MOBILE HEALTHCARE DELIVERIES IN MATERNAL AND CHILD HEALTH: A CASE STUDY OF LOW AND MIDDLE-INCOME COUNTRIES

Vani Aggarwal[1] *Dr. Meenal Sharma Jagtap*[2]

ABSTRACT

Mobile health services are viewed as a convenient way to access high-quality information. New health innovations such as electronic health services, telemedicine, mobile telephony, health wearables, sensors and mobile computing offered a variety of opportunities to monitor, access and transfer vital health information around the world. These technologies can tackle health problems even from remote areas via mobile communication and improve quantity of care specifically in low and middle income countries. However, there are several challenges such as patient related, healthcare professionals related, IT related and applications related challenges that need to be addressed to realize the effectiveness of m-Health interventions. Empirical evidences show favorable dynamics of telecom market, higher internet penetration, health awareness as some of the supporting factors for mobile healthcare deliveries in many developing countries. Also, the total number of studies on mobile health applications increased steadily from 2011 to 2015. A study revealed that 61% of the patients in the emerging markets are aware about mHealth applications/services while only 37% of total patients in the developed countries are aware about mHealth deliveries. The market size of mobile health services is continuously expanding and is likely to reach USD 370 billion by the end of 2017 in annual healthcare cost savings worldwide; the mobile healthcare industry is expected to reach USD 12 billion by 2018 as nearly 50% of physicians are using mHealth applications on daily basis.

Many low and middle income countries implemented various mobile health initiatives to improve maternal and child health. This section of the society is highly vulnerable and need special care to generate healthy growth in any country. This paper extracted information from various studies and government report to analyze the major mobile health initiatives in different developing countries and how effective were these interventions in terms of mortality reduction, increasing communication between health workers and villagers, providing training to community healthcare workers, tracking pregnant women and child immunization status. There is a need to tap the potential mobile health market especially in a lower resource setting areas to incur maximum benefit out of these mobile devices.

***Key words**: Mobile phone, mHealth, Developing countries, Maternal health and Child health.*

Introduction

"mHealth is not a separate industry, but rather it's the future of a healthcare industry that's evolving to care for patients differently, putting them first to deliver services better, faster and less expensively" (PwC)

In the world of digitalization, mobile applications are converting phones into medical devices. Mobile health (mHealth) services have been continuously receiving a huge attention from health professionals, patients, clinicians, service providers, policy makers, and researchers. mHealth applications take the advantage of built-in features of smart phones such as cameras, touch screen, sound system, light, wireless connectivity, and software of the device that processes various functions like interactive questionnaires, algorithms, formulae, calculators, clinical decision support tools, and other parameters (Cortez, 2013). Further, mHealth application could generate treatment recommendations to patients and customize diagnoses by comparing user specific data to vast bodies of clinical research and medical knowledge (Cortez, 2013).

[1] Research Scholar, Amity School of Economics, Amity University Gurgaon, vaniagg005@gmail.com, +91-9654228633
[2] Associate Professor & Programme Coordinator, Amity School of Economics, Amity University Gurgaon, msjagtap@ggn.amity.edu, +91- 9958882084

Also, mHealth includes a lot more than healthcare applications on mobile phones. It involves health sensors, wireless networks to monitor various health issues, professional to provide emergency treatment, mobile devices to access health information and numerous healthcare services. Mobile phone is a multi-purpose device capable of performing a multiple functions that are beyond its primary task of communication (PwC, 2017).

"Smartphone has been the catalyst for the transition of E-health to mobile health (mHealth)"
(Perera, 2012)

Engagement of a mobile phone in health sector could result various instant benefits specifically in case of preventable diseases. mHealth could result in major advances in various areas such as; (a) expanding healthcare coverage, (b) improving decision making, (c) managing chronic conditions and (d) providing suitable healthcare in emergencies (Varshney, 2014). Specifically, healthcare workers and families are major users of mHealth services such as monitoring, emergency response, healthcare practitioner support, healthcare surveillance, and healthcare administration etc (PWC, 2012).

Mobile health services are viewed as a convenient way to access high-quality information. New health innovations such as electronic health services, telemedicine, mobile telephony, health wearables, sensors and mobile computing offer a variety of opportunities to monitor, access and transfer vital health information around the world. Key drivers of these technologies are remote monitoring, help conception, manage anxiety and fear, ensure baby care and comfort, provide postpartum support and facilitate economic child care (Research, 2015). These technologies can tackle health problems even from remote areas via mobile communication and improve quantity of care specifically in low and middle income countries. However, there are several challenges such as patient related, healthcare professionals related, IT related and applications related challenges that need to be addressed to realize the effectiveness of mHealth interventions (Varshney, 2014). The decisions on these challenges will have a significant impact on the decision of "how future mobile health services will be designed, developed, evaluated, and adopted globally" (Varshney, 2014).

India is the second largest producer of mobile phones by volume after China, annual production of handsets increased approximately four times from 3 million units in 2014 to 11 million units in 2017 (TOI, 2018). The ubiquity and mobility function of mobile phones make it approachable and user friendly in healthcare sector. In the world of digitalization, people prefer to use virtual services rather than visiting a brick and mortar building as they look for a more convenient experience.

To facilitate easy, quick and affordable access to healthcare services, healthcare providers are adopting innovative measures/solutions specifically in remote areas of the developing countries. According to a report (Frost & Sullivan, 2018), telehealth[1], mobile health (mHealth), and artificial intelligence (AI)[2] were identified as top three technologies in the healthcare deliveries.

For effective mHealth interventions, features of smartphones are designed in such a way that these could facilitate six foundational functions in the healthcare sector (Borus M, Tomilson M, et al, 2012):

i) information about health behaviours, health risks and available resources related to health

ii) facilitate text messages, calls, videos that helps to provide trainings

iii) monitoring behaviour in real time, including unobtrusive and automatic monitoring to reduce the burden of self-monitoring

[1] To deliver healthcare via using telecommunications and virtual technology is known as telehealth.

[2] Computer systems able to perform tasks normally requiring human intelligence.

iv) shape health behaviours through continuous monitoring, feedback, reminders

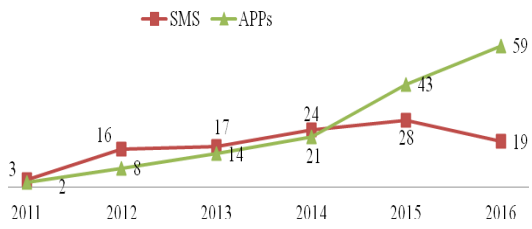
v) supporting development and maintenance of healthy behavioural routines by linking to peers, friends, family, or healthcare workers for social support and instrumental support services

vi) facilitates quick results of diagnostic test and linking to healthcare

After the arrival of mobile connectivity and expansion of networks, new business models have emerged to enable and accelerate low cost access to healthcare deliveries. The GSMA mHealth tracker estimated that there are nearly one thousand mHealth interventions worldwide and most of them are in the developing countries (GHL, 2013).

Empirical evidences indicate that favorable dynamics of telecom market, higher internet penetration, health awareness are some of the supporting factors for mobile health services and deliveries in India. As people become more mobile and travel becomes more accessible, patients are expecting that the healthcare record system to provide essential health information over mobile devices.

Fig.1.1 Trend of published studies on mHealth intervention (SMS/App), 2011-2016



Source: (Chen et al, 2018)

Fig.1.1 shows that the total number of publications on mHealth in reproductive maternal and new born child healthcare increased significantly from 2011 to 2016. The total number of studies on mobile health applications increased steadily from 2011 to 2015; while studies on SMS increased slightly from 2011 to 2015 and decreased afterwards.

Indian healthcare sector is experiencing a new wave of opportunities by reinventing in the existing delivery models to enhance healthcare services penetration in India. In effort to provide affordable services to Indian population both public and private sector are working for the advancement of technologies in the healthcare sector. Recently, medical researchers are discussing about new technologies and digitalization of health services such as ICT (Information and Communication Technology), eHealth, mHealth, virtual clinic, robotic operations, remote surgeries etc.

With technological advancement, there are two potential areas where mHealth services could support the government of India's "existing plans to strengthen its corps of community health workers and improve their performance" to contribute in maternal and child health (UNF). Firstly, improve the accuracy, completeness and timeliness of data captured by community health workers to monitor and track pregnant women, mothers and children.

Secondly, accelerate efforts to provide community health workers with refresher training and continuing education by establishing a pan-India platform that delivers accessible, relevant and high-quality mobile content for self-learning. These days home healthcare is the cheaper and more comfortable option for the patients, though in a nascent stage market is served largely by unorganized players, start-ups and recent hospital initiatives (Sharma N. C., 2018).

Health wearables are new solutions developed by many healthcare industries especially in developing countries where resources are constraint and propensity to consume of healthcare products are not so good. Moreover, mHealth services could be visible as more healthcare opportunities such as from wearables to apps. With a passage of time, health wearable are finding place in the healthcare system to improve health facilities. These wearables are connected to

the mobile phone or other electronic devices to track health information of the patients.

Although, empirical evidences on the comparative effectiveness of these applications are not much available and work is going on. But with sufficient financial investment and trainings it is possible to switch from paper based HIS (Health Information System) to mobile HIS database in MNCH (Mother, new-born and child health) (Nguyen et al, 2015).

"Investments from pregnancy through 3 years of age are the foundation of health and well-being throughout life" (WHO, 2018)

Every year 2, 89,000 pregnant women and 6.6 million children under age of five die due to lack of healthcare facilities (Maternal and Child health). In a developing country like India, one of the contributing factors to a high child mortality rate is low vaccination rate. It is difficult to create health awareness among rural India and their unwillingness to approach clinics led to lower immunization rate that causes child deaths. Even if some of them have knowledge and willingness for vaccination but they are not aware about the time of the vaccination and immunization programs.

Also, there is a long standing disparity between mortality rates as neonatal mortality rates are not declining as quick as deaths among children aged 1-59 months (WHO, 2018). Therefore, health wearables are the new technology that facilitates storage of health data and transfer health information as these devices are well connected to mobile.

Mobile technologies/devices/solutions can be leveraged to extend the coverage of healthcare delivery to the sections of population those have been performing poor in the maternal and child heath indicators like maternal mortality rate, infant mortality rate, under-five mortality rate, neonatal mortality rate, etc. However, poor network coverage is one of the concerns for India. For instance, patient being monitored for a heart attack cannot be left at the mercy of an underdeveloped mobile network (Wipro, 2012). Further there are many challenges in using mHealth services in maternal and child healthcare especially in a developing country like India.

Section 1.1 comprises an introduction on mHealth in maternal and child health i.e. how mHealth services has been categorized, drivers of mHealth applications and section 1.2 evaluates total market size of mHealth devices. Further, section 1.3 analyzed the different mobile health interventions implemented in low and middle income countries to improve maternal and child health. Section 1.4 concludes the paper and provides food for thought to the policy makers on the effective leveraging of mobile devices in healthcare sector.

1.1 mHealth: an Introduction

"Mobile health may also decentralize and demystify medicine by shifting the locus of care away from expensive medical facilities and professionals, and towards digitally-empowered patients" (Cortez, 2013)

Without the invention of the mobile phone, the mobile health industry could not have a beginning. In 1949, mobile telephone services were expanded to 100 towns and 5000 customers under a program introduced by the AT&T (Gruessner, 2015). There were many technological barriers to continue that program across the country. Later, mobile phones became an essential good and companies like Apple, Samsung have developed various complex smartphones with many features. This stimulated the development of mHealth applications worldwide. Mobile health revolution started in the US in 2007 after a release of the first iphone; an executed connected an iphone to a blood pressure monitor and to a blood glucose meter. Although, mHealth could trace its roots before 2007 as well to personal digital assistants (PDA), website like WebMD. But "the first iPhone introduced an era of torrential creativity with mobile communications devices" (Cortez, 2013).

With existing traditional methods of healthcare deliveries, it is difficult to cater population of any country specifically developing countries. Mounting pressure on

the healthcare system generated an urgent need to adopt digital initiatives by the government of all the countries. Access to new technologies in emerging and developed nations has leveraged the power of mobile phones to deliver adequate healthcare solutions worldwide.

Mobile health has a capability to connect health facilities seekers to healthcare providers regardless of location. These applications are constantly transforming the entire healthcare system with new value propositions and innovative solutions; from wearables to apps (Frost & Sullivan, 2018). Over 100 countries are using mobile phones to explore/achieve better health and healthcare facilities (WHO, 2014). World Health Organization (WHO) has categorized mHealth services to ensured effective healthcare delivery (Table.1.2) and reported the most frequently used mHealth initiatives globally includes health call centres/health care telephone help lines (59%), emergency toll-free telephone services (55%), emergencies (54%), and mobile telemedicine (49%); while the least frequently reported initiatives are health surveys (26%), surveillance (26%), awareness raising (23%), and decision support systems (19%) (WHO, 2011).

Table.1.1 Categories of mHealth (based on WHO 2009 Survey)

Communication between individuals and health services

- Health call centres/Health care telephone help line
- Emergency toll-free telephone services

Communication between health services and individuals

- Treatment compliance
- Appointment reminders
- Community mobilization
- Awareness raising over health issues

Consultation between health care professionals

- Mobile telemedicine

Intersectoral communication in emergencies

- Emergencies

Health monitoring and surveillance

- Mobile surveys (surveys by mobile phone) and Surveillance
- Patient monitoring

Access to information for health care professionals at point of care

- Information and decision support systems
- Patient records

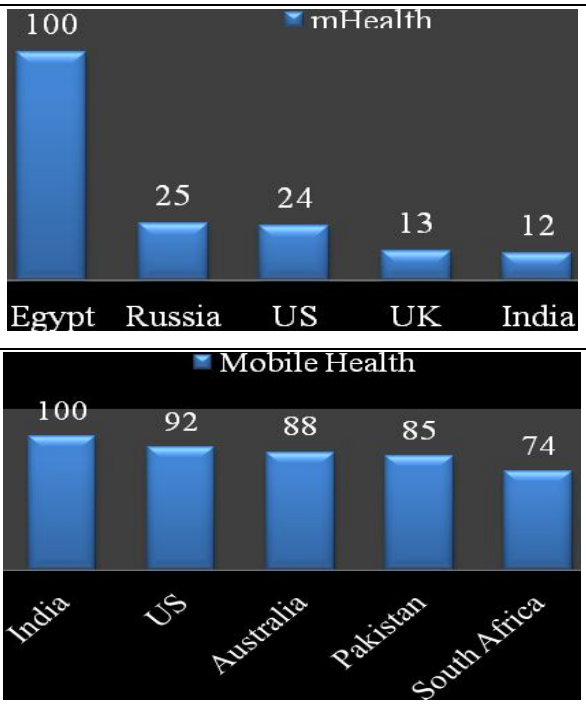
Source: WHO 2011

Most frequently used mHealth applications in the healthcare sector are client education and behavior change, sensors and point of care devices, registries and vital event tracking, data collection and reporting, electronic health records, electronic decision support, provider-provider communication, provider work planning and scheduling, provider training and education, human resource management, supply chain management and financial transactions and incentives (Alain B Labriquea, 2013). Mobile health solutions/devices are constantly addressing health problems including growing number of chronic disease related to lifestyle, expensive existing national health facilities, a need to provide equal access to healthcare services regardless of time and place (Silva B, et al, 2015). The scope for leveraging mobile health services as an alternative healthcare delivery channel is substantial in a developing country like India as number of mobile and internet users are increasing continuously.

Globally, mobile traffic is growing very fast; global average for mobile internet traffic as a percentage of the total web traffic is 50% as of January 2017 and it has been estimated that it is likely to grow 7 folds from 2016 to 2021 (PwC, 2017). Further, India ranks second in this parameter with 78% of mobile traffic; indicating increasing role of mobile phones in various sectors including health and it is an important factor for mHealth adoption (PwC, 2017). In the search terms of mHealth including mobile health, health

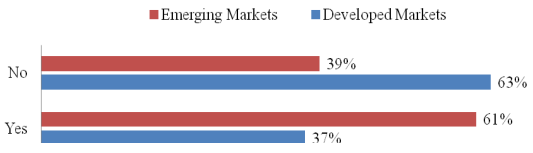
apps, medical apps, India ranks among the top five countries (Fig.1.2)[3] as of June 2017 (PwC, 2017). With other developed countries, Pakistan and South Africa are under top five category of mobile health search.

Fig.1.2 mHealth related search, June 2017



Source: (PwC, 2017)

Fig.1.3 mHealth awareness (%of Patients)



Source: PWC Report, 2012

Several studies have mentioned the role of mHealth to efficient and cost effective provision of healthcare deliveries in both developed and developing nations. However, fig.1.3 clarifies that 61% of the patients in the emerging markets are aware about mHealth applications/services while only 37% of total patients in the developed countries are aware about mHealth deliveries. Therefore, it indicates that there is more awareness of mHealth applications in emerging economies as compared to developed nations which leads to a better future of mHealth market in developing nations. PWC published a report on the willingness to use mHealth services (PWC, 2012); patients are likely to adopt mHealth services only if it will improve access to healthcare facilities, lowers cost and increases control in the healthcare sector (Fig.1.4).

Similarly, doctors are likely to adopt mHealth applications if there is an incentive of efficient and improved quality health outcomes (Fig.1.5). It is always difficult to measure the exact parameters that support mobile health or barriers to mobile health. Health seekers are concerned about data security, reliable health information, cost effectiveness etc. Therefore, it is necessary to satisfy the domestic population to adopt mHealth services or applications.

From health providers' perspective, it is vital to focus on quality care, access to all, easy and quick access to healthcare facilities, availability of mobile network, access to mobile phone and internet, digital literacy etc. Adoption of mHealth applications requires support from both the sides; health providers and health seekers. Otherwise, it would not incur benefit to any of them in a society. There were various concerns while using mHealth application in developing region. For instance, cost of mHealth applications and its usage were major concern while using mobile health services.

Fig.1.4 Drivers of mHealth for Patients

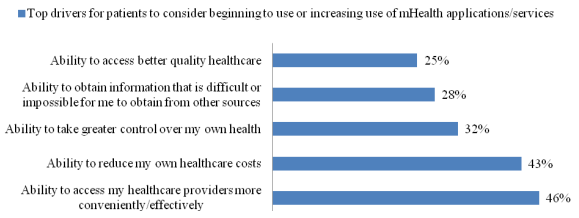
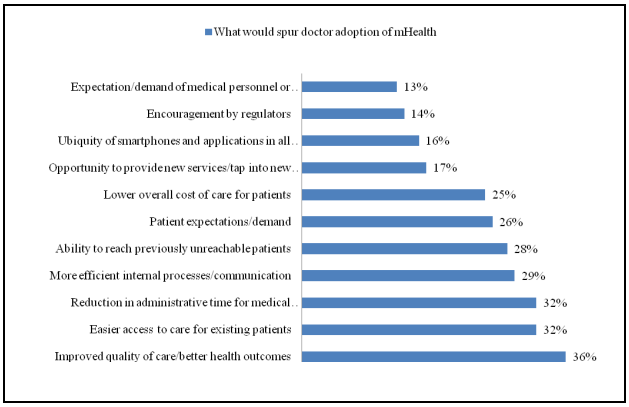


Fig.1.5 Incentives for doctors to adopt mHealth

[3] A higher value means a higher proportion of all queries, not a higher absolute query count

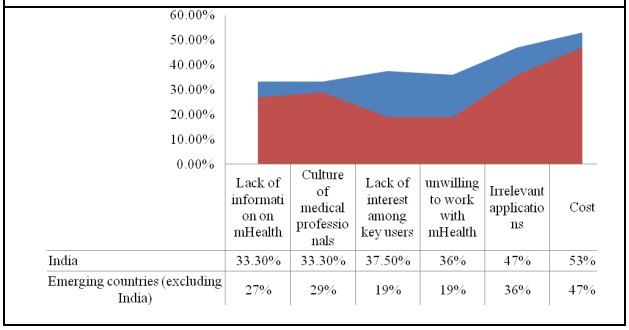


Source: PWC Report, 2012

Similarly, lack of interest among key users, culture of medical professionals and lack of information on mHealth were the top barriers for mobile health providers in emerging economies (Fig.1.6). In using mobile health application, a lot of manual intervention is must; use of SMS, audio/video and other applications. This makes these mobile applications unattractive to consumers and a big deterrent for most of the users.

However, mobile integration with sensor or any other external device could reduce manual intervention and simplify the process by automating these applications (PwC, How mHealth can relovutionize the Indian healthcare industries, 2017).

Fig.1.6 Barriers to adopt mobile health in emerging economies



	Lack of information on mHealth	Culture of medical professionals	Lack of interest among key users	unwilling to work with mHealth	Irrelevant applications	Cost
India	33.30%	33.30%	37.50%	36%	47%	53%
Emerging countries (excluding India)	27%	29%	19%	19%	36%	47%

Source: (PwC, 2017)

1.2 mHealth Market

"mHealth helps to reduce healthcare expenditure by limiting the number of hospital visits and also reduces readmissions" (Global mHealth Market: Snapshot, 2018)

In the developing countries, public health expenditure accounted about USD 1 trillion per year; if 0.5% of it allocated to digital health for the next 5 years then cumulative USD 25 billion would be available for digital health companies (GSMA, 2017). In the recent years mobile health market has expanded significantly.

Global mHealth market has been segmented into three sections based on product; connected medical devices[4], mHealth applications[5] and mHealth services (Global mHealth Market: Snapshot, 2018). It has been expected that the global mHealth market to grow at a CAGR of 36.5% during the time period of 2017-2022 (to reach USD 21.71 billion by 2022) (Market Research Future, 2018).

It has been predicted that mHealth market could reach to USD 370 billion by the end of 2017 in annual healthcare cost savings worldwide (Research S. , 2017). Also, it has been estimated that the mobile healthcare industry to reach USD 12 billion by 2018 as nearly 50% of physicians are using mHealth applications on daily basis (Gruessner, 2015).

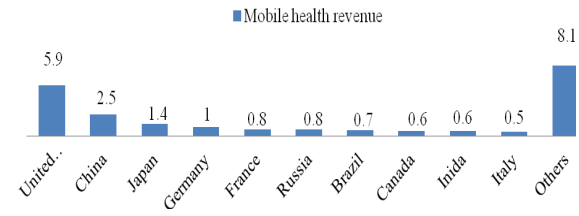
The top two mobile health markets by spending were expected to be the United States and China in 2017 by a PWC study (Fig.1.7). According to a study, India will hold the 8th position in terms of mobile health revenue in 2017; with revenue of USD 0.6 billion (PWC, Touching lives through mobile health: Assessment of the global market opportunity, 2012). Mobile health indicators such as mobile penetration, healthcare access, geographical division, per capita income, diseases profile and dependent population are different across various regions. Consequently, adoption rate of mHealth services are expected to vary across countries. For example, share of monitoring services in the total mobile

[4] Heart rate monitors, activity monitors, electrocardiograph, fetal monitoring, neuro monitoring etc.

[5] mHealth applications is further segmented into fitness & wellness, diabetes, cardiovascular diseases, central nervous system disease, respiratory diseases, musculoskeletal diseases, smoking cessation, medication adherence and others.

revenue will typically be greater in high income countries while the contribution of diagnosis services will be higher in low income level group (which have shortage of physicians, hospital beds, etc.) (PWC, 2012). Market driven factors includes patient's involvement in personal healthcare, implementation of smartphones and wearable devices into health sector, portability of health devices (wireless technology), benefits of Cost effectiveness and patients' convenience (Market Research Future, 2018).

Fig.1.7 Top 10 countries based on Mobile Health Revenue (in USD billion), 2017



Source: (PWC, 2012)

Mobile health market of the United States (US) is the fastest growing segment of telehealth market and it has been estimated that this market would worth of USD 24.63 billion by 2021 (Frost & Sullivan, 2018). Increased utilization of mHealth devices like smartphones, tablets, wearables and medical grade applications are some of the factor stimulating this expansion (Frost & Sullivan, 2018).

"mHealth has the potential to dramatically reduce the costs of healthcare operations, while improving the quality of healthcare" (Research S. , 2017)

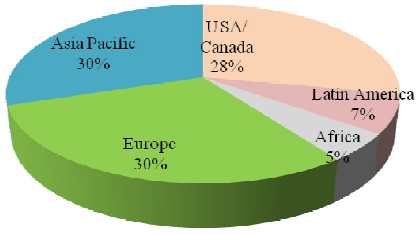
North American was the largest mHealth market in 2016 (USD 9.8 billion). Factors contributed to this expansion in North American region were higher healthcare expenditure, various health initiatives by the government, high rate of adoption of new technologies and increased funding by both the private and public organizations (Global mHealth Market: Snapshot, 2018). Further, America is the largest mHealth market share holder with a share of 34% (Market Research Future, 2018). Fig 1.8 shows that the PWC has been estimated in a report that Europe (30%) and Asia pacific (30%) markets are likely to hold largest mHealth share in 2017 (PWC, 2012).

Asia pacific mHealth market (worth USD2.3 billion in 2014) projected a remarkable growth rate due to increasing awareness of mHealth devices and services that aid in improve the quality of life for patients stricken with lifestyle diseases (like diabetes, hypertension, obesity etc.) (Malik A, 2016). It has been forecasted that this market is likely to grow with a compound annual growth rate (CAGR) of 35.8% during the period 2015-2020 (Malik A, 2016).

Further, the total global market size of mHealth services has been estimated to reach USD 23 billion in 2017 (Fig.1.9) and in the five developed countries (United Kingdom, Germany, France, Italy and Spain) has been expected to reach USD2.89 billion by 2020 (Frost & Sullivan, 2018). However, mHealth market in a developing country like Brazil is still in a nascent stage. But increasing broadband penetration, availability of mobile networks and devices are stimulating growth of mHealth market.

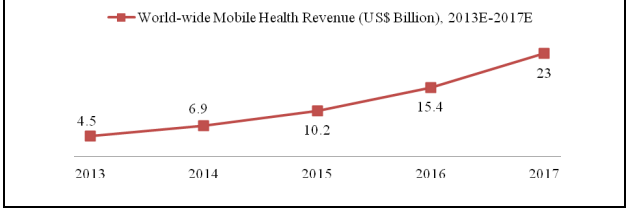
It has been expected that mHealth market in Brazil would reach to USD1.43 billion by 2020 (26.3% CAGR during 2016-2020) (Frost & Sullivan, 2018). Mobile health market of Latin America is a promising market due to "increasing government initiatives and increasing funding by public and private investors and establishment of new companies and new product launches" (Global mHealth Market: Snapshot, 2018).

Fig.1.8 Estimated Global mobile health market opportunity by regions, 2017



Source: (PWC, 2012)

Fig.1.9 Worldwide mobile health revenue



Source: PWC (PWC, 2012)

From the global perspective, different countries have different needs to adopt mHealth solutions. For example, "the high prevalence of chronic diseases, an ageing population, and the need for improving efficiency and quality of care is driving the adoption of mHealth in Europe" (Frost & Sullivan, 2018). In terms of economic benefits of these interventions in RMNCH, USD 20 dollars benefit could be generated for every dollar. In case of developing nations, rate of increase in GDP per capita of china and India are 1.0% and 0.7% per year respectively; as a result of the effect of lower fertility on age structures (Axelson H, et al, 2013).

1.3 mHealth interventions: Case studies of developing countries

"The adoption of mobile health in emerging markets like India versus developed markets is a paradox. In developed markets, mHealth is perceived as disrupting the status quo, whereas in emerging countries it is seen as creating a new market, full of opportunities and growth potential" (PWC).

In order to check the mHealth interventions across countries in maternal and child health area, several case studies were identified in the UNICEF report on innovations (mHealth) in maternal and child health sector in different low and middle countries. (Ngabo F, Nguimfack J, Nwaigwe F, et al, 2012) evaluated a mHealth study in Rwanda where mobile phones were used as means to support community health workers in their clinical decisions and to promote provider to provider communication to improve pregnancy management. (Cole-Ceesay R, Cherian M, onko A, et al, 2010) studied a package of maternal health interventions in the Gambia; where mobile phones were used to link village health worker and traditional birth attendants with health providers and medical facilities like ambulance.

Mobile health applications were also used in Guatemala (Martínez-Fernández A, Lobos-Medina I, et al, 2015) that enabled tele-community facilitators to ask about consultations, to send clinical data and get trainings. Mobile health initiative in Indonesia facilitated communication among midwives and obstetricians; resulted increase in confidence and problem solving attitude of midwives (Chib A, 2010). Table 1.2 demonstrates a detail analysis of mobile health interventions in maternal and child healthcare sector of low and middle income countries.

The m4Change project was implemented in Nigeria to promote mobile health applications improve maternal and child health conditions. Mobile phone application including data collection tool, decision support algorithm was developed to provide quality antenatal care in the primary health centres. (Adanikin AI, et al, 2014) conducted a study where appointment reminders were sent to women to attend the postpartum visit after their deliver in Nigeria.

(Odney TA, Bukusi EA, Cohen CR, etal, 2014) evaluated an impact of SMS reminders on HIV-positive pregnant women in Kenya to check the effectiveness of mobile health services. Similarly, a study conducted by (Kaewkungwal J, Singhasivanon P, et al, 2010) in the Thailand-Myanmar border where smart phones were used for data collection and sending automated text messages to mothers and children when their visits were due and also on child immunization status and ANC visit.

Table.1.2 Cross Country mHealth interventions in MNCH		
Source	**mHealth Intervention**	**Outcomes**
Afghanistan		
(Dimagi, 2012)	Mobile phone to improve antenatal and postnatal care of women; mobile application trainings for men and women	i) Skilled deliveries were increased by 22.3% ii) 20% increase in the number of women who received antenatal care
Bangladesh		
(Nutrition, 2012)	Mobile phone based labour notification system; to improve both maternal and neonatal mortality (ensure the presence of nurses at birth to collect placentas and cord blood)	i) Mobile phone was used in 89% of deliveries ii) In 68% of the cases, the team of nurses sent to attend birth arrived prior to placental expulsion
(Messinger C et al, 2017)	mHealth services for increasing access to menstrual regulation (MR) among low-income women at risk for clandestine abortion	i) MR clients expressed positive opinions of mHealth services as a means of improving women's access to affordable and timely MR. ii) Mobile phones had benefits with respect to information dissemination and making appointments, **Challenge:** emphasized the necessity of in-person consultations for effective sexual and reproductive healthcare.
Cambodia		
(Observatory, 2012)	Cam e-WARN: monitoring disease outbreaks via SMS; Neonatal tetanus, Acute watery diarrhoea/cholera, Dengue, Acute lower respiratory Infection, influenza	i) Rapid detection of early stage disease outbreaks. ii) Increased the accuracy of disease outbreak reports compared to the ad-hoc telephone hotline surveillance system
Ethiopia		
(Little A, Medhanyie A, et al, 2013) and (Medhanyie AA, Little A, et al, 2015)	For data collection, smart phones were given to MWs and HEWs and trained to use health applications on ANC, postnatal care and appointment information on deliveries	i) HEWs and MWs were comfortable in using the device and required little technical assistance ii) Unrestricted usage of phones generated confidence, sense of ownership and empowerment among HEWs and MWs iii) 87% of users believed that electronic version of the form were useful for follow-

		up and reminders **Challenge:** Problems with username and password settings, smartphones got locked up
(Tesfaye S, Barry D, et al, 2014)	Mobile phone intervention to increase appointment reminders and health education; Health Extension Workers (HEWs) sent text messages to clients	i) Significant increase in postnatal care; from 5% to 51% in the Amhara and from 15% to 47% in the Oromiya region ii) 1.7 times increased in ANC visits of women iii) 4.9 times increased in postnatal care of women who had access to HEWs mobile phone numbers
Gambia		
(Cole-Ceesay R, Cherian M, onko A, et al, 2010)	Mobile phones were linked between CHWs and TBAs to increase communication between Community Healthcare workers (CHWs) and health facilities (providers, ambulance, etc.);	109 patients were transferred from communities to local hospitals **Challenge:** lack of call credit and short battery life of mobile phones
Ghana		
(Andreatta P,Debpuur D, et al, 2011)	Low literacy level of TBAs; MWs and TBAs were trained to use mobile phones (how to send text messages) to report postpartum haemorrhage (PPH) data such as occurrence, management and outcome	i) Increase in data reporting; 425 births were reported by 9 of 10 birth attendants ii) 13 cases of PPH and one case of neonatal death were also reported
Guatemala		
(Martínez-Fernández A, Lobos-Medina I, et al, 2015)	Mobile phones were given to 125 Community Facilitators (CFs) to provide decision support (consultations), data collection and to receive training	i) Significant reduction in maternal mortality rates ii) 116,275 general consultations, 6783 women were monitored, and 2014 emergency transfers were coordinated by CFs
(Dimagi, 2012)	Commcare mobile application was used in Alta Verapaz to improve maternal care and high rates of malnutrition and malaria	i) Increased monitoring of high-risk pregnancies and upcoming deliveries ii) Data availability simplified the evaluation of productivity and performance of CHWs by monitoring the number and duration of visits completed and the number of patient forms submitted
India		
(Sharma R et	SMS to facilitate oral health	Health information delivered to mothers;

al, 2011)	education (mothers and children)	increased mothers' knowledge and practice of child's oral health
(Dimagi, 2012)	Mobile application (MOTECH Suite) was introduced to improve delivery of family health interventions and quality of health services in rural India	Over 50% increased (from 6.7% to 59.5% in the total number of women visited by a Frontline Workers (FLW) within 24 hours after delivery in less than one year
Indonesia		
(Chib A, 2010) and (Lee S, Chib A, et al, 2011)	Mobile phones provided to midwives, midwives coordinators and obstetrician gynaecologist at the provincial hospital; Simple voice communication between MWs and OB-GYNs to do data transfer	i) Significant increase in confidence to store patient's data and solve difficult problems ii) Improvement in searching for numbers in phone lists and getting the phone to do what they wanted it to do iii) Increase in patients visit to health centres for medical information instead of home treatment. iv) Access to mobile phones had a direct positive effect on health knowledge of MWs
Kenya		
(Odney TA, Bukusi EA, Cohen CR, etal, 2014)	Appointment reminder sent to HIV-positive pregnant women; SMS sent on weekly basis during first 6 weeks postpartum and on every 2nd week staring on week 28 of pregnancy	i) 19.6% of intervention women attended a maternal postpartum clinic as compared on 11.8% women in control group ii) 92% of intervention group infants received HIV testing v/s 85% of control group
(Sellen D et al, 2014)	Mobile Phone based approach to increase breast feeding	The study stated that cell phone based counselling approaches were effective in supporting exclusive breastfeeding of infants.
Liberia		
(Lori JR, Murno ML, Boyd CJ, Andreatta P, 2012) and (Munro ML, Lori JR, Boyd CJ, Andreatta p, 2014)	TBAs were trained to send real-time SMS for data collection on pregnant women; provided mobile phones, call credit and solar chargers to TBAs	TBAs knowledge on mobile phone was increased; turn on mobile phones, make calls, identify mobile coverage, battery knowledge, send SMS

Mali		
(Simonyan D et al, 2013)	Mobile Phones were used for diagnosis collection and transfer of healthcare data vis JAVA applet to a central server	i) Families reported 206 episodes of disease in the intervention group and 168 in the control group. ii) Intervention group children had 85 medical consultations compared to 28 in the control group iii) Reduced child morbidity (episodes of cold, cough, diarrhoea, teething, infection, vomiting, etc.)
Niger		
(Dimagi, 2014)	A mobile application (RComs) was introduced to prescribe medicine, facilitate counselling, provide treatment and refer children to health clinics	i) This application screened acutely malnourished children on their visits ii) Helped to guide health workers through clinical examination of the child
Nigeria		
(McNabb M ,Chukwu E, Ojo O, Shekhar N, et al, 2015)	Mobile phones were provided to CHWs and trained on health applications; ANC decision support algorithms and health counselling messages during visit	i) Measuring blood pressure increased from 87% to 97% ii) Performance in provision of HIV increased from 67.5% to 82.2% iii) Health education increased iv) 83% patients were satisfied with the ANC services
(Adanikin AI, et al, 2014)	Appointment reminders were sent twice to women; at 2 weeks and 5 days before scheduled postnatal care appointment	i) 98% women received SMS reminder; 50% were more likely to attend their postnatal appointment than who did not received SMS ii) Total cost of sending 2,252 SMS reminder was USD 21.12
(Oyeyemi SO and Wynn R, 2014)	Mobile phones were given to pregnant women to increase primary health facility utilization	i) The total facility utilization rate of pregnant women increased significantly ii) The total facility utilization rate of the primary health care centres increased significantly

Pakistan		
	Introduced mobile application to address high maternal and neonatal mortality and morbidity in flood-affected areas;	i) Upgraded BEmONC services by implementing a comprehensive package ii) Facilitated 24/7 service delivery, incentives and performance-based financing iii) eHealth monitoring and communication for development (C4D)[6]
Rwanda		
(Ngabo F, Nguimfack J, Nwaigwe F, et al, 2012)	Rapid SMS system was introduced to increase communication between Community Healthcare workers (CHWs) and health facilities (providers, ambulance, etc.); 432 CHWs were trained and 500 mobile phones were distributed among them	i) 100% of CHWs were compiled with reporting ii) Facility based deliveries were increased by 27% iii) 3 maternal deaths and 137 child deaths were registered in the system iv) 163 SMS were sent associated with danger signs v) 11,502 pregnancies were registered (81% of total estimated)
Senegal		
(Observatory, 2012)	EpiSurveyor: to collect public health and other data on mobile phones; Maternal Health data collection	Use of Partograms to assist labour increased on average by 28% among all ten regions involved in the project, compared to a 1% increase in the use of partograms in areas outside the EpiSurveyor pilot study.
	During delivery, use of donated prepaid mobile phones to allow mothers to contact hospitals	
South Africa		
(Rotheram-Borus MJ et al, 2011)	Mobile phones were used to collect routine information, complete questionnaires and to upload numeric, voice, and text-based data on women and their babies during	Mobile phones were innovative in data collection; effective in low-resource settings

[6] Communication for development (C4D) is an approach promoted by UNICEF that uses a two-way process for sharing ideas and knowledge using a range of communication tools and approaches that empower individuals and communities to take actions to improve their lives.

	pregnancy and at one week, six months, and twelve months post-birth	
Tanzania		
(Lund S, Nielsen BB, Hemed M, et al, 2014), (Lund S, Hemed M, Nielsen BB, et al, 2012) and (Lund S, Rasch V, Hemed M, et al, 2014)	Automated SMS system was introduced to facilitate appointment reminders and health education to mothers; women received unidirectional test messages and a mobile phone voucher to enable bidirectional contact with healthcare providers	i) 44% of total women received more than 4 ANC visits compared to 31%; 59% women believed that text messages influenced their decision to attend ANC ii) 30% women contacted health providers via mobile phones iii) 71% women asserted that educational message helped to understand danger sign during pregnancy iv) skilled birth attendance were increased by 60% compared to 47%
Thailand		
(Kaewkungwal J, Singhasivanon P, et al, 2010)	Smart phones to capture remote data and send SMS; automatically generated lists and message reminders to mothers and children when their visits were due, data collection on child immunization and ANC visit	i) 280 pregnant women attended 900 ANC visits; 59% women were on time as compared to 44% before intervention ii) 45% of child immunization status were recorded and updated on mobile phones iii) 44.2% children were received vaccination on time compared with 34.4% before intervention iv) 17% of parents received SMS reminder on their phones v) 10% of women received SMS reminder on their phones
Vietnam		
(Ngoc NT1, Bracken H, Blum J, Nga NT, et al, 2014)	Phone follow-up of pregnant women; completed a semi quantitative pregnancy test at their initial visit to determine baseline Human Chorionic gonadotropin (HCG) and again after 2 weeks later at their homes	i) 85% intervention women did not require an additional clinic visit ii) Phone follow-up and home pregnancy test were effective in screening ongoing pregnancies

Zambia		
(Seidenberg P et al, 2012)	Automated notification system based on mobile phone texting to diagnosis of infant infection with (HIV)	This texting significantly shortened the time between sample collection and results notification to the relevant health providers and facilities; time of result notification to a health facility fell from 44.2 days to 26.7 days and mean time to notification of a caregiver also fell significantly (from 66.8 days to 35.0 days)

1.4 Conclusion

Despite high economic growth and technology advancement, many developing countries have a higher burden of diseases with the greatest burden of maternal, new born and child death (WHO Report 2011). Ensuring a healthy development of the child ought to be the primary concern of any country and in order to achieve success in this vision, it is necessary for developing countries like to introduce better health monitoring solutions (eHealth, mHealth, etc.) in the healthcare sector. If mobile devices could be effectively leveraged then it could help to address healthcare issues like accessibility and affordability worldwide. In healthcare deliveries, health determinants such as public health spending, sanitation facilities, health awareness, fmale education, access to mobile phones, digital literacy are correlated with better health outcomes such as higher life expectancy, lower mortality rates and good life style. Hence, mobile devices have a significant role in healthcare delivery and there is a need to tap the potential mobile health market to improve health system in low and middle income countries.

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