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Value Co-creation in Design of mHealth Applications for Maternal Healthcare Service Delivery

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Abstract. mHealth has potential to improve maternal healthcare in low resource contexts. Several mHealth applications have been developed but are not implemented nor can they be scaled up partly due to their methodological quality. Although mHealth applications have been designed to improve maternal healthcare service delivery, it is still unclear on how to design mHealth applications for maternal healthcare that drive value co-creation from a service dominant logic (SDL) perspective. In this paper, a case study approach is used to investigate designs of four mHealth applications from Uganda and Cameroon. Interviews were held with developers and health workers involved in the design process of the applications. Results were analyzed using SDL value co-creation model. Overall findings show that designs of existing mHealth applications for maternal healthcare include some aspects of value co-creation but still lack design guidelines that would better support value co-creation. Guidelines for designing mHealth applications that co-create value in maternal healthcare are proposed. Future investigations on how proposed guidelines influence the use of mHealth applications to trigger value co-creation in maternal healthcare are suggested.

Keywords: Value co-creation, mHealth, Design guidelines.

1 Introduction

Improving maternal healthcare is a high priority for the world health organization [1]. The rapidly growing presence of mobile phones in Sub-Saharan Africa provides a unique opportunity in transforming the way maternal healthcare services are delivered [2]. Mobile technologies have supported the delivery of health interventions through mHealth. mHealth is defined as “medical and public health practice supported through mobile devices to practitioners, researchers, and beneficiaries, real-time monitoring of beneficiary vital signs and direct provision of care” [3]. mHealth has improved utilization of maternal healthcare services and is supported by funding bodies, the mobile phone industry and public health authorities.

Design of mHealth interventions is becoming increasingly important [4]. Most studies on mHealth for maternal healthcare in low and middle income countries are of poor methodological quality and few have evaluated impacts on patient outcomes [5]. This makes them difficult to replicate [6], scale and to translate research into practice [5].

Many mHealth interventions are designed on existing traditional health system constructs [7] in which, patients cooperate by accepting information provided by the

doctors without questioning it (i.e. passive compliance)[8]. Such interventions may not be as effective as those that involve end-users in the design process [7] and may lead to low quality of life [8]. In addition, there are few studies that describe the features of maternal health related mHealth interventions comprehensively [9]. Premature adoption of untested mHealth technologies may limit positive behavior change and fail to accomplish their objectives or may yield adverse outcomes [10].

Applications need to be designed with adequate consideration of their intended users to obtain best value out of them[11]. To improve healthcare management and services, health systems are being transformed to actively engage patients in healthcare service experiences as they co-create value with health workers [8]. Service dominant logic (SDL) [12][13] enables us to explore the process of value co-creation which is defined as “the processes and activities that underlie resource integration and incorporate different actor roles in the service ecosystem” [14]. It is still unclear on whether the designs of mHealth apps (applications) for maternal healthcare incorporate value co-creation aspects from an SDL perspective. Using data from mHealth app developers and health workers in Uganda and Cameroon, SDL is adopted to address this gap by exploring the research question: In what ways are the designs of existing mHealth apps incorporating value co-creation aspects and, how can mHealth apps be designed to improve value co-creation in maternal healthcare?

The main contribution of this paper is to propose guidelines for understanding and improving value co-creation in the design process of mHealth apps for maternal healthcare within the context of SDL. This paper addresses the need for further developmental work concerning the application of SDL to healthcare and, the support required for value co-creation in healthcare [15]. It also addresses the need to pay attention to the role of stakeholders in the design of healthcare services [16].

In the following sections, literature on mHealth apps in maternal healthcare, SDL and value co-creation in healthcare is reviewed. The method used in the study is described, results are presented and proposed design guidelines are discussed. Finally, the paper summarizes findings, provides limitations and directions for future research.

2 Literature Review

2.1 mHealth Applications in Maternal Healthcare

Mobile phones have the potential to transform healthcare especially in low resource contexts where healthcare infrastructure and services is insufficient [17]. Mobile technology provides opportunities to permit safe, accessible, coordinated and effective maternal healthcare [18]. mHealth can overcome challenges associated with the delivery of maternal healthcare services including distance, limited computer access, lack of healthcare workers and healthcare delivery costs [19]. mHealth plays a role of improving communication and enhancing the integration of care processes [20].

A systematic review on the role of mHealth in maternal healthcare by Feroz et al [21] shows that mHealth is mainly used for client education and behavior change communication through SMS reminders but less used on registries and vital event

tracking, data collection and reporting, enabling a provider to provider communication and electronic health record. mHealth plays a role of improving communication and enhancing the integration of care processes [20]. In addition, mHealth increases the productivity of health care providers and systems, and empowers patients [22]. mHealth enhances the quality of life and appropriateness of care [23].

Most of the mHealth interventions are designed for healthcare beneficiaries other than healthcare providers [9]. mHealth helps to pursue new healthcare models thereby shifting from inpatient to outpatient care, which enables care to be delivered in rural settings and other places without access to medical personnel [24]. mHealth technology makes it possible to design patient-centered health service that encourages the role of patients in medical treatment [9] but many mHealth apps are designed with minimal input of users to be supported [25]. Various models of mHealth interventions are being used to support pregnant women through safe pregnancy and childbirth in low and middle-income countries [9]. Braa and Sanner [3] developed a reference typology that advocates for the use of hybrid solutions to deliver mHealth services in low resource settings. There are limited mHealth studies that use theoretical understanding to explain adoption and appropriation of technology for measurable health outcomes [26].

2.2 Service Dominant Logic and Value Co-creation in Healthcare

SDL views customers as co-creators of value [14][27] and suggests that organizations should design their value offerings as a service platform that enables service exchange and value co-creation [14]. Service platform is “a modular structure that consists of tangible and intangible resources and facilitates the interaction of actors and resources”[14]. Vargo and Lusch [27] elaborate on the narrative of value co-creation in SDL which is composed of institutions and institutional arrangements, service ecosystem, actors, resource integration and service exchanges. They define institutions as “humanly devised rules, norms and beliefs that enable and constrain action” and institutional arrangements as “a set of interrelated institutions”.

Actors are “resource integrators in a network of other actors” [14]. Resource integration is the process of combining resources for usefulness of value while service exchange is the process of coordinating, sequencing and integrating tasks and activities [14]. Service ecosystem is “a self-contained, self-adjusting system of loosely coupled social and economic resource integrating actors constrained by shared institutional logics and mutual value creation through service exchange”[14]. SDL focuses on the broader role and functions of the ecosystem to include ways in which the digital infrastructure holds together diverse actors and enables collaboration in the ecosystem[14]. This paper considers this broader role of an ecosystem and applies SDL as an analytical lens in order to foreground perceived use-value. However, doing so does not explicitly attempt to background the exchange value which is a valid critique on how SDL is sometimes adopted [28]. The important work of developing, hosting and ensuring financial sustainability of the mHealth apps are not in focus of this paper.

Value co-creation in healthcare improves the quality of life through better healthcare management and services [8]. The need to “understand what customers do when

they co-create value in healthcare” [8] has attracted research in healthcare value co-creation. McColl-Kennedy et al [8] provides a typology of customer value co-creation styles in healthcare. In addition, Pinho et al [29] identify factors that support value co-creation among actors and how they relate to healthcare outcomes. Loane et al [30] elaborate on how the exchange of social support enables customers to co-create value within online health communities. Sharma et al [31] identify capabilities required by healthcare organizations to facilitate customer participation in value co-creation. There is little guidance to explain the capabilities and resources healthcare organizations should develop to facilitate co-creation of value [31]. There is need for more research on value co-creation in healthcare [15].

3 Method

3.1 Selection of Research Approach and Study Setting

A case study approach [32] was used to examine the design of mHealth apps. The high maternal mortality rates in developing countries inspired the selection of cases of mHealth apps that were developed with a purpose of reducing maternal deaths in these countries. Uganda and Cameroon were selected cases because of their high maternal mortality rates of 343 and 596 per 100,000 live births respectively [33]. Another reason for selection was because it was easy to get access to the developers of the apps. In addition, the two apps in Uganda, referred to as App A and App B in this article, operate in districts with high rates of teenage pregnancies with a likelihood of 1 to 4 teenage girls getting pregnant per year and the district is hilly. Therefore, pregnant women are located in hard to reach areas with poor road infrastructure and have to walk long distances to health facilities. Another reason for selecting the other two apps, referred to as App C and App D in this article, was because of their wider coverage. App C covers 25 districts in Uganda while App D was developed in Cameroon and is used in 5 African countries including Uganda.

3.2 Selection of Participants and Data Collection

To gain an understanding of the mHealth apps used for maternal healthcare, meetings were held with Professors at one of the universities in Uganda. The professors recommended four mHealth apps that were developed in Uganda and one app that was developed in Cameroon. Follow up meetings were held with consultants and a program manager from three of the five apps to gain an understanding of how the idea of developing the apps was conceived. The information collected from the meetings led to the development of interview guides. Participants from only four mHealth apps were interviewed because it was difficult to get access to the developers of the fifth app. Each of the four apps had only one developer which limited the sample size. For App D, a Medical Director was interviewed instead of a developer, due to access limitations (Table 1).

Qualitative methods of data collection were used as shown in Table 1. Methods involved interviewing app developers and conducting a focus group discussion (FGD)

with health workers who were involved in the design process. Meeting minutes together with documentation which included workplans, proposals and monthly reports of the apps were reviewed to complement the interview data.

Table 1. Data Collection and Study Participants.

Data collection method	Participants	No. of participants
Interviews	mHealth Application Developers	3 (App A, B and C)
	Medical Director	1 (App D)
Focus group discussion	Health Workers	6 (App B and C)
Meetings	Professors, consultants	2, 2 (App B and C)
	Program Manager	1 (App A)
Document reviews	PDF files and Presentations	-

3.3 Data Analysis Methods

Data was analyzed using thematic analysis method [34]. Interviews and FGD were recorded and transcribed. Transcriptions were used to identify, label and categorize keywords which led to the generation of initial codes. Generated codes were grouped into themes. Themes were reviewed iteratively and refined. Final themes were compared and mapped to the components of the value co-creation model [27]. Although institutions and institutional arrangements are part of the model, they were excluded from the analysis because the focus of the paper was on the design of the apps other than the supporting institutions. Therefore, themes for service ecosystem included: architecture of supporting digital infrastructure, limitations of the architecture, and rewards for participation. Themes for actors included: actors involved in the design of the apps and their roles. Themes for service platform included: value offerings of the mHealth app, design models and valuable features. Themes for service exchange and resource integration included: sharing of health information, providing app reviews, accessibility, content relevance and presentation and rules of service exchange.

4 Results

4.1 Service Ecosystem of the Supporting Digital Infrastructure

Architecture of the Digital Infrastructure. mHealth apps service ecosystem is mainly determined by funders, mentors and app developers. The scope in the ecosystem determines the kind of architecture that was used for designing apps. App A, C and D have a modular architecture and use a cloud-based server for Microsoft to store the data collected by the app while App B stores information on a memory card attached to the device. App D uses application programming interfaces (APIs) to connect to other platforms such as those of mobile telecom operators. The reasons behind the selection of the architecture of mHealth apps were mainly to reduce costs, for con-

venience, to increase usability, and for connection to other APIs. It was also noted that despite the existence of the district health information system (DHIS) in the two countries from which the investigated mHealth apps are being used, these apps do not connect to the DHIS. As indicated by the medical director of App D: *“We are not linked to the DHIS because it does not collect individual data, it can provide the number of women vaccinated without their details, connecting to it does not help us”*. In addition, while App B, C and D were developed from scratch, App A was developed from an existing open source technology called SANA from Massachusetts institute of technology (MIT), therefore, the SANA framework was customized to suit the needs of the developers.

Limitations of the Architecture. Limitations to the architecture being used by the app developers include: the customization of the SANA platform is time consuming and requires a lot of training due to the use of different concepts for various modules, lack of flexibility especially for App B which runs on a configured device, high power consumption for the sensors, the integration process with other platforms through APIs causes a lot of errors and is time consuming especially in cases where the APIs do not match. In addition, the architecture is limited by performance issues as quoted from the application developer of App C: *“...as we keep on adding more modules, we need to get better android phones that have high speed but these are costly.”*

Architecture of Participation. For all the mHealth apps, users are facilitated with data bundles and credit to make calls to pregnant women however, no specific rewards are provided to the users. For App A and B, the architecture of participation is not transparent enough to enable developers to provide rewards to the participants. As indicated by the app developer of App A: *“There is no way we can know that so and so posted this information since the logins are facility based, there is no rewards for midwives. For village health team members (VHTs), we have personal login .. but we do not give them rewards.”* For app C and D, there is a transparent architecture of participation, the users of the app are rewarded for their participation as quoted from the medical director for App D: *“Once you download the app, you earn a coin and we ask questions in form of quizzes to test your knowledge, if you get them right, you receive more coins. once you share the information on whatsapp or facebook, you still earn a coin”*. The developers of App D are working on a module where pregnant women can retrieve these coins to pay for bills at hospitals. App D also has a provision where pregnant women can be rewarded for best practices. App C has a targets tab that counts the achievements for each community health promoter (CHP) per month depending on the set targets. The targets are used to provide monetary rewards to the CHPs. As quoted from the developer of App C: *“We communicate every month across all our branches that we are going to attach this amount to this activity. The targets tab marks off completed tasks during the month and the CHPs know how much they have worked for”*

4.2 Actors and Their Roles

The design process for mHealth apps for maternal healthcare includes funders, mentors, social media marketing staff, content development guiders (CDG), Health Infor-

mation Advisers (HIA) health workers (HW), midwives, medical personnel (MP), CHPs, VHTs, pregnant women (PW), district health officers (DHO), regulatory body / government, mHealth application developers and sales people. Two of mHealth apps were designed to have pregnant women as the final users while the other two had health workers as users of the mHealth apps. The roles of these actors in the design process are illustrated in Table 2.

Table 1. Actors and Actor Roles in Design Process of mHealth Apps

mHealth app	Functions	Actors	Actor roles	End users
App A (used since 2016)	Register, follow up and refer PW, track missed appointments	App Developer	Design and code the application	VHTs and Midwives
		Funders	Fund app development and establish scope	
		Mentors	Oversee and guide the development process for quality and effectiveness	
		Social Media Marketing Staff CDG	Carry out media marketing and update the public on the new additions to the app Ensure appropriateness of content developed	
App B (used since 2017)	Assess pregnancy condition, sense condition of the baby, notify health workers about pregnancy condition	App Developer	Configure the device and code the app	PW and VHTs
		Pregnant Women	Provide requirements for the app	
		Health Workers	Provide information about current practices and features to include in the tool	
		DHO	Provide access to health facilities	
		Funders	Provide training and funds	
App C (used since 2016)	Register, assess, follow up and refer PW, reward for participation, calculate due date, share pregnancy tips, notify for appointments	Regulatory Body	Check if the device meets the set standards	CHPs
		App Developer	Design and code the app	
		Owner of the Idea	Idea conception	
		CEO	Oversees the development process	
		DHO	Provide feedback on app upgrades	
		CHPs	Use the app to interact with PW	
App D (used since 2017)	Same as App C and provides a platform for dialogues between PW and doctors and search for specialists	Pregnant Women	Provide feedback during interactions	PW and HW
		Funders	Provide funds and requirements for modules	
		App Developer	Design and code the application	
		MP	Identify problems and gaps in the field	
		Sales Personnel	Provide feedback from the field	
		Pregnant Women	Provide feedback to developers	
		Health Workers	Provide relevant information	
HIA	Review all developed SMS for significance and ethical relevancy to pregnant women			

4.3 Service Platform

Value Offerings for the Designed mHealth Applications Service Platform. The service platform of the mHealth apps was designed with a purpose of supporting pregnant women in order to reduce high maternal mortality rates. The support given to pregnant women is in form of monitoring their health status, providing them with timely information, improving their antenatal care (ANC) seeking behaviors and enabling them to ask questions when needed. As quoted from the medical director for App D: *“The problem we noted was that lots of pregnant women forget their appointments and they don’t have the right information or have limited information about pregnancy and don’t have easy access to ask questions on what they are facing at that point in time”*. In addition, mHealth apps were designed to strengthen the follow up system in order to encourage more girls to visit the health centers. A developer for App A: *“These are pregnant teenage girls and have that stigma since it is their first time and we thought if we could follow them up, they might be able to attend ANC”*

Design Models of mHealth Service Platform. Based on the results, the service platform requirements depend on the model used to deliver services to the pregnant women. Two models were identified, the web-based model and the mobile application model. As quoted from the medical director of App D: *“To reduce the gap between class A and class B mums, we use both SMS model and the smart phone application”*

For App D, the web-based model was used to automatically deliver SMS messages to pregnant women to remind them to go for ANC, it also sends educative messages automatically based on the age of the pregnancy and in addition, a woman can send a message and receive a response from the medical personnel. The mobile based model which is used by all apps to deliver other services that include exchange of health information and interactions between the pregnant women and healthcare professionals, and interactions between the healthcare workers and pregnant women. The mobile based model requires users to have smart phones that run on Android 4.4 and above, having internet connection, having a phone to receive SMS from the app, memory of at least 500MB and sometimes Bluetooth connection to sensors. While mHealth apps A, B and D were simple and easy to use, App C required extensive training before it can be used because it is designed for people who have knowledge about healthcare. As quoted from the developer for App C: *“We take CHPs through 1-month training and we run two refresher trainings every month...they also sit for certification exams that is recommended by the ministry of health.”*

Valuable Features of the mHealth Service Platform and Derived Value. The most valuable features in the design put forward include: registering pregnant women, assessment of the pregnancy, sensing the condition of the baby, recording of follow up notes, availability of health information, a platform for pregnant women that connects directly to a doctor, pregnancy due date calculator, searching for a specialist and a nanny, responding to questions in form of quizzes to earn coins. As quoted from the medical director of App D: *“About 58% will return just to read the health content for that week and to get information about pregnancy for that week”*

In addition, the perceived value derived from the mHealth apps is measured in terms of completed recommended ANC visits, increased deliveries at health facilities,

predicted complications, increased number of pregnant women registered on the platform, health facilities that have subscribed to the services offered by the app, SMS messages sent out to pregnant women and dialogues with pregnant women, improved attitude and practices of women, reduced deaths of pregnant women, improved interactions between midwives and VHTs and tracked missed appointments.

4.4 Value Co-creation via Resource Integration and Service Exchange

Pregnant women co-create value as they share information with others through social media and are rewarded for participation and sharing own experiences. In addition, they ask questions to medical specialists either through SMS or through direct talks. In this way, services are exchanged. As quoted from the medical director of App D *“We have a shot code whereby a woman can send a message and receive a response from a medical doctor in form of an SMS, that’s for the SMS model. The smart phone application offers a platform where women can talk directly to a medical doctor”*.

User reviews of the application is one way in which users can integrate resources in form of knowledge and skills to improve the app. App A, B and C have no provision for users to provide app reviews. However, developers obtain feedback from the users during monthly visits or through individual calls made to the users or through in-service trainings or to the health workers at the health facilities. For App D, users provide app reviews on the Google play store where the app is downloaded from or review directly when they download the app. As quoted from the developer of App C *“Review and feedback is gathered during in-service trainings. The users have actually helped us in modeling this app for instance they tell us which sections of the app are crowded”*

Users of the app have access to all features that provide the needed health information but technical information is limited to administrators and app developers. As quoted from the developer of App A *“The dashboard is used daily by the DHO to access information about the number of pregnant girls mapped to health centers and VHTs use it weekly to see which women are due for ANC”*. Accessibility of health information empowers them to provide the required services. As quoted from the developer of App C *“The app enables community health promoters to interact with the pregnant mothers and recommend medicines or referrals to the government hospital depending on the situation.”*

Applications designed for use by the VHTs and CHPs have different content presentations. For instance, App A provides summary content for both VHTs and midwives at registration. For VHTs, the app enables them to assess the risk of the pregnant women at registration and the app provides detailed information during ANC visits to the midwives. Content which is knowledge resources provided by the medical professionals are presented in different formats including text, video and images. As quoted by the medical director for App D *“You can watch a video that gives you steps to prepare lemon water and also has written information that you can read but most of it has images and illustrates things that you are reading”*. SMS sent out in form of educational messages or health tips are reviewed to ensure that they are relevant to women.

Regarding the rules of exchange of services, the apps provide a platform for pregnant women to exchange messages with medical specialists. As quoted from the medical specialist for app D *“When pregnant women post questions to the app platform, these questions are responded to by medical professionals who have login credentials. However, pregnant women do not know which doctor has responded to them.”*

In addition, exchange of information happens between VHTs and midwives. VHTs share records of pregnant women with the midwives in charge but they cannot share information with other VHTs. As quoted by the developer of App A *“When the VHT maps a girl, she appears in the list of mapped girls assigned to the midwife in charge of that VHT”*. Midwives at the same health facility share a phone and health information because they use a general login credential attached to that health facility, but midwives from different parishes cannot share information. It makes it difficult for these health workers to collaborate especially in cases where supported women shift to other areas. CHPs are assigned specific areas of operation and are given login credentials which are mapped to a branch for that area. The logins are used to identify their contributions which are rewarded accordingly. But these CHPs do not share information with other CHPs. As quoted from the developer of App C *“CHP logins are tagged to the details of that health worker, there is no sharing of what is happening where, coz there is a lot of privacy information to hide, once logged in you stick on what you post.”*

5 Discussion

Based on the value co-creation model by Vargo and Lusch [27], designs of existing mHealth apps include some aspects of value co-creation but still lack some of the design guidelines that would better support value co-creation. Five guidelines are proposed to support designs of mHealth apps for maternal healthcare.

Guideline 1: Integration of mHealth Apps with Local Digitized Health Information Systems. The scope and architecture of the apps is determined by various actors. A good practice is the use of application programming interfaces (APIs) to connect apps to networks of mobile telecom operators. It was also noted that among investigated apps, no app connects to other HIS including the local digitized district health information system (DHIS), which the government uses to plan for resources at health facilities. The underutilization of mHealth could be due to a failure to embed it into broader information systems [24]. Existing HIS can be strengthened through mHealth solutions by leveraging on the backbone DHIS that is already shared in the current HIS setup and work practices [3]. The integration would provide more innovation opportunities to improve work practices in maternal healthcare.

Each app stores data differently and there is no integration nor sharing of modules among apps. The lack of integration of the existing apps hinders maternal health workers to have a shared view of the status of pregnant women in different districts and makes it difficult to plan for resources needed to support them. In addition, if a woman migrates from one place to another, their details may be recaptured by another app leading to duplication of data and limits resource integration. The lack of a shared

awareness among actors limits their service ecosystem to capitalize on the diverse set of expertise and capabilities offered by other actors in the network [14]. This limits innovation opportunities and hinders scaling up of the mHealth apps.

SDL suggests a layered-modular architecture which provides more opportunities for innovative resource combinations hence potential for service innovation [14]. Designs of mHealth apps use a modular architecture in which the addition of new modules slows down the apps. Performance could be improved if resources, i.e. knowledge, skills and technology from various app developers are combined to match the problem context. Resources can be exchanged with app developers and customized to suit their needs.

Guideline 2: Involvement of Actors with Different Roles in the Design Process.

Evidence shows that various actors were involved in the design process of mHealth apps including end users of the apps. Each of these actors plays a role in the process hence supporting other actors. SDL identifies three broad roles of actors in the co-creation process which include ideator, designer and intermediary [14]. In the design process of the apps, health workers, pregnant women, medical personnel, idea owners and funders play the role of ideators because they bring knowledge about their needs and unique work context. They also provide feedback which guides the upgrade process through new service requests hence, opportunities for innovations. Incorporation of end-user feedback and expert opinion in the development process improves app usability and improves health behaviors [25].

App developers, content development guiders and health information advisors play the role of designers in the design of mHealth apps. They develop platforms or communication mechanisms that enable actors to mix and match resources which lead to new services. Mentors, social media marketing staff, sales personnel, district health officers and regulatory bodies play the role of intermediary. Intermediary role actors make nonobvious connections across service ecosystems in ways that provide value for themselves and others [14]. These actors explore connections among diverse resources offering knowledge exchange across service ecosystems such as social media, community and health facilities.

Guideline 3: Transparent Architecture of Participation and Rewards.

For some apps, a good practice of having a transparent architecture in which app users are rewarded for participation is noted. The architecture of participation enables participants' contributions to be coordinated, integrated and synchronized coherently through transparent rules of exchange [14]. One way of rewarding participation is to base rewards on successful execution of monthly targets and on active participation of users in various activities. Mechanisms are needed on how such rewards can be used to pay for medical bills at health facilities. Rewarding participation motivates users of the apps and leads to collaborative value co-creation. The architecture of participation enables app developers to establish different types of incentives that drive participation in networks and provides an opportunity to design new methods to share value among participants [14] hence leading to new innovations that support value co-creation.

Guideline 4: Mixed Model Designs with Different Value Offerings.

The perceived value offered by the mHealth apps is to reduce maternal deaths. Mixed model designs including web-based, SMS and smartphone-based models, are devel-

oped to enable different classes of actors to easily access resources and participate in resource integration and service exchange. The nature of avenues provided for interaction and exchange directly affects service innovation [14]. mHealth solutions need to cope with situations that lack wireless communication to enable data storage on the phone for later upload when connectivity is available, therefore hybrid solutions improve service delivery [3]. The mixed models have valuable features that enable actors to exchange services which include registration, assessment, communication and information sharing. Perceived value from these features are directed towards PW and CHPs/VHTs and include improved health seeking behaviors, attitudes and practices of PW, predicted complications, improved knowledge sharing through interactions between PW and CHPs, using features such as pregnancy due date calculator. This value is measured in terms of completed ANC visits, number of deliveries at health facilities, predicted complications, dialogues, and pregnant women registered on the platform. However, this study did not measure real value achieved due to time constraints.

Guideline 5: Mechanisms for Resource Integration and Service Exchange. The apps provide mechanisms through which users share knowledge and experiences. Knowledge and skills enhance human viability to create new resources through resource integration [14]. Actors co-create value as they share knowledge with others. mHealth apps enable pregnant women to share knowledge and experiences with peers and doctors. Loane et al [30] argue that participants create and obtain value through generalized exchange of social support among peers. Actors are provided an opportunity to conduct app reviews which encourages them to provide feedback to developers thereby exchanging services and provides opportunities for innovation. In addition, enabling users to access health information empowers them to provide the required services or to practice the health tips provided by the app.

The different ways in which content is presented to actors greatly affects the way they engage in the value co-creation process. Evidence shows that health content is presented in various formats for easy understanding by different actors. Repackaging of knowledge to make it more appropriate to the actors enables them to engage in the co-creation process. Content that is presented to a healthcare professional, may not be appropriate for presentation to a pregnant woman because of the cognitive distance between the two actors. The need to obtain a common perspective from actors with cognitive distance creates innovative ways hence enabling value to be co-created.

mHealth apps should provide a platform with transparent rules of service exchange. Implementation of rules of exchange facilitates the coordination of actor contributions and their interactions [14]. Evidence shows that the rules of service exchange hinder the value co-creation process by limiting information sharing among actors and, making it difficult to know the value propositions from various actors.

6 Conclusion and Future Work

Using the value co-creation model of SDL provides an opportunity to improve the designs of mHealth apps for maternal healthcare through the proposed guidelines. The

guidelines include: integration of mHealth apps with local digitized HIS, involvement of actors with different roles in the design process, transparent architecture of participation and rewards, mixed model designs with different value offerings and mechanisms for resource integration and service exchange.

The study is limited by a small number of mHealth apps from developing countries and with few developers whose views may vary from other app developers. Future work on how proposed guidelines influence the use of mHealth apps to trigger value co-creation in maternal healthcare is recommended.

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