mHealth initiatives for non-communicable disease (NCD's) – a scoping review of the Indian scenario

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Abstract— **mHealth initiatives are cost effective, quick and less resource intensive technology assisted initiatives which help to strengthen the Health system. High mobile penetration and availability of cheap and high-speed data network across India has been conducive to implement mHealth initiatives in Indian health system. In recent decade India has seen a surge in mHealth initiatives. With this scoping review we intent to understand the current scenario of mHealth initiatives in NCD care. We searched on databases like PubMed and Google Search for terms like mHealth, mobile phones, cell phones, telemedicine, primary care, secondary care, rural health, Prevention, Diagnosis, Management, Risk factor control, NCD's, Non communicable Diseases, Chronic Disease, Health Systems. The total number of articles analysed in this study were 42. We presented the technology, device used in study, study settings and type of mHealth vertical used based on ICT classification of mHealth initiatives and the condition addressed.**

Our observations were, most of the mHealth initiatives were conducted in rural areas, with states like Tamil Nadu, Andhra Pradesh reporting maximum number of studies. Diabetes was the most researched condition followed by cardiovascular diseases. Most of the mHealth initiatives were conducted through smartphones, and cell phones withClient education and behaviour change communication (BCC) being most implemented vertical.

The mHealth initiatives are key to strengthen Indian healthcare system to tackle rising burden of NCD's in India. There is a need for continuous surveillance system to monitor and propagate mHealth research as per health systems requirement.

Index Terms: **NNon-CommunicableDiseases, Health IT, Digital Health, mHealth, Behaviour Change Communication.**

INTRODUCTION

Mobile Health (mHealth) is relatively new concept, defined by Global Observatory for eHealth (GOe) as medical and public health practice supported by mobile devices, such as mobile phones, patient monitoring devices, personal digital assistants (PDAs), and other wireless devices(1).mHealth initiatives includes technology based use of hand held devices like mobile phones, smartphones, PDA's, tablets, point of care diagnostic devices, laptops, personal computer, and plethora of other electronically assisted devices which might aid in client education and behaviour change communication, diagnostics, data collection, electronic decision support, provider to provider communication, provider training and education, human resource management, supply chain management, financial transactions(2). World Health Organization (WHO), Johns Hopkins University Global mHealth Initiative, the United Nations Children's Fund (UNICEF), and Frog Design have jointly developed the''mHealth and ICT Framework'' to describe mHealth innovations in the reproductive, maternal, new-born, and child health (RMNCH) field, in which mobile health technologies have been broadly implemented over the last decade across the globe(2). Table 1. Lists the 12 categories of mHealth and ICT Framework.

TABLE 1. Examples of Mobile Phone Functions Used in Common mHealth and ICT Applications		
	Common mHealth and ICT Applications	Examples of Mobile Phone Functions
1	Client education and behaviour change communication (BCC)	Short Message Service (SMS) Multimedia Messaging Service (MMS) Interactive Voice Response (IVR) Voice communication/Audio clips Video clips and Images
2	Sensors and point-of-care diagnostics	Mobile phone camera Tethered accessory sensors, devices Built-in accelerometer
3	Registries and vital events tracking	Short Message Service (SMS) Voice communication Digital forms
4	Data collection and reporting	Short Message Service (SMS) Digital forms

		Voice communication
5	Electronic health records	Digital forms Mobile web (WAP/GPRS)
6	Electronic decision support (information, protocols, algorithms, checklists)	Mobile web (WAP/GPRS) Stored information ''apps'' Interactive Voice Response (IVR)
7	Provider-to-provider communication (user groups, consultation)	Short Message Service (SMS) Multimedia Messaging Service (MMS) Mobile phone camera
8	Provider work planning and scheduling	Interactive electronic client lists Short Message Service (SMS) alerts Mobile phone calendar
9	Provider training and education	Short Message Service (SMS) Multimedia Messaging Service (MMS) Interactive Voice Response (IVR) Voice communication Audio or video clips, images
10	Human resource management	Web-based performance dashboards Global Positioning Service (GPS) Voice communication Short Message Service (SMS)
11	Supply chain management	Web-based supply dashboards Global Positioning Service (GPS) Digital forms Short Message Service (SMS)
12	Financial transactions and incentives	Mobile money transfers and banking services Transfer of airtime minutes

The ICT frame work has become the standard tool for categorizing mHealth initiatives as per there application in Health system strengthening.

mHealth has gained a lot of attention of medical researchers due to the factors like, ability to provide low-cost and user friendly service, potential to enhance the speed and accuracy of healthcare delivery, rapidly expanding base of mobile phone users in developing countries(2,3). mHealth is particularly of relevance to developing countries like India, wherein the healthcare workforce is limited and burdened by tackling dual burden of communicable and non-communicable diseases. A Price Waterhouse Coopers (PWC) and Confederation of Indian Industry (CII) report on mHealth in Indian healthcare industry quantifies the potential of mHealth initiatives in India, with rising penetration of mobile phones and cheap high speed internet connectivity, India accounts for 50% of the global internet traffic and the internet usage is expected to achieve compound annual growth of 47% till 2021(4). India ranks among top five countries with most mHealth apps developed and installed from Google play store, Google Play store lists 491 free and 24 paid applications available under Health and Fitness category(5). Government of India, National Health Portal maintains the list of mobile applications and websites dealing with mHealth in Indian context, it lists 74 applications and websites which are highly reviewed and recommended for initiation of mHealth initiatives in Indian healthcare setup(6). The George Institute for Global Health, India had conducted a scooping review titled "mHealth Interventions for Health System Strengthening in India" in 2016, the study reported timeline of mHealth articles published in peer reviewed journals. Between 1997- 2016 over 189, mHealth studies were published in peer reviewed journals, there has been significant rise in mHealth interventions directed add Non communicable disease (NCD) care in past decade (2012-2016) with overall rise in mHealth interventions across all the health care verticals(7).

A recent systematic review of mHealth initiatives in India and China (published separately) presents the scenario of mHealth in the world's top two mobile phone markets. Most of the mHealth studies form India and China were addressing the service delivery issue, by harnessing the technology to address the workforce shortage, connect with far to reach areas and behaviour change communication, second most commonly published studies were on use of Point of care diagnostics for improving service delivery. Finance and Governance were the areas with least amount of mHealth studies published in peer-reviewed journals as per the data available from the systematic review(8,9). The mHealth scenario of India and China is similar, both have a large population with high mobile penetration and cheap internet access, the population is spread across a large geographical terrain with limited access to healthcare facilities and vast scope for implementing technology based innovations for strengthening the healthcare system.

Non communicable diseases and lifestyle diseases are the ones which require constant communication between the healthcare provider and the patient for successful management of the condition. mHealth has a lot of potential to strengthen the healthcare system for tackling the increasing burden of NCD's.

We undertook this scooping review to understand the current scenario of mHealth initiatives on NCD management in Indian healthcare setup.

OBJECTIVE

The objective of this review to present the current scenario of mHealth initiatives on NCD management in Indian healthcare setup, in terms of type of technology used, type of healthcare vertical covered, population covered, geography covered.

MATERIALS AND METHODS

We searched PubMed, Google Scholar using MeSH Terms like primary health care, diagnosis, disease management, telemedicine, non-communicable diseases. The terms like Mobile Phones, Smartphones, Mobile Health, mHealth, Cell Phones, Laptop, Personal computer were added with Boolean operator "OR" combined with terms like Primary care, Secondary Care, Tertiary care, Prevention, Diagnosis, Management, Risk factor control, NCD's, Non communicable Diseases, Chronic Disease were combined using Boolean operator "AND". The search was restricted to India, English language, without any timeline. For Google Scholar the terms like mHealth, Primary care, Secondary care, Tertiary care, Diagnosis, Management, NCD's was used. We did not search for grey literature and papers published in local languages.

We included all the publications that catered to use of technology for management of NCD's, while publications on use of mHealth initiatives of Maternal and Child care, infectious diseases were excluded. mHealth initiatives which strengthened the healthcare setup for tackling of NCD's were also included. Review articles, and systematic reviews were not included in the study analysis.

Our search strategy yielded 277 results, after initial screening for duplicates and removing publications not satisfying inclusion criteria, our final count was of 42 publications. We did not check for the scientific rigour or undertook risk of bias assessment in our review as both the things were not part of our study objective.

RESULTS

Our search revealed that the first ever published literature on mHealth initiatives on NCDs in India was reported in year 2005.Table 3 (Annexure I) list all the studies reviewed by under for the review purpose, we included the year of publication, type of device used, type of mHealth initiative, study setting, type of study design and corresponding mHealth

initiative as per ICT classification. We plotted the number of mHealth initiatives published between 2005 and 2018, and the graph shows steady increase in mHealth initiatives undertaken in recent years.


Graph 1. Studies Published on Year wise basis
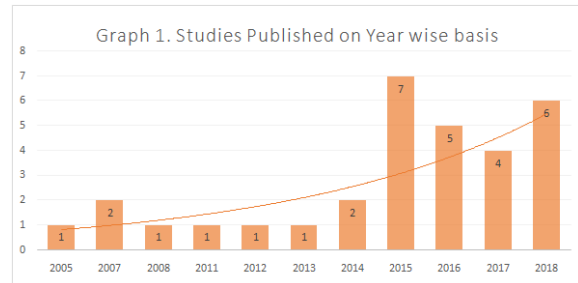
Smartphones and Cell Phones (Cell phones are defined the basic mobile phones which are primarily used for texting and calling) were the most commonly used devices contributing to almost 60% of all the NCD mHealth initiatives published. Graph 2. Lists the detailed share of each device.

Graph 2. Devices used for NCD mhealth initiatives in India
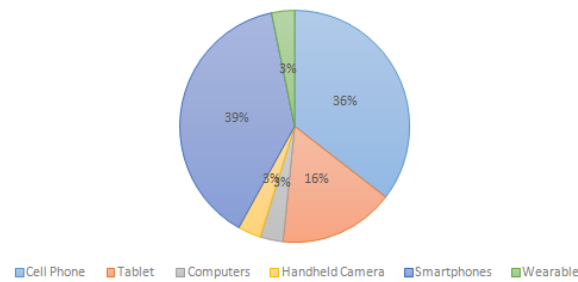
The mode of use of mHealth initiatives for NCD's is mostly Application (30%) based followed by Telemedicine (24%) and Point of Care (POC) devices (18%). Graph 3 Presents the percentage wise distribution of mode of use

Graph 3 – Mode of use of mHealth Initiatives for NCD's in India
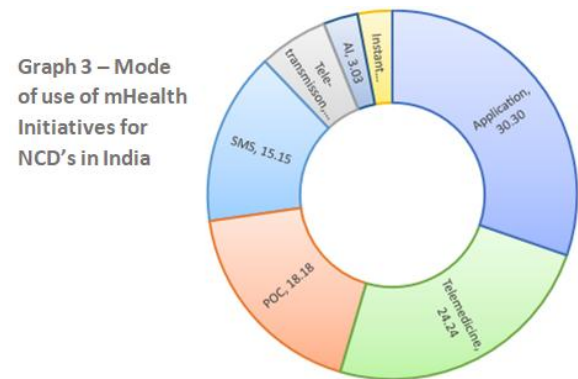
Geography wise 60% of the mHealth initiatives on NCD's were targeted on Rural populations. Tamil Nadu (n =10) reported most number of case studies, followed by Andhra Pradesh (n= 8), Himachal Pradesh (n=4), Maharashtra (n=3), Karnataka,

Haryana, New Delhi, Uttar Pradesh (n=2 for each state), and Odisha (n=1). Graph 4 plots the state wise number of studies on mHealth published on NCD's

Graph 4 - State Wise Distribution Of mHealth Initiatives On NCD's
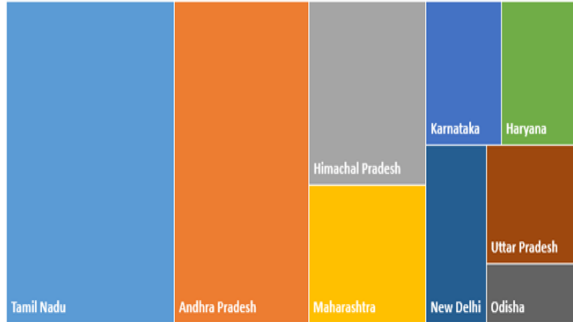
70% of all the mHealth initiatives on NCD's were focused on Primary care, whereas Secondary and Tertiary care contributed to 30%. Diabetes was the most researched condition, followed by cardiovascular diseases and hypertension, other commonly researched conditions were Ophthalmic disorders, Mental health, Stroke and Health systems strengthening for NCD's.
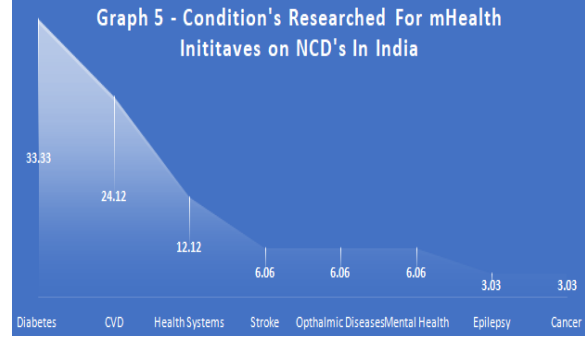

Graph 5 - Condition's Researched For mHealth Initiatives on NCD's In India

Table 2. List of mHealth initiatives stratified by common NCD's								
	Diabetes	CVD	Health Systems	Stroke	Ophthalmic Diseases	Mental Health	Epilepsy	Cancer
Client education and behaviour change communication (BCC)	7	2	2	NA	NA	2	1	1
Sensors and point-of-care diagnostics	4	5	NA	1	NA	NA	NA	NA
Registries and vital events tracking		1	NA	NA	NA	NA	NA	NA
Data collection and reporting	2	1	NA	1	NA	NA	NA	NA
Electronic health records	1	3	NA	NA	NA	1	NA	NA
Electronic decision support (information, protocols, algorithms, checklists)	4	3	NA	1	NA	1	NA	NA
Provider-to-provider communication (user groups, consultation)	1	2	1	NA	NA	NA	NA	NA
Provider work planning and scheduling	NA	NA	NA	NA	NA	NA	NA	NA
Provider training and education	NA	NA	NA	NA	NA	NA	NA	NA
Human resource management	1	NA	NA	NA	NA	NA	NA	NA
Supply chain management	NA	NA	NA	NA	NA	NA	NA	NA
Financial transactions and incentives	NA	NA	NA	NA	NA	NA	NA	NA

Table 2. stratifies the ICT based mHealth initiatives by list of NCD's; undertaken in India. Client education and behaviour change communication (BCC) is the most common mHealth initiative undertaken in India for NCD's. Most of the communication was undertaken in SMS or direct reminder calls, for aiding in follow up (10–15), some initiatives creating awareness about the condition using IVR, video clips and similar interactive media(11,13,15–23). The next most commonly explored mHealth vertical was sensors and point of care diagnostics, Ophthalmic screening(24–27),

screening for diabetic retinopathy(28–30), diabetes(16,20,31) was the most commonly undertaken initiatives. Electronic decision support, to ground healthcare work force was another mHealth vertical which has gained lot of attention with Cardiovascular diseases and Diabetes screening and risk profiling being the most common initiative(16,17,20,32–34). Mental Health, was a topic with increasing interest, with studies harnessing mHealth initiatives for Client education and behaviour change communication(22), Maintaining electronic records and training the front line

healthcare workers. Cancer had the least mHealth initiatives amongst all the NCD's with only one study undertaking SMS's to train individuals for oral self-examination suffering from Oral Squamous cell carcinoma (35).

mHealth verticals like supply chain management, provider work planning, financial transactions ever not implemented for NCD's in India. If implemented have not been published as a peer reviewed publication and hence were not the part of study. Many Non-governmental organisations like IKP Centre for Technologies in Public health have developed Health Information management system(36), Grameen Foundation(37) have developed and been using web based app based health information management system. Table 3. (Annexure I) Provides the comprehensive list of all the mHealth undertaken in India for NCD care.

DISCUSSION

With this study we present the current scenario of Health initiatives in India on NCD care. Our observations on mHealth initiative are; Most of the mHealth are limited to southern India with Tamil Nadu, Andhra Pradesh, Maharashtra, Karnataka contributing to most of the published literature. Single or two studies have been reported by Haryana, Delhi, Himachal Pradesh and Odisha. Most of the Low and Lower middle epidemiological transition states have not reported any mHealth initiative on NCD's in peer reviewed journals. We also had a quick scan on Health and Lifestyle related applications available on google play store in India, the search was for free and paid apps with user ratings of 4 star and above; the search shown491 free and 245 paid apps, most of which were catering to exercises, diet planning, weight lot, pedometer, some OEM apps for monitoring physical activity like Fit bit, Mi Fit, Samsung Health, Google fit are highly rated and popular. The government of India, Ministry of Health and Family Welfare has been publishing Electronic Health Record (HER) standards with latest publication being updated in 2016.(38)

The limitations of our study are, it was based only on the peer reviewed publications published in English and the database search was limited to Medline and Google Scholar. Most of the industry research involved in mHealth initiatives, the validation studies undertaken by industry if published in peer reviewed journals were included in our study. The grey literature including student's thesis, conference proceedings was not part of our search strategy.

The strengths of our study are, it is first of a kind of review to understand the mHealth initiatives scenario for NCD's in India. The Systematic review by Bassi et al (8) was one such effort, where the authors looked at the quality of mHealth studies reported in India. Our objective was to present the current scenario in terms of, type of technology used, type of healthcare vertical covered, population covered, geography covered.

Our observations and recommendation are,

1. The mHealth initiatives in India are currently picking up the trendon NCD's in India, but the system is highly fragmented with most initiatives being undertaken to resolve locally faced issues with the help of technology. The academia and industry largely works within its own silos and this has led to studies concentrating on particular mHealth verticals, while other being neglected.

2. India and China both the countries are with large rural population and high penetration of mobile and internet service with cheap data availability are currently fore runner initiating mHealth initiatives for strengthening health care systems and none of the countries has a system in place to register and track the progress of mHealth initiatives and to aid in continuous knowledge updates and policy making.

3. A surveillance system to map the mHealth initiatives with ability to provide real times updates on the initiatives and consolidated data on trends, designs, technology update would further increase the scope of implementing mHealth initiatives on NCD's in India

CONCLUSION

mHealth initiatives are the future to strength the Indian healthcare system against ever increasing burden of NCD's. It is high time India develops and implements a surveillance system to constantly track the mHealth initiatives on NCD's, which would help to decide the track of future research initiatives.

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Annexure I – Table 3. list of all the mHealth undertaken in India for NCD care

Author	Year of Pub	Device Used	Techn ology	U/R	State	Setti ng	Disease	Verticle Name	Study design
Satish Kumar(10)	2015	Cell Phone	SMS	Urba n	Tamil Nadu	Prim ary	Diabetes	Client education and behavior change communication (BCC)	RCT
Ranjan Shetty(39)	2017	Tablet	POC	Rura l	Karnatak a	Prim ary	CVD	Sensors and point-of-care diagnostics	Diagnostic Accuracy
LipilekhaPatnaik (11)	2015	Comput ers, Cell Phone	SMS	Urba n	Odisha	Terti ary	Diabetes	Client education and behavior change communication (BCC);	RCT
Malay Verma(24)	2009	Handhel d Camera	Tele-trans misso n	Rura l	Tamil Nadu	Prim ary	Opthalm ic Diseases	Electronic decision support (information,protocols, algorithms, checklists); Data collection and reporting;	Cross Sectional
Khanna V(23)	2015	Smartph ones	Instan t Mess age	Urba n	Tamil Nadu	Terti ary	Health Systems	Provider-to-provider communication (user groups, consultation);	Cross Sectional

Devarsetty Praveen(17)	2014	Smartph ones	Applic ation	Rura l	Telangn a	Prim ary	CVD	Electronic decision support (information,protocols, algorithms, checklists)	Validation study
Maoyi Tian(16)	2016	Smartph ones	Applic ation	Rura l	Haryana	Prim ary	CVD	Client education and behavior change communication (BCC); Provider-to-provider communication (user groups, consultation);	Cluster RCT
Pallab K Maulik(22)	2017	Smartph ones	Applic ation	Rura l	Andhra Pradesh	Prim ary	Mental Health	Client education and behavior change communication (BCC); Electronic decision support (information, protocols, algorithms, checklists)	Cross Sectional
Bahrani K(40)	2017	Cell Phone	Telem edicin e	Urba n	New Delhi	Terti ary	Epilepsy	Client education and behavior change communication (BCC)	RCT
Cassie A Ludwig(25)	2016	Smartph ones	Applic ation	Rura l	Andhra Pradesh	Prim ary	Opthalm ic Diseases	Sensors and point-of-care diagnostics	Diagnostic Accuracy
Ambady Ramachandran(12)	2013	Cell Phone	SMS	Urba n	Tamil Nadu Andhra Pradesh	Prim ary	Diabetes	Client education and behavior change communication (BCC);	RCT
K Sureshkumar(2 1)	2016	Smartph ones	Applic ation	Urba n	Tamil Nadu	Terti ary	Stroke	Client education and behavior change communication (BCC)	Cross Sectional
Meenakshi Gautham(34)	2015	Smartph ones	Applic ation	Rura l	Tamil Nadu	Prim ary	Health Systems	Electronic decision support (information,protocols, algorithms, checklists); Provider work planning and scheduling; Provider training and education;	Cross Sectional
Surya Bali(13)	2007	Cell Phone	Telem edicin e	Rura l	Uttar Pradesh	Prim ary	Health Systems	Client education and behavior change communication (BCC)	Cross Sectional
Sudhir Sharma(41)	2016	Cell Phone	Telem edicin e	Rura l	Himacha l Pradesh	Prim ary	Stroke	Client education and behavior change communication (BCC); Provider-to-provider communication (user groups, consultation);	Cross Sectional
Susairaj Priscilla(31)	2015	Wearabl e, Cell Phone	POC, SMS	Urba n	Tamil Nadu	Prim ary	Diabetes	Client education and behavior change communication (BCC); Sensors and point-of-care diagnostics	Cross Sectional
Vamadevan S. Ajay(20)	2016	Smartph ones	Applic ation	Rura l	Himacha l Pradesh	Seco ndar y	Diabetes	Electronic decision support (information,Electronic decision support (information,protocols, algorithms, checklists)	Cohort
Pratik Shah(27)	2018	Tablet	POC	Rura l	Maharas htra	Prim ary	CVD	Sensors and point-of-care diagnostics; Electronic health records	Cross Sectional
Viswanathan Mohan(14)	2012	Cell Phone, Tablet	Telem edicin e, POC	Rura l	Tamil Nadu	prim ary	Diabetes	Client education and behavior change communication (BCC); Sensors and point-of-care diagnostics	Cross Sectional
Ramachandran Rajalakshmi(28)	2015	Smartph ones	POC	Urba n	Tamil Nadu	Terti ary	Diabetes	Sensors and point-of-care diagnostics	Diagnostic Accuracy
Ramachandran Rajalakshmi(30)	2018	Comput ers	AI	Urba n	Tamil Nadu	Terti ary	Diabetes	Electronic decision support (information,	Diagnostic Accuracy
Devraj Jindal(32)	2018	Smartph ones	Applic ation	Rura l	Haryana, Karnatak a	Prim ary	Diabetes	Client education and behavior change communication (BCC); Electronic decision support (information, protocols, algorithms, checklists); Data collection and reporting; Human resource management;	Clinical Trial
Arvind Raghu(33)	2015	Smartph ones	Applic ation	Rura l	Andhra Pradesh	Prim ary	CVD	Electronic health records	Cross Sectional
Chauhan V(42)	2018	Smartph ones	Tele- trans misso n	Rura l	Himacha l Pradesh	Prim ary	CVD	Sensors and point-of-care diagnostics; Electronic decision support (information,protocols, algorithms, checklists)	Cross Sectional

Vanshree Patil Balasinorwala(43)	2014	Computer	Telemedicine	Rural	Maharashtra	Primary	Mental Health	Client education and behavior change communication (BCC); Electronic health records	Cross Sectional
Sagar Vaishampayan(35)	2017	Cell Phone	SMS	Urban	Maharashtra	Tertiary	Cancer	Client education and behavior change communication (BCC)	Cross Sectional
Gopal Datt Joshi(44)	2011	Computer	Telemedicine	Urban	Andhra Pradesh	Primary	Diabetes	Sensors and point-of-care diagnostics; Data collection and reporting; Electronic decision support (information, protocols, algorithms, checklists); Provider-to-provider communication (user groups, consultation);	Cross Sectional
Sekar P(45)	2007	Computer	Telemedicine	Rural	Andhra Pradesh	Primary	CVD	Sensors and point-of-care diagnostics	Cross Sectional
Math RS(46)	2008	Tablet	POC	Urban	New Delhi	Primary	CVD	Sensors and point-of-care diagnostics	Diagnositc Accuracy
Nikhil SrinivasapuraVenkateshmurthy(47)	2018	Tablet	Application	Rural	Andhra Pradesh	Secondary	CVD	Client education and behavior change communication (BCC); Data collection and reporting; Electronic health records; Registries and vital events tracking; Electronic decision support (information, protocols, algorithms, checklists); Provider-to-provider communication (user groups, consultation);	Cluster RCT
Dinesh Kumar(48)	2018	Cell Phone	SMS	Rural	Himachal Pradesh	Primary	Diabetes	Client education and behavior change	RCT
L Kapoor(15)	2005	Cell Phone	Telemedicine	Rural	Uttar Pradesh	Primary	Health Systems	Client education and behavior change communication (BCC); Provider training and education;	Cross Sectional