Transforming Bangladesh's Health Sector in the Fourth Industrial Revolution

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Abstract

Bangladesh has achieved significant progress on indicators related to Sustainable Development Goal (SDG) 3, which calls on countries to guarantee that everyone enjoys good health and well-being. Nonetheless, Bangladesh's health system remains fundamentally vulnerable due to years of neglect. The Fourth Industrial Revolution (4IR) is expected to disrupt the existing health system by increasing the speed of care, improving the ability to manage illnesses, and changing the role of patients as well as the relationship between patients and healthcare providers. Leveraging the 4IR to make progress in the health sector in Bangladesh would require significant investments in technology from the government, private sector, and international development partners. This study utilises nationally representative data from the Bangladesh Health Facility Survey 2017 to describe the impact of use of technology and information services on health outcomes. The findings from this study show that the number of live discharges per month was higher in health facilities where a computer, or an internet connection, or a dedicated statistician was available, compared to health facilities where these facilities were not available. In light of these findings, a blockchain-based electronic health records database for Bangladesh was proposed. Such a database would empower a machine learning-driven preventive health system, and would serve as the basis for establishing home hospitals where patients would be able to remain at home and still obtain medical services from hospitals in their vicinity through a combination of location-based mobile applications and video conferencing.

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1. Introduction

1.1 Brief overview of the state of healthcare in Bangladesh

Bangladesh has made important progress on indicators under Sustainable Development Goal (SDG) 3, which calls upon countries to ensure healthy lives and promote well-being for all. Maternal deaths have decreased from 648 maternal deaths per 100,000 births in 1986 to 165 maternal deaths per 100,000 births in 2019 (BBS, 2019a). Mortality rate of children below the age of 5 years decreased from 102.8 deaths per 1,000 live births in 1997 to 32.4 deaths per 1,000 live births in 2017 (World Bank, 2019). Neonatal mortality rate, or the number of neonates dying before reaching 28 days of age, decreased from 47.9 deaths per 1,000 live births in 1997 to 18.4 deaths per 1,000 live births in 2017 (World Bank, 2019a).

Nevertheless, the health system of Bangladesh is still fundamentally fragile. Years of neglect have left the health system in the country in despair. The infrastructure of the health sector is weak, and the governance in the health sector is in a poor state. As of 2017, there was one hospital bed for every 1,196 individuals in the country (BBS, 2019b). Among the health facilities in Bangladesh, 5.1 per cent had emergency transport, 21.5 per cent had alcohol-based disinfectant, 27.5 per cent had medical masks, 28 per cent had all basic equipment, 34.5 per cent had lab facilities, 43.1 per cent had regular electricity, 55.1 per cent had soap and water, 83.7 per cent had paracetamol oral suspension, 86.3 per cent had thermometer and 90.1 per cent had improved water source, as of 2017 (NIPORT, ACPR & ICF, 2018). Apart from the lack of infrastructure and equipment, health facilities in Bangladesh were also not staffed with adequate numbers of healthcare providers. As of 2018, there was 1 registered physician for every 1,581 individuals in the country (BBS, 2019b). Among the health facilities in Bangladesh, 28 per cent had specialists[1], 59.1 per cent had general practitioners[2] and 79.7 per cent had nurses, as of 2017 (NIPORT, ACPR & ICF, 2018). Corruption is widespread in the health sector of Bangladesh, which is manifested in multiple forms, such as mis-invoicing the price of medical equipment and fake doctors with fake certificates (Murshed & Saadat, 2018). Patients in public hospitals who want to get good health services are often expected to pay bribes (Abdallah, Chowdhury & Iqbal, 2015). Research has shown that the efficacy of government expenditure in the health sector of Bangladesh declines due to corruption (Murshed & Saadat, 2018).

1.2 The need for investing in technology in the health sector

Artificial intelligence (AI), robotics and the Internet of Medical Things (IoMT) are having profound impacts on the health industry worldwide. The Fourth Industrial Revolution (4IR) is expected to disrupt the existing health system along four major themes: speed of care, ability to manage illness, role of patients, and relationships between healthcare providers, healthcare recipients, and other stakeholders (Washington, 2018). Research has shown that robotic surgical methods have led to a reduction in infections of surgical wounds which kill 4.5 per cent of those who are afflicted (Bernaert, 2016). Among the developing countries, Cuba set an example by improving their health sector by using both advanced technology and cognitive skills of human beings to ensure quality health services for people from all walks of life (Pineo, 2019).

From Bangladesh's perspective, taking advantage of 4IR to make progress in the health sector will require huge investment from the government, private sector, and international development partners. Without such investment in the health sector, the targets under SDG 3 cannot be achieved by 2030.

[1]Specialist (consultant) medicine [including cardiology], specialist (consultant) general surgery, specialist (consultant) obstetrics/gynecology, specialist (consultant) pediatrics, specialist (consultant) psychiatry, specialist (consultant) anesthesia or any other specialist not listed above.

[2]Medical officer (MBBS) (any non-specialist doctor, including assistant surgeon, emergency medical officer (EMO), indoor medical officer (IMO), maternal and child health/family planning medical officer (MCH/FP), residential medical officer (RMO), regardless of designation or title) or medical officer—anesthetist or dental surgeon.

However, total budget allocation for the health sector in Bangladesh increased only by 12 per cent in fiscal year (FY) 2021–22, from BDT 29,247 crore in FY2020–21 to BDT 32,731 in FY2021–22, which was lower than the 14 per cent average annual increase in total budget allocation for the health sector between FY2010–11 and FY2021–22. Actual expenditure in the healthcare sector decreased by 6 per cent from BDT 18,677 in FY2018–19 to BDT 17,532 crore in FY2019–20. Health budget utilisation, or actual expenditure as a percentage of revised budget allocation, has worsened significantly over the past decade. Total health budget utilisation decreased from 92 per cent in FY2009–10 to 74 per cent in FY2019–20. Budget allocation for health in Bangladesh has been less than 1 per cent of GDP for the past 13 years, indicating that the health sector was never a priority sector for the government. In comparison, at least 30 least developed countries (LDCs) spent more than 1 per cent of their GDP on healthcare in 2017. Thus, at this juncture, there is a clear need to identify the areas where investments in technology may be able to improve the quality and increase the affordability of health services.

1.3 Research objectives

In this aforementioned context, the key objectives of this study are as follows:

i. Assess the use of technology in the health sector of Bangladesh;
ii. Examine the benefits of emerging technological developments in terms of monitoring the progress of patients, improving diagnosis of diseases, and managing chronic illnesses;
iii. Identify the challenges attached to the adoption of technology in the health sector of Bangladesh;
iv. Describe the impact of using technology and information services in health facilities on health outcomes; and
v. Recommend policies for leveraging technology to improve the quality of health services and ensure access to health services at affordable prices for all.

2. Impact of Technology and Information Services on Health Outcomes

2.1 Technology and information services in healthcare facilities in Bangladesh

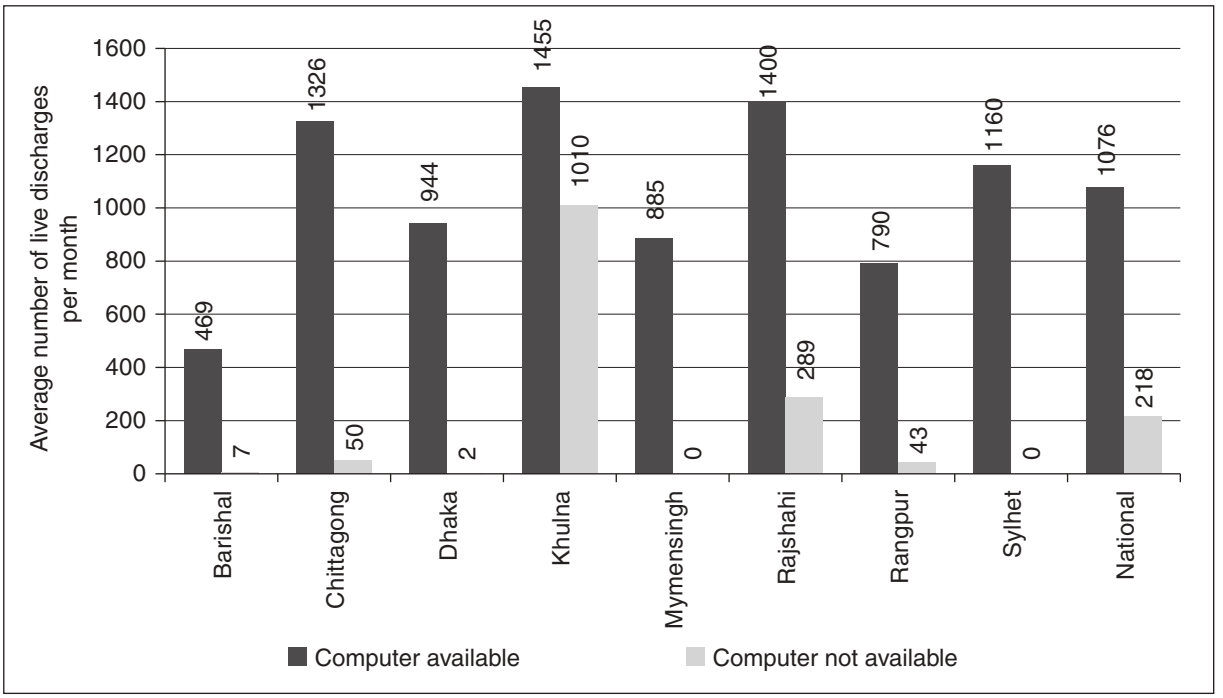
Preliminary analysis of the nationally representative data from the Bangladesh Health Facility Survey 2017 (NIPORT, ACPR & ICF, 2018) shows that, on average, health facilities where a computer was available had 858 more live discharges per month, compared to health facilities where a computer was not available (Figure 1). Analysis on a more disaggregated level also confirmed that, in every region of the country, availability of a computer in a health facility sector was correlated with higher average number of live discharges per month.

On average, health facilities where an internet connection was available had 331 more live discharges per month, compared to health facilities where an internet connection was not available (Figure 2). Analysis on a more disaggregated level also confirmed that, in every region of the country, availability of an internet connection in a health facility was correlated with higher average number of live discharges per month. Hence, use of technology in health facilities, as manifested by the availability of computer and internet, was correlated with better health outcomes.

On the other hand, on average, health facilities, where a dedicated statistician was available, had 545 more live discharges per month, compared to health facilities where a dedicated statistician was not available (Figure 3). Analysis on a more disaggregated level confirmed that the availability of a dedicated statistician in a health facility was correlated with higher average number of live discharges per month in every region of the country, except Dhaka.

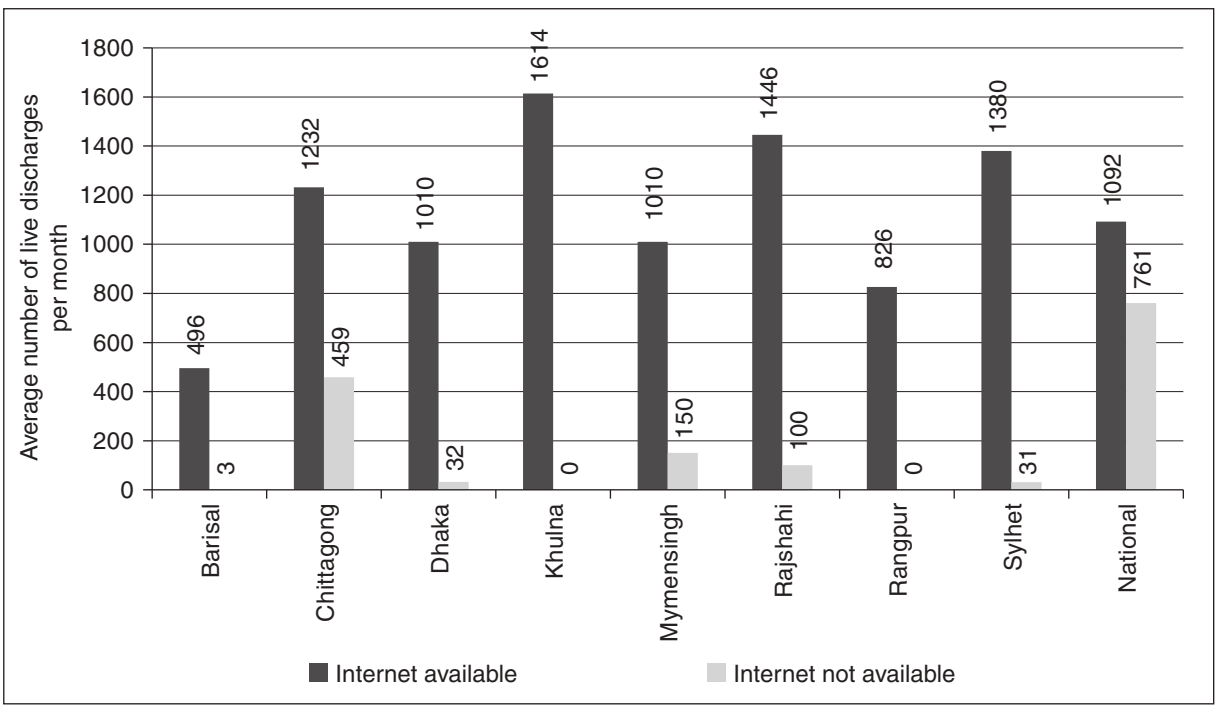
Finally, on average, health facilities where healthcare or health service providers received

Figure 1: Average Number of Live Discharges Per Month by Region, Classified by Availability of Computer



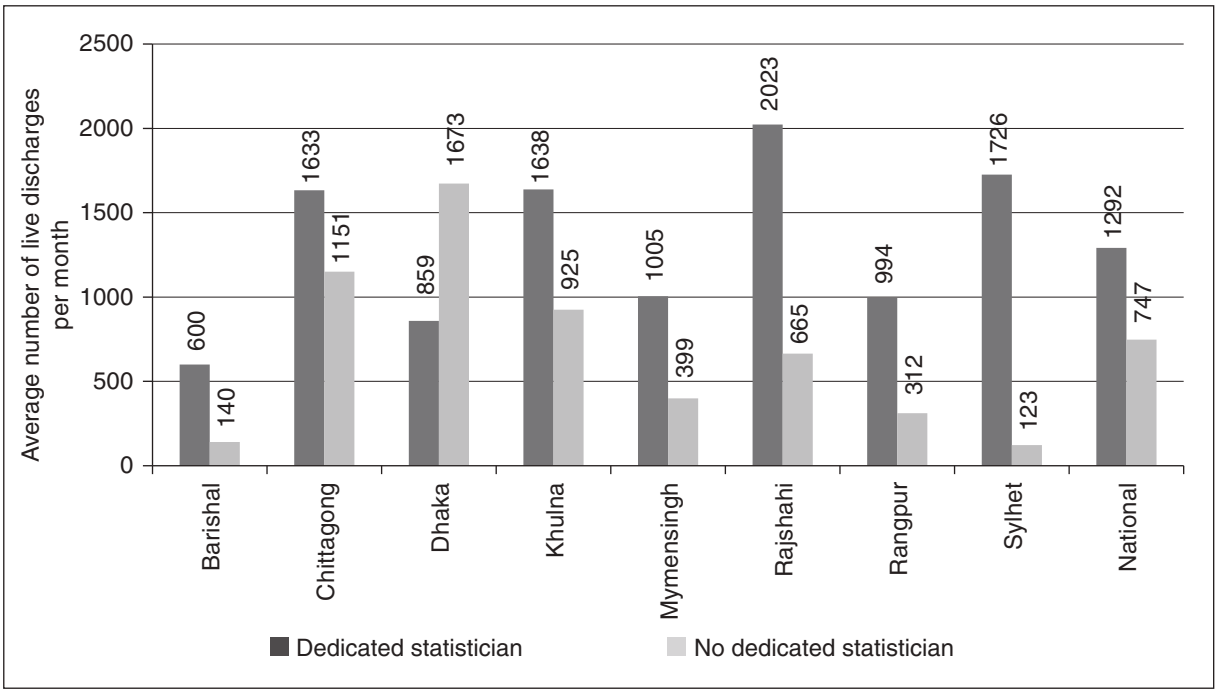
Source: Authors' illustration based on the data from Bangladesh Health Facility Survey 2017 (NIPORT, ACPR & ICF, 2018).

Figure 2: Average Number of Live Discharges Per Month by Region, Classified by Availability of Internet



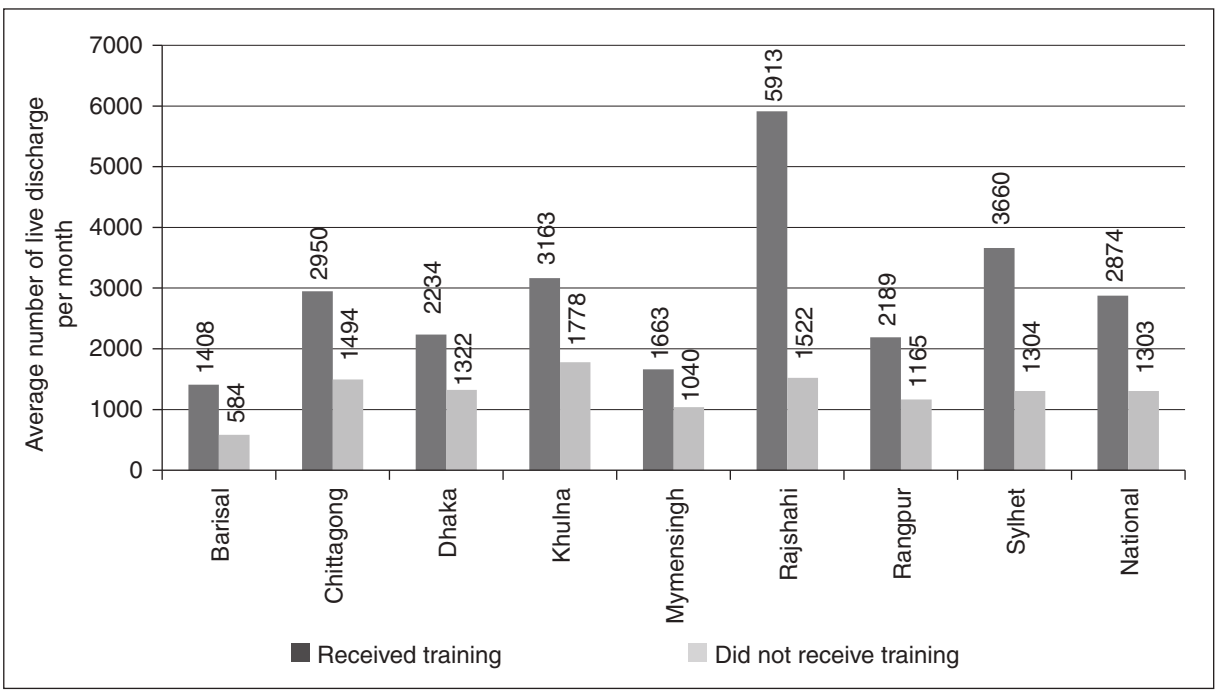
Source: Authors' illustration based on data from Bangladesh Health Facility Survey 2017 (NIPORT, ACPR & ICF, 2018).

Figure 3: Average Number of Live Discharges Per Month by Region, Classified by Availability of Dedicated Statistician



Source: Authors' illustration based on data from Bangladesh Health Facility Survey 2017 (NIPORT, ACPR & ICF, 2018).

Figure 4: Average Number of Live Discharges Per Month by Region, Classified by HMIS Training Received by Healthcare Providers



Source: Authors' illustration based on data from Bangladesh Health Facility Survey 2017 (NIPORT, ACPR & ICF, 2018).

health management information system (HMIS) training had 1,571 more live discharges per month, compared to health facilities where healthcare or health service providers did not receive HMIS training (Figure 4). Analysis on a more disaggregated level also confirmed that, in every region of the country, HMIS training received by healthcare or health service providers in a health facility was correlated with higher average number of live discharges per month. Hence, use of information services in health facilities, as manifested by the availability of dedicated statistician and HMIS-trained staff, was correlated with better health outcomes.

3. Blockchain-Based Electronic Health Records System

3.1 Concept

A blockchain is a chain of blocks that contains information (Nofer, Gomber, Hinz & Schiereck, 2017). Blockchain-based applications rely on a distributed ledger technology or a decentralised peer-to-peer consensus network of people using an open source software over an innovative internet protocol (Nakamoto, 2008).

Each block in a blockchain contains the data, the cryptographic hash of the block, the cryptographic hash of the previous block, a time-stamp and a random number for verifying the hash. A cryptographic hash is a mathematical function that transforms an arbitrary-length input into an encrypted output of a defined length. This means that, regardless of the data input, a cryptographic hash always encrypts the data in such a way that the output is of the same length. Each cryptographic hash is a set of letters and numbers which is unique to a block and all the data in it. Hence, change of data inside a block changes its cryptographic hash, and hence transforms it into a new block altogether.

Requests for entries of new data or creation of new blocks are processed only when computing power is used to calculate the cryptographic hash of the block. In other words, entering new data or creating new blocks involves solving mathematical puzzles using the processing power of the computers in the blockchain network. New data is entered or new blocks are created only when all the computers on the blockchain network have analysed the new data or new block and confirmed that it is actually new and did not previously exist in the blockchain. In order for data to be entered or a new block to be approved, it must show "proof-of-work" or evidence that computer processing power was expended to solve the mathematical puzzle and calculate the cryptographic hash (Nakamoto, 2008). As a means of strengthening security and deterring potential attackers, "proof-of-work" cannot be shown instantaneously, regardless of the computer power used. Depending on the type of blockchain, "proof-of-work" is established after a certain duration of time has elapsed. For instance, it takes approximately 10 minutes to establish "proof-of-work" for bitcoins.

Validation of new data or blocks is made possible by the use of timestamps and cryptographic hash. Since each block is timestamped, its place in the blockchain may be identified. Similarly, since each block contains the cryptographic hash of the previous block, it is intrinsically linked to other blocks, and thus all the blocks collectively form a chain. The use of timestamps and cryptographic hash also means that all the computers on the blockchain network are aware of all the blocks in the chain and agree on the sequence of the blocks (Nakamoto, 2008). Therefore, rather than having a trusted central authority that checks every change, a blockchain has a peer-distributed timestamp server which creates computational proof of the chronological order of changes. Having a peer-to-peer distributed network also adds to the security of a blockchain. Since there is no single point of failure, a blockchain may continue to function normally even if one or more of the computers on its network are compromised. This is because copies of the data on the blockchain are publicly available to all the computers on the network and are not stored centrally in any particular location.

Validation of each block involves cryptography which is computationally impractical to reverse for an attacker. Since blocks are chained using cryptographic hash, any attempts to tamper with

the cryptographic hash of one particular block will render all subsequent blocks on the chain invalid since they would no longer contain a valid cryptographic hash of their previous block. Hence, any potential adversaries who are planning a cyber attack on any specific block must not only show the "proof-of-work" and calculate the cryptographic hash of that block, but also do the same for all subsequent blocks on the chain.

As long as the majority of the computers on a blockchain network are honest, the entire system is secure (Nakamoto, 2008). However, if potential adversaries can collectively assemble more computer processing power than all the honest computers on the blockchain network, then the security of that blockchain network may be compromised. However, most blockchain-based applications provide incentives for computers to remain honest and support the network as a whole rather than to turn malicious. For instance, honest computers on the bitcoin blockchain are rewarded with bitcoins for expending their computing power to process financial transactions in the network.

3.2 Implementation

Blockchain technology may serve as the foundation for building an electronic health records database (Theodouli, Arakliotis, Moschou, Votis & Tzovaras, 2018). In a blockchain-based electronic health records database, each block represents data ownership and viewership permissions shared by the members of the blockchain network. Members of the blockchain network include the patients who are the owners of the health data, and health service institutions such as hospitals, clinics, pharmacies, medical universities and public health research institutes who are the viewers of the data. The privacy of the patient's sensitive health data on the blockchain-based electronic health record database is ensured since the data may only be retrieved using the secret private key owned by the patient. Viewers of the data on the blockchain network can see the health data, but cannot see the identity of the patients themselves since all the data is anonymised.

Patients may be incentivised to join the blockchain-based electronic health records database by informing them that they will be able to easily access the full record of their medical history any time and also take control of who gets access to which portion of their data and at what time. Health service institutions on the network may be rewarded by granting them access to anonymous health data for research purposes in exchange for providing the computer processing power required to maintain the blockchain.

A blockchain-based electronic health records database will not be able to keep track of the current health status and medical history of patients, but also offer a range of other services, such as: i) enchancing interoperability of health records and promoting health data sharing; ii) strengthening security of sensitive medical data and protecting patients' identity; iii) generating a socioeconomic database for designing effective population health management strategies; iv) reducing inaccuracies and frauds in health service bills and financial transactions; v) allowing pharmaceutical drugs to become traceable and reducing drug counterfeiting; vi) increasing transparency by enabling public review of authenticity of clinical trials; vii) detecting complications from use of medicines; viii) providing public health data for mapping the impact of epidemics and pandemics; and ix) connecting organ donors to organ recepients (Attaran, 2020).

3.3 Benefits

There are a number of benefits of a blockchain-based electronic health records database which provides accurate, up-to-date and comprehensive medical records. These include: i) data integrity and authenticity (Nichol & Brandt, 2016); ii) privacy and anonymity (Linn & Koo, 2016); iii) distribution accoss all participants of the network (Ekblaw, Azaria, Halamka & Lippman, 2016); iv) security from decentralization (Yue, Wang, Jin, Li & Jiang, 2016); v) transparency and accountability (Hashemi, Faghri & Rausch, 2016); and vi) auditability of data (Yang & Yang, 2017).

3.4 Challenges

Blockchain technology is hitherto at its nascent stage and has hardly been available long enough to assess the impact of its usefulness. There are a number of challenges associated with implementing a blockchain-based electronic health records database. Some of these include: i) high initial cost of deployment (Roehrs, Costa & Righi, 2017); ii) increase in electricity consumption (Liu, Zhu, Mundie & Krieger, 2017); and iii) limitations on the size and types of data that can be stored on the blocks (Rabah, 2017).

4. Preventive Approach to Health with Machine Learning

4.1 Concept

Machine learning is the process of instructing computers to optimise a performance criterion based on example data or prior experience (Alpaydın, 2010). Machine learning algorithms can autonomously adjust their performance according to the data that they are provided with. Unlike traditional computer software which merely executes instructions, machine learning algorithms get better at predicting relationships and classifying outcomes as they are fed with more and more data.

Broadly, there are three major classes of machine learning algorthims: i) supervised learning algortithms, which learn from a set of labelled example data; ii) unsupervised learning algorithms, which learn from a set of unlabelled example data; and iii) reinforcement learning algorithms which learn via criticism that provides information on the quality of solutions.

4.2 Implementation

Machine learning is useful in situations where it may not be feasible to immediately design a computer programme to tackle a problem. This may include situations where human expertise is insufficient or where the problem itself evolves over time. Machine learning algorithms may be deployed on a blockchain-based electronic health records database to obtain useful insights that will be able to design effective strategies for adopting a preventive approach to health.

4.3 Benefits

Machine learning algorithms make it possible to predict diseases long before the onset of illness. Research has shown that machine learning algorithms can produce highly accurate systems for predicting diabetes (Yuvaraj & SriPreethaa, 2019).

High-technology curative healthcare used in developed countries is capital intensive and requires enormous financial resources. In developing countries like Bangladesh, a commitment to disease prevention can be a successful public health strategy. Machine learning algorithms may be used in conjuction with epidemiologic studies which identify specific risk factors that increase people's likelihood of contracting specific diseases. This will make it possible to design community interventions and individual counselling that promote behavioural change beneficial for disease prevention.

4.4 Challenges

At present, the primary challenge in implementing machine learning algorithms for establishing a preventive health system in Bangladesh is the lack of health data. Machine learning algorithms are only as good as the data that they are provided with. Hence, the absence of a national electronic health records database is preventing Bangladesh from reaping the benefits of machine learning for operationalising preventive approaches to health.

5. Home Hospital: A Radical New Platform for Healthcare

5.1 Concept

In the absence of adequate government funding for healthcare, the ordinary people of Bangladesh have been compelled to spend their own money to obtain healthcare services. Out-of-pocket expenditure on healthcare in Bangladesh is not only the highest in South Asia, but is also increasing over time

(World Bank, 2021). Out-of-pocket expenditure on healthcare increased from 61 per cent of current health expenditure in 2000 to 74 per cent of current health expenditure in 2018 (World Bank, 2021). In comparison, out-of-pocket expenditure on healthcare as a percentage of current health expenditure was 13 per cent in Bhutan, 63 per cent in India, 51 per cent in Nepal, 56 per cent in Pakistan, and 51 per cent in Sri Lanka in 2018 (World Bank, 2021). To make the matters worse, consumer price index (CPI) of medical care and health expenses increased from 156.1 in July 2012 to 251.13 in March 2021 (Bangladesh Bank, 2021). As a result, people from lower income groups are finding it increasingly difficult to afford healthcare in Bangladesh. In fact, the proportion of population pushed below the USD 1.90[3] poverty line due to out-of-pocket expenditure on healthcare increased from 2.84 per cent in 2005 to 6.98 per cent in 2016 (World Bank, 2021).

The "home hospital" model is envisioned as a revolutionary and disruptive healthcare platform that will substantially reduce the cost of medical treatment (Saadat, 2020). Patients who might normally be confined to hospital wards or cabins are allowed to remain at home. They register themselves with a doctor of their choosing from one of the nearby hospitals using a mobile-based application. Using the mobile-based application, the patient consults with the doctor through video-conferencing. Furthermore, the patient is visited on a regular basis by medical and nursing staff who ride their bicycles to the patient's house and give the same services that they would provide if the patient was admitted to the hospital. Small medical equipment is also rented and temporarily installed at the patient's house. If the patient's health deteriorates considerably, to the point that they require critical care, the consultant doctor suggests them to be transferred to an actual hospital's intensive care unit (ICU). In this way, the patient saves money on accommodation and meals, which would otherwise account for a significant percentage of his or her medical expenditures, and consequently the patient is able to get medical treatment at a lower cost.

[3]2011 US dollars at purchasing power parity.

5.2 Implementation

In order for a home hospital to be regarded as a genuine altenative to admission in a conventional hospital, it should meet the following requirements: i) provide health services which are ordinarily not available at home; ii) be acceptable to both patients and their care-givers; iii) be manageable for nurses and doctors; iv) be available at a lower price than conventional hospital care; and v) lead to positive health outcomes (Knowelden, Westlake, Wright & Clarke, 1991).

If a blockchain-based electronic health records database can be implemented in Bangladesh, then it may serve as the basis for establishing home hospitals. Patients will use their unique patient identication number to register themselves on the home hospital mobile application. Once they are have registered successfully, data of their entire medical history will automatically be synchronised with their home hospital mobile application profile. Registered patients will be able to see a list of hospitals near to their present location. Patients will be able to choose their preferred hospital from a menu of options. Selecting a specific hospital will take them to a deeper layer menu where they will be able to see lists of client services offered by the hospital, medical equipment available for rent, ambulances available, diagnostic tests available, duty doctors available, and nursing staff available. From these lists, patients will be able to see the prices and other detailed information for each service offered by the hospital.

Once patients choose their desired service, a countdown timer will appear showing them how long it will take for their requested service to arrive. The corresponding hospital will automatically be informed that a patient has selected a particular service from their hospital, and they will dispatch the appropriate personnel to the patient's home and take any other necessary steps immediately. The corresponding hospital will also be able to gain access to the patient's medical history through the blockchain-based electronic health records database. This will enable the hospital to understand the patient's medical condition adequately and provide appropriate services accordingly.

Depending on the cicumtances, a patient may choose to become home-hospitalised with a hospital for any duration of time through the home hospital mobile application, just like they would be admitted to a real hospital. Home-hospitalised patients would stay at their homes, but be treated like in-patients by the hospital. As such, duty doctors and nursing staff will travel on bicycles and visit the home-hospitalised patient multiple times each day to physically examine the condition of the patient, collect blood or urine samples for diagnostic tests, or provide any other health services. Duty doctors and nursing staff will regularly monitor the health condition of the patient to ensure that they are still eligible for home hospitalisation, and do not require any critical care.

Additionally, the home hospital mobile application would also include lists of specialist doctors, along with their consultation fees and detailed biographies. From such lists, patients would be able to book appointments with any doctor and subsequently consult with their chosen doctor through video conferencing. Patients who will be home-hospitalised would automatically be attached with a relevant specialist doctor. Such specialist doctors will speak with all of their home-hospitalised patients each day during virtual rounds conducted over video conferencing.

5.3 Benefits

In a study conducted in Peterborough, England, in 1991, it was found that a home hospital was sufficient for the needs of most patients, and few patients who received health services from a home hospital required further treatment at an actual hospital (Knowelden, Westlake, Wright & Clarke, 1991). In another study on 455 elderly patients who required admission to an acute care hospital, it was shown that a home hospital was both viable and effective in providing hospital-level care while remaining at home (Leff et al., 2005). Elderly patients who were treated at a home hospital received health services of similar quality to that of an acute care hospital, had fewer complications, required shorter duration of treatment, and spent significantly less money on their treatment (Leff et al., 2005). Interviews with patients who were admitted in a conventional hospital revealed that 72.3 per cent patients would opt for a home hospital for their treatment, if such a facility was available (Burton et al., 1998).

In the context of Bangladesh, the home hospital platform would usher in a multitude of benefits for the stakeholders, such as patients, doctors, and nursing staff, as well as for the community and economy. Patients would be able to obtain health services at a lower cost compared to health services received from a conventional hospital. Patients would also be able to obtain such health services from the comfort of their home, which will save their time and reduce their risk of hospital-acquired infections and illnesses. The home hospital platform would be particularly beneficial for elderly patients in urban areas who are suffering from chronic illnesses. In times of epidemics and pandemics, a home hospital platform would be able to reduce the burden and pressure on regular hospitals. However, a home hospital platform cannot be operated using the number of doctors and nursing staff currently employed in hospitals. Thus, the launching of a home hospital platform will create employment opportunities for many doctors and nurses in Bangladesh. The home hospital platform would allow hospitals to increase their revenue by reaching out to patients who were otherwise not able to afford their regular health services.

5.4 Challenges

Family members and friends of patients receiving healthcare services at a home hospital have acknowledged that such an arrangement limited their own activities in the house, but also mentioned that they did not regard this as a burden (Knowelden, Westlake, Wright & Clarke, 1991). Interviews with patients who were admitted in a conventional hospital revealed that 71.8 per cent patients felt that a home hospital would not burden their families (Burton et al., 1998). However, since most studies which have concluded that home hospitals are beneficial were based on small sample sizes, their conclusions may not be externally valid for other samples of patients. Thus, further rigorous research and pilot-testing may be required before implementing a home hospital model nationwide in Bangladesh. Additionally,

patients' preference for home hospital treatment was found to be contingent on the type of disease that they were suffering from. For instance, patients with chronic obstructive airway disease preferred being treated at a conventional hospital rather than a home hospital (Shepperd et al., 1998).

The technology for establishing a home hospital platform already exists in Bangladesh. However, there remain a number of hurdles on the path to offering health services through a home hospital platform. First, the lack of a universal inter-operable unique patient identification number and electronic health records database make it virtually impossible to implement a home hospital platform. Second, a company providing a home hospital platform may be a third party digital platform which would make such a company difficult to classify or regulate. Third, a home hospital platform may initially find it difficult to convince traditional hospitals to join their network. Fourth, the quality of health services provided through a home hospital platform would be difficult to monitor. Fifth, a home hospital platform would be limited by the availability of high-speed broadband internet and the number of actual hospitals in the area where the patient is located. Since neither the availability of high-speed broadband internet nor the geographic distribution of hospitals is homogeneous across the country, it is likely that a home hospital platform would, at least initially, be effective only in urban areas.

6. Conclusions and Recommendations

6.1 Conclusions

While the health sector of Bangladesh is generally considered to be technologically lagging behind many other countries, there is no time better than the present to leverage the technologies of the 4IR to improve health outcomes for all.

This study has utilised nationally representative microdata of 1,600 health facilities and 5,400 health service providers from the BHFS 2017 to describe the impact of the use of technology and information services on health outcomes. The findings from this study show that the number of live discharges per month was higher in health facilities where a computer or an internet connection or a dedicated statistician was available, compared to health facilities where these facilities were not available.

6.2 Recommendations

In light of these findings, a blockchain-based electronic health records database for Bangladesh was proposed. Such a database would power a machine learning-driven preventive approach to health, and would serve as the basis for establishing home hospitals where patients would be able to stay at home and still obtain medical services from hospitals in their vicinity through a combination of location-based mobile applications and video conferencing.

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Acronyms

4IR	Fourth Industrial Revolution
AI	Artificial Intelligence
CPI	Consumer Price Index
EMO	Emergency Medical Officer
FY	Fiscal Year
HMIS	Health Management Information System
ICU	Intensive Care Unit
IMO	Indoor Medical Officer
IoMT	Internet of Medical Things
LDC	Least Developed Country
RMO	Residential Medical Officer
SDG	Sustainable Development Goal

Bangladesh has made important progress on indicators under Sustainable Development Goal (SDG) 3, which calls upon countries to ensure healthy lives and promote well-being for all. Nevertheless, the health system of Bangladesh is still fundamentally fragile due to years of neglect. The Fourth Industrial Revolution (4IR) is expected to disrupt the existing health system by increasing the speed of services, improving the ability to manage illnesses, and changing the role of patients as well as the relationship between patients and healthcare service providers. Taking the full advantages of 4IR in terms of health services in Bangladesh would require significant investments in technology from the government, private sector, and international development partners. Without such investment in the health setor, the targets under SDG 3 cannot be achieved by 2030. This study points out the need to identify areas where investments in technology can help improve the quality and increase the affordability of healthcare.

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