Data Science and Analytics in Healthcare

Impact of Mobile Health and Wellness Services on Society

Research essay

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1 Introduction

Healthcare-related issues are without a doubt the biggest hindrance to sustained global growth, and they are made worse by a range of socio-economic issues and scarcity of resources. Poor healthcare access is a significant roadblock to global social and economic advancement. Globally, two billion people lack access to necessary pharmaceuticals, while 400 million people lack even the most basic healthcare (Balasubramaniam, K. (2002), p90-107). The upshot is that the health needs of a quarter of the world's population go unmet. The challenge of figuring out how to support them while receiving healthcare falls on the worldwide community because a sizeable portion of the global population still lacks access to necessary prescription pharmaceuticals.

In light of this, the WHO chose the theme of Universal Health Coverage (UHC), or healthcare for all people, everywhere, for World Health Day in 2018. The strategy calls for universal access to essential healthcare services. Variables including systemic financial constraints and chronic diseases brought on by an aging population can have an impact on the accessibility, availability, and quality of care. Many challenges in healthcare might be reduced and their negative impacts lessened by using current and developing technology. Studies show that the healthcare system in India, which has the major rural population in the world, has to be improved with new ideas. Kumar, H., et. al., (2020) in the study presents a framework that may analyze gathered data from portable devices to offer ideas for the creation of policy for rural healthcare in India.

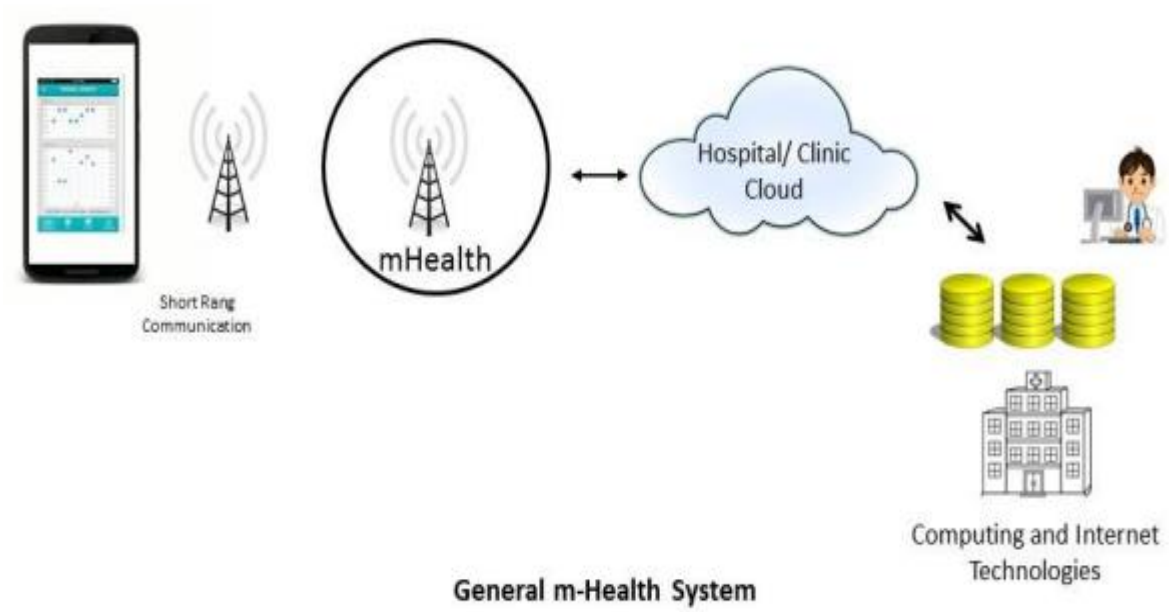

Figure 1: The fundamental building block of m-Health(Istepanian, R. et. al, (2017) p. 102-108)

The usage of mobile-enabled applications for gathering or disseminating health care information and data, or "m-health" (m-health), has significantly increased since the introduction of mobile communication devices like smartphones and tablet computers. These applications offer a

fresh approach to enhancing health outcomes as well as a chance for active patient and provider involvement in healthcare. The treatment of people with chronic conditions including diabetes and congestive heart failure as well as the prevention of cardiovascular disease may make substantial use of this technology. The rapid growth of the m-health sector has not been matched by the science needed to verify the clinical efficacy (and safety) of health-related applications. The US Food and Drug Administration recently published guidelines that will ensure the effectiveness and safety of m-health apps in a manner comparable to those of other medical devices. This is a result of the widespread usage of smartphones and m-health applications.

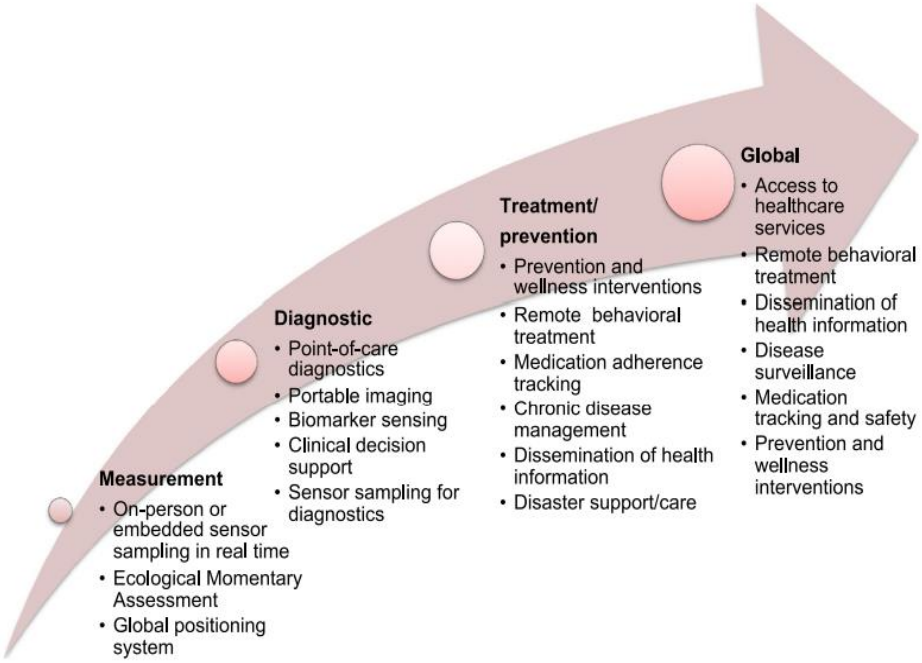

Figure 2: Continuum of m-health tools(Kumar, S., et. al., 2013 p.228-236)

In sub-Saharan Africa, there is a lot of interest for successful m-health initiatives, but little is known about their usefulness or effectiveness. Text message reminder systems have been used in the majority of randomized trials evaluating m-health therapies. Two systematic studies have supported this by sending reminders as text messages to improve presence at medical appointments with a strong evidence base.

2 Use of m-health for pandemic management

The recent Ebola and Severe Acute Respiratory Syndrome (SARS) outbreaks demonstrated the screening, discovery, and monitoring of such widespread pandemic through m-health applications(Bempong, N. E. et. al., 2019). In contrast to Low-and Middle-income countries (LMINs), most High-Income Countries (HICs) have used m-health technologies and applications to combat the current COVID-19 epidemic and other communicable diseases. Currently, a Canadian study has shown that m-health applications have been used for COVID-19 case screening, diagnosis, and monitoring(Alwashmi, M. F, 2020). Applications for m-health are being deployed in several HICs to track down contacts of COVID-19 cases as part of the worldwide effort to stop this

outbreak. Osei, E et. al., (2021) in the previous studies conducted in China, m-health has been recognized as a strategy for COVID-19 patient screening and treatment, which helps to lower the transmission risk to other patients and healthcare workers. Studies have revealed that m-health applications have likely to improve the early diagnosis of the highly contagious COVID illness when evaluated to the standard techniques of disease analysis and action to cure. Once more, the US survey showed that m-health applications were incorporated into the healthcare delivery system to monitor medical personnel for COVID-19 symptoms to aid in the global fight against this epidemic. According to research done by Rao and Vazquez (2020), m-health applications helped doctors in Switzerland for the early finding of COVID-19 cases and isolate affected people to break the spread of the disease and lower the infection rate. Public health professionals in Singapore employed an m-Health app as a crucial tool to screen and find people who had been exposed to COVID-19 infected patients to cut the transmission chain.

3 Utilization of m-health applications in Low and Middle-Income Nations' healthcare (LMINs)

The introduction of m-health interventions had a profoundly revolutionary impact on how healthcare is delivered, especially in terms of supporting patient care, diagnosing conditions, keeping track of one's health, and data accuracy, among many other areas. The incorporation of m-health technology into the currently offered medical services is opening up fresh, diverse avenues for high-quality healthcare. With the help of innovative technology, the healthcare system, professionals, and patients may all work together to promote high-quality medical care. In the upcoming years, mobile technology use and influence are probably going to grow. It has been identified through surveys that the vast improvement found in m-healthcare (i.e over 80% of the worldwide in 2017 whereas just 39% in 2013). In comparison to 2014, it is predicted that there will be 2.87 billion smart mobile device users worldwide by 2020 Reisman, M. (2017).p572. Low-cost smartphones offer the essential capabilities and features, as well as the required connectivity, to handle health-related applications (Istepanian, R. S., & Woodward, B. (2016)).

The benefits of m-health in LMINs are the following: m-health applications include examination, prescription and treatment adherence monitoring, appointment reminders, patient-provider communication, and screenings for infectious and non-infectious diseases in pregnant women and children.

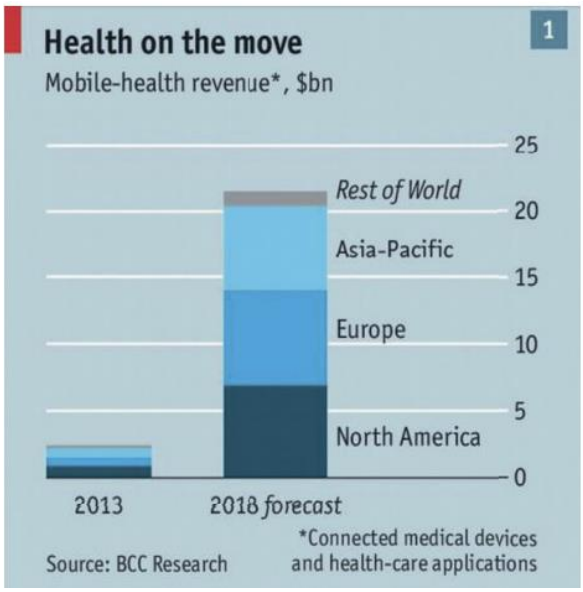

Figure 3: Global m-health markets (Madanian, S.,2019).

4 Mobile Applications for Healthcare

Around a billion people in India use mobile phones, and 75% of those people can access mobile applications. In these situations, using mobile apps for remote healthcare is expected to offer serval advantages, including patient management, increased effectiveness and time savings, cost savings, and illness analysis, which in turn helps advance disease research. In the last five years, several health apps have been developed to satisfy the core needs of healthcare services. These health applications can be loosely categorized into five classes based on how they are used in the medical industry. These are

1. Getting references and information.
2. Online counseling.
3. A system for making clinical decisions.
4. Patient surveillance.
5. Creation of In-advance alerts

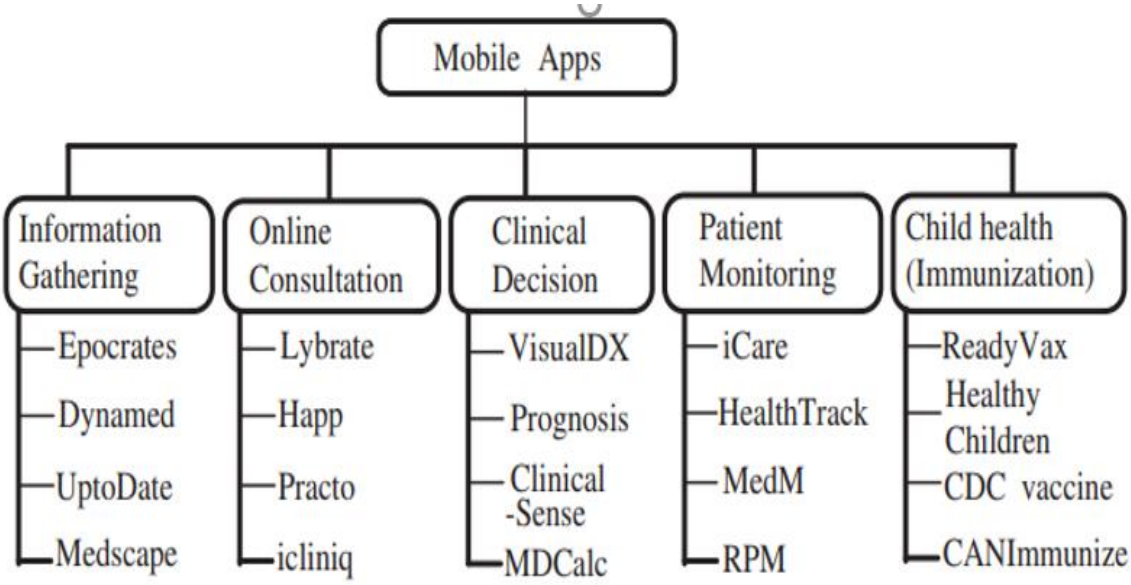

Figure 4: State of Art of mobile health app (Silva, B. M et. al., 2015)

Studies from Chib and Wilkin (2012) and, White (2012) were analyzed to identify the facts and factors associated with it. Technology availability and use, as well as the usefulness of the findings in terms of fulfillment, response rates, data precision and percentage of inaccuracy, and system costs, were recognized as the technological inputs necessary for the deployment of m-health.

5 Methodology

Various methods of the m-Health phenomenon, various theoretical and investigation strategies have been reviewed in this essay.

5.1 m-Health 2.0 and big data

In general, Big data is categorized into two types (Istepanian, R. S., & Al-Anzi, T. (2018).):

Structured data: For large data, these often relate to the data that is predefined in terms of length and format (e.g., integers, date, strings, etc.). These data are produced by various devices, including computers, smartphones, sensors, weblogs, etc. Only one-fifth of the collected data generated typically consists of this kind of data. Structured health data is the data taken from EPR, EHR, monitoring at home, treatment data, prescriptions, etc.

Unstructured data: Major portion of the data collected from many sources, including common data from social media, mobile data, video, and web content, is generally referred to as big data and does not follow a certain structure. Social health information such as clinical notes, medication records, and instructions acquired through postings in tweets, Facebook, and blogs are instances of unstructured data.

The significance of big data and its effects on healthcare in common and digital health, in particular, are still being discussed in relation to healthcare. This argument is relevant to and

important for m-health given the anticipated rollout of the Fifth Generation (5G) mobile network. After 2020, ecosystems are connected by the Internet of Things (IOT) and its communications infrastructure. These innovations are expected to enable the connection of billions of smart gadgets and mobile phones across a range of wireless network topologies and formats. Most portable devices and sensors will be connected using 5G mobile networks and their compatible/wireless technologies. This is also complemented by a new generation of smart wearables that will be released soon. Big data can present considerable opportunities in a wide range of m-Health use cases. The eight main areas that Olla and Shimskey (2015) utilize to categorize the m-Health use cases are point-of-care diagnostics, wellness, patient observance, compliance, behavior change, education and orientation, effectiveness and output, and environmental observance.

The following can be used to demonstrate the connection between and possible influence of big data for different use cases:

Point-of-care diagnostics: Mobile medical equipment can be used at home, or in an ambulance/hospital, to do tests including glucose, cholesterol in blood, and urine level assessments to quickly gather results and treat the patient. In a study carried out by King and his fellow researchers (2016), the use of big data techniques for the examination of point-of-care diagnostics data has a substantial likeliness of enabling precision medicine or individualized therapy (Stroux, L., et. al., 2016, p356-371).

Wellness: Applications in the wellness category encourage beneficial user actions like exercise and diets. The information gathered through wearable technology is linked with other wellness devices and is utilized to enhance patient wellness, investigative techniques, and treatment approaches, though it is not designed to prevent, diagnose/treat any diseases directly. MyFitnessPal, a mobile app that helps users track their caloric intake and create diet charts, uses big data techniques to do sophisticated analyses on the data it collects.

Patient observance: Making the possibility of scrutinizing real-time data from a patient's handheld device to spot significant changes in critical parameters. Guo et al. (2016) studied and reported that patients can learn how to recognize their activities by carrying just a regular smartphone with standard motion sensors. Jiang et al. (2014) outlined a big data solution for ongoing senior care that alerts appropriate caregivers and sends relevant data to a big data system for analysis when it is necessary (Waterlander, W., et.al., 2014).

Compliance: To ensure that a patient is accurately following the recommended treatment or healthcare plan, a patient may be observed. With this self-testing, data observed from portable biomedical equipment are also included. The patient observation records can be studied using big data analytics technologies to minimize the effects of non-compliance on patients.

Behavior change: The availability of individualized treatment and diagnostic models as well as helpful resources for changing everyday habits are both included in patient health records. By way of illustration, Chen et al. (2016) propose employing big data analytics to categorize the diagnostic variables of cancer. Big data techniques are suggested by Quan Do et al. (2015) to be used on data gathered from mobile apps to track asthma triggers, predict asthma episodes, promote self-management, and connect with healthcare professionals. Various studies supported the relevance of a big data-driven approach for tailored care (Chawla and Davis 2013).

Education and orientation: m-Health apps might offer current information that can be utilized to instruct individuals and medical professionals. Big data can offer a perspective and insights into the medical curriculum when used in medical education. Moreover, for a wide range of investigations and projects, students and professionals can access massive data sets.

Effectiveness and output: Physicians now have detailed access to patient medical histories, including previous treatments, drugs, and other medical information, thanks to big data applications in healthcare. The diagnosing procedures can be improved by having quick and trustworthy access to such information. Thus, shortening the time needed to diagnose patients, this will not only lower the cost of diagnosis but also improve its effectiveness.

Environmental observance: By examining social media like Twitter, Facebook, and blogs, one can investigate flu or other plagues in a territory. Using real-time tweet streams, a recent study suggests a prototype application to gather and examine influenza cases across various regions (Wang et al. 2016).

The suggested architecture is made up of three main parts: the output directed towards the mobile care monitor, Artificial Intelligence and big data analytics, and medical data gathered from patients via social media and handheld devices (Alotaibi, S. R. (2020)). The probable system's design is shown in Figure 5. The process of examining a sizable amount of collected data from different sources and presented in different formats is fully processed by the integration of AI with big data platforms which enables a decision-making process instantaneously. The patient's data is then analyzed utilizing various analytics techniques, such as data mining and artificial intelligence. Big data analytics can be applied to find abnormalities by analyzing large data gathered from many datasets and their sources, such as biomedical imaging and signals, physiological sensing data, and genetic data. Just the two modules that make up an AI-based engine are the stream analysis module and the AI-based report management tool which examine the queries generated by the big data analysis tool.

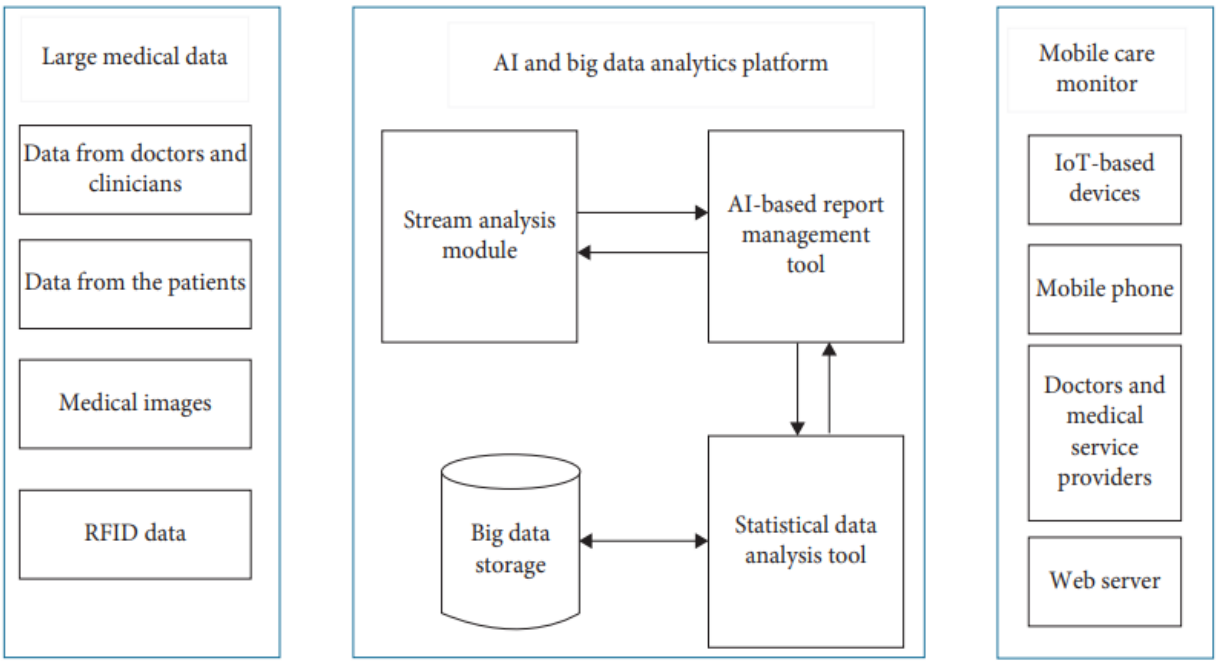

Figure 5: Architecture of the proposed AI and big data analytics-based m-health system (Alotaibi, S. R. (2020)).

6 Concerns with m-health

6.1 Using Open Infrastructure and Data Standards

M-health technologies can increase research competence through design and technological capabilities, as well as by creating modular platforms to share information and, standardize and organize data. Key interfaces working between the hardware and software parts of the open m-health system should be designed and selected in collaboration with stakeholders, according to the open platform based on the Internet environment. Additionally, an open m-health strategy necessitates the publication and public accessibility of interfaces. This methodology should decrease the necessity of starting any project from "fresh" and instead build upon already developed apps. Open m-health is creating a set of open-source, interoperable modules for the analysis and arrangement of m-health data for utilization by data researchers and practitioners.

The open platforms also show that using uniform measures and standards could be advantageous for m-health research. Two examples of the kinds of things that these standards might include are the creation of databases and the use of "metatags" on sensor data to enable cross-reference. The use of standard metrics like those in the NIH PROMIS program (Patient Reported Outcomes Measurement Information System), the Neuroscience toolkit (www.nihtoolbox.org/Pages/default.aspx), and PhenX (www.phenx.org/) could also advance the field by enabling the same kinds of resemblance.

6.2 Privacy, Security, and Confidentiality

The handling of privacy, security, and confidentiality concerns arise from the possibility that m-health data could expose extremely private information, including social interactions, geographic location, emotional state, and other potentially delicate health issues. With the growing use of video surveillance for public safety in recent years, society has tended to favor the collecting of personal data for the benefit of the broader public. For the m-health research community, it is currently challenging to uphold participant privacy and confidentiality while continuing to advance research.

According to recent research, this can be accomplished by separating numerous data flows and employing privacy protocols that deal with data secrecy, validity, and integrity. A single lost communication or piece of information is usually insufficient to make inferences that could jeopardize someone's confidentially, but several intercepted transmissions from a source can establish an unrecognizable profile. Unlinking, the last step is essential because of this. When location information is available, this is especially true. The secrecy, validity, and integrity of the data are guaranteed through encryption, which modifies the data using a key known only to users on either end of the transmission. Each data packet's linking attributes are scrambled using a unique key that can only be accessed by the dispatcher and the recipient. These challenges may be fundamental for research participants who need the most medical attention, such as the elderly and underprivileged or low-income groups. The connecting properties of each data packet are encrypted using a special key that is only accessible by the sender and user.

Data transmission issues and incorrect patient data entry that could have an impact on a patient’s health status when medical choices are made are additional dangers linked with the use of m-health therapies. As well, employing m-health applications remotely could be risky in cases of drug combinations and patients with hypoglycemia that could cause complications, according to a research in LMINs. Similar studies conducted in LMINs found that several m-health applications created for opioid dosage conversion or melanoma detection had low performance since they did not adhere to evidence-based recommendations. Additionally, due to insufficient patient data privacy, patients and healthcare professionals who utilize m-health apps to enhance healthcare delivery may be seriously at risk. Moreover, studies have shown that programming errors may increase the risk for m-health apps that perform difficult functions, such as medication dosages. Furthermore, erroneous or out-of-date content in m-health applications may enhance the danger of injury to potential users.

6.3 India's healthcare system and challenges

In addition to the universal problems in healthcare, India's healthcare system also has problems with money, infrastructure, and disparities between rural and urban areas. Indians pay

more than 62% of their medical costs out of their savings because the government's overall healthcare budget is modest (4.7% of GDP) given the size of the country's population. In comparison to other growing economies, India is considerably behind in this area. When it comes to disparities in access to healthcare, India has unique difficulties. In India, only one government hospital bed and one government physician for every 10189 citizens were found. Rural areas account for more than 86% of hospital visits, and the majority of these patients must travel a considerable distance to get to the hospital. In some areas, when the population is large, there are not enough physicians, nurses, and other health professionals to meet the demand. Due to the concentration of medical professionals in metropolitan regions (80% of doctors and 60% of hospitals), rural areas require more than 3000 doctors. There aren't many registered practitioners in rural India, 57.3% of doctors lack a medical degree, and 31.4% of allopathic doctors only have Class 12 training, as per a WHO survey (HRG, S. (2009).).

However, m-health and big data analytics may build healthcare more readily available, affordable, and accessible for broader communities. As a result, the healthcare system in India may benefit from current advancements. The use of mobile technology and its consequences are expected to increase in the future years. Compared to just 39% in 2013, polls indicate that mobile technology and gadgets accounted for over 80% of the global market in 2017. In 2020, there will be 2.87 billion more smart mobile device users worldwide than there were in 2014 (Madanian, S, et. al., 2019). The fact that low-cost smartphones have the features, capabilities, and connectivity needed to handle health-related applications could enhance the importance of m-health worldwide. As m-health becomes more popular, countries are investing more resources to it, and it helps to literate the society and communities in healthcare which promotes well-being rather than very expensive medical interventions and hospitalization.

M-health can provide new healthcare alternatives if technology is adopted into the Indian healthcare system, especially in low-resource settings where healthcare institutions are limited by their infrastructure, knowledge, and human resources. Indian healthcare may benefit greatly from m-health, particularly in rural areas where access to medical care may be constrained. M-health could make basic healthcare services more accessible to these populations, and the data it generates from the analysis could be used to help shape future healthcare needs. The following reasons suggest that India might be able to benefit particularly from m-health (Madanian, S et. al., 2019):

1. Rural Indians struggle to receive proper and timely healthcare treatments since there aren't enough resources or access to them. The bulk of people in India resides in rural areas, hence a new healthcare system is required. M-health may be able to help in this circumstance.

2. Over 1 billion mobile customers made up 86.8% of the population in India by 2018–24, with 42% of those subscribers residing in rural regions and over half of them owning a smartphone. The

main factor causing a surge in these regions has been the accessibility of inexpensive internet-capable devices.

3. Majority of people in India, including the population of illiterates and those from disadvantaged backgrounds, have access to smartphones and are also very familiar with their features. Around 70% of people over 15 and over 86% of those between the ages of 15 and 24 are literate. Since 2005, the literacy rate among seniors has steadily risen and is now around 58%. In the upcoming years, cell phones will also be available to people in undeveloped countries that lack literacy. Recently, efforts have been made to create m-health applications that are accessible to those with limited literacy.

4. There are presently over 165000 healthcare applications available worldwide, and this number is growing exponentially. In India, the combined revenue from m-health services and goods was $50 million in 2014, and it is anticipated that this amount will progressively increase to $650 million by 2020–31. These variables may promote the development of m-health, which may support and influence several public health schemes for the provision of healthcare. M-health promises steady growth in the selection of healthcare applications among customers, which could increase m-Health uptake and use. From merely encouraging a healthy lifestyle to sickness and treatment, m-health has advanced. With the potential to eventually dominate the market, m-Health services in India have evolved from their initial fitness app roots to now include doctor consultations, diagnostics, preventive care, and the search for medical services.

7 Limitations

Global mHealth initiatives are extremely concerned about privacy and data security (Shaw, R. J, et. al., 2013). Through m-Health, a person's lifestyle and activities, frequency, and severity of symptoms, present location, and social interactions can all be gathered (Kotz, D., 2011). Legal safeguards cannot keep up with the rate at which new technologies are invented and made available to the public (Yang, Y. T., & Silverman, R. D. (2014)). The U.S. Food and Drug Administration is currently closely examining liability and legal consequences relative to the protection of patient privacy (FDA, 2013). Before beginning program development, each country's privacy and malpractice laws should be taken into account, and suitable steps should be made to protect the privacy of any data obtained from participants.

The different m-health models that have been suggested, which are based on AI and big data analytics, have a lot of advantages but also some disadvantages that should be considered. Large population, entire reliance on technology, inevitable flawed system accuracy, and a lot of privacy and security concerns.

The patient or user is the only source of data for these m-Health systems. If the patient loses both their mobile phone and user ID/password, all of the data may be lost, either temporarily or permanently. The safety and confidentiality of the health data it contains could have a variety of

issues. The risk of sensitive information leaking out and being shared with unauthorized users is present in such situations.

8 Conclusion

The most substantial advancement in technological progress in recent studies is m-Health. It is a technique that leverages portable devices and technology for health interventions. Similar to this, the use of Artificial Intelligence and big data analytics in healthcare is considered a major accomplishment in the intellectual healthcare system. This essay describes clear insights into the m-healthcare system based on multiple studies and its widespread use. The challenges and issues faced during the implementation of m-health applications are discussed. The review also highlights the use of m-health during pandemic situations.

References

Alotaibi, S. R. (2020). Applications of artificial intelligence and big data analytics in m-health: a healthcare system perspective. Journal of healthcare engineering, 2020.

Alwashmi, M. F. (2020). The use of digital health in the detection and management of COVID-19. International Journal of Environmental Research and Public Health, 17(8), 2906.

Balasubramaniam, K. (2002). Access to medicines: Patents, prices and public policy—consumer perspectives. In *Global Intellectual Property Rights* (pp. 90-107). Palgrave Macmillan, London.

Bempong, N. E., De Castañeda, R. R., Schütte, S., Bolon, I., Keiser, O., Escher, G., &Flahault, A. (2019). Precision Global Health–The case of Ebola: a scoping review. Journal of global health, 9(1).

Chib, A., Wilkin, H., Ling, L. X., Hoefman, B., & Van Biejma, H. (2012). You have an important message! Evaluating the effectiveness of a text message HIV/AIDS campaign in Northwest Uganda. *Journal of health communication*, *17*(sup1), 146-157.

Cui, M., Wu, X., Mao, J., Wang, X., &Nie, M. (2016). T2DM self-management via smartphone applications: a systematic review and meta-analysis. *PloS one*, *11*(11), e0166718.

Do, Q., Tran, S., & Robinson, K. (2015, December). Big data and mHealth drive asthma self-management. In 2015 International Conference on Computational Science and Computational Intelligence (CSCI) (pp. 806-809). IEEE.

Guo, X., Zhang, X., & Sun, Y. (2016). The privacy–personalization paradox in mHealth services acceptance of different age groups. Electronic Commerce Research and Applications, 16, 55-65.

Haghi, M., Thurow, K., & Stoll, R. (2017). Wearable devices in medical internet of things: scientific research and commercially available devices. Healthcare informatics research, 23(1), 4-15.

HRG, S. (2009). PRIMARY HEALTH CARE ACCESS REFORM: COMMUNITY HEALTH CENTERS AND THE NATIONAL HEALTH SERVICE CORPS.

Istepanian, R. S., & Al-Anzi, T. (2018). m-Health 2.0: new perspectives on m-health, machine learning and big data analytics. Methods, 151, 34-40.

Istepanian, R. S., & Woodward, B. (2016). M-health: Fundamentals and Applications. John Wiley & Sons.

Istepanian, R. S., Casiglia, D., & Gregory, J. W. (2017). M-health (m-Health) for diabetes management. British Journal of Healthcare Management, 23(3), 102-108.

Kotz, D. (2011, January). A threat taxonomy for mHealth privacy. In 2011 Third International Conference on Communication Systems and Networks (COMSNETS 2011) (pp. 1-6). IEEE.

Kumar, H., Singh, M. K., Gupta, M. P., &Madaan, J. (2020). Moving towards smart cities: Solutions that lead to the Smart City Transformation Framework. *Technological forecasting and social change*, *153*, 119281.

Kumar, S., Nilsen, W. J., Abernethy, A., Atienza, A., Patrick, K., Pavel, M., ... &Swendeman, D. (2013). Mobile health technology evaluation: the mHealth evidence workshop. *American journal of preventive medicine*, *45*(2), 228-236.

Leigh, M. W., Hazucha, M. J., Chawla, K. K., Baker, B. R., Shapiro, A. J., Brown, D. E., ... & Genetic Disorders of Mucociliary Clearance Consortium. (2013). Standardizing nasal nitric oxide measurement as a test for primary ciliary dyskinesia. Annals of the American Thoracic Society, 10(6), 574-581.

Madanian, S., Parry, D. T., Airehrour, D., & Cherrington, M. (2019). mHealth and big-data integration: promises for healthcare system in India. BMJ health & care informatics, 26(1).

Madanian, S., Parry, D. T., Airehrour, D., & Cherrington, M. (2019). mHealth and big-data integration: promises for healthcare system in India. *BMJ health & care informatics*, *26*(1).

Osei, E., &Mashamba-Thompson, T. P. (2021). Mobile health applications for disease screening and treatment support in low-and middle-income countries: A narrative review. Heliyon, 7(3), e06639.

Rao, A. S. S., & Vazquez, J. A. (2020). Identification of COVID-19 can be quicker through artificial intelligence framework using a mobile phone–based survey when cities and towns are under quarantine. Infection Control & Hospital Epidemiology, 41(7), 826-830.

Reisman, M. (2017). EHRs: the challenge of making electronic data usable and interoperable. Pharmacy and Therapeutics, 42(9), 572.

Shaw, R. J., Bosworth, H. B., Hess, J. C., Silva, S. G., Lipkus, I. M., Davis, L. L., & Johnson, C. M. (2013). Development of a theoretically driven mHealth text messaging application for sustaining recent weight loss. JMIR mHealth and uHealth, 1(1), e2343.

Silva, B. M., Rodrigues, J. J., de la Torre Díez, I., López-Coronado, M., & Saleem, K. (2015). Mobile health: A review of current state in 2015. *Journal of biomedical informatics*, *56*, 265-272.

Stroux, L., Martinez, B., Coyote Ixen, E., King, N., Hall-Clifford, R., Rohloff, P., & Clifford, G. D. (2016). An mHealth monitoring system for traditional birth attendant-led antenatal risk assessment in rural Guatemala. Journal of medical engineering & technology, 40(7-8), 356-371.

Waterlander, W., Whittaker, R., McRobbie, H., Dorey, E., Ball, K., Maddison, R., ... &Mhurchu, C. N. (2014). Development of an evidence-based mHealth weight management program using a formative research process. JMIR mHealth and uHealth, 2(3), e2850.

White, A., Thomas, D. S., Ezeanochie, N., & Bull, S. (2016). Health worker mHealth utilization: a systematic review. *Computers, informatics, nursing: CIN*, *34*(5), 206.

World Health Organization. (2017). Global diffusion of eHealth: making universal health coverage achievable: report of the third global survey on eHealth. World Health Organization.

Yang, Y. T., & Silverman, R. D. (2014). M-health applications: the patchwork of legal and liability issues suggests strategies to improve oversight. Health affairs, 33(2), 222-227.

Madanian, S., Parry, D. T., Airehrour, D., & Cherrington, M. (2019). mHealth and big-data integration: promises for healthcare system in India. BMJ health & care informatics, 26(1).