mHealth Interventions for Health System Strengthening in India: Current Status and Future Directions

Introduction
Gains in management of communicable diseases and reproductive maternal and child health conditions, combined with demographic transition have caused a shift in the burden of mortality and morbidity to non-communicable diseases (NCDs) [1]. In India, the contribution of NCDs to deaths increased from 37.9 % in 1990 to 61.8 % in 2016 [2]. The pauci-symptomatic nature and the long-term management and medication availability requirements force a change in the approach to NCD care delivery from facility-based service to domiciliary care in which the consumer is not in constant contact with the healthcare system. Integrated care delivery is required using a risk factor-based rather than disease-specific approach, with need for periodic reassessment and treatment modification. Rural areas are at particular disadvantage due to inadequacy and maldistribution of workforce and services.

Technological innovations present the possibility of turning a mobile device into key component of healthcare delivery. Reduction in cost of handsets and increase in network coverage has led to a rapid expansion in ownership in India. The number of mobile connections in India has grown to over 1 billion with 42% of the subscribers living in rural areas [3]. Out of 650 million active mobile users in 2017, nearly 300 million had a smartphone [4].

Mobile health or mHealth, defined by the Global Observatory for e-health as ‘medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistant (PDAs), and other wireless devices’ is increasingly being used to support NCD care delivery [5]. Potential advantages include reducing response time by using trained non-physician health workers, providing decision support, minimizing variability in the quality of delivered care, optimizing monitoring and patient engagement, eventually reducing the cost of care and improving outcomes [6].

A number of initiatives that use mobile devices for delivering healthcare are currently being developed and implemented in India [6–9]. Given the considerable financial and human resources being invested in planning, development and implementation of these initiatives, it is critical to ascertain their role in strengthening healthcare systems.

We undertook this review to identify the published mHealth or telemedicine (provision of healthcare services using tele-communication technology) initiatives in India in the context of the health system building blocks and their potential for health systems strengthening. The review also presents the disease area, type of tele-communication device used, geographical distribution of the study sites and target users
of the innovation for these published mHealth initiatives in India. Finally, we highlight actions required for ensuring an effective role of mHealth interventions in strengthening the Indian health system.

**Methods**

A search of the literature was done to identify mHealth or telemedicine articles published from India between January 1997 and June 2017. The electronic bibliographic databases and registries searched included MEDLINE, EMBASE, Joanna Briggs Institute EBP Database and Clinical Trial Registry of India. The key search terms used included device (smartphones, cell phone, mobile phone, tablet, PDA, laptop, personal computer); service (Interactive Voice Response {IVR}, text message, global positioning system, video-conferencing); intervention (primary care, secondary care, tertiary care, disease prevention, disease control, disease management, risk factor control, telemedicine, mHealth); diseases (NCDs, communicable diseases, maternal and child health); India. The list of subheadings (MeSH) and text-words used along with the detailed strategy used for searching the databases is listed as Multimedia Appendix 1.

The information technology (IT) devices included computer, fixed line phone, PDA, feature phone, smartphone, and wearables. Articles related to the health effects of IT devices were excluded from this review.

We included primary research articles (experimental, quasi-experimental, pre and post intervention, cohort studies, descriptive and analytical cross-sectional studies, exploratory studies and protocols for experimental/quasi-experimental studies), review articles (systematic and narrative reviews), system description studies (describing system architecture), case studies and opinion papers. A database was developed using Microsoft Office Access interface, and information was abstracted in two stages.

**Stage 1:** Year of publication and disease focus were abstracted for all the selected articles. The disease focus was classified under i) communicable, maternal, perinatal and nutritional conditions; and ii) NCDs, using the World Health Organization (WHO) Global Health Estimates classification [10].

**Stage 2:** Research articles containing primary data were carried forward to the second stage. Data related to geographical location, devices used, intended target users, target health system domain, and type of mHealth application/tool used were extracted. Review articles, system description studies, case studies and opinion papers that did not have specific information on the above-mentioned indicators were excluded at this stage.

The WHO Health System Building Block Framework was used to arrange the abstracted information under the following heads: (i) service delivery; (ii) health workforce; (iii) health information systems; (iv) access to essential medicines; (v) financing; and (vi) leadership/governance [11]. Framework developed by Labrique et al. was used to classify the identified mHealth application/tool as per their types and uses.
We grouped all consumer-centric interventions by adding medical consultations offered through mobile technologies to the ‘client education and behaviour change communication’. Health workers’ awareness and perception of mHealth were included under ‘provider training and education’.

The Cochrane risk of bias assessment tool was used to assess risk of selection bias, reporting bias, performance bias, detection bias and attrition bias in randomized control trials (RCTs). Agency for Healthcare Research and Quality (AHRQ) standards score was used to arrive at a composite indicator of quality (Good, Fair, and Poor) for RCTs. Study quality was considered i) ‘good’ if it met all criteria (low for each domain, as per Cochrane risk of bias tool), ii) ‘fair’ if the risk of bias was high for one domain or unclear for two and unlikely to have biased the outcomes and iii) ‘poor’ if two or more criteria had high or unclear risk of bias likely to have affected the outcomes. The quality assessment for observational cohort, pre-post and cross-sectional studies was done using the National Institutes of Health, U.S. Department of Health and Human Services quality assessment tool [13]. Two reviewers (AB and OJ) independently assessed the quality of the selected evidence. Any discordance in the selection, categorization or quality assessment was resolved by discussion.

Results
The combined search strategies yielded 2150 citations. After removing duplicates, a total of 1303 articles were screened for their relevance. Following the title and abstracts screening, a total of 886 articles were filtered out for criteria related to country, language and non-relevance. A total of 417 articles were selected for full-text evaluation. Exclusion of 99 articles not having mHealth/ IT as the primary intervention, resulted in the final selection of 318 articles. (Figure 1)
Figure 1: Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Flow Diagram

**Identification**
- Records identified through database and registry searching (n=2150)
  - MEDLINE (n=926)
  - EMBASE (n=1146)
  - Joanna Briggs Institute (n= 75)
  - Clinical Trial Registry of India (n = 3)
- Records screened after removing duplicates (n = 1303)
  - Records excluded (n=886)
    - Filtered for country (n=213)
    - Filtered for language (n=47)
    - Non-relevant titles and abstracts (n = 626)

**Screening**
- Full-text articles assessed for eligibility (n = 417)
  - Articles excluded as information technology device not used as a primary tool (n=99)

**Eligibility**
- Articles included in the review (n = 318)
  - Primary Research Articles (n=125)
    - Experimental (n=11)
    - Quasi-experimental and pre-post intervention (9)
    - Cohort (n=4)
    - Descriptive and Analytical Cross-sectional Studies (n=69)
    - Exploratory (n=26)
    - Protocols for experimental and non-experimental studies (n=6)
  - Review Articles (n=16)
    - Systematic reviews (n=2)
    - Narrative reviews (n=14)
  - System Description Studies (n=46)
  - Case Studies (n=49)
  - Opinion Articles (n=82)

**Data Abstraction**

Stage 1: All selected articles (n=318)
- Year of publication and disease focus abstracted

Stage 2: Primary research articles (n=125)
- Geographical location, devices type, intended target users, health system domain, and type of mHealth intervention abstracted
Figure 2 shows the distribution of the articles and disease focus. About 45% of the selected articles had a NCD focus, 15% were directed towards the domain of communicable, maternal, perinatal and nutritional conditions and the remaining 40% addressed cross-cutting topics. The first 10 years (1997-2006) saw only a small number of articles, with focus on the role of telemedicine in improving the health services through medical consultations and communication between the healthcare providers. A sharp increase was seen after the 2012, driven primarily by NCD focused articles.

**Figure 2: Year-wise Distribution of the Published Articles and Disease Area**

Table 1 presents distribution of the type of studies published between 1997 to 2017, divided into 5-year periods. Out of the 318 articles, more than 25% were opinion-based articles, followed by 21% descriptive and analytical cross-sectional studies. Less than 4% followed an experimental design that allowed evaluation of the impact of interventions on the health outcomes. Most studies published between 1997-2006 were case studies or opinion articles.
A majority of studies had been conducted in the South Indian states, with Tamil Nadu (27) and Karnataka (24) leading the list (Figure 3). Delhi (17) and Maharashtra (13) had the highest number of sites from the rest of the country. No articles were published from Jammu and Kashmir and North-East Indian states. Seven published articles reported findings from multi-centric studies.

**Table 1: Year-wise Distribution of the Type of Published Articles**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Study Type</th>
<th>Time Period</th>
<th>1997-2001</th>
<th>2002-2006</th>
<th>2007-2011</th>
<th>2012-2017</th>
<th>Total n (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Experimental</td>
<td></td>
<td>2</td>
<td>9</td>
<td></td>
<td>11 (3.4)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Quasi-experimental and pre-post intervention</td>
<td></td>
<td>1</td>
<td>8</td>
<td></td>
<td>9 (2.8)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Cohort Study</td>
<td></td>
<td></td>
<td></td>
<td>4</td>
<td>4 (1.3)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Descriptive and analytical cross-sectional studies</td>
<td></td>
<td>4</td>
<td>12</td>
<td>53</td>
<td>69 (21.7)</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Exploratory</td>
<td></td>
<td></td>
<td></td>
<td>5</td>
<td>21</td>
<td>26 (8.2)</td>
</tr>
<tr>
<td>6</td>
<td>Protocols (Experimental and quasi-experimental)</td>
<td></td>
<td>1</td>
<td>5</td>
<td></td>
<td>6 (1.9)</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Systematic and narrative reviews</td>
<td></td>
<td>3</td>
<td>13</td>
<td></td>
<td>16 (5)</td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>System architectural</td>
<td></td>
<td></td>
<td></td>
<td>7</td>
<td>39</td>
<td>46 (14.5)</td>
</tr>
<tr>
<td>9</td>
<td>Case study</td>
<td></td>
<td>2</td>
<td>8</td>
<td>19</td>
<td>20</td>
<td>49 (15.4)</td>
</tr>
<tr>
<td>10</td>
<td>Opinion article</td>
<td></td>
<td>7</td>
<td>13</td>
<td>23</td>
<td>39</td>
<td>82 (25.8)</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>9</strong></td>
<td><strong>25</strong></td>
<td><strong>73</strong></td>
<td><strong>211</strong></td>
<td><strong>318 (100)</strong></td>
</tr>
</tbody>
</table>

**Figure 3: Geographical Distribution of the Study Sites (n=125)**
Figure 4 shows the devices used in the studies. Personal Computers (desktops, notebooks) and fixed line phones were the most commonly used tools until 2011. Articles using feature phones and smartphones as a technology device emerged after 2012.

**Map source:** Ministry of External Affairs, Government of India [14]
A total of 125 articles provided information about the end-users of the tool. Physicians were the most frequent end-users (44%), followed by patients (27%) and general community (11%). Only 7% of the initiatives aimed at engaging community health workers (CHWs).

Risk of Bias and Quality Assessment
Table 2 presents the risk of bias assessment for the selected RCTs. Overall, the methodological rigor of the included studies was poor. One study [15] had low risk of bias in all categories, whereas others had a high risk for bias in two or more categories. Four studies failed to provide enough information to allow assessment of risk of selection, performance or detection bias (i.e. unclear risk of bias).

**Table 2: Risk of Bias Assessment for RCTs**

<table>
<thead>
<tr>
<th>Author</th>
<th>Random sequence generation</th>
<th>Allocation concealment</th>
<th>Blinding (participants and personnel)</th>
<th>Blinding (outcome assessment)</th>
<th>Selective reporting</th>
<th>Incomplete outcome data</th>
<th>Other sources of bias</th>
<th>AHRQ score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Jain et al., 2010 [16]</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Fair</td>
</tr>
<tr>
<td>Sharma et al., 2011 [17]</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Unclear</td>
<td>Low</td>
<td>Low</td>
<td>High&lt;sup&gt;a&lt;/sup&gt;</td>
<td>Poor</td>
</tr>
<tr>
<td>Prasad et al., 2012 [18]</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Unclear</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Poor</td>
</tr>
<tr>
<td>Ramachandran et al., 2013</td>
<td>Low</td>
<td>Low</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Fair</td>
</tr>
<tr>
<td>Study</td>
<td>Quality</td>
<td>Description</td>
<td>Sample Size Justification</td>
<td>Confounder Adjusting</td>
<td>Exposure Definition</td>
<td>Outcome Measures</td>
<td>Attrition Rate</td>
<td></td>
</tr>
<tr>
<td>------------------------</td>
<td>---------</td>
<td>-------------</td>
<td>---------------------------</td>
<td>----------------------</td>
<td>---------------------</td>
<td>------------------</td>
<td>----------------</td>
<td></td>
</tr>
<tr>
<td>Radhakrishnan et al., 2014</td>
<td>Low</td>
<td>Unclear</td>
<td>High</td>
<td>High</td>
<td>Unclear</td>
<td>Low</td>
<td>Low</td>
<td>Poor</td>
</tr>
<tr>
<td>Shet et al., 2014 [21]</td>
<td>Unclear</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Fair</td>
</tr>
<tr>
<td>Kaur et al., 2015 [22]</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Poor</td>
</tr>
<tr>
<td>Kumar et al., 2015 [23]</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Poor</td>
</tr>
<tr>
<td>Patnaik et al., 2015 [24]</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>High</td>
<td>Poor b</td>
</tr>
<tr>
<td>Arora et al., 2017 [15]</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Good</td>
</tr>
<tr>
<td>Limaye et al., 2017 [25]</td>
<td>Low</td>
<td>High</td>
<td>High</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Low</td>
<td>Poor</td>
</tr>
</tbody>
</table>

*a Contamination, source of recruitment of the study subjects is not mentioned

b High and unequal attrition rates noted between the two study arms

Multimedia Appendices 2-4 provide details of quality assessment of the studies. More than 80% of the cross-sectional studies had stated their research objectives/questions (Multimedia Appendix 2). Criterion related to description of the study population, demographics, clinical profile, and recruitment location was satisfied in 70% of the studies. Sample size justification was not provided in >90% studies, with convenience sampling being the commonest approach. Only 15% of the cross-sectional studies reported adjusting for potential confounders. Definition of the exposure (independent variables) and outcome measures (dependent variables) was present in about 60% of the studies.

All the four cohort studies had stated their objectives and defined study populations (Multimedia Appendix 3). However, none of the studies had provided justification for the chosen sample size. All 4 studies used clearly defined, accepted methods for assessment of both exposure and control groups. Only two studies reported loss to follow-up.

Only two of the pre-post single group studies had a sufficient sample size, while others were feasibility studies with no sample size justification (Multimedia Appendix 4). Outcomes measures were defined in all and one study had used non-validated tool for outcomes measurement. Outcome assessor blinding was not reported in any of the pre-post studies.
Health Systems Building Blocks

The classification in Table 3 is based on the primarily targeted health system building block and mHealth tool. Multimedia Appendix 5 provides details of the multiple health system building blocks targeted by each article. A majority of these articles had their focus on one (36%) or two (46%) blocks, most frequently service delivery and health workforce. About 17% articles targeted three building blocks and only 2% articles had initiatives that had bearing on four building blocks of the health system.

Table 3: Classification of the mHealth Initiatives Based on Different Health Systems Building Blocks and mHealth Tools

<table>
<thead>
<tr>
<th>mHealth Tools</th>
<th>WHO Health System Building Block Classification</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Service delivery</td>
</tr>
<tr>
<td>Client education and behaviour change communication</td>
<td>61</td>
</tr>
<tr>
<td>Sensors and point-of-care diagnostics</td>
<td>2</td>
</tr>
<tr>
<td>Provider training and education</td>
<td>11</td>
</tr>
<tr>
<td>Provider-to-provider communication</td>
<td>5</td>
</tr>
<tr>
<td>Electronic decision support</td>
<td>3</td>
</tr>
<tr>
<td>Data collection and reporting</td>
<td>1</td>
</tr>
<tr>
<td>Registries/vital event tracking</td>
<td>1</td>
</tr>
<tr>
<td>Provider work and planning and scheduling</td>
<td>4</td>
</tr>
<tr>
<td>Electronic health records</td>
<td></td>
</tr>
<tr>
<td>Supply chain management</td>
<td>1</td>
</tr>
<tr>
<td>Total</td>
<td>72</td>
</tr>
</tbody>
</table>
Health service delivery
Nearly 60% (n=72) of the primary research articles had service delivery strengthening as a primary focus. Key activities covered included patient consultations, remote diagnosis and follow-up through video-conferencing. Mobile phones were primarily used for treatment adherence reminders (text and IVR), appointment reminders and behaviour change messaging (n=8) [18,21,26–31]. Development process was described in 21 articles, 32 articles reported utility [16–25,28,29,32–55] and 20 user acceptability of the initiative [26,30–31,56–72]. Other aspects explored were technology related perception of the end-users (n=13) [27,73–83], patient satisfaction (n=2) [84,85], assessment of healthcare professional needs and challenges related to health service delivery using IT (n=2) [86,87].

Health workforce
Nearly 20% (n=25) of the articles had health workforce as the primarily targeted health system domain. Establishment of a provider-to-provider communication through tele-consultations, remote trainings and capacity building were commonest health workforce strengthening activities. Objectives included reporting changes in the knowledge scores of the healthcare workers following a tele-education interventions (n=11) [88–98] or a survey of mHealth/telemedicine related knowledge, attitude and practice (KAP) among the healthcare professionals without any intervention (n=8) [16,99–106]. Articled describing use of mobile applications for screening, referral, guideline-based care and provider work planning appeared only after 2013. Development and utility of CHW centric intervention that facilitated task shifting for disease screening, referral and health information dissemination was discussed in 5 articles [107–111].

Essential medical products, vaccines and technologies
Medical products and technology were the focus of 12% (n=14) of the selected articles, with nearly half relating to eye care [112–119], specifically using remotely operated technological tools for disease diagnosis (n=6) [113,116,120–123]. One study evaluated patient experience for health monitoring [124], and another evaluated a mobile-based vaccine management tool [125].

Health information
About 10% (n=11) of the articles evaluated strengthening of the health information system, with focus on vital event tracking, disease surveillance and case notification in rural areas [126–135]. Articles were mostly related to communicable diseases, maternal, perinatal and nutritional conditions. One study evaluated mobile and tablet based systems for collection of data related to behaviour research [136].
Leadership and governance and Financing
Three studies addressed leadership, governance and financing related issues. Finding the challenges related to the financing of the existing mHealth programmes and the legal issues related to tele-consultations in India were the key objectives of these studies [137–139].

Discussion
We describe for the first time the landscape of mHealth initiatives from a health system perspective from the second most populous country of the world that faces major challenges in healthcare delivery. The emerging evidence base around mHealth in India shows a progress from anecdotal telemedicine user stories to primary research articles, providing evidence on effectiveness in achieving the health objectives. The shift of focus of the mHealth initiatives over time towards NCDs is similar to the finding from China [140].

A notable finding was the concentration of mHealth solutions in a few states, with almost complete exclusion of the others including some of the most underserved areas – like the north-eastern regions, and Jammu and Kashmir where mHealth might introduce greatest efficiency. A recent report by the Global Burden of Disease Study group pointed out at the heterogeneity of diseases and risk factors between Indian states [141]. Inter-state variations in the structure and performance of healthcare delivery systems add to the challenge of last mile healthcare delivery. Therefore, it is important to test solutions in different states, especially the disadvantaged states that have the potential of experiencing the most transformative change.

The evolution in device choice may indicate changing consumer preferences in the contemporary mobile technology. However, the scientific basis for selecting these devices was not clearly articulated. Choice should take into account the technological know-how of end-users, local health systems, nature of intervention and availability of resources required to support the technology. The relevance of this knowledge becomes more important as these solutions are targeted to CHWs and patients to promote self-management and health promotion in communities.

Analysis in terms of the WHO health system building blocks revealed focus on service delivery and workforce strengthening, with relative neglect of health governance and health financing domains. Most of the reported mHealth interventions were being implemented as standalone solutions often with no health systems integration strategy. To reap maximal benefits, mHealth innovations should function as integrable tools that yield positive outcomes related to access, equity, quality and responsiveness.

Client education, which increases access to health information, was the most widely used mHealth service delivery tool. However, contextual background to health information being provided to the clients was not
provided in the articles we reviewed. Similar findings in terms of the mHealth tools used emerged from China [140].

While assessing the studies for the methodological rigor, we found the use of non-validated instruments (survey and questionnaire) to be common. Sample size justification was provided only in a minority of reports. Use of convenience sampling has been a cause of prevalent scepticism related to mHealth interventions [142]. Another major flaw was the lack of a proper experimental design that allows generation of high-quality evidence. This combination of use of narrowly focused interventions in relatively small populations using loose experimental designs raises serious questions about internal as well as external validity of these studies and led to the use of a derisive term ‘pilotitis’ to describe these mHealth studies.

Limitations
Any review is only as good as the quality of the studies that are included. Studies published in biomedical literature only represent a subset of mHealth interventions since a fair number never submitted to academic journals. The mHealth applications that are available through the application stores were outside the scope of this review. Secondly, conducting a meta-analysis related to the effectiveness was not possible due to large differences in the methodologies used and outcome variables. Lastly, while reporting the focus of the interventions we used WHO’s health system building blocks and selected the primarily targeted health system domain. Caveat for interpreting these findings is that a number of interventions would have a synergistic effect on other health system domains. For instance, any intervention that is focused on capacity building of the health workforce would not only have an impact on the ‘health workforce’ building block but would also improve the quality of care thus strengthening the ‘service delivery’.

Conclusions
In conclusion, mHealth initiatives are being increasingly tested to improve healthcare delivery in India. Despite the widespread perception that healthcare delivery capacity could be rapidly scaled up for achieving universal health coverage by leveraging the expanding mobile communications networks and high ownership of mobile devices, the quality of evidence remains suboptimal. Robust scientific evaluation of effectiveness through appropriately designed and sampled studies, powered on clinical endpoints is critical for establishing the on-field appropriateness of mHealth initiatives. Our review highlights an urgent need for focused research aimed at generating high quality evidence on efficacy, user acceptability, and cost effectiveness of mHealth interventions aimed towards health systems strengthening taking into account contextual factors and size and specifics of the problems being addressed. A pragmatic approach would be to include an implementation research component into the existing and proposed
digital health initiatives to support generation of evidence for health system strengthening on strategically important outcomes.

Acknowledgments
We are thankful to Qualcomm Wireless Reach for providing funding support.

Abbreviations

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>AHRQ</td>
<td>Agency for Healthcare Research and Quality</td>
</tr>
<tr>
<td>ART</td>
<td>Antiretroviral therapy</td>
</tr>
<tr>
<td>CHW</td>
<td>Community Health Worker</td>
</tr>
<tr>
<td>CVD</td>
<td>Cardio Vascular Disease</td>
</tr>
<tr>
<td>DM</td>
<td>Diabetes Mellitus</td>
</tr>
<tr>
<td>HIV</td>
<td>Human Immunodeficiency Virus</td>
</tr>
<tr>
<td>ICU</td>
<td>Intensive Care Unit</td>
</tr>
<tr>
<td>IT</td>
<td>Information Technology</td>
</tr>
<tr>
<td>IVR</td>
<td>Interactive Voice Response</td>
</tr>
<tr>
<td>KAP</td>
<td>Knowledge Attitude Practice</td>
</tr>
<tr>
<td>mHealth</td>
<td>Mobile Health</td>
</tr>
<tr>
<td>MNCH</td>
<td>Maternal, Newborn and Child Health</td>
</tr>
<tr>
<td>NCD</td>
<td>Non Communicable Disease</td>
</tr>
<tr>
<td>PDA</td>
<td>Personal Digital Assistant</td>
</tr>
<tr>
<td>PRISMA</td>
<td>Preferred Reporting Items for Systematic Reviews and Meta-Analyses</td>
</tr>
<tr>
<td>RCT</td>
<td>Randomized Control Trial</td>
</tr>
<tr>
<td>SMS</td>
<td>Short Message Service</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
</tr>
</tbody>
</table>

Multimedia Appendix 1: Search Strategy for Databases
Multimedia Appendix 2: Quality Assessment for Cross-Sectional Studies
Multimedia Appendix 3: Quality Assessment for Observational Cohort
Multimedia Appendix 4: Quality Assessment for Pre-Post studies
Multimedia Appendix 5: Study Objectives, mHealth Tool Used and Health System Framework Classification of the Selected Articles
References


11. World Health Organization. WPRO | The WHO Health Systems Framework. WPRO WPRO | 
WHO Western Pacific Region; 2017; Available from: http://www.webcitation.org/70WpuVeGX; 
http://www.wpro.who.int/health_services/health_systems_framework/en/

12. Labrique AB, Vasudevan L, Kochi E, Fabricant R, Mehl G. mHealth innovations as health system 
strengthening tools: 12 common applications and a visual framework. Glob Heal Sci Pract 2013 

Institute (NHLBI) . Available from: http://www.webcitation.org/70WpuVeGX; 
https://www.nhlbi.nih.gov/health-topics/study-quality-assessment-tools


management of pressure ulcers in people with spinal cord injury in low- and middle-income 
PMID:27995939

PMID:20357810

17. Sharma R, Hebbal M, Ankola A V, Murugabupathy V. Mobile-phone text messaging (SMS) for 
providing oral health education to mothers of preschool children in Belgaum City. J Telemed 
Telecare England; 2011;17(8):432–436. PMID:22025742

18. Prasad S, Anand R. Use of mobile telephone short message service as a reminder: the effect on 

mobile phone messaging in prevention of type 2 diabetes by lifestyle modification in men in India: 
a prospective, parallel-group, randomised controlled trial. lancet Diabetes Endocrinol England; 


34. Singh M, Das RR. Utility of telemedicine for children in India. Indian J Pediatr India; 2010 Jan;77(1):73–75. PMID:20091379


57. Mishra A, Kapoor L, Mishra SK. Post-operative care through tele-follow up visits in patients


86. Martinez Alvarez M, Chanda R, Smith RD. How is Telemedicine perceived? A qualitative study of
perspectives from the UK and India. Global Health England; 2011;7:17. PMID:21599962


108. Kaphle S, Chaturvedi S, Chaudhuri I, Krishnan R, Lesh N. Adoption and Usage of mHealth Technology on Quality and Experience of Care Provided by Frontline Workers: Observations From Rural India. JMIR mHealth uHealth 2015;3(2):e61. PMID:26023001


111. Maulik PK, Kallakuri S, Devarapalli S, Vadlamani VK, Jha V, Patel A. Increasing use of mental health services in remote areas using mobile technology: a pre-post evaluation of the SMART Mental Health project in rural India. J Glob Health Scotland; 2017 Jun;7(1):10408. PMID:28400954


116. Sreelatha OK, Ramesh SV, Jose J, Devassy M, Srinivasan K. Virtually controlled computerised
visual acuity screening in a multilingual Indian population. Rural Remote Health Australia; 2014;14(3):2908. PMID:25190644


126. Krishnan A, Nongkynrih B, Yadav K, Singh S, Gupta V. Evaluation of computerized health management information system for primary health care in rural India. BMC Health Serv Res


138. Meher SK, Biswas A, Ratha BK. Legal issues among doctors in the implementation of teleconsultation: a study at AIIMS, New Delhi, India. Stud Health Technol Inform Netherlands; 2013;192:1107. PMID:23920881

139. Jaroslawski S, Saberwal G. In eHealth in India today, the nature of work, the challenges and the finances: an interview-based study. BMC Med Inform Decis Mak England; 2014;14:1. PMID:24387627

