**4**
Response Time (sec)	205	233	228	200	212	**1078**
Number of trials	53	52	52	60	61	**278**

After calculation, the mobile based TBA health care system achieved an uptime of 93.30%, Downtime of 0.40%, MTBF of 8.82, Reliability of 0.88, Average Response Time of 3 seconds and Availability of 97.60%.

4.3.1 Usability Results

The results of administering the System Usability Scale (SUS) questionnaire are presented in Table 2:-

Table 2

System usability scores

Acceptability Level	Number of Users	Percentage (%)
Acceptable	50	83
Not Acceptable	10	17

In this Table, 50 out 60 Users had acceptable SUS scores. This means that they were satisfied using the system and hence found it effective in strengthening their ability to help in remote management of the patient's condition from home.

4.3.2 Utility Results

A tailor-made questionnaire was also administered to SBAs, TBAs and registered pregnant mothers. The results showed that all the 60 users perceived the system to the useful in helping them save time, improve self-care, better manage their patients, and interact with partners easily.

When asked whether they preferred using the mobile based design for strengthening TBA health care or hospital visit, all the users voted for mobile based design for strengthening TBA health care system. When asked whether they would be willing to participate in another tele monitoring exercise, all users voted yes.

5. Discussion

In this section, we discuss the outcomes of the design and development and testing of the mobile based design for strengthening TBA health care system for strengthening SBAs heath systems. With the development of the mobile based design for strengthening TBA health care system the SBAs were empowered in managing their patients remotely, through consultations with SBAs in the facilities. Using the various gadgets, the SBAs were able to monitor their vitals daily during the pregnancy, at birth and after. The vital parameters measured were transmitted to the SBAs immediately. The SBA then provided feedback to the TBAs in form of medication recommendations general health tips or standard protocols, to help them manage the issues to normalcy. From the research findings 43 out of 40 TBA were satisfied by the systems performance. We can therefore create a clearer picture of the mobile application overall usability. 85 percent of the study respondents had usability scores above average and hence found the system acceptable and effective in helping them manage their condition while at home.

From the performance results, the mobile based design for strengthening TBA health care system achieved an excellent reliability score of 0.91. This means that probability that the system will function as expected without failure(s) within a period of 10 hours is 0.9.In other words, out of 10 hours of operation, a failure will only occur in the ninth hour.

Similarly, the mobile based design for strengthening TBA health care system achieved an availability of 98.62%. This translates to an acceptable downtime of 3.65 days per year. This downtime is not substantial to the users and may not affect the usability and utility of the system. The design of the mobile based design for strengthening TBA health care, which is an android mobile application, is characterized by tasks that involve transmission and retrieval of data to and from a remote database. The Android client is connected to the remote server through PHP web services. As a result, it takes time for the remote server to give feedback to the users once a task has been performed. Therefore measures must be taken to ensure that the response time is not too lengthy, as too much delay has been proved to have a negative effect on user's satisfaction and productivity (causes frustrations) .In order to deal with the delay during processing of a user's request, process dialog indicators were used. This therefore means that the acceptable time limit, according to (Ray & Salihu, 2004), for transmission and retrieval of data to and from a remote database is 10 seconds.

From the research findings of this study the average response time for data transmission and retrieval from the remote database was 4 seconds, which is acceptable. We can therefore conclude that, the excellent reliability and availability level, and the short response time contributed to the overall usability and utility of the mobile based design for strengthening TBA health care system. Usability results showed that 37 out of 40 SBAs were satisfied with using the system, while all patients found the system useful in their process of self-care.

The current practice adopted by these patients in managing the pregnancy is making frequent visits to the health center as recommended by the medical specialists. Most of these patients claimed that the frequent visits were tiring and time consuming. The patients' also travelled for long distances to have their attend clinics. This practice was therefore impractical especially for critically-ill patients. Consequently, most of these patients had neglected check-ups and had therefore focused on actual delivery only. This put the patient's at risk as unanticipated birth problems could lead to devastating consequences.

With the development of the mobile telemedicine system patients did not have to make frequent hospital visits. Initially, patients were required to travel for long distances to have

their vitals taken and pregnancy issues solved. On average patients used to travel for at least 5 km and hence spent at least 2 hours of time. But with the introduction of mobile based design for strengthening TBA health care system, TBAs were able to monitor and manage their patients remotely with the expert advice from SBAs without having to travel with the patient to the health care facility. From the statistics above, all TBAs and patients, both male and female, perceived the system to be useful in helping them save time and financial resources.

On average most patients had their vitals taken in health care facilities every month. This is after they visited the facility physically. But with the gadgets for monitoring vitals, SBAs were able to take readings at weekly intervals. This created self-awareness to the patients about their vitals as recorded during visits by TBAs. It was therefore easy to take preventive measures early enough before the condition deteriorated. The vital parameters measured were transmitted to the SBAs at the facility immediately.

The SBAs provided feedback to the TBAs and patients in form of medication recommendations or protocols, to help them manage the pregnancy, child after birth. Through this continuous frequent monitoring exercise, TBAs and patients were thus able to take good control of pregnancy. From the utility results, all patients perceived the system to the useful in helping them take care of their BP.

From the patient's pregnancy history data, it was clear that most of the patients adhered to the monthly measurements that were requested by the medical specialist. This showed how passionate the patients were about the concept of tele medicine. When asked whether they would be willing to continue using the mobile based design for strengthening TBA health care system, all the patients said yes. At the same time, when asked whether they preferred their old practice of making hospital visits to mobile based design for strengthening TBA health care system, all patients voted for telemedicine system.

Generally, the mobile based design for strengthening TBA health care system provided great help to remote patients, TBAs and SBAs. This research study was not without any limitations. First, only patient's with android-enabled phones were enrolled for the study. Patients who were passionate about remote maternal care but didn't have android-enabled phones were therefore locked out. This problem can be addressed by developing a similar mobile tele-monitoring system to accommodate other mobile platforms. Secondly, some patients felt frustrated especially when the mobile internet connectivity went down or was slow. They complained of not being able to login and send readings of their vitals quickly. This can be addressed by developing a similar mobile application that does not involve internet usage.

5.0 Conclusion and Recommendations

5.1 Conclusions

In this research, we have managed to develop a mobile based design for strengthening TBA health care system in low resource setting. Patients and traditional birth attendants were able to collect and transmit their queries faster and on time to the health care facility. The doctor was able to provide regular feedback to the traditional birth attendants and patients to address their maternal health issues. The tele-monitoring system has proved to be usable and useful to the patients in managing prenatal, birth and antenatal issues raised by the users. It is now clear that the concept of mobile based design for strengthening TBA health care can become a reality in Kenya. If adopted, it is therefore possible to extend health services to undeserved areas. The success of this mobile based design for strengthening TBA health care system may therefore be considered as a baseline towards achieving better management of maternal health issues in low resource settings. With the impressive results from the study, similar mobile based design

for strengthening TBA health care systems can also be developed for managing other conditions remotely in Kenya and beyond. The 2 weeks testing period of this study was not adequate enough to substantially quantify the benefit of the telemedicine system in strengthening the role of traditional birth attendants. As a result a long-term trial is therefore recommended.

5.2 Recommendations

The following areas, arising from the research project are proposed for further research:-

- Data collection in this mobile based design for strengthening TBA health care system was done manually. Further research is required to ensure automatic transmission of the readings of vitals from the mobile vital monitoring devices to the android application via Bluetooth technology.
- This mobile based design for strengthening TBA health care system was only restricted to users with android enabled mobile devices. Further research is required to develop a similar mobile tele-medicine system which can run on any other mobile platforms like J2ME, Apple or Window phones.
- In order to ensure sustainability of this mobile based design for strengthening TBA health care system, further work is required to ensure that it is integrated with already existing m health systems in Kenya.

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