Towards an Integrated mHealth Platform for Community-based Maternity Health Workers in Low-Income Communities

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ABSTRACT

A variety of actors with diverse perspectives such as maternity health workers (MHWs), pregnant women, providers and other community organizations constitute the perinatal services system designed for low-income communities. Yet, little is known about the nature of service delivery challenges that seem inevitable in this setting. We sought to understand prenatal services system from the perspective of MHWs and identify areas that can be improved by mHealth solutions. We collected qualitative data from twenty-eight target MHWs via an online survey, and used the open coding approach to identify themes. The findings showed that MHWs face a number of challenges while providing services like education, referrals etc. Notable challenges were lack of coordination with other stakeholders, unmet professional development needs, maintaining privacy and difficulties with client education, communication and record exchange. MHWs expressed the need for innovative technologies to facilitate client education and open communication with other maternity health actors. Our findings suggest that there is a great demand for communication and service delivery tools in community-based MHWs. But, new solution need to be integrated within existing tools and environment while empowering MHWs with professional and educational support.

CCS CONCEPTS

•**Information interfaces and presentation (e.g., HCI)** →Miscellaneous;

KEYWORDS

maternity health workers; pregnancy; low socioeconomic; community-based; care coordination; design; communication

ACM Reference format:
Beenish Moalla Chaudhry, Louis Faust, and Nitesh V. Chawla. 2018. Towards an Integrated mHealth Platform for Community-based Maternity Health Workers in Low-Income Communities. In *Proceedings of PervasiveHealth '18: 12th EAI International Conference on Pervasive Computing Technologies for Healthcare, New York, NY, USA, May 21–24, 2018 (PervasiveHealth '18),* 10 pages.
DOI: 10.1145/3240925.3240938

PervasiveHealth '18, New York, NY, USA

DOI: 10.1145/3240925.3240938

1 INTRODUCTION

Like many regions in the world, less affluent communities in the United States (US) experience higher infant mortality rates compared to their counterparts [33]. The majority of these deaths is attributed to poor pregnancy outcomes that can be avoided by appropriate perinatal care. Unfortunately, in United States, low-income individuals under-utilize or avoid this preventive care due to cost, complexity of health systems and lack of knowledge. For these individuals, community-based (e.g. civil society, non-governmental, faith-based and voluntary) organizations provide viable alternatives for obtaining maternity services during pre-conception, prenatal and postpartum periods. A growing body of literature recognizes the importance of community-based maternity services in reducing costs associated with prenatal care and improving the physical, social, emotional, and mental health outcomes in mothers, babies and families [17, 23].

Community-based maternity services are typically provided by a combination of trained paraprofessionals (community health workers, peer health educators, etc.) and professionals (public health nurses, prenatal care coordinators, social workers, midwives, etc.), whom we will collectively refer to as Maternity Health Workers (MHWs) from hereon. The type of services provided by MHWs is determined by the model of care advocated by their organizations, which typically ranges from maternal education and counseling on healthy behaviors to referrals for other sources of care. Depending on the model, MHWs may also serve pregnant women in a variety of settings such as home, doctors' office, hospital or other community organizations. In a typical case, a MHW works one-on-one with a woman throughout her pregnancy to arrange a full spectrum of services whenever the need arises. MHWs with medical training also provide medical care.

Like other community-based workers, MHWs face many challenges in delivering their services such as coordinating care within a disintegrated health system and communicating with clients. Other challenges are related to working with low literacy levels, cultural differences and other social structural barriers. In other words, MHWs contend against numerous points of disruptions that can impact the quality of services and have implications for clients.

Evidence suggests that, across the globe, mHealth (mobile health) has helped community health workers improve the range and quality of services, particularly maternal and child health education [8]. Therefore, one approach to addressing disruptions is developing a mHealth solution. mHealth involves the use of mobile devices (smartphone, tablet, personal digital assistant, etc.) for health care delivery and management. Thus far, the majority of research in this area has been situated in low to middle income countries where

mHealth has been shown to help MHWs diagnose at-risk pregnancies [6], improve knowledge and reduce costs around care [13, 35]. The studies in high-income countries have been done with MHWs in hospital or clinical settings, who typically work with high-income patients and use hospital electronic health records [11, 39]. The mHealth solutions for community-based MHWs in high-income countries have rarely (to our knowledge, not at all) been studied [22].

User involvement during developing a new technology is imperative to ensure solutions meet users' needs and abilities [25]. In this paper, we present a qualitative study of the community-based maternity health services led by MHWs in various parts of the US, with the aim of investigating opportunities for designing mHealth solutions. Our three main contributions are:

- Shed a light on the duties and activities of community-based MHWs who provide services to pregnant women in low-socioeconomic communities
- Identify challenges in the services delivered by MHWs that have implications for clients
- Discuss opportunities for designing applications based on the identified needs

2 RELATED WORK

We conducted a comprehensive review of the literature published within the last six years and found mHealth solutions for MHWs in various stages of development. Following, we summarize the state of the research from both under-developed and developed regions of the world.

2.1 Design Explorations

User research with MHWs across the globe provides various use cases for mHealth. From their work in Pakistan, Mahmood and colleagues found significant disparity in the knowledge and practices of low-literacy MHWs, regarding health data recording and reporting. The researchers suggested that a mobile app with supervisor connectivity can improve reliability and validity of primary maternal care delivered by low-resource MHWs [28].

In another work, Mahmud and colleagues investigated design opportunities with midwives in the Netherlands. They found that Dutch MHWs do not use well-developed tools to support their workflow. The researchers suggested that an interactive tool be developed to support information sharing between mothers and midwives. They also discussed the design of a mobile app that would allow midwives to remotely access required medical software during home visits, helping them improve their care delivery practices [1, 2].

2.2 Socio-technical Evaluations

Socio-technical evaluations can help identify concerns of those who will be impacted by the technology. For technologies designed for MHWs, such evaluations have produced positive results. MHWs from a rural setting in US felt that the use of a tablet for depression screening can lower several barriers such as literacy, writing errors and redundancy while guarding the privacy of clients [23]. In another study, hospital-based Australian midwives thought that a tablet, due to its form factor, can minimize disruptions that are often inevitable while using computers [11].

Lee and colleagues developed and tested a theoretical model to inform strategies to implement mHealth solutions in developing countries using Indonesia as an example. The model explains that smartphones improve midwives' knowledge self-efficacy by providing access to peer and institutional knowledge resources in the field [26]. This is supported by other research that shows that two-way communication (with other midwives or supervisors) built into mobile apps is helpful in enhancing the effectiveness of low resource midwives in developing regions [32]. Even though, MHWs with low literacy skills require training before feeling comfortable with texting.

2.3 Communication Tools

In high-income countries, there has been an interest in designing tools to strengthen MHW-client relationships for promoting healthy behaviors. Bacchus and colleagues found that MHWs' use of tablet computers during home visits made it easier for their clients to disclose intimate partner abuse. MHWs, however, felt that talking about abuse through a computer was impersonal and it impeded discussion [5]. Soltani and colleagues developed a theory-informed health application that enabled MHWs to send targeted and personalized text messages. The evaluation of showed that the tool, MOMTech, was feasible to use by MHWs within a clinical setting and it helped clients in limiting weight gain during pregnancy [39]. Other technologies that help MHWs influence harmful health behaviors such as smoking [42] and depression [24] in pregnant women, according to evidence-based guidelines, have also been developed. Initial evaluations of these tools have shown that they are acceptable and feasible to use by rural MHWs.

In the context of developing world, a two-way text messaging app between pregnant women and MHWs increased the likelihood of the presence of a skilled birth attendant during labor [13]. This research, however, did not measure the impact of the tool on continuity and quality of care during pregnancy.

2.4 Data Collection and Screening Tools

Due to limitations of resources in low-income countries, it is common to find women facing complications during pregnancies [40]. Hence, majority of technology-based solutions in the under-developed world are concerned with assisting MHWs with the detection of high-risk pregnancies and other complications [6]. In Bangladesh, a mobile diagnostic tool allowed MHWs to collect and send data to a central system to triage at-risk mothers. This method improved MHWs' efficiency and quality of delivered care [3]. In another tool, the diagnostic algorithm ran on the edge device, hence network dependence was reduced [29]. In general, research shows that diagnostic systems aid in the investigation of patient data, improving MHWs' adherence to guidelines, or automated screenings [20, 21, 24].

There is also ample literature on development and evaluation of medical screening tools, particularly portable ultrasound scanners, for low-resource midwives in low-income countries [29]. Ultrasounds can reliably detect many high-risk conditions early in the pregnancy, making it possible to take necessary actions to prevent

complications. For less skilled MHWs who cannot interpret ultrasound scans, mobile applications that support remote interpretation of ultrasound scans have been developed to imporve service delivery [4]. The literature, overall, demonstrates that, in the developing countries, a well-integrated ultrasound program within an effective health care system has the potential to significantly impact maternal and child health.

2.5 Decision Support Systems

To design data collection tools for MHWs in the developing world, researchers employ user-centered design approach to accommodate users' unique needs and environmental constraints [7, 41]. From their usability evaluation study with Ghanaian midwives (involving multi-fidelity prototypes (digital and paper)), Velez and colleagues found that MHWs need documentation and informational tools to evaluate and monitor their clients and their own care practices. But such tools must reduce data entry to help MHWs simultaneously meet funders' documentation requirements [41]. The findings suggest that MHWs have a complex multi-dimensional workflow that requires thoughtful and careful design.

In summary, researchers have developed mHealth tools to help low-skilled MHWs in low-income countries conduct risk assessments and obtain knowledge at the point of care. Major limitation of this work is that it is targeted towards MHWs in the developing world. It cannot be directly transferred to the developed world because these regions differ in technology, economic and service infrastructures, health workers' literacy levels and clinical protocols etc. [22]. In high-income countries, focus has been on developing tools to help hospital or clinical MHWs communicate with clients for specific health conditions. This work largely ignores MHWs who are low resource and work in low-income communities of the developed world. In fact, we are largely unaware of the mHealth tools that can help address challenges faced by the target MHWs. Our work in this paper attempts to fill these gaps.

3 STUDY

This study describes the first phase of an ongoing research on implementing a technology-based solution to address challenges faced by MHWs and improve implications for pregnant clients. Our collaborators are MHWs affiliated with a community-based maternal and child health organization called Healthy Start. The design and evaluation of the developed technology is described in forthcoming publications [9, 10].

3.1 Methods

In this study, our aim was to investigate workflow challenges and needs of community-based MHWs who serve pregnant and postpartum women in low socio-economic communities. We focused on understanding care coordination, education and communication practices of MHWs. After obtaining approval from the Institutional Review Board (IRB), we prepared a 30-item survey questionnaire with the help of our collaborators (Table 1).

The survey link was emailed to more than 200 pregnancy-related community-based organizations across the country. We purposely targeted organizations that served low-income, Medicaid-eligible pregnant or postpartum women. An informed consent was obtained as part of the survey. Thirty-two MHWs completed the survey, each receiving a $10 gift card for her time and feedback.

Table 1: Composition of the Survey

Question No.	Description	Type
1-6	Demographics	Mixed with choices
7-28	Practice-focused	Open questions
29-30	Technology-focused	Open questions

3.2 Participants

All survey respondents were females who held different job titles. Eight participants described themselves as social workers (SWs), eight as prenatal care coordinators (CCs), two as community health workers (CHWs), four as health workers in pregnancy resource centers (PRCs), two as case managers (CMs), two as certified birth doulas (CBDs) and two as certified nurse midwives (CNMs). Three participants had diverse experiences by virtue of a previou s job or certifications. For example, one participant described herself as, "*Birth doula, postpartum doula, childbirth educator, evidence-based birth instructor and a few other titles all in the childbirth field. I started this field in 2012.*"

Participants' years of education and experience were also variable. Four participants had high school degrees, three had obtained their diplomas, seven had 4-year college degrees and the rest had completed their post-graduate university education. Twelve participants had less than five years of experience, seven had less than twenty years, and six had more than twenty years, with 42 years being the highest number. Three did not report years of experience.

Some participants served a specific population, such as "*Some college, earning annual income of $0-14,000, African American, English-speaking*". Others served a culturally and ethnically diverse population consisting of individuals speaking different languages (e.g. Spanish, Hmong, Arabic etc.). "*The majority of our clients are receiving MediCal. High School is the average educational level. The majority of the clients is Hispanic. They can speak both English and Spanish. We serve a large community that consists of many ethnic backgrounds and we have clients from junior high to college and the working class.*" Overall, surveyed participants classified their clients as low-income Medicaid-eligible individuals. "*82% of our clients have incomes lower than $29K.*" The number of clients served by one MHW varied greatly from 24 to 135 per year. And, the number of encounters per client could range from 1 to as many as needed (as high as 35).

3.3 Analysis

Twenty-eight responses were selected for analysis. Data were excluded if the respondent did not work in a community-based setting or did not serve a low-income population. The selected data was analyzed using a thematic and iterative approach. Using grounded theory, the first author and one external researcher performed open coding and clustered similar codes under major themes. The researchers then came together to compare, discuss, and whenever needed, make adjustments to the themes in collaboration with our partners, Healthy Start. This process was repeated until the themes were stable and there was agreement in the coding. The final version

of the code book contained 38 codes that represented challenges and opportunities for application developers. We classified these codes into eight main themes described in the next section.

4 RESULTS

Even though, the survey respondents held different job titles, they provided overlapping services. Notable services included education, resources, referrals, and personal support where challenges were identified. The information exchange aspect of these services was accomplished, mainly, via written and verbal means, and sometimes via digital means. But, due to varying client circumstances, these methods had limited usefulness. Many MHWs used alternative means such as personal support via social media and regular phone calls to provide these services. Here, challenges included working against clients' apathy, low literacy levels and limited resources. The disintegrated health system, privacy regulations and lack of trust among other providers also had implications for clients. Finally, dealing with inconsistent/changing care practices and obtaining evidence-based information were other major barriers to providing quality care.

4.1 Juggling Multiple Job Tools

Everyone except five participants described themselves as expert or daily computer users. The remaining did not use any digital tool for their work-related activities. Majority of participants used a variety of applications, including online translation services, note-taking apps, database management systems (e.g. Apricot, Microsoft Access) and electronic medical records (EMRs) etc. Two participants also used medical screening devices, i.e. ultrasound and digital hemoglobin machines. One pregnancy center had recently adopted a software application mandated by the Federal Maternal and Child Health Department to manage their workflow and complete recommended assessments. Some were using state-mandated software applications along with patient portals with high-risk mothers. Other reasons for using a software application included documenting client information to guide care and generating reports for their grantors.

It was also common among participants to use social networking websites, specifically Facebook to advertise ongoing activities at their centers or to communicate with their clients on a daily basis. Based on clients' preferences, some MHWs also emailed brochures and/or appropriate websites to their clients. Many participants also used smartphones to send and receive text messages and photographs from their clients. Though, using personal phones for work purposes was not favored by many MHWs. "*I don't want to use my personal cell phone to communicate with clients, they seem to feel if they know my cell number, that they can text me at all hours. I don't want to take work home with me.*"

Some MHWs also used phone translation services to communicate with non-English speaking clients. For delivering information to clients, many MHWs routinely played PowerPoint presentations and DVDs on waiting room or classroom monitors. Tablets (iPad and Surface) were also frequently used for educational purposes on important topics such as smoking and labor during meetings. Many MHWs also recommended proprietary mobile applications available on online app stores to their clients.

4.2 Complexities of Risk Assessment

Participants who described themselves as CCs, CNMs and SWs developed careplans for their clients by conducting risk assessments throughout the pregnancy. An assessment typically, consists of a series of questions related to medical history, current pregnancy, substance use and psycho-social needs of clients. The first assessment called intake is usually the most comprehensive assessment. "*Intake is an office visit to gather demographic information, medical/pregnancy hx, nutrition info, ATOD (alcohol, tobacco, opioid and drugs) info, social hx/stressors.*" This information is then used to create personalized care plans consisting of referral information, educational materials, medical paperwork and health goal recommendations that align with client's needs. "*The assessments are to provide and discuss educational materials related to prenatal and postnatal health and infant care, provide community resources and Medicaid information documents to enroll themselves and their babies.*" The intake assessment also guides the careplan course for the remainder of pregnancy.

Maternity health agencies, affiliated with or funded by the government, are restricted to using assessments forms instituted by the government health departments or funding agencies such as Health Resources and Services Association (HRSA). "*Now we use forms provided by HRSA since our program is funded by them.*" These guidelines are flexible making it possible for assessments to be adjusted according to client's or provider's needs. "*We follow the CCNC guidelines/assessment forms and usually do monthly face-to-face meetings depending on patient needs or provider requests.*" The frequency of assessments also varies — ranging from once a week to once a month to once a trimester (including postpartum period), but is normally driven by a client's needs and medical conditions. "*Typically, it is 30 minutes to an hour each visit. The frequency is as needed for medical concerns and stage of pregnancy. Prenatal visits 10—15 per pregnancy, attend labor and birth (2—24 hours). Postpartum visits 3—4 hours each, well women care visits 30-45 minutes.*" Independently operating maternity health agencies conducted only one assessment at intake.

Assessment forms are completed by either MHWs or by clients. When clients fill them out, it allows MHWs to save time and focus on improving the quality of their services. "*Our mothers sometimes fill out these assessments and then we enter them into our database for reporting purposes.*" MHWs who filled out these forms on behalf of clients, wished to have an automated system to obtain this data. Asking clients to complete these forms on their own was not always possible because of literacy and other barriers. "*Some clients' educational level makes it difficult for them to comprehend some of the questions being asked.*"

4.3 Challenges in Personalizing Education

All MHWs routinely organized educational events but they struggled to individualize these events for clients. SWs and CHWs were, particularly, interested in tailoring such activities according to their clients' needs and backgrounds. "*We really try to individualize the program to client's needs. Not every client does well with the computer-based. Some have done great with looking at videos and looking through different sites, others haven't.*" Some MHWs even

used specific engagement techniques to educate mothers at various levels, including"*hands on activities, lectures, slides, posters and group activities to teach the class as everyone learns differently.*"

Even though MHWs did not believe that paper-based written materials were the best methods to share information, they did not have many options other than distributing paper brochures and pamphlets. MHWs pointed out that many clients simply do not have organizational skills to make effective use of written information. "*Too much printed information is shared that may easily get ignored, lost or thrown away. Having information in one place would be great for clients to be able to look back to read it over and over.*" MHWs also complained that they cannot assess clients' understanding when clients attempted to teach themselves by reading brochures, especially without having a prior classroom overview. "*Don't know how much they (clients) actually read and understand the materials we give them.*" The absence of this feedback loop means MHWs cannot identify gaps in client's understanding - data that can help tailor programs and interventions.

Another complaint was that paper-based education is ineffective with clients who had limited literacy skills. Based on their experiences, MHWs had found that repetition is the key to teaching. "*Many of our clients are 'functionally illiterate' meaning they have very poor reading skills. They tend to have problems retaining written materials and more often education is delivered most effectively by telling and retelling facts.*" Many MHWs felt that the presentation of written information was also an essential aspect of education, especially millennial mothers who are exposed to the colorful world of technology. "*I think some materials are largely effective and others not. I have found that the majority of clients will read brochures if they look modern, pretty and have bullet points rather than a lot of text.*" For this reason, many MHWs, particularly CNMs, wanted to prescribe FDA-approved mobile applications. "*The younger generation would prefer to primarily use technology if possible. I've often wondered if an app would be an option for our learning environment.*" And, they were less interested in personalizing education but following a pre-arranged curriculum to deliver required education.

Lastly, there was a challenge with serving diverse ethnic backgrounds. Many MHWs simply did not have educational materials in every language or had sufficient cultural understanding to effectively serve their clients. "*Language barriers. We do not have a full compliment of in-person interpreters and, sometimes, we rely on phone interpreters, which often takes longer and degrades the rapport.*"

4.4 Challenges in Reminding and Following up

Depending on her care plan, a client is often required to complete specific tasks. For example, she may be required to bring paperwork to complete insurance enrollment, she may also be required to schedule an appointment with her provider, etc. MHWs who were SWs and CCs actively helped their clients adhere to recommended careplans. (We did not see this trend in CMs). Oftentimes, this entailed sending reminders to ensure timely completion of various tasks. One participant summed up different kinds of reminders that are typically needed to ensure adherence. "*Reminder to get labs done, reminder to follow up on labs done, reminder to follow up on missed appointments, reminder to rebook missed appointments, reminders of appointments, reminder to provide pregnancy updates.*"

Respondents who used technologies, reported using software applications to manually or programmatically create schedule of appointments for each client. "*The reminders are a mix - many are set by calculations that are programmed into the database and some are set by the CC. I could come in to work and run a list of contacts that are scheduled for today, although I don't do it daily - I prefer to run my "To-Do" lists weekly, so I can get a sense of what the week looks like. Some days get jammed up, so I'll do some extra contacts on a day that is a little lighter.*"

Following up with their clients is also necessary in many cases. For example, MHWs want to know whether a client met with a referral, what happened during the meeting, reasons for missing an appointment, did the client read brochures, did she understand the information etc. "*Follow-up calls are made to check on a client if she has been instructed to get further care outside our organization, to just encourage the client, to relay results from ultrasound.*" Following up is the most challenging part of a MHW's job. But, the problem is that clients usually do not answer phone calls and/or return messages. The lack of client input creates knowledge gaps making it difficult for MHWs to maintain continuum of care. "*We do not know if the client followed up. Did she see the provider or visit her referrals? And what happened during that visit? What did the doctor say? What kind of follow-up is necessary? We never find out what happened and the women never tell us until we see them again.*" Another challenge is managing a large number of clients who need follow ups at different times. "*I often have several different text conversations going at once.... My number of contacts in a month usually runs around 120 or so - that's a mix of ALL types of visits.*"

4.5 Challenges in Providing Personal Support

MHWs routinely encounter clients who lack motivation and commitment to improve their own health. "*The challenge is people's commitment to their own personal betterment and also that they're often mandated by FACS to come to our programs and they might view it as just another program that they have to go to.*" All MHWs agreed that the best way to help clients with low motivation is by building trusting relationships and providing personal support in all areas of daily living. "*We surround our clients with support and build relationships with them; relationships are what keep them coming back each week.*" SWs and CCs extended these relationships beyond the office doors through communication via Facebook, text messages and emails. They preferred these methods over phone calls because clients were more comfortable with sharing problems, asking questions and clarifying confusions on these platforms.

MHWs found it most difficult to motivate a client when she had different values or had heard conflicting information from her friends and family. SWs and CCs, in general, were very respectful of their clients in these circumstances. "*Clients tend to get misinformation from friends and family. They believe this information as the truth. We dialogue with them about their beliefs and find out about their experiences. We do not tell them they are wrong, we show them different ways to experience their pregnancy and parenting. We come alongside them.*" Changing clients' values is a sensitive issue that MHWs approach through various counseling strategies. "*I use motivational interviewing and solutions-focused therapy to meet the mothers where they are at and encourage them to take their own next*

steps with my support, if needed." It was also common for MHWs to reward their clients for making efforts in changing behvaiors.

There were several MHWs who believed that external and internal factors such as lower literacy skills and limited resources were linked to lack of motivation. To address this problem, the CHWs were interested in empowering pregnant women and creating healthier communities. Involving other family members in organized events and activities while providing them a reward for doing so was a part of this endeavor. Many MHWs extended this support by creating peer-support groups that encouraged mothers to share their experiences with other mothers. Mothers valued peer support because it not only empowers others but also empowers self. "*We encourage peer-counseling so mothers can learn how to empower themselves and have a healthier community. They learn how they can educate their community by sharing what they have learned.*"

4.6 Inconsistent Information Creates Barriers

MHWs, particularly, CCs and CNMs expressed concern that inconsistent information on issues related to pregnancy was a major barrier in providing quality care. Laws and conventions around pregnancy care practices were also matters of concern, since they evolve based on new findings and evidence. "*One challenge in providing prenatal education and guidance on healthy pregnancy is conflicting views/laws/education regarding topics such as marijuana use in pregnancy. Physicians' uncertainty and inconsistency in addressing these issues as well.*" Attending professional conferences is one way to stay up-to-date but MHWs were constrained by time and cost. "*It is challenging to keep current with the information because of the cost.*" Moreover, having limited availability of educational content that addressed needs, issues and concerns of their communities was a major concern for MHWs. For example, MHWs who were in high infant mortality areas wanted educational content that specifically addressed problems responsible for high infant mortality rates in their regions.

4.7 Privacy Restrictions Impact Care

Privacy and security of clients' data is of paramount importance but, this often negatively impacts care coordination. For example, sharing of medical information with any medical provider requires patient's consent. MHWs often have difficulties obtaining approval if the client, whose consent is required, cannot be reached. Delays in sharing information delays the delivery of required care. "*Communication is usually medically based between medical clinics. We all face the challenge of confidentiality. Getting the signed consent from the client is often a challenge. It is one more thing dependent on the client's time and transportation.*"

Ensuring client's privacy during home visits was particularly important for SWs and CHWs. These MHWs reported that clients often hesitate to share private information, such as partner's violence, drug usage, etc. This means, oftentimes, clients do not receive services they truly need. "*Some clients live with family. During the home visit, privacy can be an issue because the intake paperwork has some very personal questions on it.*" Respecting client's time, place and attitudes was another aspect of privacy that MHWs have to be mindful about. Some clients only want to meet or talk when they have officially scheduled meetings, or when they have emergencies. However, it often leads to delays in care. "*Sometimes I call and they do not pick up because they are busy or at work. Then I just leave them a message. It is a problem when they do not call back.*"

Communicating with clients via social media such as Facebook or text messages was common among SWs and CCs. But many refrained from using these tools because they were concerned with the violation of the Health Information Portability and Accountability Act (HIPAA). "*Facebook is pretty good but I know at some point I need to move away from it because it is not HIPAA compliant.*" Others believed that these tools are unsuitable in the health context because of their marketing techniques. "*Many sites harvest information for marketing, hence confidentiality is a major concern when using online media for communication.*" Others felt that digitizing medical information may never become an option since online security may never become a reality. "*Security issues for communicating lab results using digital tools is a major concern, it may not ever be able to be automated.*"

4.8 Discontinuity of Care Among MH Actors

CNMs, CMs and CCs complained that, even though, they are an important part of pregnant women's care, the current health care environment often diminishes their importance. "*We are part of their [pregnant women] care but we are not being treated as such.*" Lack of trusting relationships between various maternity health actors leads to non-communication resulting in many missed collaboration opportunities. "*These entities often do not know that I am involved or don't know that they can reach out to me.*" MHWs can obtain client's data from referrals or hospitals only if a client has signed the consent. In the absence of a consent, both quality and continuity of care are impacted. "*Without client consent, being unable to reach an OB office and getting put on hold is a barrier we often face.*" Particularly, CNMs often find themselves without medical data about their clients, which is very crucial during labor and delivery. "*Hospitals make it difficult for transfers- the OB hospitalists can be very unkind to midwives! There should be collaboration and Mds should not bully APRNS.*"

PRCs were not interested in acquiring medical records of their clients. Instead, their interest was networking with other maternity health actors to bump up enrollments and improve their visibility in the community as a resource for pregnant women. "*We generally stay out of the relationship, even if it is still pending, so as not to blur any lines between the other provider and our client. But we continue to seek opportunities to network with other healthcare and community service entities to increase our visibility.*"

4.9 Summary

Amidst the diversity of MHWs there exist many similarities. For example, many seek to empower their clients, this is done by face-to-face meetings where clients are given the opportunity to lead the conversations. These meetings also provide MHWs with opportunities to motivate clients and direct behavioral changes. All work alongside other healthcare personnel including providers and nurses, and are open to meeting clients at multiple locations such home or doctor's office. In terms of practice, majority believed that integration into the wider health system is a necessity. Among the

Table 2: An overview of the study participants

Title	Attitudes	Concerns	Activities
CC ($n = 8$)	-build relationship throughout pregnancy -make information accessible to clients -understand clients to personalize care -technology can solve communication and knowledge access problems	-integration with wider health system -clients may not have resources -clients resist change -technology cost is prohibitive -privacy and confidentiality -keeping information current	-incentives for engagement -social media to communicate -group counseling -referrals, education, resources, personal support, follow-ups and assessments
SW ($n = 8$)	-respecting clients' perspectives to bring change, motivational interviewing -individualizing care to clients' needs -empower clients to care for themselves -technology can improve workflow -technology can provide services	-clients' apathy, self-limitations, lack of resources -integration with wider health system -client privacy -existence of inconsistent information	-assessments, education, counseling, personal support, follow-ups -incentives to encourage retention
PRC ($n = 4$)	-accommodate client's needs -build relationships -getting clients excited about their health -interest in using technology	-clients do not have resources -clients are not committed -providers are hard to reach -keeping information current -service awareness in community	-peer-facilitated sessions -incentives for engagement -assessments, education, reminders, resources (information+material), personal support -social media to communicate
CBD ($n = 2$)	-keep services client-led -empower clients to make decisions about birth -clients are easy to work with -face-to-face is more effective	-ensuring client confidentiality -integration with wider health system	-focused on childbirth -less involved in pregnancy -education and referrals
CHW ($n = 2$)	-clients need help to overcome barriers -involve the entire family in care -empower communities to solve problems -awareness of wider social issues	-clients do not have resources -health system is unfriendly towards clients	-high school level education -work alongside other providers -assessments, referrals, education -use social media to communicate
CM ($n = 2$)	-motivate clients and change behaviors -sensitive to clients' needs -sensitive to provider's needs -adherence to protocols	-outdated resources -clients resist change	-already integrated in the system -conduit between client and health system -case management, education, personal support, follow-ups
CNM ($n = 2$)	-face-to-face wins over technology -build trusting relationships -adherence to mandated protocols -resolve medical issues	-ensuring client confidentiality -integration with wider health system	-referrals, education, personal support, guidance -use of an EMR

various tasks required of MHWs, educating clients and offering referrals for further resources was common among all (refer Table 2).

Besides overall similarities, we identified some sub-patterns in attitudes, concerns and activities among the maternity health actors. PRCs, CHWs and CCs viewed technologies as a means to build relationships and communicate with clients. CNMs and CBDs considered face-to-face interactions more powerful than technology-mediated ones. Only CCs, SWs, CMs and CNMs were expected to adhere to strict medical protocols. CBDs had the most limited interaction scope with clients (i.e. during childbirth), and they reported most positive experiences with clients. CNMs and CMs were the most medically inclined MHWs while others were focused on addressing complex psycho-social issues of the clients. While CCs, SWs, PRCs and CHWs all were aware of factors that would bar clients from actively engaging in their own care, CHWs showed a deeper level of empathy towards clients' challenges.

5 DISCUSSION

We surveyed community-bas ed MHWs from several states in US to find directions for designing mHealth solutions for care delivery challenges and improve implications for pregnant women. Risk assessment, education, referrals, reminders and personal support are main activities of MHWs for which they use a variety of tools. Effective communication with clients is necessary but is difficult due to clients' lack of motivation or limited resources. Another challenge relates to coordinating care with other maternity health actors within a disintegrated health system. Following, we discuss design implications and associated challenges based on our findings.

5.1 Incorporate support for motivation

Even though MHWs come alongside clients for the betterment of their health, clients' apathy can stall these efforts. To increase client motivation, MHWs often provide material rewards when clients meet certain goals such as attending educational events. A promising research direction would be to investigate the design of technologies that rewards pregnant women meeting her goals. Mobile applications with gamification design principles incorporating virtual rewards have shown to improve self-management practices in chronic disease patients [30]. It would be interesting to compare the impact of virtual versus real reward designs on the motivation of pregnant women.

MHWs also noted that some challenges of pregnant women are socio-structural in nature as opposed to behavioral. This implies that there is need to place greater focus on understanding the pregnant women and their needs. Some MHWs engaged family members in prenatal programs or created empowered communities to influence client motivation. Therefore, exploring the design of motivation tools that allow MHWs to target ecological factors (around a woman), including family members, is a promising direction. Research has shown that family-level socio-technical systems can not only improve individual's awareness of their own health behaviors but also of their family members. The awareness helps family members provide each other positive social support for healthy behavior [36]. It would be interesting to investigate what kind of family or social system exists around the audience of target MHWs. Typically, their clientele is found in shelters and low resource settings.

It is also possible that MHWs see their clients as needing reminders and providing follow-ups because they are driven by the action-oriented nature of the culture. This implies that sometimes these actions may not be necessary. Studies show that MHWs with optimal competence do not always perform to the best of their ability which can result in lack of adherence to guidelines in routine tasks [6, 15, 34]. Systems could be designed to generate a score indicating the level of need or relevance of the reminder being sent by the MHW. Such a system would have to be based on a data-driven model that is informed by the MHWs' history of actions.

5.2 Support delivery of educational resources

There are many opportunities to improve delivery of prenatal health education both inside and outside the community-based organizations. Within their centers, MHWs use a variety of technologies such as tablets and DVDs to educate their clients but find pregnant women resisting change (or having challenges transferring knowledge into action). The future of patient education is largely considered to be mobile application since they make it possible to provide education in various modalities (i.e. voice, video, e-paper, graphics, SMS, etc.), accommodating a variety of learning styles and preferences. Moreover, early research shows that mobile applications produce statistically significant effects in targeted behaviors. For example, it has been shown that mobile apps can help users manage nonspecific low back pain [33]. There are also apps designed as intervention tools to encourage healthy habits, such as a sun protection app that provides real-time sun safety advice [5]. Unfortunately, existing mobile applications have not yet delivered their ultimate potential in terms of meeting users' needs [12]. Davis and colleagues implore that moving forward, consumers and interdisciplinary professionals should be involved early in the design, if these apps are to be prescribed for healthy behavior outcomes.

There is also an opportunity to develop educational mobile apps using new technologies, such as virtual and augmented realities that MHWs can use to supplement their current in-center educational events and activities. This is a relatively under-explored area in maternal and child health field but evidence shows that virtual reality interventions can lead to behavioral change in daily life. In fact, for specific phobias, virtual reality interventions are as effective as traditional behavior therapy [31]. If alternate reality based solutions are shown to be more effective than current methods in producing behavior changes, then transportation issues for clients can be addressed to a certain extent too. Moreover, clients will be able to have face-to-face time with MHWs that may be more effective in terms of producing behavior changes. Finally, to address the issue of cultural and language differences we suggest a multi-lingual application such as 'Duolingo' (www.duolingo.com) that can be used by MHWs to supplement their efforts to educate mothers, rather than relying on telephone or live interpreters that are expensive and time consuming.

The main considerations in creating and implementing new tools and technologies for MHWs would be cost and acceptability. Since community-based organizations work with limited budget and resources, new tools have to be affordable. Moreover, many MHWs have to use specific software or databases to fulfill reporting requirements. This means additional tools might be inconvenient or may not be welcomed. New technologies should be eiter integrated within the existing tools or integrate the existing tools in one place for easy access. We also want to stress the application of distributed cognition framework to this problem. The distributed cognition inspired design of Senathirajah and colleagues' EHR, that combined information elements from multiple sources on a screen via drag/drop actions, can inform the design of a system (for MHWs) that integrates multiple technologies in one place [37].

5.3 Build feedback loops to ensure compliance

MHWs need feedback on a number of client activities such as completion of assigned tasks, follow-ups on referrals, provider appointments, utilization of shared resources, completion status of recommended tasks, etc. This data is used to identify gaps in care and develop targeted interventions. The surveyed MHWs recommended that to support client compliance, systems should be developed that can automatically flag cases requiring further attention and generate calls from a triage nurse specialized in crisis intervention. For example, a client who is not reading any educational content or not following up with referrals should be flagged and reported automatically to her MHW, so she can provide intervention or help. Moreover, MHWs should have reduced burden of following up and reminding. Automatic emails or texts can be used to remind clients to contact her MHW to schedule the visits or to provide pregnancy updates. The contact schedule for each client will be personalized based on her gestational age at the time of intake and risk factors.

There should also be a better collaboration with other organizations (referrals) involved in the care of the pregnant women (as

described in the next section). The MHWs should be able to receive required information to ensure their records are complete and accurate. The literature has examples of many technologies that refer pregnant women to various human and health services [14] but, in our review, we did not find any research that refers women back from these services to MHWs. Therefore, exploring technologies that can facilitate this process is an urgent need.

5.4 Strive for fluidity of information

Since MHWs work with a network of providers and resources, systems for them should be integrated with the wider health care systems. In fact, there is a need to increase information fluidity between all maternity health actors. The design and development of any tool for MHWs should focus on the wider context as opposed to one user group or organization. It should support data exchange and integration with health care systems including EHRs and mobile data collection platforms [18, 27]. The surveyed MHWs saw integrated EHRs as a critical direction that could empower them, "*greater utilization of EHRs [electronic health records] that can talk to each other*". However, EHRs offer benefits to clinical practices but MHWs are not classified as medical providers, therefore, it would be interesting to explore whether integration with personal health records (PHRs) is a better option.

Moreover, since pregnant women interact with every entity in this shared-care environment, a client-facing PHR could be a valuable tool to promote the integration of maternity health actors. Given that the adoption of smartphones is increasing among all millennial women, regardless of socio-economic status [38], smartphones can be utilized as data transfer tools. The pregnant women could walk away with a small text-file summarizing each interaction which she can later share with other parts of the health care system. Research suggests that both pregnant women and hospital clinicians have generally positive experiences using a PHR [19].

In addition, MHWs must share data with other actors that are part of referral networks. In particular, details regarding client follow-ups, recommended care, etc. can inform care at a new location. Typically, community-based referral organizations are low-resource and may not be able to afford expensive EHRs or additional staff to fulfill multiple data entry tasks. Therefore, technologies are needed to streamline data flow of different modalities such as web applications, phones, fax machines, etc. Hkkinen and Korpela evaluated a solution for system integration to address information needs and communication problems within maternity care networks [18]. They pointed out that since a variety of stakeholders are involved who use different tools according to their varying needs, integration is needed at many levels. We support researchers' suggestions of applying an activity-theoretic framework to further investigate the design of a multi-faceted information system in this space.

5.5 Support MHWs' professional development

To contend against inconsistent information and fluctuations in practice guidelines, MHWs must continuously pursue knowledge and update their understanding of the target population. Lack of time and funding are some barriers to achieving this goal. Therefore, technologies should be designed to support professional development of MHWs. Grason and colleagues describe a web-based portal called Maternal and Child Health (MCH) Navigator that was implemented to support ongoing education and training for a diverse MCH workforce. The tool contains 248 training modules culled from a variety of sources. The initial evaluation of Navigator showed that it promotes professional development among individuals and an overall culture of continuous learning in organizations [16]. The authors point out that an ongoing partnership between state and local MCH professionals and the MCH academic community will play an essential role in sustaining the product.

The surveyed MHWs recommended that recent laws, guidelines and evidence-based findings should also be readily available at the point of care. In addition, they desired access to mentors and experts to resolve issues and difficult cases. Moreover, MHWs want up-to-date educational content that are tailored to specific clients. Many state health departments in United States maintain up-to-date web-repositories of articles, instruments and tools, etc. specifically designed for literacy-challenged individuals. Educational tools for MHWs should be linked to such evidence-based, updated resources to reduce the distance between source and point-of-usage of information. Care will have to be taken to ensure that using these resources is free from copyright violations.

6 LIMITATIONS

This study captures the perspectives of community-based MHWs who provide services to pregnant women. Though this is an important stakeholder group and perspective, it does not speak for the mothers and other stakeholders. However, our analysis identifies sub-patterns of behaviors within different MHWs that has helped in capturing a broad perspective of the situation. It is also possible that the role of MHWs in the US varies by state. Since we did not capture state information in our survey, we could not identify these differences. We also did not capture enough number of participants to find differences between different maternity health actors. The close-ended nature of the surveys also may not have given us a complete picture of challenges faced by MHWs, as deeper issues and/or clarifications can surface through unstructured conversations. However, our Healthy Start collaborators were involved in the analysis and helped clarify several questions. Moreover, it is important to keep in mind that technology is not a panacea for every socio-economical problem. Therefore, our discussion, though suggesting possible solutions, does not address every problem in this space.

7 CONCLUSIONS

This study provides insights into community-based MHWs' activities and perceived challenges of providing maternity services to a low socio-economic population. We discuss integrated design directions to empower MHWs with professional and educational support. These solutions also highlight the potential advantages of using mobile apps in a community-based setting. Technologies designed for community-based MHWs would have to be integrated with the wider health system and clients' PHRs. The next stage of this ongoing research is the implementation of the EHR/mobile application using the design suggestions in this paper. We will collaborate with our partner MHWs to develop and ultimately evaluate the solution.

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