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Mobile health applications during epidemic management in India: a review

Rajgourab Ghosh[1,*], Sanjeev Kumar[2]

[1]Amity Institute of Biotechnology, Amity University, Kolkata, India, rajgourav@hotmail.com
[2]All India Institute of Medical Sciences, Bhopal, India, docsanjiv@gmail.com

Abstract

INTRODUCTION: Smart cities endeavour to provide a good quality of life to its inhabitants. The COVID-19 pandemic necessitates redrawing the framework of epidemic management in India. Information, Communication & Technology (ICT) solutions such as mobile health (mHealth) can complement this.
OBJECTIVES: To review ICT and mHealth used for epidemic management in smart cities of India.
METHODS:A systematic review was conducted to identify the use of ICT or mHealth applications for epidemic management in smart cities. A predefined search strategy and a predefined eligibility criterion to search for articles published in English on Medline were used.
RESULTS: Our study showed ICT and mHealth use has increased during the recent COVID-19 pandemic in India and available solutions can be applied in smart city framework to improve epidemic management and achieve mHealth targets.
CONCLUSION: We conclude that there have been many advances in the provisions of ICT and mHealth interventions in India in context to smart cities and scope for improvements abound.

Keywords: ICT, mHealth, smart cities, epidemic, disease surveillance

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*Corresponding author. Email:rajgourav@hotmail.com

1. Introduction

Smart cities are conceptualized around the ideas that they would provide a good quality of life to its inhabitants using principles of equity, efficiency, and foresight. Several nations have developed policies to design smart cities. The smart cities are expected to have robust and flexible core infrastructure and incorporate technologies to this end. Innovations in the data sciences and technology have become the guiding principle in improving human health with changing urban landscape (Ramaswami *et al*, 2016). These innovations have often been termed as *Smart Solutions* which include Smart Mobile phones (Smartphones), Smart applications (Apps) for these phones, etc. Under the Smart Cities Mission of the Ministry of Urban Development, Government of India (MoUD), New Delhi Municipal Council (NDMC) has been selected as one of the first twenty cities (*http://smartcity.ndmc.gov.in/*). Many municipal services can now be availed simply through tapping on an app e.g. NDMC311 App or calling a number. Also dedicated websites are used to provide doorstep delivery of public services by the New Delhi government (*https://ar.delhigovt.nic.in/content/doorstep-delivery-public-services*) or provision of cash for elderly or immobile patients through India Post. (*www.indiapost.gov.in*) are a part of smart city project. Similar smart solutions include continuous and remote monitoring of the health status of the elderly (Majumder *et al.*, 2017). Smart solutions in healthcare can save both lives and money. The use of such smart health solutions would further transform a usual city into a smart city and add to the mission of 'Universal Healthcare'. This becomes more evident and a necessity in the ongoing pandemic of COVID-19. As a part of providing good quality of life, smart cities are expected to be resilient to epidemics.

The public health care system of India has been strewn with inadequacies in funding, infrastructure, and human resources. It has been reported that there are only 7 hospital beds on an average for every 10,000 of its population. Health resources have remained favourable towards urban India with 65–70 % of infrastructure and human resources allocation though ~70 % of the population resides in rural areas (Morris *et al*, 2016). In April 2020 there were nearly 1.9 million hospital beds, 95000 ICU beds, and 48,000 ventilators in India (Kapoor G. *et al*, 2020). Decision making in public health requires timely input in form of data relating to public health problems, infrastructural deficiencies, lacunae in human resources in healthcare, and implementation gap of the interventions. By understanding the distribution and determinants of health-related events in specified populations scientifically, diseases, and other health problems can be controlled before taking their toll on human life and economy. Monitoring and Surveillance form the backbone of any well-performing public health system. In surveillance, health data is collected, collated, analyzed, and interpreted in an ongoing manner. It provides information for action. Health surveillance includes detection of disease outbreaks, registration of cases, confirmation by standard methods, line-listing and reporting of these cases, data analysis and interpretation, epidemic preparedness, response, and control, followed by feedback. Understanding of chain of infection helps in identifying the targets in the chain such as cases, source, reservoir, mode of transmission, susceptible host, portal, or entry or exit of the infectious agent.

COVID-19 pandemic necessitates redrawing the framework of epidemic management in India. Surveillance and monitoring are some of the important processes in epidemic management. The government launched the Integrated Disease Surveillance Project (IDSP) in late 2004 as the response mechanism to outbreaks and epidemics. But, the IDSP's current model of surveillance is not equipped efficiently for population-level infectious disease surveillance. This gap has been especially pronounced during the ongoing COVID-19 epidemic of India. While IDSP is supposed to identify outbreak and epidemic based on surveillance data, it doesn't provide updates on the current status of the ongoing COVID-19 pandemic in India. Predictability for newer containment areas is missing on IDSP or other portals such as the National Centre for Disease Control (NCDC). The multiplicity of agencies involved in epidemic surveillance and the absence of timely information have undermined the risk communication available to citizens. There are examples of the use of crowd sourced data to provide dynamic and updated information on the COVID-19 pandemic both at the global level and in India. Websites such as *www.worldometer.info* and *www.covid19india.org* have been widely used both by health experts and citizens to keep themselves updated. It would be useful to know about smart health solutions for epidemic management in India. In the current article, we have tried to identify and evaluate mobile health applications used for epidemic management in India.

2. Methodology

2.1. Eligibility Criteria

We used the following criteria to include studies for our systematic review:

1. Original studies using primary data published in English language reporting about health issues in smart cities of India
2. Original studies using primary data published in English language reporting use of ICT (especially mobile health or mHealth applications) by frontline health workers or other categories of health staff of India
3. Original studies using primary data published in English language reporting methods of epidemic management in India

2.2. Search Strategy

We used the following search expressions on PubMed on 23 June 2020 to identify eligible studies:

1. smart [ti] AND city [ti] AND India
2. (smart city) AND ICT
3. ((mobile [ti] AND health [ti]) OR mHealth [ti] OR ICT [ti] OR (information [ti] AND Communication [ti] AND technology [ti])) AND India

(epidemic [ti] OR pandemic [ti] or outbreak [ti]) AND (management [ti] OR surveillance [ti] OR reporting [ti] OR investigation [ti]) AND India).

2.3. Selection of studies and data extraction

Both authors independently checked the articles obtained through the search process for eligibility. Both the authors used a standard data extraction sheet to collect the required variables (epidemic management, mobile health or mHealth, smart city, etc). The results were screened and finally eligible original studies were included for the identification of smart ICT solutions for epidemic management used in India.

3. Results

Two articles were obtained by using the expression “smart [ti] AND city [ti] AND India” for search. The number of studies obtained by using the other three search strategies was 25, 181, and 174 respectively. Title and abstracts of these studies were scanned to screen for eligibility. By using these search criteria, we could not find any studies on the use of ICT for epidemic management in India for smart cities. Hence we proceeded to conduct a narrative review of selected studies from this pool.

4. Discussion

4.1 Disease surveillance and epidemic management system in India

Many of the public health level disease control programs target one or all stages of the chain of infection of a particular disease. The concept of quarantine also emanated from the surveillance of plague in 13th century Europe. Eradication of Smallpox was possible through surveillance of cases and containment. This was aided by the vaccination of all susceptible in the containment zone. Eradication of Poliomyelitis was possible through surveillance of the Acute Flaccid Paralysis (AFP) cases and vaccination drives among under-five children in the country. (Banerjee *et al*, 2000) One of the recent examples of successful containment of a potential national-level epidemic was the outbreak of Nipah Virus (NiV) in Kerala. Timely identification of the outbreak followed by appropriate containment measures helped dissipate the risk of the outbreak becoming a state or national level epidemic. Surveillance was one of the keys to this success through quick identification of the NiV source in Pteropus bats, contact tracing of diagnosed cases, and risk communication with the public. (Sahay *et al*, 2020). Similarly, during the 2003 pandemic of severe acute respiratory syndrome (SARS), surveillance and containment measures helped in mitigating the risk of spread to other countries by using effective quarantine, mobility control, and contact tracing (Tognotti E., 2013). This strategy of quarantine is currently the primary step in controlling the current pandemic scenario of COVID-19.

At the national level too, efforts to establish a proper surveillance system have been done time and again. The Government of India initiated its efforts towards a robust national level disease surveillance mechanism through the launch of the IDSP in 2004 to obtain timely data for action on diseases having potential for outbreak and epidemic. (Sharma *et al*, 2010) This was preceded by the National Surveillance Program for Communicable Diseases (NSPCD) started in 1997-98 by the National Institute of Communicable Diseases (NICD) in 5 districts on a pilot basis. IDSP website mentions that there is a Central Surveillance Unit (CSU) in Delhi connected to State Surveillance Units (SSUs) in all states and union territories which are further connected to District Surveillance Units (DSUs) in all districts. A laboratory-based IT enabled disease surveillance system exists for epidemic-prone diseases. IDSP has a system of rapid response teams (RRTs) which is activated on suspicion of a possible outbreak of a disease from the local population. But the IDSP network seems to be inefficient for population-level communicable disease surveillance. Data for the 'rapid response' is collected every week through reporting by health workers, clinicians, and laboratories. Subsequently, the team visits the concerned area to establish the presence of the outbreak, its nature, and its extent. Most of these tasks are done in offline mode. Periodic innovations such as SMS based disease surveillance system for real-time monitoring was tried in Andhra Pradesh, but not scaled at the national level. There are 675 DSUs in the country currently. CSU provides supervision and feedback to PRUs. (Das *et al*., 2020) A media scanning and verification cell was established in 2008 at NCDC, New Delhi to monitor health news emanating from mass media. This team has trained epidemiologists and public health consultants and monitors global and national media to provide ‘early warning’. There are partners such as the website *www.healthmap.org* started by a group of researchers from Boston Children Hospital which aids the process. The media verification is conducted manually by the central team. The team at NCDC activates the respective District Surveillance Officer to verify any public health news arising from their area and reported in the media. The last report of such media alerts on the IDSP website was available for 2016. IDSP also has a system of obtaining disease alerts directly from citizens through its 24x7 Toll-free number 1075. An attempt to integrate health information for action has been made through the launch of the Integrated Health Information Platform (IHIP). Under this, an IDSP mobile app has been developed for use by health workers, clinicians, and laboratory staff to record IDSP related data in selected districts of India.

4.2 Development of technologies for ICT and health monitoring in smart cities

Computing technologies have dramatically changed the face of healthcare. Examples are the provision of tele-healthcare services (mHealth), Electronic health records (EHRs), and personal health records (PHRs) which made an appearance in the early 1990s in the USA. EHR technologies are getting harmonized by the integration of health data with other domains such as socio-economic, environmental, and behavioural and such integration is working towards precision medicine. (Evans RA, 2016) Mobile diabetes remote monitoring and self-management has been one of the early application areas of mHealth (Istepanian *et al*., 2016).

India being a vast country has its own limitations in providing healthcare especially specialized ones to far-flung areas as well as densely populated city spaces and this is where the role of mHealth can be extremely important. In the times of current epidemics and pandemics like HIV, SARS, NiV, COVID-19, etc. it assumes greater use and applicability. The use and accessibility of broadband and mobile services are now a reality in India where most of the city dwellers have mobile phones and broadband connections. A simple app registered to a user and connected to city health services can be a game-changer in case of any health-related emergency. Services such as simple text messages have been tried successfully to improve treatment adherence. (Lemay *et al*, 2012, Stenner *et al*, 2012). The ICT and mHealth based approach to coordinate care systems (Tamrat *et al*, 2012) remote monitoring (RM) of disease and surveillance (Place *et al*, 2014) can be effectively used to highlight their uses in a smart city-based approach to mHealth. Under the Smart city project for improving Health infrastructure New Delhi Municipal Corporation (NDMC) as a pilot project has installed **Health ATM's** in few places in New Delhi. Automated health screening with integrated devices with checkup option of over 40 health parameters is being made available to citizens. A walk-in to the Health ATM allows a patient to have quick preventive health checkup on prescription of doctors. The patient can also communicate with a doctor through a web camera provided in the Health ATM (*http://smartcity.ndmc.gov.in/content/projects/project-details/health-atms*). These improvements in health infrastructure are a boost for providing mHealth benefits especially during an epidemic when appointments with doctors are rare.

The use of big data has also transformed disease surveillance in developed countries. Analysis of Google search behaviour through the inbuilt tool Google Trends (™) has shown that epidemics can be predicted earlier than traditional surveillance methods. This method has been shown to produce an early warning of seven days for the H1N1 epidemic in the USA. Similar Google Trends (™) analysis has been shown to have a time-lag correlation with other outbreaks of Ebola Virus Disease, Zika, Dengue Fever, Chikungunya as well as COVID-19 in many countries. But these studies have been done after the outbreaks and epidemics were over. Google Trends (™) provides such analysis at the city level too. Similar big data analysis has been tried using data from Twitter (™) and YouTube (™) too. Smart city administrators can use this tool to see whether it can predict outbreaks and epidemics in real-time or help in identifying hot-spots during ongoing epidemics.

4.3 mHealth in India: Policies and actions

The number of mobile connections in India has grown to over 1.1 billion with around 56 % of the subscribers living in urban areas. The internet subscribers are pegged at 38.02 per 100 citizens among these, the wireless internet subscribers approximately comprise 98 % of all internet subscribers. Nearly 500 million people owned a smartphone in 2018 (COAI, 2019). These emerging changes require evaluation of their role in the health system strengthening. India also adopted the National Digital Communications Policy (NDCP) in the year 2018. Due to this policy, it is expected that the use of telemedicine would increase, more so during the ongoing COVID-19 pandemic. NDCP aspires to promote ICT towards the achievement of sustainable development goals (SDGs). (51st World Telecom and Information Society Day, WTISD, United Nations). Targets of mHealth may be achieved in developing countries (Malvey *et al*, 2017). Health systems have developed and incorporated the use of mobile devices in their healthcare providers in India (Majumder *et al*, 2015).

A National Digital Health Blueprint (NDHB) has been developed by taking advantage of the National Digital Health Eco-system (NDHE) facilitated by the Ministry of Health and Family Welfare (MoHFW). The overall vision of NHP (National Health Policy) 2017 is the guiding light for NDHB. A specialized National Digital Health Mission (NDHM) will implement the NDHB in a time-bound manner using a written action plan. There is a layered framework in NDHB. It consists of a vision and a set of principles as the core of the framework. The core leads to layers having hardware and other infrastructure, software data hubs, structural building blocks, indicators of standards, and regulations. Websites (eg. *https://www.nhp.gov.in/*) and mobile applications (e.g. MyHealth) provide access and delivery of the services. There are integrated Call-Centres for real-time monitoring. It has been envisaged that most of the services would be delivered using the 'mobile-first' principle. (NDHB, MoHFW, India, 2020). This kind of policy based on the push towards digitalization of medical infrastructure using ICT and mobile technology will greatly propel the momentum towards the integration of mHealth components into a smart city framework very conveniently and will be greatly helpful in managing diseases and epidemics.

4.4 Epidemics management through mobile-based technologies

Epidemics of communicable diseases can reach a larger susceptible population in a shorter period of time due to higher proximity in residential areas, workspaces, public transport, market places, etc. At the time of an epidemic, all resources are stretched beyond limits and it is prudent to focus resources according to the severity and incidences of the disease. It is also desirable to save time and prevent program errors to avoid inappropriate risk communication with people. Epidemics are characterized by Case definition i.e. suspected, probable, or confirmed. Indicators such as cumulative incidence (CUI), secondary attack rate, infection mortality rate, etc. are used to describe the disease frequency. CUI is the proportion of new cases developing among the total susceptible population at the beginning of the outbreak or epidemic. High-risk areas may be shown in different parts of the city and evolving scenarios of high CUI or decrease of it (Chen Q *et al*., 2016). Space-time Scan Statistics (STSS) has been used to capture disease-specific time and location distribution through both retrospective and prospective methods. The STSS has special utility in identifying the clustering of cases during epidemics. The number of cases with its location shared can help in assessing the control and command center of smart cities to decide how many and what type of personnel need to be deployed to manage that particular incident in real-time with lesser chances or errors. There are software such as SaTScan to obtain such results. (Kulldorff *et al*, 1996 and Kulldorff *et al*, 2001). Other methods such as indicator-based surveillance (IBS) and event-based surveillance (EBS) are used for early detection of outbreaks. (Pavlin *et al*, 2003) Public health officials would receive reports of previously defined diseases in the form of structured and validated reports from laboratories in the IBS method. Information obtained from non-health sources such as mass media, society emanating and propagating rumours, news stories, social media posts, blog contents, messaging systems, and websites, etc constitutes EBS. (CDC Bulletin, May 30, 2019) Automated intelligence methods such as Open-source intelligence (OSINT) are other modes of surveillance (Griggs *et al,* 2013, Asi *et al*. 2018). By using one or more of these methods of surveillance, health-related data can be shared on a common platform and communicated directly to the smart city suite of apps, where the respective agencies involved in healthcare can intervene and can provide immediate relief.

Mobile devices can be used both by Health workers and community-dwellers in field conditions to obtain primary data from the affected areas within the smart city ICT framework to help in coordinating the epidemic management efforts effectively. It is cheaper to use mobile health technologies in comparison to many other health system efforts. Mobile phones can be quickly equipped with data collection platforms or apps to transmit the data of individuals of the locality within the city with tagged geo locations and help in mapping of the disease. While there are plenty of apps in the Android Play Store (Google Inc., USA) and App store (Apple Inc., USA) free or paid, a large number of them are local / country-specific in nature while others are global. These rely on validated data obtained from govt approved data centers like hospital or municipal reports whereas a large number of apps take and consolidate data from unvalidated sources like crowd sourcing platforms, social media sites, and third-party data sources. Common examples during the ongoing COVID-19 pandemic are www.worldometer.info, www.covid19india.org, etc. Specific keywords were used such as infection, infectious diseases, outbreak, epidemic, pandemic, surveillance, public health, bioterrorism, CBRNE and reported 17 Applications for surveillance of one disease, seven for many diseases, and two Apps related to possible bioterrorism agents (Mohanty *et al*, 2019). These Apps consisted of tracking in real-time on an interactive map, daily alerts, reporting of diseases/ outbreaks by users, and options to monitor many diseases together. Another modality of epidemic management recently being used is based on crowd mobility data. Disease spread is often promoted by the movement of people. Therefore, by developing spatial-transmission models of infectious diseases, the epidemic spread can both be monitored and predicted. Data incompleteness or unavailability for countries like India is an issue for such endeavors. By using methods of network analysis, the dynamics of disease transmission in epidemics can be elucidated better (Ali and Keil, 2006, Neiderud C-J, 2015). Analysis of data about the movement of people can provide evidence on public response to interventions such as social distancing guidelines. (Buckee *et al*, 2020). Such mobility networks can help in the identification of containment zones rather than incomplete lockdowns in cities when accessed through ICT. The 'National Informatics Centre', (NIC) India has established connectivity through broadband at 378 data centers. These data captures can complement IDSP's systems. However, bureaucratic labyrinths and challenges in the operationalization of the call centers of IDSP and EDUSAT (Education Satellite) are obstacles in the dependability and consistency of such high-end technology. (Das *et al*, 2020). Further, these mobility datasets can be used to assess where people's movements are originating from a disease hotspot and this might pre-empt public health authorities on the emergence of new clusters.

Any city faces immense challenges in controlling the spread of dangerous epidemics depending on biomedical waste management, decontamination of ambulances every time by thorough cleaning or fumigation. Terminal decontamination of patient care centers or hospitals used to treat patients is also an important part of epidemic management. A smart city system would also monitor the time table and status of the above decontamination procedures of various hospitals in real-time using ICT to instill confidence in city dwellers for the treatment of diseases during epidemics. In any handheld mobile communication device, the use of web-browsers can be of importance if there are no apps developed yet for a particular issue.

4.5 Covid-19 as a case study for epidemics monitoring using mHealth.

The 'COVID-19' pandemic is a life-changing ongoing event in which almost the whole of the global population came to a halt. More than nine million people became sick and more than 0.4 million died. The lockdown in many countries has led to harsh living conditions for others. The highly communicable and deadly nature of the disease without any cure has forced people to stay away from contact and to maintain extreme hygiene and follow social distancing measures. The use of ICT during the 'COVID-19' epidemic has been unprecedented. Researchers have reported the use of apps in this regard. In a study, the Google (™) Play and the Apple (™) app stores were searched using the terms *'COVID-19'*, *'coronavirus'*, *'pandemic'*, an *'epidemic'*, individually. The authors also ran a keyword search for COVID-19-related apps using the phrase *'COVID-19 mobile apps in India'*. The search was conducted in the first week of April 2020 and updated on May 3, 2020. Out of the 346 app information, the authors reported that 27 apps (54%) provided information on preventive strategies not targeted to COVID-19, 19 apps (32%) were related to movement-monitoring, eight apps (16%) had functionality for contact tracing, and identification of hotspots (Bassi *et al*, 2020).

The Government of India launched "**Aarogya Setu**", an app available in 11 Indian languages. This has especially been designed for COVID-19 contact tracing, warning, and self-assessment (*www.mohfw.nic.in*) while it helps in self-assessment using a questionnaire it can be used for contact tracing in real-time. It helps in alerting the user against any unintended exposure or contact with any probably infected persons or their proximity to any containment area or zones within the city using a Bluetooth (™) interface on their smartphones. Since the adoption of guidelines on home quarantine of asymptomatic patients, this or similar app can incorporate user fed data about the daily status of symptoms, physical parameters like temperature, heart rates, and oxygen saturation levels to preempt smart health systems to identify the need for a hospital transfer. The use of the "**myGov**" app (www.gov.nic.in) has been a source of health information to people about the disease. The "**Ayush Sanjivani**" app (*www.ayush.nic.in*) launched by the Indian government can help people on the selection and use of Immunity boosting herbal/ ayurvedic concoctions. The need for volunteers during the epidemic becomes paramount due to immense pressure on the existing health services. Another website *www.covidwarriors.gov.in* provides a platform for trained human resources in health and volunteers to get deployed at short notice. This kind of volunteer-based service can be amalgamated into the smart cities' smart app concept. Some states like Delhi have already launched a "**Delhi Corona**" app (*www.delhi.gov.in*) for providing the state-specific data such as bed availability in state-run hospitals based on real-time occupancy of coronavirus affected patients among other useful statistics and information. The use of Health ATMs upgraded with testing facilities can also provide a big relief for citizens of a smart city when it is difficult to get doctor's appointments during an epidemic. These facilities when added to the smart city ecosystem of apps or suite of apps concept can quickly help in assigning the patient to the nearest hospital which has beds available and prevents any inconvenience to patients or health workers to find hospitals and save critical time and prevent early deaths.

The Community Health Workers (CHWs) in India were conceived for 'task-shifting' from higher-level medical providers, such as doctors and nurses, to lay workers, especially in response to the burden of the HIV epidemic (WHO, 2006). India has trained CHWs like "Accredited Social Health Activists" (ASHAs) and Anganwadi Worker (AWWs) who often provide door to door services. Most of the states had already trained these CHWs in the use of ICT and provided them smartphones During previous program implementation such as RMNCH+A. During the ongoing COVID-19 epidemic, these Health Care Workers (HCWs) have helped in preliminary screening in the community and obtain real-time data on epidemic status. The Village resource centers (VRC) of Indian Space Research Organization are examples of improving connectivity between tertiary care hospitals and primary health care centers. (*http://eresource.org/content/files/remote_rural_population.htm*). Such connectivity can be used between different quarantine centers or primary health centers in a smart city framework. Services like referral of patients to higher levels of care or providing information about available beds for hospitalization can be achieved faster.

While any epidemic causes severe mental stress and individuals are directly or indirectly affected by the disease, the affected persons can contact various helplines or use their mobile phones to chat with the counselors of government or NGOs using ICT enabled technologies even while staying in their containment zones. A 24×7 toll-free mental health rehabilitation helpline 'KIRAN' (1800-500-0019) was recently launched on 7 Sept 2020. The helpline, which was developed by the Department of Empowerment of Persons with Disabilities (DEPwD), aims to provide the first line of counselling in response to the increasing mental health issues among people due to the Covid-19 pandemic. Among the worst affected by the epidemic are the HCWs dealing with this epidemic daily. Health staff, especially in the government system, often suffers mental health issues. These have an increased likelihood of escalation during the current COVID-19 pandemic. A dedicated helpline for all frontline personnel is helpful. Helplines have been started on mental health both at the national level and by many state government and health-related associations. For example, there is Karnataka State Helpline 104, IMA helpline 999116375, and 999116376, as well as one from NIMHANS helpline

(080-46110007). While telephone helpline exists, an ICT using a mobile app providing direct AV communication links connected to the vital parameters detecting anxiety of the HCWs can be activated to bring the support system including psychiatrists, families, and friends together to support the HCWs in times of stress.

One of the biggest fallout of the COVID-19 pandemic has been the difficulty of non-COVID-19 patients to obtain healthcare. This brought focus on another important constituent of mHealth which is Telemedicine and telehealth. There has been recent improvement in internet infrastructure in the form of improved speeds, larger storage capacity, harmonized data transmission formats, better encryption, and safety in password protection. Data safety norms have improved since the passage of *the Health Insurance Portability and Accountability Act or HIPAA* of 1996, USA. Health information is now more readily available in digitized form. Telemedicine has been scaled up especially during the COVID-19 pandemic (Devin *et al*, 2020). The Indian government also revised the telemedicine guidelines in March 2020 to motivate the healthcare providers to increase its use without fear of legal hassles. The Indian government also launched the "**e-sanjeevani OPD**" as an online OPD service to this effect. Several mobile apps by the private sector like Practo (™), Lybrate (™), DocsApp (™), etc. are already functional or being launched to newer regions. A large number of private registered medical practitioners (RMP) can opt for the inbuilt app-based diagnosis tools using ICT enabled visuals and discussions and safely provide relief to patients right from their home. The issue of protection of data available on these platforms is a constant concern. *Digital Information Security in Healthcare Act ('DISHA')* was drafted by MoHFW which is to be subsumed in the *'Data Protection Framework on Digital Information Privacy, Security & Confidentiality' Act* being drafted by the Ministry of Electronics and Information Technology (MeitY). In the meantime, MoHFW has circulated telemedicine practice guidelines with relaxations during the COVID-19 epidemic on 25th March 2020. Recorded video tutorials and patient self-help guides can be transmitted via video-sharing platforms like YouTube (™). In case of communication which requires feedback and monitoring by doctors, live demonstrations in telemedicine apps are required. Recently another mobile app the "**eBlood Services**" Mobile Application by MoHFW was launched. Indian Red Cross Society (IRCS) has partnered in this effort.

Another major necessity of many people during any disaster especially like these epidemics is the access to monetary resources, especially for those in containment zones or not having transportation facilities to go to banks or ATMs. Doorstep delivery of Cash was started by Indiapost Payments Bank, Department of Post, Govt. of India (*www.indiapost.gov.in*) using AADHAR based digital verification of the person by the visiting post-office personnel using the mobile technology and access. Similarly provision of essential commodities like food and medicines was also compromised during the lockdown. Doorstep delivery of ration and medicine and many other services using ICT and telecommunication services helped tide over these difficulties for city dwellers where lockdown was more stringently enforced. All the above problems being faced by the people staying in cities can be very easily sorted out by using ICTs along with access to mobile devices and the citizens of smart cities can use the full features of mHealth and successfully sustain the deadly epidemic.

5. Conclusion

The ongoing pandemic of COVID-19 has tested the earlier framed national policies and recent developments in ICT interventions in real-time. In this review, we conclude that there have been many advances in the provision of mHealth interventions at national and state levels. ICT solutions such as IHIP of IDSP, "**Aarogya Setu**" app, "**myGov**" app, "**Ayush Sanjivani**" app, "**e-sanjeevani OPD**" app, "**eBlood Services**" app, "**Delhi Corona**" app, etc have successfully launched for healthcare provisions. Innovations like the **Health ATMs** connected to doctors or HCWs to help citizens are very useful towards the integration of mHealth in the smart cities framework especially during epidemics. Though we couldn't identify any published ICT intervention to manage epidemics in smart cities of India, we believe that the recent advances in mobile and ICT related technologies introduced at national and state levels can be customized for this purpose too. The rapid advance and access of handheld or mobile devices to the citizens in cities in general and smart cities, in particular, should usher in a wave of ICT and mobile telecommunication based medical interventions. The recent policy decisions by the Government of India and the release of NDHB, 2020 has brought a much-needed boost in this direction. The principles of equity, efficiency, and foresight relevant in unleashing full features of mHealth for smart cities in India need to incorporate the opportunities presented by the amalgamation of ICTs into these policy changes. The implementation of timelines will benefit mHealth and its incorporation into smart city networks and disease management much more easily. The importance and seamless integration of citizens' health data with municipal, health, and other public services using the mHealth platform in a smart city framework during an epidemic cannot be more emphasized with the current changes for densely populated cities of India.

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References

[1] Ramaswami A, Russell AG, Culligan PJ, Sharma KR, Kumar E. Meta-principles for developing smart, sustainable, and healthy cities. Science. 2016; 352(6288):940-943. doi:10.1126/science.aaf7160

[2] Majumder S, Aghayi E, Noferesti M, *et al*. Smart Homes for Elderly Healthcare-Recent Advances and Research Challenges. *Sensors (Basel)*. 2017;17(11):2496. Published 2017 Oct 31. doi:10.3390/s17112496

[3] Tognotti E. Lessons from the history of quarantine, from plague to influenza A. *Emerg Infect Dis*. 2013;19(2):254-259. doi:10.3201/eid1902.120312

[4] Banerjee K, Hlady WG, Andrus JK, Sarkar S, Fitzsimmons J, Abeykoon P. Poliomyelitis surveillance: the model used in India for polio eradication. *Bull World Health Organ*. 2000; 78(3):321-329.

[5] Sahay RR, Yadav PD, Gupta N, et al. Experiential learnings from the Nipah virus outbreaks in Kerala towards containment of infectious public health emergencies in India. *Epidemiol Infect*. 2020; 148:e90. Published 2020 Apr 23. doi:10.1017/S095026882000082

[6] Evans RS. Electronic Health Records: Then, Now, and in the Future. *Yearb Med Inform*. 2016; Suppl 1(Suppl 1):S48-S61. Published 2016 May 20. doi:10.15265/IYS-2016-s006

[7] Information and communication technology network. Integrated Disease Surveillance Programme, Ministry of Health & Family Welfare, Government of India. https://idsp.nic.in/index4.php?lang=1&level=0&linkid=408&lid=3691

[8] Istepanian RSH, Woodward B. m-Health: Fundamentals and Applications. Hoboken, NJ: Wiley-IEEE Press, 2017.

[9] Petteway R, Mujahid M, Allen A, Morello-Frosch R. Towards a People's Social Epidemiology: Envisioning a More Inclusive and Equitable Future for Social Epi Research and Practice in the 21st Century. *Int J Environ Res Public Health*. 2019; 16(20):3983. Published 2019 Oct 18. doi:10.3390/ijerph16203983

[10] Lemay NV, Sullivan T, Jumbe B, Perry CP. Reaching remote health workers in Malawi: baseline assessment of a pilot mHealth intervention. *J Health Commun*. 2012;17 Suppl 1:105-117. doi:10.1080/10810730.2011.649106

[11] Stenner SP, Johnson KB, Denny JC. PASTE: patient-centered SMS text tagging in a medication management system. *J Am Med Inform Assoc*. 2012;19(3):368-374. doi:10.1136/amiajnl-2011-000484

[12] Tamrat T, Kachnowski S. Special delivery: an analysis of mHealth in maternal and newborn health programs and their outcomes around the world. *Matern Child Health J*. 2012;16(5):1092-1101. doi:10.1007/s10995-011-0836-3.

[13] Place J, Farret A, Del Favero S, Bruttomesso D, Renard E. Assessment of Patient Perceptions About Web Telemonitoring Applied to Artificial Pancreas Use at Home. *J Diabetes Sci Technol*. 2014;8(2):225-229. doi:10.1177/1932296814525540

[14] Kapoor G., Sriram A., Joshi J., Nandi A., Laxminarayan R.COVID-19 in India: State-wise estimates of current hospital beds, intensive care unit (ICU) beds and ventilators https://cddep.org/wp-content/uploads/2020/04/State-wise-estimates-of-current-beds-and-ventilators_20Apr2020.pdf (www.cddep.org)

[15] Morris M, Powick A, de Vettori E, et al. Deloitte 2016 Global Healthcare Outlook: Battling costs while improving care. 2016. https://www2.deloitte.com/content/dam/Deloitte/global/Documents/Life-Sciences-Health-Care/gx-lshc-2016-health-care-outlook.pdf

[16] COAI, STT section, Deptt. Of telecommunication, India, 2019. https://dot.gov.in/sites/default/files/TelecomAccountFinanceManual_Oct.07_1.pdf

[17] Malvey DM, Slovensky DJ. Global mHealth policy arena: status check and future directions. *Mhealth*. 2017;3:41. Published 2017 Sep 22. doi:10.21037/mhealth.2017.09.03

[18] Majumdar A, Kar SS, S GK, Palanivel C, Misra P. mHealth in the Prevention and Control of Non-Communicable Diseases in India: Current Possibilities and the Way Forward. *J Clin Diagn Res*. 2015;9(2):LE06-LE10. doi:10.7860/JCDR/2015/11555.5573

[19] Sharma R, Luthra P, Karad A, Dhariwal AC, Ichhpujani RL, Lal S. Role of information technology (IT) in public health, India (problems & prospects): Role of information communication technology (ICT) in disease surveillance under Integrated Disease Surveillance Project (IDSP). *J Commun Dis*. 2010; 42(2):101-110.

[20] NDHB, MoHFW, India, 2020 https://main.mohfw.gov.in/sites/default/files/FinalReportLiteVersion.pdf

[21] Chen Q, Lai S, Yin W, et al. Epidemic characteristics, high-risk townships and space-time clusters of human brucellosis in Shanxi Province of China, 2005-2014. *BMC Infect Dis*. 2016;16(1):760. Published 2016 Dec 19. doi:10.1186/s12879-016-2086-x

[22] Kulldorff M. A spatial scan statistic. Commun Stat: Theory Methods. 1997;26:1481–1496. doi: 10.1080/03610929708831995.

[23] Kulldorff M. Prospective time-periodic geographical disease surveillance using a scan statistic. J Roy Stat Soc A Stat. 2001; A164:61–72. doi: 10.1111/1467-985X.00186.

[24] Pavlin JA, Mostashari F, Kortepeter MG, et al. Innovative surveillance methods for rapid detection of disease outbreaks and bioterrorism: results of an interagency workshop on health indicator surveillance. *Am J Public Health*. 2003;93(8):1230-1235. doi:10.2105/ajph.93.8.1230

[25] Griggs D, Stafford-Smith M, Gaffney O, et al. Policy: Sustainable development goals for people and planet. *Nature*. 2013; 495(7441):305-307. doi:10.1038/495305a

[26] Asi YM, Williams C. The role of digital health in making progress toward Sustainable Development Goal (SDG) 3 in conflict-affected populations. *Int J Med Inform*. 2018;114:114-120. doi:10.1016/j.ijmedinf.2017.11.003

[27] Mohanty, B., Chughtai, A., and Rabhi, F., 2019. Use of Mobile Apps for epidemic surveillance and response – availability and gaps.. Global Biosecurity, 1(2), pp.37–49.

[28] Keil R, Ali H. Governing the Sick City: Urban Governance in the Age of Emerging Infectious Disease. *Antipode*. 2007;39(5):846-873. doi:10.1111/j.1467-8330.2007.00555.x

[29] Neiderud CJ. How urbanization affects the epidemiology of emerging infectious diseases. *Infect Ecol Epidemiol*. 2015;5:27060. Published 2015 Jun 24. doi:10.3402/iee.v5.27060

[30] Das M, Singh H, Girish Kumar CP, John D, Panda S, Mehendale SM. Non-vaccine strategies for cholera prevention and control: India's preparedness for the global roadmap. *Vaccine*. 2020;38 Suppl 1:A167-A174. doi:10.1016/j.vaccine.2019.08.010

[31] Buckee CO, Balsari S, Chan J, et al. Aggregated mobility data could help fight COVID-19. *Science*. 2020;368(6487):145-146. doi:10.1126/science.abb8021

[32] Bassi A, Arfin S, John O, Jha V. An overview of mobile applications (apps) to support the coronavirus disease 2019 response in India. *Indian J Med Res*. 2020;151(5):468-473. doi:10.4103/ijmr.IJMR_1200_20

[33] Taking stock: Health worker shortages and the response to AIDS. Geneva, World Health Organization, 2006 available at *http://www.who.int/hiv/toronto2006/takingstockttr.pdf*

[34] Devin M, Chen J., Chunara R, Testa P A, Nov O., COVID-19 transforms health care through telemedicine: Evidence from the field, J. Am Med Informatics Asso., Published online ahead of print 2020 Apr 23: ocaa 072 (PMCID: PMC7188161)

[35] Mahajan V, Singh T, Azad C. Using Telemedicine During the COVID-19 Pandemic. *Indian Pediatr*. 2020;57(7):652-657.

[36] MoHFW, Government of India *https://www.mohfw.gov.in/pdf/HCWMentalHealthSupportGuidanceJuly20201.pdf*