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Utilizing mobile health technology at the bottom of the pyramid

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Abstract

Among the Millennium Development Goals, MDG 5 Maternal Health has as its dual objectives: (a) reduce by three quarters the maternal mortality ratio; and (b) achieve universal access to reproductive health. Existing maternal health survey instruments were evaluated, modified, adapted, and used to assess perceptions and practices by mothers in villages located in the state of Gujarat in western India as well as women residing in urban Mumbai (formerly Bombay). Women who had recently given birth were asked a series of questions regarding maternal attitudes and behaviors before, during, and shortly after pregnancy including basic health data (i.e., height and weight), basic health care data (i.e., antenatal, delivery, and postnatal visits by health care professionals), and basic reproductive health practices (i.e., the knowledge of, use, and availability of birth control methods). The results from the surveys will ultimately be used to assess the efficacy of an IT-based intervention wherein pregnant moms will register with an SMS text message thereafter receiving reminders about health, simple questions, and follow-up to improve health outcomes during and immediately following pregnancy.

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1. Introduction

Electronic health (eHealth) is defined as the convergence of wide-reaching technologies like the Internet, computer telephony/interactive voice response, wireless communications, and direct access to healthcare providers, care management, education, and wellness. It is also defined as the use of Information and Communication

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technology (ICTs) to provide and support health care independent of the physical location of involved parties. Mobile health (mHealth) is defined as a subset of eHealth that uses mobile devices to deliver health services [1]. mHealth typically refers to the use of portable devices with the capability to create, store, retrieve, and transmit data in real time between end users for the purpose of improving patient safety and quality of care. Examples of approaches in mHealth include the use of wireless technologies to transmit and enable data content easily accessible to health workers using netbooks, smart phones, and other hand held devices.

However, as previously defined this approach is limited because health care providers are viewed as the end users of mHealth technologies. One of the advantages of mHealth technologies is the ability to interact directly with patients, and to encourage peer-to-peer sharing as well as coaching on the part of health care providers through online communities of patients and providers. mHealth services are being used by patients and providers in demonstration projects around the world including mobile telemedicine services in India (i.e., Health Management and Research Institute), in Mexico (i.e., Medical Home) and Bangladesh (i.e., Healthline).

While mHealth is rapidly advancing with the advent of more powerful mobile phones (i.e., the iPhone), one of the phone's most basic functions – text messaging (also known as SMS) – has been the most widely used and studied. The exchange of information via SMS has been demonstrated to be a potentially powerful tool in effecting behavior change. Recent examples of such prevention and health promotion interventions include smoking cessation, weight loss, depression and sexual health. In the past, relatively few studies have been conducted to test the efficacy of mHealth programs as a channel for full-fledged health promotion programs, with most mobile programs focusing on reminder systems or similar limited behavioral cues to action. However, this situation has begun to change, one sign of which is heightened interest in mHealth theory and development of behavior change models that incorporate the unique features of the mobile channel [2].

Limited access to health services is linked to low antenatal care and maternal and perinatal mortality. mHealth could be a useful strategy to improve antenatal care at the bottom of the pyramid (i.e., approximately two billion people living on less than two dollars USD per day). The benefits of uni-directional text messaging have been suggested through the success of limited programs implemented in Zanzibar (i.e., Wired Mothers) [3], the USA (i.e., Text4Baby), and Serbia (i.e., Beba Dolazi, which means 'the baby is coming'). In each of these programs, gestational period specific text messages are sent to subscribed women to provide educational material. However, the impact of these uni-directional, education-focused programs is still in evaluation [4].

The objective of this study was to perform field interviews with women in rural and urban settings within the state of Gujarat, India as well as Mumbai (formerly Bombay), India, respectively, to determine perceptions and behaviors as well as to explore the use of SMS services to educate and empower women in antenatal and postnatal settings.

2. Methods

Data from India's 2011 Census shows 59% of the country's households have a mobile phone. Recognizing the opportunities available through mHealth, the Government of India (GoI) has recently launched the "E-Mamta: Online Mother and Child Tracking System" to reduce the current maternal and infant mortality rates. The pilot program uses an online tracking system to monitor the health of pregnant females and infants with instantaneous capabilities to document adverse health events. It is envisioned that future implementations of the program will enable health authorities to initiate preventive action rapidly and avoid unnecessary maternal and infant mortality. Currently, E-Mamta is being implemented in the state of Gujarat. As one of the most industrialized states, Gujarat enjoys one of the highest per capita incomes throughout India. Unfortunately, Gujarat also has one of the highest MMR of 172 per 100,000 live births. A stated goal of E-Mamta is reducing the MMR below 100 to contribute towards the achievement of MDG5b.

In December, 2009 two nurses from Hinduja Hospital, Mumbai accompanied a team of study abroad students from the USA to conduct home health interviews as well as to measure the height and weight of children in three villages in rural Gujarat. In December, 2012 a follow-up visit to rural Gujarat was conducted as part of a second study abroad trip with students from the USA. During the December, 2012 visit, a pilot study was completed to evaluate maternal health and antenatal care. A cross section of twenty women were selected by convenience and interviewed in the villages of Jol, Lingda, and Bamroli within rural Gujarat. To compare results of rural and urban

conditions, a cross section of twenty women were selected by convenience at the Postnatal Clinic and In Patient Center affiliated with Hinduja Hospital, Mumbai. The 2010 version of the California Maternal and Infant Health Assessment (MIHA) was translated into Hindi (used in Mumbai), Gujarati (used in Gujarat), or Marathi (used in Mumbai).

3. Results

In terms of wealth distribution and income generation, the population of the world can be framed as an economic pyramid. The top of the pyramid represents 2 billion people with highest levels of income (i.e., North America, Western Europe, and the Pacific Rim), the middle of the pyramid represents 3 billion people (including parts of emerging economies such as India, Brazil, and China), and the bottom of the represents approximately 2 billion people who live on less than \$ 2 per day (including most of Sub-Saharan Africa as well as the endemic poor who inhabit countries with emerging economies such as India) (i.e., The World Factbook). This bottom of the pyramid (BOP) represents low-income markets in which health services are often inadequate as they are neither accessible nor affordable. At the BOP there are only 7 hospital beds and 15 health care workers for every 10,000 people. In sharp contrast to the lack of available healthcare, more than seventy-five percent of people in these low-income markets have access to mobile phones (i.e., three out of every four individuals). Mobile phone adoption has experienced such dramatic growth at the BOP because it is relatively inexpensive for the end-user as well as faster and simpler to implement as part of national infrastructure [2]. The widespread adoption of mobile phones by the BOP is a central element for mHealth. There is widespread evidence that mHealth can scale well to combat evolving health challenges for patients in the BOP by ensuring lower cost, wider coverage and better solutions [1]. A recent study describes fifty-one mHealth projects operating in 26 BOP markets around the world [2].

To determine perceptions and behaviors as well as to explore the use of SMS services to educate and empower women in antenatal and postnatal settings, the MIHA was translated and administered to a cross sectional sample of convenience for village and urban women in Gujarat and Mumbai, respectively. While the complete survey can be found online, examples of the types of questions include:

- 1) today's date, and the date when your most recent baby was born?
- 2) did you ever have a baby that weighed less than five pounds or was born before 37 weeks of gestation?
- 3) before you got pregnant, were you receiving government support for food? Did you have health insurance?
- 4) before you got pregnant, how much did you weigh? How much weight did you gain during pregnancy? How tall are you?
- 5) during your pregnancy, how would you rate your overall physical health? How would you rate your overall mental health? Did you have someone to support you? Did you seek antenatal care?
- 6) did you want to get pregnant? How long did it take before you knew you were pregnant? Were you excited to get pregnant?

These questions are designed to assess a wide range of data related to the health of the mother and the child before, during, and immediately following pregnancy in terms of physical, mental, and emotional health status.

Table 1 compares demographic data of women in rural Gujarat as well as urban Mumbai who participated in this survey. The results are presented as percentages of the total (i.e., 20 women were sampled in rural Gujarat and the values listed represent percentage of responded for this sample). Although the same size is limited, some trends appear. For example, the average age of the women examined in this study is approximately equal between the two geographic regions. But the level of education appears to be substantially different with women from the villages receiving less education as compared to women in the urban region. It is interesting to note that the primary language spoken at home is substantially different among the subjects in this study, and that would have an impact on the use of a text based system for exchanging information among women and health care providers. While the average annual household income for women living in the urban region is approximately twice as high as the village income, it should be noted that the costs of living in the urban environment often are higher; thus the purchasing power parity of the two groups of women may be similar.

Table 1 Demographics of women within India (results presented as percentages).

Category	1	2
Age 18-25 years old	57	64
26 years old and above	43	36
Education none	0	7
< 8 th grade	36	7
Some high school	45	21
Graduate of high school	9	50
Some college	9	15
Language Hindi	0	50
Marathi	0	50
Gujarati	100	0
Income* <50,000 RS per year	27	14
50,000 - <100,000 RS per year	27	7
100,000 - <200,000 RS per year	27	65
>200,000 RS per year	18	14

1 Rural Gujarat villages

2 Urban Mumbai

* the nominal rate of exchange among RS and USD is approximately 50 RS per USD

Table 2 compares the results of answers to questions for women in villages in Gujarat, women in urban Mumbai (formerly Bombay), as well as the statewide survey results for California for the 2010 survey year. The results for California include statistically significant sample sizes (i.e., results from more than 500,000 respondents). The results are presented as percentages of the total (i.e., 20 women were sampled in rural Gujarat and the values listed represent percentage of responded for this sample). Therefore, while observations can be made among these data, it is important that over interpretation of the results should be avoided.

The data suggest that prior births, including premature births and births via C-section, are similar among all groups. Surprisingly, the women in India indicate that their health status prior to pregnancy is ‘excellent’ which is similar to the results observed in California. It is interesting to note that the occurrence of diabetes and gestational diabetes among the women of India is substantially lower as compared to the observations in California, and the use of folic acid supplements during the month prior to conception among Indian women suggest that the number of carefully planned pregnancies within India is similar to the planning process in California. As expected, the women within India are less inclined to being overweight or obese; yet a larger portion of the women within India are likely to suffer from inadequate weight gain during pregnancy with a substantial difference between women in the villages as compared to the urban setting. Surprisingly, despite the lack of weight gain among Indian women there were no reports of food insecurity. This may be due to the perception of food that varies among the women of India and the women of California (i.e., ‘beans and rice’ appear to be readily available and readily acceptable to the women within India). Similarly, despite the fact that the women within India are substantially less wealthy as compared to women in California, only two Indians (of 40 sampled) responded in the affirmative to the question, “do you have a lot of unpaid bills?” Birth spacing, birth control, and back sleeping were similar among Indian respondents and comparable to the results from California; whereas the behavior of exclusively nursing more than 3 months postpartum was substantially higher among Indian women; especially among rural India women. Of note, the trend in breastfeeding increased with income and education among California women while it decreased in comparing rural and urban women within India suggesting that extreme poverty as well as extreme affluence both encouraged breast feeding. Most of the women from India were uninsured, yet all of them reported to be married at the time of conception which appears to be substantially different as compared to the California responses. Thus, the women in India appear to seek security and safety through marriage as opposed to security from employment or insurance.

Table 2 Comparison of the results among surveys in India and surveys for the state of California (2010 MIHA results).

Category	1	2	3	4	5	6	7	8	9	10	11	12
Prior low birth weight/premie	18	7	7	10	11	10	14	7	11	11	9	8
Prior c-section	9	0	5	15	27	17	17	16	19	18	16	16
Excellent health before preg	100	93	87	90	88	84	88	97	80	88	89	96
Diabetes or gestational diab	0	0	5	10	22	11	18	10	14	11	12	12
Daily folic acid use	55	43	24	31	45	24	29	47	24	27	28	49
Overweight before preg	0	0	23	25	27	28	28	20	31	28	27	18
Obese before preg	0	0	12	21	19	24	26	14	25	22	23	12
Inadequate weight gain during	90	29	23	16	23	20	18	15	24	20	16	15
Excessive weight gain during	0	21	40	44	42	45	42	43	44	41	48	41
Food insecurity during	0	0	26	20	13	31	20	3	32	25	19	4
'A lot' of unpaid bills	0	7	15	22	21	30	24	11	23	23	30	10
Separated or divorced	0	7	15	8	4	14	5	2	13	10	9	2
Discussed birth spacing	64	36	48	38	42	40	40	38	42	38	40	38
Discussed birth control	64	36	92	88	83	86	84	92	82	85	89	92
Infant on back to sleep	73	79	68	75	75	71	71	81	65	75	74	81
Breastfeed only (3 month)	100	43	10	34	35	21	24	52	18	18	31	53
Uninsured	100	93	17	19	10	31	26	4	30	29	23	5
Unmarried	0	0	94	41	25	67	41	13	71	57	46	10

1 Rural Gujarat villages

2 Urban Mumbai

3 MIHA, by maternal age, 15-19 years old

4 MIHA, by maternal age, 20-34 years old

5 MIHA, by maternal age, 35+ years old

6 MIHA, by income, <100% federal poverty line

7 MIHA, by income, <200% federal poverty line

8 MIHA, by income, >200% federal poverty line

9 MIHA, by education, <high school graduate

10 MIHA, by education, high school graduate

11 MIHA, by education, some college

12 MIHA, by education, college graduate

Among the data collected for women within India, the ages of the women in both groups were comparable with approximately 50% below 25 years of age. As anticipated, both educational attainment and annual household income were higher for women interviewed at a maternal health clinic in an urban environment (Mumbai) as compared to rural women (Gujarat). Other results were as might be expected with inadequate weight gain reported for the majority of the rural women in Gujarat, and breastfeeding exclusively after delivery being substantially higher for the rural women as compared to the urban women. It is interesting to note that depression and other pregnancy hardships were prevalent in the urban women in Mumbai (data not shown), while nutritional supplements received during the course of pregnancy were slightly higher for the rural women as compared to the urban women (data not shown). Collectively, these results demonstrate a number of points relevant to mHealth strategies. For example, language could be a barrier in the delivery of information via SMS. Additionally, differences in educational levels might suggest differences in literacy (or comfort with learning through reading), and this might influence the perception of SMS-based information dissemination.

4. Discussion

Though mHealth is defined as a subset of eHealth, it is widely identified as a separate healthcare paradigm. mHealth alone has all the potential to automate and expedite the healthcare delivery processes, reduce costs, engage with patients and offer them more convenience and appeal through this new service. Furthermore, mHealth is based on some unique attributes (e.g., ubiquity, instant connectivity, convenience, personalization and timeliness), which can be leveraged to empower patients and healthcare service delivery in any setting. Collectively these differences contribute to the view that mHealth is a new healthcare paradigm transforming health services around the world.

The hierarchical nature of the historical model is immediately evident with healthcare providers separating patients from data (including healthcare knowledge). In this role, providers control access to knowledge (i.e., the upward flow of data) and disseminate the results of labs to patients (i.e., the downward flow of data). The eHealth model employs IT creating a web of links among providers and data repositories (i.e., pharmacists can cross check drug interactions as prescribed by multiple providers for the same patient; and primary care providers can interact directly with data sources traditionally reserved for experts in other fields such as MicroMedEx used by poison control specialists). Additional examples in the eHealth model include the Virginia Henderson International Nursing Library as well as The Circle (both provided by Sigma Theta Tau the International Nursing Honor Society). The number of interactions in the mHealth model is further increased through the ubiquity of SMS-enabled mobile phones. In particular, within the eHealth model patients have direct access to healthcare data (i.e., WebMD) as well as peer and professional coaches as part of online wellness communities (i.e., ShareCare.com). While definitive benefits of these increased interactions have not yet been fully quantified, it is apparent that a greater exchange of information is likely to result in improved health outcomes for patients lacking direct access to providers because of limited National healthcare resources such as long distances between patients and healthcare facilities as well as well a lack of healthcare capacity in developing countries.

Perceptions of poor quality of care may dissuade patients from using available healthcare services because health concerns are among the most salient of human concerns. If the system cannot be trusted to guarantee a threshold level of quality, it will remain underutilized, be bypassed, or used as a measure of last resort. Overall, the importance of quality perceptions and consumer trust has been implied in existing mHealth studies because of their strong effects on continuance intentions channel. Despite the profound impact of quality and trust on continuance intentions, there is a paucity of research in mHealth to analyze trust relationships channel [2]. A thorough review of the literature reveals that it has been under researched in the case of antenatal care, and most explorations of mHealth are still largely fragmented and anecdotal. The results of the surveys conducted as part of this study, and the impressions observed by the authors when interacting with women in both the rural villages of Gujarat and the urban setting of Mumbai strongly suggest that targeted mHealth approaches hold promise to meet MDG 5, Maternal Health through education and empowerment.

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