Service Design as a Catalyst for Patient-Centered eHealth Innovation:

An Architectural Design Framework for Cloud-Based Maternal Health Information Service in Underserved Setting

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ABSTRACT

Today's healthcare industry is confronted with a myriad of challenges amidst emerging trends and opportunities which trigger a paradigm shift in healthcare design from stand-alone products to holistic services. These three dimensions are critical in assessing and managing healthcare, particularly in underserved settings. This study aims to maximize opportunities presented by both design and information and communication technologies to enhance the implementation of integrated people-centered health services. It is a qualitative study conducted across six government health facilities within Nairobi slums in Kenya as a case study of maternal health information services. Co-design-oriented service design research strategy is employed while a representative sample of (n=47) participants is drawn from different stakeholders in the public health sector. An architectural design framework for cloud-based patient-centered health information service is designed to support maternal care in underserved settings. A prototype service (AfyaTab app) is developed as a proof-of-concept of the proposed design solution.

KEYWORDS

Africa, Cloud Computing, Design Research, Developing Countries, Healthcare Design, Informal Settlements, Information and Communication Technology, Integrated Health Services, Kenya

1. INTRODUCTION

Today's health care industry is confronted with a myriad of challenges, alongside emerging trends and opportunities which trigger a paradigm shift in health care design from stand-alone products to holistic services systems encompassing products, interactions, experiences, and services globally (Hackett, Kazemi, & Sellen, 2018; Pamedytyte & Akoglu, 2019; Tsekleves & Cooper, 2017). Among the key challenges experienced include long-term health care, social interaction and support, lifestyle, health & well-being, and active living (Tsekleves & Cooper, 2017). Emerging trends, according to

the authors include person-centered health care, holistic health care, community health care, and preventative health care, which would determine the future direction of health care service, practice, and provision. Opportunities at the same time include co-design, evidence-based design, digital design, holistic design, and prototyping through which design can offer value within the health care environment in terms of solving these challenges thereof (Tsekleves & Cooper, 2017). The three dimensions of health design (challenges, trends, and opportunities) play a critical role in monitoring, tracking, and analyzing health and well-being services in underserved settings where the majority of the citizens lack access to basic services including health care (Botts, Horan & Thoms, 2011; Czaja, et al., 2015; Foot, et al., 2014). Vulnerable population groups, and particularly those living in Sub-Saharan Africa region often experience inequalities in terms of standards of living, life expectancy, and resource restrictions including health care as well as the opportunity to utilize information and communication technologies (ICT) due to the digital divide (Botts et al.,2011; Czaja, et al., 2015). The delivery of health care in low-and middle-income countries (LMICS) is primarily hindered by political, social, cultural, economic, environmental, and geographical barriers which influence people's socioeconomic potential (Roztocki & Weistroffer, 2016; Williams, Mohammed, Leavell, & Collins, 2010). Also, noticeable is the existence of poor health infrastructure, which leads to weak health systems (Oleribe, et al., 2019) while low-income levels prompt the inability of individuals to afford basic services including primary health care (Lade, Jaitpal, & Chitnis, 2014). Moreover, there has been resistance to innovation and change among the stakeholders across the health care industry (Malmberg, et al., 2019), and particularly in the technology innovation sphere (Grisot & Lindroth, 2019).

The above situation certainly compromises the efforts to implement integrated people-centered health services (IPCHS), which is the global strategy and the central ambition for achieving health care reforms (World Health Organization, 2016a; Foot, et al., 2014), and also the fundamental design principle which is basically what matters to people (Hu & Bai, 2014)). The World Health Organization (WHO) defines people-centered care as the approach to care that consciously adopts individuals', cares', families', and communities' perspectives as participants in, and beneficiaries of, trusted health systems that are organized around the comprehensive needs of people rather than individual diseases, and respects social preferences (World Health Organization, 2016a). The objective of the framework is to create a supportive health care environment and to develop non-medical therapeutic strategies and interventions to promote health and disease prevention rather than treatment and or curing of diseases (World Health Organization, 2015). Therefore, the concept 'patient-centered care' emanates from the people-centered policy framework, which seeks to provide care that is tailored to patient health care needs, and whose goal is to empower the patients to become active participants in their care. Conway et al (2006) summarizes the core concepts of patient- and family-centered care in four dimensions namely: respect and dignity, information sharing, participation and collaboration respectively. It is in pursuit of the agenda for Sustainable Development Goal 3 (SDG 3), that is, to oversee the global health and the wellbeing of all people, and particularly efforts towards reducing global maternal mortality ratios (World Health Organization, 2020).

Unfortunately, the adoption of the framework is far from the reality because the voices of patients and their families have not been heard regarding the design of health care due to the paternalistic narrative of "patients seen but not heard" (Townsend, Adam, Birch, & Friedman, 2013, p.752), which is contrary to principles of the people-centered care policy (Czaja, et al., 2015; Foot, et al., 2014; Salgado, et al., 2017; Bantom, de La Harpe & Ruxwana, 2016). Particularly, despite the potential of digital innovations towards patient-centeredness (Grisot & Lindroth, 2019), existing eHealth models in the underserved setting are deficient in meeting these needs hence poor delivery of care to the citizens (John & Shenoy, 2014; Sneha & Straub, 2017; Nabyonga-Orem, 2017). eHealth interventions remain under-researched in terms of supporting and or promoting patient-centered care, which involves the application of ICT to promote healthy lifestyle choices, monitoring individual's wellness, and providing personal health data for self-management (Miah, 2017; Runaas, et al., 2017). Generally,

this situation is attributed to the unavailability of integrated large-scale eHealth interventions in developing countries (Miah, 2017), and thus limiting access to health services hence the inequitable distribution of health care resources (Kaur, 2012). In terms of antenatal (ANC) coverage assessment, several issues have been reported concerning the inadequacy of maternal health information systems (HIS) including variation in data quality, data unavailability, and data heterogeneity, which involves different data sources, types of data, and data users respectively, and thus challenging existing efforts to measure ANC coverage as well as its content and quality, and thus leading to poor policy decisions by decision-makers (Moller, Petzold, Chou, & Say, 2017; Lattof, et al., 2020), and hence unavailability of ANC data. Particularly, cloud-infrastructures have not been sufficiently utilized in underserved context(s) as a large-scale ICT innovation to provide effective and efficient eHealth services (Miah, 2017). This is indicative of the fact that the potential of new ICT solutions in health care remains unfulfilled hence the need to rethink the design of existing eHealth services, and hence the motivation behind this study. Greater support is, therefore, needed to implement innovative digital registries and data platforms to overcome existing gaps concerning information needs for maternal health care (Lattof, et al., 2020).

To bridge this gap, there is a need to employ human-centered approaches such as service design (SD) strategy, which is human-centered, multidisciplinary, holistic, and repetitive hence its ability to effectively leverage technological innovation(s) in health care to deliver person-centered care (Malmberg, et al., 2019; Patrício, et al., 2020; Salgado, et al., 2017). Larger-scale and user-centric digital innovations such as cloud computing (CC) and mobile health (mHealth) should be adopted to re-organize health care practice (Grisot & Lindroth, 2019; Hu & Bai, 2014; Lee, Cui, Tu, Chen, & Chang, 2018). This will enhance the creation of cost-effective eHealth innovations which are sensitive to individuals' values, taste, and preferences, and thus accelerating their adoption among the underserved populations (Gordon, et al., 2016; Salgado, et al., 2017). Particularly, in the recent past, an increased demand for CC technologies has been witnessed in the health care sector due to the rapidly changing health care environment (Reddy & Reddy, 2014). This has been triggered by the need to provide effective and low-cost medical services hence competition among healthcare providers to make this dream a reality. The aim of the study is to optimize opportunities presented by both design and information and communication technologies (ICT) to enhance the implementation of integrated people-centered health services (IPCHS) in the quest to achieve health care reforms. The research question is: How can an integrated ICT-facilitated health and wellbeing service be designed to support patient-centered maternal health information services in the underserved setting? We propose a framework for cloud-based patient-centered health and wellbeing information architecture (CPHIA) to support the delivery of maternal health care in an underserved context like Kenya. While we prioritize maternal health care, we believe that our design solution will go a long way to address the gaps in maternal health information services, with a specific focus in Kenya and Africa as a whole, and thus contributing towards achieving SDG 3 goals. This is to the ensure availability of patient-centered ANC data for positive pregnancy experience and better policy decisions and interventions to improve maternal healthcare (Ataguba, 2018; Lattof, et al., 2020).

2. MATERNAL HEALTH CARE IN KENYA

Among the top priorities in the global health care agenda is to improve the quality of maternal health care, as provided for in target 3.1 of SDGs, whose aim is to reduce maternal mortality rate (World Health Organization, 2020; World Health Organization, 2016b). However, the aforementioned challenges, which are prevalent within the LMICS equally face Kenya's health care sector particularly rapid urbanization growth and thus leading to expansion of informal urban settlements/slums and therefore, causing environmental problems (Bakibinga, et al., 2014; Mutisya & Yarime, 2011). These include poor sanitation and drainage system(s), lack of clean water supply, and thus poor social and environmental conditions (Mutisya & Yarime, 2011). The situation is compounded with high disease

burden among other challenges that compromise the quality of health care in the country (Ministry of Health, 2016; Bakibinga, et al., 2014; Kimathi, 2017). Nairobi County in particular, being the host of the capital city experiences the problem of overcrowding & congestion in slum areas which triggers the rampant spread of communicable diseases (Bakibinga, et al., 2014; Mutisya & Yarime, 2011). Among the communicable diseases are HIV/AIDS, tuberculosis (TB), reproductive health, neonatal while Non-Communicable diseases (NCD) include cancer, diabetes, and hypertension (Nairobi City County, 2014). A study conducted in Nairobi slums revealed that populations in these environments had the worse health outcomes as opposed to their rural counterparts according to APHRC (2002) cited by Fotso (2009). These challenges continue to impact negatively on the delivery of public health care which denies women access to quality maternal care. For instance, the average 1st - 4th ANC clinic visits coverage was 93% however, the 4th visit coverage was the lowest at 48.6%. Also, about 74% of the mothers delivered in health facilities while 26% delivered elsewhere (Nairobi City County, 2014). The maternity period is a major life event that has health implications for both the mother and the baby, and particularly those women expecting their first baby (Grimes, Forster, & Newton, 2014). This prompts the need for pregnant women to seek information (ANC advice) to help them during their transition to motherhood because a good deal of important learning needs may arise during this period while they adjust themselves to their new role of motherhood (Grimes et al., 2014), without which the women continue to avoid medical health care even when the hospital care is needed (Salgado, et al., 2017). The ANC period is regarded as an opportunity to reach out to pregnant women with interventions that may be vital to their health and well-being as well as that of their children (Ataguba, 2018). According to the author, there is a growing concern to improve maternal and child health outcome indicators globally, especially within developing countries hence the need to rethink the design of existing interventions.

3. CLOUD COMPUTING IN HEALTH CARE

The National Institute of Standards and Technology (NIST) defines the concept of CC as a model for enabling ubiquitous, convenient, online demand network access to a shared pool of configurable computing resources including networks, servers, storage, applications, and services that can be rapidly provisioned and released with minimal management effort or service provider interaction (Mell & Grance, 2011). It is, therefore, a form of distributed computing model that provides computing resources to the users in an on-demand pay-as-you-go model (Whaiduzzaman, et al., 2014), and whose aim is to increase the opportunities for cloud user(s) by accessing leased infrastructure and software applications remotely. The WHO, on the other hand, defines eHealth as cost-effective and secure use of ICT in support of health-related operations including service delivery, surveillance, literature, education & literacy, knowledge and research (Alamri, 2012)). Basically, the concept of eHealth is, therefore, part of both the global and local initiatives to facilitate health care reforms, which can be achieved through redesigning existing eHealth interventions to help reduce inequalities in public health care (Clark & Wu, 2016). An eHealth cloud, therefore, is meant to facilitate seamless access, sharing, and or exchange of health/patient data and their medical history from multiple sources, analyze and diagnose it to enable health professionals to make informed decisions regarding the choice of treatment to be given (Miah, Hasan, & Gammack, 2017). CC, in particular, has all the features that are vital for effective innovations which include; cost-effectiveness, user-centric, ubiquitous computing/network access, secure use of ICT services, health interoperability, capacity for big data storage, knowledge sharing, and health education & research services among other capabilities (Hu & Bai, 2014; John & Shenoy, 2014).

Generally, ICT and eHealth projects have the potential to revolutionize health care for example in the areas of telemedicine, electronic medical records (EMR), health HIS, mobile health care (mHealth) and eLearning tools among others (Shiferaw & Zolfo, 2012). This is because ICT solutions have the capacity to mitigate most of the challenges facing the health sector in terms of reducing health

care cost, medical errors due to lack of access to patient data, and fragmentation of health systems due to the digital divide between remote/rural and urban health care centers among other issues, and thus enhancing access to health care among other benefits (Bantom et al., 2016; Manya, Nielsen & Pundo, 2016). Particularly, the recent hype of CC and the proliferation of smart mobile devices enhance the adoption of mobile cloud computing (MCC), which is a distributed combination model of user-centric digital innovations, which have the capability for ubiquitous computing. (Liang, et al., 2013; Whaiduzzaman, et al., 2014). Furthermore, smart mobile devices continue to become cheaper and accessible particularly in Sub-Saharan Africa where the majority of the vulnerable populations live, who are devoid of basic services including primary health care (Nyatuka & de la Harpe, 2019; Boudreaux, et al., 2014). According to Manya et al (2016), Digital innovations such as CC, therefore, can greatly enhance and strengthen health systems in underserved settings (Nyatuka & de la Harpe, 2019) through providing cost-effective eHealth interventions including mHealth. Manya et al (2016) assert that CC can be used as a catalyst for integrating HIS in developing countries. According to literature, recombination of digital innovations, and particularly CC and mHealth have demonstrated great potential to deliver patient-centered care (Grisot & Lindroth, 2019; Koumaditis, Katelaris, & Themistocleous, 2015; Lee et al, 2018; Slaper & Conkol, 2014). However, the use of ICT innovations in health care in general including CC is not without challenges which may be infrastructural, technological, and data security & privacy among other issues which curtail efforts towards successful implementation of the interventions (Ali, Shrestha, Soar, & Wamba, 2018).

3.1 Challenges Faced In Implementing eHealth Services

Despite efforts to implement innovative eHealth interventions, this still remains a challenge for many governments in the developing world, Africa included. According to literature, both social and technical limitations are responsible for the design-reality gap which is largely evident in Africa and is among the greatest impediments to the success of eGovernment projects in general including eHealth (Heeks, 2002; Heeks, 2003; Nguyen, Ha & Braa, 2015; Ramli, 2017; Nyatuka & De La Harpe, 2021). This situation is compounded with poor supporting infrastructure due to bad politics, poor government funding, lack of technical skills, and also geographical barriers especially in rural areas thus causing rampant fragmentation of health systems Cilliers & Flowerday, 2014; Etoundi & & Onana, 2016; Gebre-Mariam, 2018; Manya et al.,2016). Particularly, the complexity of health care systems is under-estimated (Røed, 2012), and which comprise of many stakeholders including health care providers (hospitals and medical insurance companies), patients, families, and government among other stakeholders who interact at different levels (Lipsitz, 2012), and thus poor coordination of health care services. Also, despite advances in the use of ICT in health care, consumers' needs have not been adequately addressed concerning (Hackett, Kazemi, & Sellen, 2018) health information flows regarding privacy and security practices (Patterson, 2013), which triggers negative perceptions in the adoption of new eHealth technologies in the context of personal privacy and confidentiality (Hackett, Kazemi, & Sellen, 2018).

4. THE SERVICE DESIGN CONCEPT

Rethinking the design of health care helps in providing technical, social networks, and health care education support to promote patient-centered care including self-management (Hu & Bai, 2014; Grisot & Lindroth, 2019). One of the key approaches to achieve this is the SD strategy, a human-centered approach that facilitates mediation between customer needs and service providers (Tsekleves & Cooper, 2017). The service concept has potential value in terms of contribution to the future of health care organizations and services since it empowers consumers to become active participants when designing health care services and or activities (Tsekleves & Cooper, 2017). According to the literature, the service concept has been used successfully in previous health projects to mitigate the challenges thereof (Bate & Robert, 2006; Kronqvist, Erving, & Leinonen, 2013; Lin et al., 2011). Therefore,

SD is seen as a means to involve patients and their families in health care service development and hence provide an opportunity for patients' voices to be heard (Malmberg, et al., 2019). Healthcare organizations have embarked on investigating and adopting the SD concept to help in addressing the challenge of innovation in health care (Malmberg, et al., 2019; Lin et al., 2011; Mager, 2017). Being a multidisciplinary, human-centered, collaborative, and iterative approach to service innovation, the SD concept remains the choice of the desired transformation. It is against this background the SD approach is recognized as a catalyst for both organizational and service transformation (Malmberg, et al., 2019). In their study to examine the core areas that inform SD research (SDR), Joly et al. (2019) identified IS, which is related to IT as one among six dimensions that have been recognized to offer support and enablement of service innovation. In this case, therefore, the SD strategy becomes a key context for applying ICT, which digitizes information interactions in service to facilitate value creation which subsequently contributes to service innovation (Patrício, de Pinho, Teixeira, & Fisk, 2018; Lim, et al., 2018). There is a need, therefore, to leverage opportunities presented by design in order to create a supportive health care environment (Tsekleves & Cooper, 2017). Therefore, this study combines opportunities presented by both SD and ICT, and specifically CC to design cost-effective patient-centered eHealth service to support maternal health information services in an underserved setting.

5. RELATED WORKS

Underserved settings continue to experience predominantly social, economic, and technical challenges among other issues which hinder efforts towards successful implementation of IS projects, eHealth included (Nguyen et al., 2015; Ramli, 2017; Nyatuka & de la Harpe, 2021). Particularly, despite efforts being made, the area concerning the adoption of health information technologies (HITs) is still under-researched more especially personal health records (PHRs) which are meant to provide personal health information and self-management to promote patient-centered care (Heart et al., 2017; Caligtan & Dykes, 2011). Generally, little attention has been given to the usability of PHR tools and human factors among vulnerable communities (Czaja, et al., 2015).

During a study to establish the factors influencing patients' use of electronic PHR (ePHR) services to counter implementation failures, Abd-alrazaqa et al. (2019) proposed a framework of eighteen factors which include categorized into personal factors, human-technology interaction factors, and organizational factors respectively. Personal factors dimension comprises of gender, ethnicity, and income; human-technology interaction factors were perceived usefulness and ease of use based on users' perceptions and expectations about technology; and lastly, organizational dimension focused on the implementation process, organizational structures, and perceptions of end-users towards ePHR services (Abd-alrazaq et al., 2019). A major limitation of the study, however, is that it was based on a literature review rather than empirical data hence context insensitive, and thus questionable validity of the findings. While this research considers the aforementioned factors, qualitative approaches were used to investigate the research context in order to deliver meaningful solutions in the context of use.

On realizing the lack of a unified view of patients' health history, Roehrs et al. (2017) proposed a cloud-based architectural model for a distributed PHR system to support service integration for both the patients and health care providers. The solution would enable health stakeholders, that is, patients, health care providers, and institutions to have a full view of personal health data as well as seamless access to up-to-date patient data scattered across different institutional databases (Roehrs et al., 2017). More importantly, the of the study was to empower patients to maintain a unified view of their PHR history. However, despite having considered principles of people-centered care policy including data security and privacy, the framework is merely based on a literature review rather than empirical observations hence context insensitive. Chan et al. (2010) argue that the selection of patient-oriented technologies should take into consideration situational factors, the existing technology in relation to health interventions and target patients, and empirical evidence. As a result, the proposed solution may not be generalized outside the original study context hence it must be validated in order

to be applied in different contexts. This research will employ context-specific methodologies and approaches to create PHR services sensitive to patients 'needs in the research context.

In an effort to bridge the gap on the lack of full access, viewing, and tracking of patient's medical data stored in hospital created electronic health record (HER) systems, Zhou et al. (2019) developed a mobile-based PHR app to facilitate easy management of personal health data. The authors employed a user-centered development approach whereby a new mobile PHR service (PittPHR) was created with six modules (health records, history, trackers, contacts, appointments, and resources). The app could allow users to customize their health record(s) according to individual information needs and thus supporting patient-centered care. However, despite being an empirical study, the aspect of context has not been addressed based on the understanding that the overall health care context plays a central role in the designing and implementation of patient-sensitive interventions (Waweru, et al., 2019; Tsekleves & Cooper, 2017). The proposed solution is therefore generic and thus it may not be applicable in contexts other than the original health care context. This research will employ qualitative methods to conduct a contextual inquiry to create a PHR service that is sensitive to patient information needs hence supporting patient-centered care. Noticeable is that previous studies have some major limitations in terms of mainly being theoretical and context-insensitive, a situation that weakens the applicability of proposed solutions as they lack empirical evidence. This study will use SD strategy to address these gaps by providing innovative holistic eHealth services in the context of personal health and well-being information service that meets users' needs.

6. METHODS

6.1 Research Setting

The study was conducted in the public health sector, and specifically in government health facilities within the slum areas of Nairobi City County (NCC) in Kenya which offered maternity services. The county has an average population of 4,337,080 residents (Kenya National Bureau of Statistics, 2020) with a mere 115 public facilities with 3,290 out of the required 5,208 (Nairobi City County, 2017) hence understaffed. The majority of the city's residents, that is, about 65% of the people dwell in the slums (Nairobi City County, 2013; Ziraba et al., 2009) where public services and resources are generally scarce due to poor funding by the government. One of the greatest challenges the county faces is an inadequate social infrastructure to provide foundational services including primary health care due to the effect of rapid urbanization, and thus leading to the expansion of slums in the city. As a result, the slum dwellers are faced with the problem(s) of congestion in public facilities, mass poverty, lack of basic needs such as food, water, shelter, sanitation, and social amenities including education and health as well as high burden of disease among other issues (Bakibinga, et al., 2014). Furthermore, health care facilities in these environments only provide primary health care services to the immediate communities, and therefore, they are limited in terms of personnel and technical expertise as opposed to hospital facilities that provide specialized/secondary care. The inadequacy of health care coverage, therefore, renders slum communities vulnerable to negative health outcomes.

6.2 Participant Selection

The target population for the study was potential stakeholders of maternal health care in the public health sector within NCC. Participants were selected from six health facilities that offered a range of maternity services including in-patient, comprehensive, and holistic services to the surrounding communities. The facilities include four health centers (Mathare North, Embakasi, Eastleigh, and Kibera) and two hospitals (Mutuini and Pumwani) respectively. Snowball sampling technique was used whereby individuals identified and nominated other colleagues repetitively until the relevant stakeholders were identified and eventually recruited in the study (Marshall, 1996). The stakeholder groups identified include (i) facility Managers, who played the role of the government as the policy-

makers; (ii) health professionals, who represented health care providers; (iii) clients, who played the role of potential patients who received services at the selected health care facilities; (iv) CHCs, who served as the link between health facilities and the community; and (v) ICT experts as providers of eHealth services. According to the study, the total average population of both staff and clients across the selected six facilities was 523 staff and 15,500 clients respectively. The participant recruitment process continued until data saturation was attained after which the optimum number of the required subjects was achieved (Kerr, Nixon, & Wild, 2010). For purposes of this study, a representative sample of (n=47) participants who were recruited as follows: facility managers (n=5), health professionals (n = 11), clients (n=23), CHCs (n = 4), and ICT professionals (n = 4) respectively. Both the facility managers and CHCs participants were purposively selected (Kerr et al., 2010) and then assisted in nominating other participants (Marshall, 1996) as the heads of their jurisdictions, that is, the medical personnel (nurses, clinicians, and doctors, etc.) and community health workers (CHWs) respectively. Professional participants (health professionals, CHWs, and ICT experts) were selected based on several criteria, that is, the level of education, role, career/profession, job position/rank, work experience, and work station (Marshall, 1996). Client participants were also purposively selected at random from among the population of women seeking maternity services at the selected facilities (Marshall, 1996). The selection criteria for clients include age (≥18 years), the type of health care services used i.e. (public or private), and the area of residence as at the time of the study.
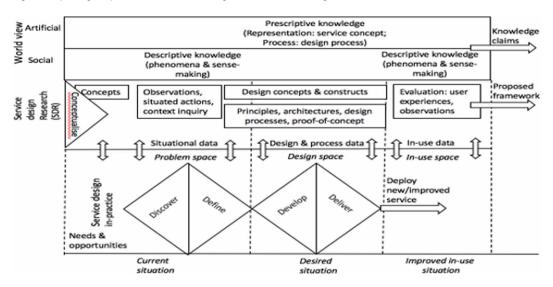
6.3 Research Design

This subsection discusses the research strategy applied, data collection, ethical considerations and data analysis respectively.

6.3.1 Co-Design-Oriented Service Design Research (SDR) Strategy

The study employed a co-design oriented SDR strategy based on theoretical underpinnings of the SD approach and the double diamond process (4 D model) whereby both the researchers/designers and the users became active participants in the design process to discover, define, develop and deliver better and innovative services (Design Council, 2015; Nyatuka & de la Harpe, 2019). The co-design process promotes user engagement and relationship building between project stakeholders and therefore, a collaborative approach through participatory learning and reflection (Walter et al., 2007; Slatterly et al., 2020). SDR enhances innovation to create new services or to improve existing services to make them more useful, usable, desirable for clients and, effective for organizations (Moritz, 2005; Pamedytyte & Akoglu, 2019). In this study, the researchers became active participants throughout the Co-design-oriented SDR process as illustrated in Figure 1, which illustrates how the data from the situational inquiry process is collected and analyzed; the research may provide methods that could be used for the design in practice; the observations and design constructs of the design in practice feed into both the next design step and the design research. It involves three distinct stages namely: problem space (discover & define the current situation); design space (develop and deliver the desired situation); and in-use space (deploy new service in an improved in-use situation) respectively (Design Council, 2015). The co-design process, therefore, enabled the researchers to collect data by listening to the participants' voices (Newell et al. 2016) in terms of gathering new ideas, concepts and experiences as design data to inform the design of the desired service/solution/situation (Salgado, et al., 2017).

This study, however, only focuses on the current situation and the desired situation (design process) to reach an improved situation, and it, therefore, does not consider the in-use situation (post-evaluation) because the proposed service needs to still be further developed into a functional service for the particular situation.

Also, theoretical themes were derived from the literature (Elliott, 2018) to guide the research in terms of data collection and analysis process. Pre-defined themes were identified from health care literature with a specific focus on maternal health services which include (i) stakeholders of maternal health; (ii) information needs for maternal health stakeholders; (iii) information practices in

Figure 1. A paradigm representation of the co-design-oriented service design research framework

maternal health care; (iv) challenges faced in managing maternal health information; (v) stakeholder perceptions on potential maternal information services; (vi) and design consideration for ICT-facilitated maternal health information services. This was meant to help the researchers to remain focused and to explore the aforementioned areas of interest in the data to be collected during the field study (Braun & Clarke, 2006).

6.3.1.1 Data Collection

The data collection process was basically conducted in two stages namely: co-analysis and co-design stage respectively.

6.3.1.1.1 Co-Analysis Research Phase

The study used qualitative methods during the field research, that is, semi-structured in-depth interviews, focus groups discussions, and participant observation to gather data from the social aspect of the research through contextual inquiry (Klein & Myers, 1999) during the discovery and define processes of the 4 D model. Data collection tools were constructed with survey questions based on pre-defined theoretical themes. Interviews and observations were specifically used in the case of professional participants. Surveys were conducted between August 2018 and March 2019, whereby both the interviews and group discussions lasted about 1 hour per session. The surveys aimed to enable the researcher to understand the nature of maternal health care services offered in the public sector in terms of the relevant stakeholders, information needs, information practices, challenges faced, stakeholder perceptions regarding potential maternity information services, and the perceived role of ICT in managing maternal health information. Focus group discussions were mainly administered on the client participants who were organized into 3 focus groups, that is, groups 1 (n=8), group 2 (n=7), and group 3 (n=8) respectively. Observations were however used across all the participant groups to gain a deeper understanding of the research context (Moritz, 2005).

6.3.1.1.2 Co-Design Research Phase

This stage entails service prototyping activity during the design and delivery processes of the 4D model to create the new service (design object) in terms of design concepts and constructs; design principles; architectures; design process; and proof-of-concept (Nunamaker et al.,2015). Particularly, design data was gathered in this process to inform features of the design object and or solution. A

variety of SD concepts, methods, and practical tools were used to facilitate interaction between the researchers and health stakeholders aid in gathering data about intended new information services (Salgado, et al., 2017). These include maternity user journey/service blueprint, case scenario for community health information flows, Mother & Child Handbook, graphics editor tool, Inkscape software, and service prototyping (Salgado, et al., 2017). The Service journey was used as a visual map to identify key service moments as well as user experience during those moments. The antenatal care (ANC) Handbook was used to identify and select the data set for ANC reporting, which would then be included as part of the menu items in the design object (prototype service). A case scenario was created to help describe and visualize the nature of community health information services to have an insight into the potential future services. Generally, the tools were used to explore users' expectations and perceptions concerning maternal health information services, as well as mapping their needs, behaviors, and practices in the research context as input towards the design solution (Salgado, et al., 2017). Also, the study was guided by Information System (IS) design theory (Gregor & Jones, 2007), interpretive field research principles (Klein & Myers, 1999), and IPCHS framework (World Health Organization, 2016a) respectively.

Among the principles applied during the co-design process include defining the purpose and scope of the study, engaging and empowering participants/users through participatory design, the form & function of artifact architecture, contextualization and interaction between the researchers and the subjects (World Health Organization, 2016a; Gregor & Jones, 2007; Klein & Myers, 1999). During service prototyping, the researcher/designers used Inkscape software to create three potential design solutions and tested them iteratively (Design Council, 2015). Constant observation of participants' reactions was ensured during the co-design process to verify actual requirements and specifications for the intended design solution. Feedback was continually integrated into initial and subsequent screen prototypes until the final version was achieved. This was done through close monitoring of the different screen layouts including the log-in window, menu screens, font size, and other features (Salgado, et al., 2017).

6.4 Ethical Considerations

Participants' consent was obtained while the subjects were made to understand both the benefits and the risks involved before giving consent (Fouka & Mantzorou, 2011). The necessary ethical approval for the research was obtained from the Research Ethics Committee of the Faculty of Informatics and Design (FID) of Cape Peninsula University of Technology (CPUT), South Africa while authorization of the study was granted by the National Commission for Science, Technology, and Innovation (NACOSTI) of Kenya.

6.5 Data Analysis

Thematic analysis (TA) method was used whereby manual coding was performed using resources at disposal. According to Basit (2003), the choice of the coding method depends on several factors including project size, availability of funds, time as well the researcher's expertise and or inclination. Field notes from qualitative data field notes were converted into electronic text format for easy analysis to empirically determine the relevant data themes according to six pre-defined theoretical themes using Saldaña's streamlined codes-to-theory model (Saldaña, 2015). The codes (main points from the respondents) were extracted and merged with related subjects to develop core categories (Lings & Lundell, 2005). The aim was to reduce the number of concepts to ease the analysis process, and to justify the basis of emerging subjects, categories, and data themes respectively (Birks et al., 2013). To code and map occurrences from the 47 respondents' comments, the respondents were coded according to the various stakeholder categories as follows: facility managers: AP001-AP005; health professionals: HP001-HP011; women clients: MC001-MC023; community health workers: CHW001-CHW004; and ICT experts: ICT001-ICT004 respectively.

7. RESULTS AND DISCUSSION

This section presents in tabular form the study findings from the responses obtained and the subsequent co-categories that emerged according to pre-defined theoretical themes to inform the study as illustrated in Table 1. Specifically, the table summarizes and maps the quotes of various participants using the TA process through initial codes, emerging co-categories, and data themes respectively. The study then explores further the findings through literature to address the research problem.

The study identified various themes emerging from the data according to the pre-defined theoretical themes. Among the identified maternal health care stakeholders include clients, CHWs, health professionals, health organizations/providers, the government, community, and partners. The findings reveal the nature of the complexity of the health care system, which is described in the literature as a system involving many players and components who interact at different levels as well as interests (Lipsitz, 2012) hence the need for stakeholder engagement to deliver service integrated and collaborative health care services.

Under the information needs dimension, several needs were identified by different stakeholders. Particularly, pregnant women needed prenatal, ANC and PNC related information to manage their health (Mulauzi & Daka, 2018) including checkups, birth preparedness, pregnancy period, nutrition, danger signs, labor, family planning, breastfeeding, and child immunization among other information needs. Health professionals said they mainly needed information to improve on their professional skills as well as client medical history to make informed care decisions and or choices. CHWs needed information on communicable diseases, preventive care, prescriptive policy guidelines to perform their duty while healthcare managers needed policy and management-related information such as dairy/monthly reports, staffing, budgeting, and commodity supplies to manage health facilities better.

The information practices category revealed how various stakeholders to access, communicate and share information. Generally, information was being managed manually being the commonest method of managing maternal health information/history as whereby physical books were used according to Grimes, Forster, and Newton (2014). Particularly, ANC Handbook was used to record, communicate and or share personal health information as a legal government-approved document according to the study. Similarly, health professionals heavily relied on manual documentation as to their source of information as well as the means of communicating health information whereby ANC Handbook was also a major source of client information from them. Verbal and oral methods were also used during one-on-one or face-to-face meetings between health care personnel and clients for example during ANC clinic visits. The most popular digital communication media used across all the stakeholder groups was mobile technologies, and specifically the mobile phone. According to the study, each health facility had a mobile phone for staff use, especially during an emergency. Both health professionals and CHWs reported that the mobile phone was very important for communication of health information especially during follow-ups on the clients.

Several challenges were, however, reported which emanate from poor health information and communication infrastructure as already mentioned in the literature (Nabyonga-Orem, 2017; Oleribe, et al., 2019; Manya, Nielsen, & Pundo, 2016), which was the sole responsibility of the service provider (the government). The lack of complete ICT infrastructure in the health facilities resulted in an overreliance on manual documentation, which led to lack of storage space, displacement, loss, damage, and poor retrieval of health records and above all survive fragmentation due to parallel streams (data silos) in individual health institutions (Manya, Nielsen, & Pundo, 2016). Particularly, lack of IT equipment, personnel, and staff training jeopardized efforts towards the adoption of ICT services. More so, despite the mobile phone being the preferred and common mode of communication, the staff including health professionals and CHWs reported that the service provider did not provide airtime or internet to facilitate client follow-up which was a daily affair hence it was expensive as they mostly used personal mobile phones.

Table 1. Emerging data themes aligned to theoretical themes

Source	Quote	Initial codes	Co-categorie	Data themes
Stakeholders of maternal health care				
HP001	"I work with Community Health Worker/ volunteers (CHWs) and the Community Health, Assistant (CHAs) who reach out and educate pregnant women in various households, and advise them to attend antenatal clinic''	CHWs, CHAs, pregnant women	● CHWs ● Clients	Stakeholders
HP008	"I work with Medical Engineers, medical Officers, Clinical Officers, Student nurses, Nutritionist, Lab, Pharmacy, Medical schools/ KMTC, Referral hospitals"	Medical Engineers, Medical Officers, Clinical Officers, nurses, Nutritionist	● Health professionals ● Internal departments ● Health organizations	Stakeholders
CHW003	"We work with a Community Chairman, Assistant Chief, and Facility In-charge who are Community Health Committee (CHC) members, with CHAs, and Community Health Workers and MoH looking at how to improve community services"	Community Chairman, Assistant Chief, Facility In-charge, CHAs, nurses, MOH	● Community leaders ● Local administration ● Health care managers ● Ministry of health (MoH)	Stakeholders
AP005	"Important stakeholders in maternal care include clients, relatives, care givers, hospital facility, referral hospitals, county government, and partners"	Patients, care givers, relatives, referral hospitals, government partners	● Clients/relatives ● Health care providers ● Government ● Partners	Stakeholders
MC001	"I worked with my spouse and other family members during my pregnancy"	Spouse and other family members	● Family members	Stakeholders
MC004	"We consulted with experienced colleague mothers, neighbors and CHW/Vs"	Colleague mothers, neighbors and CHW/Vs	● Community health services	Stakeholders
Stakeholder information needs				
HP008	"As a nurse I use professional knowledge and skills from my training to know what form of care to give at what particular point"	Professional knowledge and skills	● Professional Knowledge	Information needs
HP010	I always seek to know surgical history of the client, family history i.e., chronic illnesses, drug allergy, obstetric history and ANC profile e.g., HB, blood group, rhesus factor and infections if any	Family history, chronic illnesses, ANC profile	● Client medical history	Information needs
CHW003	"I need information concerning the community and you don't limit yourself to health only. Sometimes you find the information is flowing to personal issues, domestic issues and even administrative. Basically, I am a public health officer and I major in preventive care"	HIV/AIDs and PMTCT, breastfeeding, maternal health and danger signs	● Communicable diseases ● Preventive care	Information needs
CHW003	"I need to know about mother and child (MCH) care guidelines, nutrition, water sanitation & hygiene, record keeping. I also need to know the population and the number of households around my working area"	MCH guidelines, nutrition, water sanitation and hygiene and population	● Guidelines ● Preventive care	Information needs
AP001	"I need daily updates on the care of patients, maternal auditing e.g., what happened and why, ANC&PNC monthly reports, average number of baby deliveries per month and staffing"	monthly reports, number of deliveries per month, staffing	● Daily activities ● Monthly reports	Information needs
AP004	"Mine is to oversee HR capacity, logistics and resource availability, planning and budgeting, carry out supportive supervision / staff audit"	HR capacity, logistics and resource planning and budgeting	● Staffing ● Budgetary requirements ● Supplies	Information needs
AP003	"My information needs include policy guidelines, health records and the tools to facilitate the same"	Policy guidelines, health records and tools	● Policy making ● Health records management	Information needs

Table 1. Continued

Source	Quote	Initial codes	Co-categorie	Data themes
MC008	"I seek to understand danger signs of pregnancy, complications and labor signs and how to manage them"	Danger signs of pregnancy, complications and labor signs	● ANC care information	Information needs
MC010	I need information concerning the sitting position while breastfeeding, breastfeeding, immunization and baby winning	Sitting position when breastfeeding, Immunizations, and baby winning	● PNC care information	Information needs
MC006	"I want to understand the expected signs of pregnancy, body changes and the right time to conceive"	Expected signs of pregnancy, body changes and weight"	● Prenatal care information	Information needs
MC002	"I would like to know nutrition and diet needs i.e., what food to eat during pregnancy and the type of maternity clothes and shoes to wear"	Nutrition and diet, Maternity clothes and shoes	● ANC care information	Information needs
Stakeholder information practices				
HP011	Photocopy machines and computers are available however, computers are not used at all. A facility mobile phone is used by staff.	Facility mobile phone used	● Information media	Information services
HP008	"We share information through monthly reports which are printed. Daily registers, ANC Handbook and or patient file including during referral from this hospital to another. Also, verbal consultation one on one with colleagues and phone calls"	Monthly reports, Daily registers, ANC Handbook/ patient file, verbal consultation, Handover report	● Manual documentation ● Information sharing methods	Collaborative information services
HP008	"We find information from the patient herself, ANC Handbook, on job trainings, basic professional training (Nursing), continuous medical Education (CME)……. It can be CMES, or trainings"	Client, Next of kin/partner, ANC Handbook, trainings, CME, lab tests	● Personal health information	Information sources
CHW001	"We share information verbally via mobile phone call and face-to-face conversations, WhatsApp, text messages and print material"	Verbal that is, phone call, face-to-face and email conversations, printed material	● Oral ● Verbal ● Written	Health communication
CHW002	"A community worker said, ''ANC Handbook is very instrumental/educative …. Recognized as a legal document''	ANC Handbook is very instrumental/educative …. As a legal document	● ANC Handbook	Health communication
MC008	"The commonly used electronic media in communicating health information is TV, mobile phone and radio and print sources"	TV, radio, mobile phone, print	● Mass media ● Verbal ● Written	Health communication
MC006	"Mobile phone is used daily but few mothers can afford smartphones"	Mobile phone is used daily	● Mobile technologies	Service provider
ICT001	"Consider government policy and regulatory framework when designing HIS"	Policy and regulatory framework	● Policy guidelines	Service provider
Challenges faced				
HP008	"Using a personal mobile phone is costly and you share your personal contacts with so many people, no privacy of the client"	Use of personal phone is costly, no privacy for the client	● Information infrastructure ● Patient privacy and confidentiality	Service provider
CHW004	"There is no facilitation in terms of airtime- we use our money to make calls only the necessary ones. The client may not have the technology so we have to use print. Also, we have computers provided by partners but there's no internet-no proper infrastructure"	There's no airtime and internet	● Infrastructure	Service provider
AP002	"Key challenges we encounter here are loss/ damaged/misplacement of records, lack of ICT equipment e.g., photocopying machine- government is not providing support, shortage of staff, lack of training on ICT for staff"	Loss/damaged/misplacement of records, lack of ICT equipment, shortage of staff, lack of IT training for staff	● Infrastructure	Service provider

Table 1. Continued

Source	Quote	Initial codes	Co-categorie	Data themes
ICT001	"There is lack of technical skills, high technology & maintenance costs"	Low technical skills/ high maintenance costs	● Expertise ● Costs	Service provider
AP003	"There is lack of space to store records, lack of ICT infrastructure, lack of staff training on IT, shortages of staff, retrieval of print information/records for maternal services e.g., birth notification is difficult and may be destroyed"	Lack of space to store records, ICT infrastructure, IT staff training, shortages of staff, poor retrieval of print information	● Infrastructure	Service provider
ICT001	Donor effect creates a silo e.g., some only cater for HIV	Donor effect and parallel systems	● Parallel systems ● Service fragmentation	Service integration
ICT004	CT infrastructure is expensive i.e., there is high technology and maintenance costs	CT infrastructure is expensive	● Infrastructure	Service provider
Stakeholder perceptions				
HP009	"Phone calls have really improved communication of new knowledge among staff (care givers), link with patients and also CHVs"	Mobile phones have improved communication	● Information infrastructure	Service provider
HP010	"The current manual information services are tedious, clients don't read ANC Handbook, the booklet can easily get lost and damaged, information go missing from the records… etc."	Clients don't read ANC Handbook, can easily get lost/ damaged, information go missing	● Loss of information	Information services
HP008	"Implement electronic services for easy capturing of data and tracking information and also emphasize periodic training of staff and continuous job training of new staff"	Implement electronic services for easy capturing of data and tracking	● Quality Health care	Service provider
CHW004	"The services should be digitized to make referencing easier to improve referencing of information easily"	Services should be digitized to make referencing easier	● Infrastructure	Service provider
CHW004	"Use of electronic devices saves cost and time because if it's print, I have to move from here to the community to hand in a document, but with ICT I can just send on WhatsApp"	Electronic devices save cost and time	● Infrastructure	Service provider
MC001	"Written information on ANC Handbook should be clear-the doctor's notes are not readable!"	Doctor's hand written notes are not readable	● Legibility	Quality health scare service
MC001	"Information is not confidential because some nurses and CHWs leak client information. Otherwise, nurses don't keep information as a secret! Nurses should be trained as counsellors"	Information is not confidential, nurses and CHWs leak client information	● Patient privacy and confidentiality	Data access
AP002	"The impact of ICT is still low since only mobile phone is used to communicate especially during emergency"	Impact of ICT is low since only mobile phone is used to communicate information	Information and communication	Health communication
Design considerations				
ICT001	"The data set in the personal health record (PHR) system should be based on MoH guidelines for reporting as provided in the Mother & Child booklet which is the minimum requirement as prescribed"	PHR data set	● Personalized information service	User-centered design service
ICT002	"Security of personal health information especially in cases of research whether patient data is aggregated or in actual form should be protected"	Security of personal health information	● Data security	Data access
ICT003	"Use mobile apps, laptops, pads…. in order for patients to easily and quickly access their data"	Mobile apps, laptops, iPads	● System components	Service contextualization

Table 1. Continued

Source	Quote	Initial codes	Co-categorie	Data themes
ICT002	Integration will require specific e-health standards such as HL7 and FHIR especially in facilities with systems already installed	eHealth standards	• Interoperability	Service integration
ICT003	"Consider important features including specifications of such components e.g., CPU speed, RAM capacity, HDD size, a web-based system, open-source software"	Important features	• Specifications	Service quality
ICT003	"Take patients as stakeholders and involve them to also own the platform"	Take patients as stakeholders	• Stakeholder's role	Stakeholder engagement
ICT003	"Data science tools and machine learning should be used in order to develop a database to mine data stored in the system"	Use data science tools	• Analytic tools	HIT utilization

The stakeholders perceived mobile technologies as among the best digital innovation that can support health communication in the research context, a fact already confirmed in the literature (Nyatuka & de la Harpe,2019; Grisot & Lindroth, 2019; Lee et al, 2018). The general perception, according to the study is that the quality of services provided was of poor quality given the absence of adequate HIT infrastructure. Both health professionals said clients that much as it is a vital document, ANC Handbook had many limitations including possible loss/damage of patient information while the doctor's handwritten notes recorded on it were sometimes not clear enough to be read by lay a layperson(s), and hence the need to digitize health information services. To improve service delivery, the study identified a number of factors to consider to create innovative eHealth services to meet information needs of users. These include user-centered design service, data access, service contextualization, service integration, service quality, HIT utilization, and stakeholder management hence the basis of the proposed solution (Nyatuka & De La Harpe, 2021).

8. PROPOSED ARCHITECTURAL DESIGN FRAMEWORK

Based on the revelations from the study, a cloud-based patient-centered health and wellbeing information architecture (CPHIA), which is a PHR service is proposed to support the delivery of maternal health care in the research context. The model adopts both mobile and cloud technologies as cost-effective, relatively affordable, and large-scale digital innovations hence their potential to transform health care in underserved settings. The users of the new service include clients, health care providers, CHWs, MoH/government, and medical research institutions respectively. All the users including health care providers (hospitals) must be registered by the government (super admin) to access or use the service according to specific roles.

Table 2 is a summary presentation of five (5) scenarios of possible information flows while the various stakeholders interact with the new service.

8.1 Proof-of-Concept of The Design

A prototype service, that is, a cloud-based mobile web app was developed (AfyaTab PHR service) to validate the proposed service/solution. The app is two ways comprising of both mobile and web app for clients/CHWs and health care providers/government/research institutions respectively. Figures 3 and 4 are the mobile app log-in window and user interface screens of the service prototype created using maternal data items extracted from ANC Handbook being the minimum reporting requirement as a proof-of-concept.
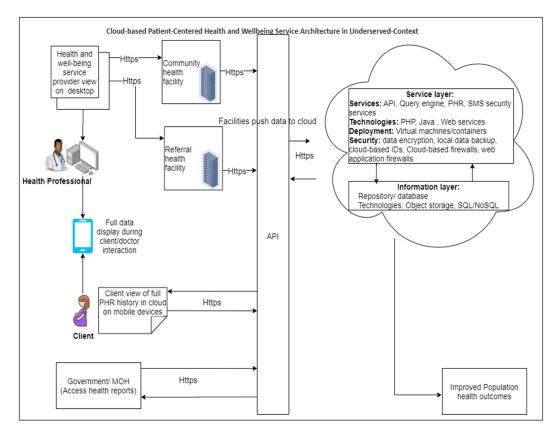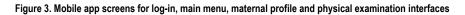
Figure 2. Cloud-based patient-centered health and wellbeing information architecture (CPHIA) for maternal health care

Table 2. Information flow scenarios for the proposed new service

Case Scenario	Description
1	The client will have direct access and control with full view of their PHR data in the cloud from multiple sources via personal mobile app for monitoring, tracking and self-management. The doctor must seek client consent to view the patient's full PHR history at the point of care/hospital
2	CHWs shall refer clients to community health facility and also for follow-up, counselling and ensuring compliance with preventive care guidelines using the mobile app
3	The service provider (government) will be super admin to add details of health care providers and research institutions in the system while the hospital administrator will add individual facility staff and patients details in the system using the web app. Hospitals can only have direct access to patient data that is generated locally withing the facility
4	Government/MoH will only have access to aggregated health data in the cloud to generate reports for decision-making and disease surveillance through the web app.
5	Medical research institutions will only have access to anonymous medical records in cloud storage for clinical/ medical research purposes through the web app.

Figure 3. Mobile app screens for log-in, main menu, maternal profile and physical examination interfaces
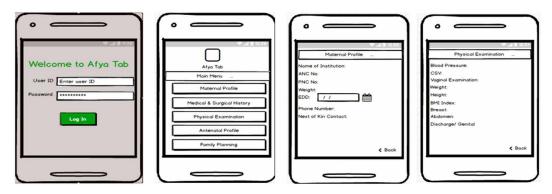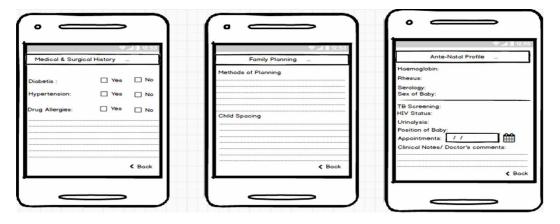

Figure 4. Mobile app screens for the medical and surgical history, family planning, and antenatal profile

9. RATIONALE FOR THE STUDY

The PCHIS framework is the blueprint for the adoption of people-centered care towards achieving health care reforms (World Health Organization, 2016a). However, the realization of the people-centered health care agenda still remains a dream rather than a reality in the developing countries particularly in urban informal settlements where people lack access to basic services including primary health care services (Bakibinga et al., 2014), and thus leading to negative population health outcomes. This is as a result of a myriad of challenges that face the public health sector in LMICS such as in Africa. Particularly, the nature of the complexity of health systems (Røed, 2012) which comprises many stakeholders with varying interests (Lipsitz, 2012) causes fragmentation of health care services which compromises efforts towards people-centered care. To remedy the situation, it is vital to rethink the design of health care through the use of human-centered approaches (Malmberg, et al., 2019) and cost-effective large-scale digital innovations (Miah et al., 2017) to create meaningful eHealth interventions as a vehicle to deliver patient-centered care services. This involves the combination of co-design-oriented SDR strategy, CC, and MCC technologies (Grisot & Lindroth, 2019; Joly et al., 2019) to deliver new improved eHealth services in the context of maternal health care. We believe

that our proposed solution will go a long way in enhancing the adoption of the people-centered care model, which is the central ambition for achieving health reforms globally, and particularly to improve health outcomes among the underserved populations.

10. CONCLUSION

The emergency of new challenges in today's health care poses a major concern to the public sector globally. Particularly, the implementation of the IPCHS framework as a blueprint for the global strategy to facilitate health care reforms has not been realized in the underserved contexts and thus making it impossible to realize people-centered health care. The vulnerable population groups particularly those in Africa often experience inequalities including in health care due to resource restrictions. This study sort to pinpoint the perceptions of the stakeholders regarding potential health information services and the role of ICT in health care as a case study of maternal care in the slum areas within Nairobi County in Kenya. Specifically, the study sheds light on the different stakeholders, information needs, information practices, challenges faced, stakeholder perceptions, and design considerations for ICT-facilitated personal health information service. Generally, the participants felt that the nature of maternal health services provided were of poor quality hence the need to leverage ICT to create meaningful eHealth interventions. The study used co-design SDR strategy as a multidisciplinary approach to develop a cloud-based patient-centered health and wellbeing information architecture to support maternal care. The proposed framework can, therefore, be used to patient-centered eHealth interventions to improve the delivery of health care in underserved settings, and thus improved population health outcomes.

11. STUDY LIMITATIONS AND FUTURE RESEARCH

This study was mainly conducted in public health facilities providing maternity services hence the exclusion of private entities who equally constitute a reasonable share of health care business where part of the Nairobi receive health care. Also, it must be emphasized that the findings of this study are based on the perceptions and opinions of maternal health care stakeholders in the Kenyan context, otherwise, the relevance of the study outside the original context should be verified empirically. Lastly, the study does not consider the in-use situation (post-evaluation stage) of the proposed service (solution) hence it still needs to be further developed into a functional service for the study context (particular situation).

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REFERENCES

Abd-alrazaq, A., Bewick, B., Farragher, T., & Gardner, P. (2019). Factors that affect the use of electronic personal health records among patients: A systematic review. *International Journal of Medical Informatics*, *126*, 164–175. doi:10.1016/j.ijmedinf.2019.03.014 PMID:31029258

Alamri, A. (2012). Cloud-based e-health multimedia framework for heterogeneous network. In *2012 IEEE International Conference on Multimedia and Expo Workshops* (pp. 447-452). Melbourne: IEEE. doi:10.1109/ICMEW.2012.84

Ali, O., Shrestha, A., Soar, J., & Wamba, S. (2018). Cloud computing-enabled healthcare opportunities, issues, and applications: A systematic review. *International Journal of Information Management*, *43*, 146–158. doi:10.1016/j.ijinfomgt.2018.07.009

Ataguba, J. E. (2018). A reassessment of global antenatal care coverage for improving maternal health using sub-Saharan Africa as a case study. *PLoS One*, *13*(10), e0204822. doi:10.1371/journal.pone.0204822 PMID:30289886

Bakibinga, P., Ettarh, R., Ziraba, A. K., Kyobutungi, C., Kamande, E., Ngomi, N., & Osindo, J. (2014). The effect of enhanced public–private partnerships on Maternal, Newborn and child Health Services and outcomes in Nairobi–Kenya: The PAMANECH quasi-experimental research protocol. *BMJ Open*, *4*(10), e006608. doi:10.1136/bmjopen-2014-006608 PMID:25341452

Bantom, S., de la Harpe, R., & Ruxwana, N. (2016). Accessibility to Patients' Own Health Information: A Case in Rural Eastern Cape, South Africa. In *Proceedings of the Annual Conference of the South African Institute of Computer Scientists and Inform* (pp. 1-9). ACM. doi:10.1145/2987491.2987505

Basit, T. (2003). Manual or electronic? The role of coding in qualitative data analysis. *Educational Research*, *45*(2), 143–154. doi:10.1080/0013188032000133548

Bate, P., & Robert, G. (2006). Experience-based design: From redesigning the system around the patient to co-designing services with the patient. *BMJ Quality & Safety*, *15*(5), 307–310. doi:10.1136/qshc.2005.016527 PMID:17074863

Birks, D., Fernandez, W., Levina, N., & Nasirin, S. (2013). Grounded theory method in information systems research: Its nature, diversity and opportunities. *European Journal of Information Systems*, *22*(11), 1–8. doi:10.1057/ejis.2012.48

Botts, N., Horan, T., & Thoms, B. (2011). HealthATM: Health cyber-infrastructure for underserved populations. *American Journal of Preventive Medicine*, *40*(5), 115–S122. doi:10.1016/j.amepre.2011.01.016

Boudreaux, E. D., Waring, M. E., Hayes, R. B., Sadasivam, R. S., Mullen, S., & Pagoto, S. (2014). Evaluating and selecting mobile health apps: Strategies for healthcare providers and healthcare organizations. *Translational Behavioral Medicine*, *4*(4), 363–3. doi:10.1007/s13142-014-0293-9 PMID:25584085

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative Research in Psychology*, *3*(2), 77–101. doi:10.1191/1478088706qp063oa

Buyya, R., Yeo, C. S., Venugopal, S., Broberg, J., & Brandic, I. (2009). Cloud computing and emerging IT platforms: Vision, hype, and reality for delivering computing as the 5th utility. *Future Generation Computer Systems*, *25*(6), 599–616. doi:10.1016/j.future.2008.12.001

Caligtan, C., & Dykes, P. (2011). Electronic health records and personal health records. *Seminars in Oncology Nursing*, *27*(3), 218–228. doi:10.1016/j.soncn.2011.04.007 PMID:21783013

Chan, C., & Kaufman, D. (2010). A technology selection framework for supporting delivery of patient-oriented health interventions in developing countries. *Journal of Biomedical Informatics*, *43*(2), 300–306. doi:10.1016/j.jbi.2009.09.006 PMID:19796709

Cilliers, L., & Flowerday, S. (2014). *User acceptance of telemedicine by health care workers*. Academic Press.

Clark, H., & Wu, H. (2016, August 19). *The sustainable development goals: 17 goals to transform our world: Furthering the Work of the United Nations*. Retrieved from UN Library: https://www.un-ilibrary.org/united-nations/furthering-the-work-of-the-un

Conway, J., Johnson, B., Edgman-Levitan, S., Schlucter, J., Ford, D., Sodomka, P., & Simmons, L. (2006). *Partnering with patients and families to design a patient-and family-centered health care system: a roadmap for the future: a work in progress*. Institute for Family-Centered Care.

Czaja, S. J., Zarcadoolas, C., Vaughon, W. L., Lee, C. C., Rockoff, M. L., & Levy, J. (2015). The usability of electronic personal health record systems for an underserved adult population. *Human Factors*, *57*(3), 491–506. doi:10.1177/0018720814549238 PMID:25875437

Design Council. (2015, March 18). *The Design Process: What is the Double Diamond?* Retrieved from British Design Council: https://www.designcouncil.org.uk/news-opinion/what-framework-innovation-design-councils-evolved-double-diamond

Elliott, V. (2018). Thinking about the coding process in qualitative data analysis. *Qualitative Report*, *23*(11), 2850–2861.

Etoundi, R. A., & & Onana, S. (2016). *Special issue on ICT for Africa development: An introduction and framework for research*. Academic Press.

Foot, C., Gilburt, H., Dunn, P., Jabbal, J., Seale, B., Goodrich, J., & Taylor, J. (2014). *People in control of their own health and care*. King's Fund.

Fotso, J. C., Ezeh, A., Madise, N., Ziraba, A., & Ogollah, R. (2009). What does access to maternal care mean among the urban poor? Factors associated with use of appropriate maternal health services in the slum settlements of Nairobi, Kenya. *Maternal and Child Health Journal*, *13*(1), 130–137. doi:10.1007/s10995-008-0326-4 PMID:18297380

Fouka, G., & Mantzorou, M. (2011). What are the major ethical issues in conducting research? Is there a conflict between the research ethics and the nature of nursing? *Health Science Journal*, *5*(1), 3–14.

Gebre-Mariam, M. (2018). Governance lessons from an interorganizational health information system implementation in Ethiopia. *The Electronic Journal on Information Systems in Developing Countries*, *84*(5), e12045. doi:10.1002/isd2.12045

Gordon, M., Henderson, R., Holmes, J. H., Wolters, M. K., Bennett, I. M., & Group, S. (2016). Participatory design of ehealth solutions for women from vulnerable populations with perinatal depression. *Journal of the American Medical Informatics Association: JAMIA*, *23*(1), 105–109. doi:10.1093/jamia/ocv109 PMID:26342219

Gregor, S., & Jones, D. (2007). The anatomy of a design theory. *Journal of the Association for Information Systems*, *8*(5), 312–335. doi:10.17705/1jais.00129

Grimes, H., Forster, D., & Newton, M. (2014). Sources of information used by women during pregnancy to meet their information needs. *Midwifery*, *30*(1), 26–33. doi:10.1016/j.midw.2013.10.007 PMID:24246969

Grisot, M., & Lindroth, T. (2019). Bounded recombinability of digital technologies for patient-cenetere care. In *MCIS 2019 Conference Proceedings.* Naples, Italy: AIS.

Hackett, K., Kazemi, M., & Sellen, D. (2018). Keeping secrets in the cloud: Mobile phones, data security and privacy within the context of pregnancy and childbirth in Tanzania. *Social Science & Medicine*, *211*, 190–197. doi:10.1016/j.socscimed.2018.06.014 PMID:29960170

Heart, T., Ben-Assuli, O., & Shabtai, I. (2017). A review of PHR, EMR and EHR integration: A more personalized healthcare and public health policy. *Health Policy and Technology*, *6*(1), 20–25. doi:10.1016/j.hlpt.2016.08.002

Heeks, R. (2002). e-Government in Africa: Promise and practice. *Information Polity, 7*(2,3), 97–114.

Heeks, R. (2003). *Most eGovernment-for-development projects fail: How can risks be reduced? iGovernment Working Paper Series.* Manchester, UK: IDPM.

Holmgren, A., & Adler-Milstein, J. (2017). Health Information Exchange in Us Hospitals: The Current Landscape and a Path to Improved Information Sharing. *Journal of Hospital Medicine*, *12*(3), 193–198. doi:10.12788/jhm.2704 PMID:28272599

Hu, Y., & Bai, G. (2014). *A systematic literature review of cloud computing in eHealth*. arXiv preprint arXiv.

John, N., & Shenoy, S. (2014). Health cloud-Healthcare as a service (HaaS). In *2014 International Conference on Advances in Computing, Communications and Informatics (ICACCI)* (pp. 1963-1966). Greater Noida, India: IEEE. doi:10.1109/ICACCI.2014.6968627

Joly, M., Teixeira, J., Patricio, L., & Sangiorgi, D. (2019). Leveraging service design as a multidisciplinary approach to service innovation. *Journal of Service Management*, *30*(6), 681–715. doi:10.1108/JOSM-07-2017-0178

Kaur, J. (2012). The role of litigation in ensuring women's reproductive rights: An analysis of the Shanti Devi judgement in India. *Reproductive Health Matters*, *20*(39), 21–30. doi:10.1016/S0968-8080(12)39604-3 PMID:22789079

Kenya National Bureau of Statistics. (2020, February 21). *2019 Kenya Population and Housing Census Volume III: Distribution of Population by Age, Sex and Administrative Units.* Retrieved July 17, 2020, from https://www.knbs.or.ke/?wpdmpro=2019-kenya-population-and-housing-census-volume-iii-distribution-of-population-by-age-sex-and-administrative-units

Kerr, C., Nixon, A., & Wild, D. (2010). Assessing and demonstrating data saturation in qualitative inquiry supporting patient-reported outcomes research. *Expert Review of Pharmacoeconomics & Outcomes Research*, *10*(3), 269–281. doi:10.1586/erp.10.30 PMID:20545592

Kimathi, L. (2017). Challenges of the Devolved Health Sector in Kenya: Teething Problems or Systemic Contradictions? *Africa Development. Afrique et Developpement*, *42*(1), 55–77.

Klein, H., & Myers, M. (1999). A set of principles for conducting and evaluating interpretive field studies in information systems. *Management Information Systems Quarterly*, *23*(1), 67–93. doi:10.2307/249410

Koumaditis, K., Katelaris, L., & Themistocleous, M. (2015). A Cloud Based Patient-Centered eHealth Record. *International Journal on Advances in Life Sciences*, 7.

Kronqvist, J., Erving, H., & Leinonen, T. (2013). Cardboard hospital: Prototyping patient-centric environments and services. *Nordes, 1*(5).

Lade, V., Jaitpal, S., & Chitnis, A. (2014). A Review of Cloud-based Healthcare System. *International Journal of Enhanced Research in Science Technology and Engineering*, *3*(10), 22–26.

Lattof, S., Tunçalp, Ö., Moran, A., Bucagu, M., Chou, D., Diaz, T., & Gülmezoglu, A. (2020). Developing measures for WHO recommendations on antenatal care for a positive pregnancy experience: a conceptual framework and scoping review. *BMJ Open, 9*(4).

Lee, Y. L., Cui, Y. Y., Tu, M. H., Chen, Y. C., & Chang, P. (2018). Mobile health to maintain continuity of patient-centered care for chronic kidney disease: Content analysis of apps. *JMIR mHealth and uHealth*, *6*(4), e10173. doi:10.2196/10173 PMID:29678805

Liang, H., Xing, T., Cai, L. X., Huang, D., Peng, D., & Liu, Y. (2013). Adaptive computing resource allocation for mobile cloud computing. *International Journal of Distributed Sensor Networks*, *9*(4), 181426. doi:10.1155/2013/181426

Lim, C., Kim, K., Kim, M., Heo, J., Kim, K., & Maglio, P. (2018). From data to value: A nine-factor framework for data-based value creation in information-intensive services. *International Journal of Information Management*, *39*, 121–135. doi:10.1016/j.ijinfomgt.2017.12.007

Lin, M., Hughes, B., Katica, M., Dining-Zuber, C., & Plsek, P. (2011). Service design and change of systems: Human-centered approaches to implementing and spreading service design. *International Journal of Design*, *5*(2).

Lings, B., & Lundell, B. (2005). On the adaptation of Grounded Theory procedures: Insights from the evolution of the 2G method. *Information Technology & People*, *18*(3), 196–211. doi:10.1108/09593840510615842

Malmberg, L., Rodrigues, V., Lännerström, L., Wetter-Edman, K., Vink, J., & Holmlid, S. (2019). Service design as a transformational driver toward person-centered care in healthcare. In In Service design and service thinking in healthcare and hospital manage (pp. 1-18). Cham: Springer. doi:10.1007/978-3-030-00749-2_1

Manya, A., Nielsen, P., & Pundo, R. (2016). Cloud Computing as a Catalyst for Integrated Health Information Systems in Developing Countries. *Assoc. Inform. Syst*, *7*, 3.

Marshall, M. (1996). Sampling for qualitative research. *Family Practice*, *13*(6), 522–526. doi:10.1093/fampra/13.6.522 PMID:9023528

Mell, P., & Grance, T. (2011). *The NIST definition of cloud computing*. NIST. doi:10.6028/NIST.SP.800-145

Miah, S., Hasan, J., & Gammack, J. (2017). On-cloud healthcare clinic: An e-health consultancy approach for remote communities in a developing country. *Telematics and Informatics*, *34*(1), 311–322. doi:10.1016/j.tele.2016.05.008

Miah, S. J. (2017). Large-Scale Innovations and Approaches for Community Healthcare Support in Developing Nations. In *Handbook of Large-Scale Distributed Computing in Smart Healthcare* (pp. 359–375). Springer. doi:10.1007/978-3-319-58280-1_13

Ministry of Health. (2016). *Kenya National eHealth Policy 2016-2030. Towards attainment of the highest standard of health through adoption and use of ICT.* Nairobi: MoH.

Moller, A. B., Petzold, M., Chou, D., & Say, L. (2017). Early antenatal care visit: A systematic analysis of regional and global levels and trends of coverage from 1990 to 2013. *The Lancet. Global Health*, *5*(10), e977–e983. doi:10.1016/S2214-109X(17)30325-X PMID:28911763

Moritz, S. (2005). *Service design: Practical access to an evolving field*. Köln International School of Design.

Mulauzi, F., & Daka, K. (2018). Maternal health information needs of women: A survey of literature. *Journal of Lexicography and Terminology*, *2*(1), 57–82.

Mutisya, E., & Yarime, M. (2011). Understanding the grassroots dynamics of slums in Nairobi: The dilemma of Kibera informal settlements. *Int Trans J Eng Manag Appl Sci Technol*, *2*(2), 197–213.

Nabyonga-Orem, J. (2017). Monitoring Sustainable Development Goal 3: How ready are the health information systems in low-income and middle-income countries? *BMJ Global Health*, *2*(4), e000433. doi:10.1136/bmjgh-2017-000433 PMID:29104767

Nairobi City County. (2013). *Health Sector Working Group Report: Medium Term Expenditure Framework Budget for the period 2014-2015/2019*. NCC.

Nairobi City County. (2014). *County Integrated Development Plan (CIDP) report for 2014*. NCC.

Nairobi City County. (2017). *Nairobi City County Health Sector Strategic And Investment Plan 2013/2014–2018/2019*. NCC.

Newell, B., Gomez, R., & Guajardo, V. (2016). Information seeking, technology use, and vulnerability among migrants at the United States–Mexico border. *The Information Society*, *32*(3), 176–191. doi:10.1080/01972243.2016.1153013

Nguyen, T. N., Ha, S. T., & Braa, J. (2015). Assembling a national health information infrastructure: The case of Vietnam. *Information Systems in Developing Countries*, *66*(1), 1–18. doi:10.1002/j.1681-4835.2015.tb00477.x

Nunamaker, J. Jr, Briggs, R., Derrick, D., & Schwabe, G. (2015). The last research mile: Achieving both rigor and relevance in information systems research. *Journal of Management Information Systems*, *32*(3), 10–47. doi:10.1080/07421222.2015.1094961

Nyatuka, D. R., & de la Harpe, R. (2019). Evaluating mHealth Interventions in an Underserved Context Using Service Design Strategy: A Case of Kenya. In *Proceedings of the third International Conference on Medical and Health Informatics 2019*. Xiamen, China: ACM. doi:10.1145/3340037.3340060

Nyatuka, D. R., & De La Harpe, R. (2021). Design considerations for patient-centered eHealth interventions in an underserved context: A case of health and wellbeing services within Nairobi's informal settlements in Kenya. *The Electronic Journal on Information Systems in Developing Countries*.

Oleribe, O. O., Momoh, J., Uzochukwu, B. S., Mbofana, F., Adebiyi, A., Barbera, T., Williams, R., & Taylor-Robinson, S. D. (2019). Identifying key challenges facing healthcare systems in Africa and potential solutions. *International Journal of General Medicine*, *12*, 395–403. doi:10.2147/IJGM.S223882 PMID:31819592

Pamedytyte, R., & Akoglu, C. (2019). Value Creation Through Service Design in a Healthcare Environment. *The Design Journal*, *22*(1), 655–668. doi:10.1080/14606925.2019.1595445

Patrício, L., de Pinho, N., Teixeira, J., & Fisk, R. (2018). Service design for value networks: Enabling value cocreation interactions in healthcare. *Service Science*, *10*(1), 76–97. doi:10.1287/serv.2017.0201

Patrício, L., Sangiorgi, D., Mahr, D., Čaić, M., Kalantari, S., & Sundar, S. (2020). Leveraging service design for healthcare transformation: Toward people-centered, integrated, and technology-enabled healthcare systems. *Journal of Service Management*, *31*(5), 889–909. doi:10.1108/JOSM-11-2019-0332

Patterson, H. (2013). Contextual expectations of privacy in self-generated health information flows. In *Proceedings of The 41st Research Conference on Communication, Information and Internet Policy*. Washington, DC: TPRC. doi:10.2139/ssrn.2242144

Ramli, R. M. (2017). *E-government implementation challenges in Malaysia and South Korea: A comparative study*. Academic Press.

Reddy, G., & Reddy, G. (2014). *Study of Cloud Computing in Health care Industry*. arXiv preprint.

Røed, K. (2012). *Socio-technical integration in health care: Socio-technical integration in health care* (Unpublished doctoral dissertation), University of Tromsø, Tromsø, Norway.

Roehrs, A., da Costa, C., & da Rosa Righi, R. (2017). OmniPHR: A distributed architecture model to integrate personal health records. *Journal of Biomedical Informatics*, *71*, 70–81. doi:10.1016/j.jbi.2017.05.012 PMID:28545835

Roztocki, N., & Weistroffer, H. R. (2016). Conceptualizing and Researching the Adoption of ICT and the Impact on Socioeconomic Development. *Information Technology for Development*, *22*(4), 541–549. doi:10.1080/026 81102.2016.1196097

Runaas, L., Hanauer, D., Maher, M., Bischoff, E., Fauer, A., Hoang, T., & Cohn, A. et al. (2017). BMT roadmap: A user-centered design health information technology tool to promote patient-centered care in pedin pediatric hematopoietic cell transplantation. *Biology of Blood and Marrow Transplantation*, *23*(5), 813–819. doi:10.1016/j.bbmt.2017.01.080 PMID:28132870

Saldaña, J. (2015). *The coding manual for qualitative researchers* (3rd ed.). Sage.

Salgado, M., Wendland, M., Rodriguez, D., Bohren, M. A., Oladapo, O. T., Ojelade, O. A., Olalere, A. A., Luwangula, R., Mugerwa, K., & Fawole, B. (2017). Using a service design model to develop the "Passport to Safer Birth" in Nigeria and Uganda. *International Journal of Gynaecology and Obstetrics: the Official Organ of the International Federation of Gynaecology and Obstetrics*, *139*, 56–66. doi:10.1002/ijgo.12381 PMID:29218714

Shiferaw, F., & Zolfo, M. (2012). The role of information communication technology (ICT) towards universal health coverage: The first steps of a telemedicine project in Ethiopia. *Global Health Action*, *5*(1), 15638. doi:10.3402/gha.v5i0.15638 PMID:22479235

Slaper, M. R., & Conkol, K. (2014). mHealth tools for the pediatric patient-centered medical home. *Pediatric Annals*, *43*(2), e39–e43. doi:10.3928/00904481-20140127-09 PMID:24512160

Slattery, P., Saeri, A., & Bragge, P. (2020). Research co-design in health: A rapid overview of reviews. *Health Research Policy and Systems*, *18*(1), 17. doi:10.1186/s12961-020-0528-9 PMID:32046728

Sneha, S., & Straub, D. (2017). E-Health: Value Proposition and Technologies Enabling Collaborative Healthcare. In *Proceedings of the 50th Hawaii International Conference on System Sciences*. IEEE. doi:10.24251/HICSS.2017.108

Steenkamp, M., Bar-Zeev, S., Rumbold, A., Barclay, L., & Kildea, S. (2010). Pragmatic indicators for remote Aboriginal maternal and infant health care: Why it matters and where to start. *Australian and New Zealand Journal of Public Health*, *34*, S5–S8. doi:10.1111/j.1753-6405.2010.00545.x PMID:20618295

Townsend, A., Adam, S., Birch, P., & Friedman, J. (2013). Paternalism and the ACMG recommendations on genomic incidental findings: Patients seen but not heard. *Genetics in Medicine*, *15*(9), 751–752. doi:10.1038/gim.2013.105 PMID:24008256

Tsekleves, E., & Cooper, R. (2017). Emerging trends and the way forward in design in healthcare: An expert's perspective. *The Design Journal*, *20*(1), 2258–2272. doi:10.1080/14606925.2017.1352742

Walter, A. I., Helgenberger, S. W. A., & Scholz, R. W. (2007). Measuring societal effects of transdisciplinary research projects: Design and application of an evaluation method. *Evaluation and Program Planning*, *30*(4), 325–338. doi:10.1016/j.evalprogplan.2007.08.002 PMID:17904636

Waweru, E., Sarkar, N. D., Ssengooba, F., Gruénais, M. E., Broerse, J., & Criel, B. (2019). Stakeholder perceptions on patient-centered care at primary health care level in rural eastern Uganda: A qualitative inquiry. *PLoS One*, *14*(8), e0221649. doi:10.1371/journal.pone.0221649 PMID:31461495

Whaiduzzaman, M., Gani, A., Anuar, N., Shiraz, M., Haque, M., & Haque, I. (2014). Cloud service selection using multicriteria decision analysis. *TheScientificWorldJournal*, *2014*, 2014. doi:10.1155/2014/459375 PMID:24696645

Williams, D., Mohammed, S., Leavell, J., & Collins, C. (2010). Race, socioeconomic status, and health: Complexities, ongoing challenges, and research opportunities. *Annals of the New York Academy of Sciences*, *1186*(1), 69–101. doi:10.1111/j.1749-6632.2009.05339.x PMID:20201869

World Health Organization. (2015). WHO global strategy on integrated people-centred health services 2016-2026. Placing people and communities at the centre of health services. WHO.

World Health Organization. (2016a). *Framework on integrated people-centred health services. Sixty-ninth World Health Assembly A, 69.* WHO.

World Health Organization. (2016b). *World health statistics 2016: monitoring health for the SDGs sustainable development goals* (1st ed.). WHO.

World Health Organization. (2020). *SDG 3: Ensure healthy lives and promote wellbeing for all at all ages*. Retrieved April 8, 2020, from https://www.who.int/sdg/targets/en/

Zhou, L., DeAlmeida, D., & Parmanto, B. (2019). Applying a User-Centered Approach to Building a Mobile Personal Health Record App: Development and Usability Study. *JMIR mHealth and uHealth*, *7*(7), e13194. doi:10.2196/13194 PMID:31278732

Ziraba, A., Mills, S., Madise, N., Saliku, T., & Fotso, J. (2009). The state of emergency obstetric care services in Nairobi informal settlements and environs: Results from a maternity health facility survey. *BMC Health Services Research*, *9*(1), 46. doi:10.1186/1472-6963-9-46 PMID:19284626

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