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Surgery

Designing a Secured Health Data Linkage for Prioritizing Policy and Improvising Implementation: A Quest for a New Horizon

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Abstract **Review Article**

The remarkable success of Bangladesh in harnessing information and communication technology for the health sector has garnered widespread acclaim, captivating global attention and admiration. Previously fragmented data systems are now unified within a centralized repository, facilitating seamless data exchange across health information systems. This integration eliminates redundancy, enhances monitoring capabilities, tracks progress on health-related SDG indicators, and empowers evidence-based decision-making. Fifteen years ago, Bangladesh's healthcare system operated on basic paper-based documentation. Today, however, Bangladesh is the world's leading user of the District Health Information System Version 2 (DHIS 2). The Health Information System (HIS) has become a crucial tool, enabling the country to monitor emerging health risks and measure progress toward ambitious health objectives, including the 2030 Sustainable Development Goals (SDGs). An effective HIS fills critical knowledge gaps for public health experts, offering indispensable insights that drive improvements in overall health outcomes. Yet, the effectiveness of an HIS is shaped by far more than data alone; it is influenced by robust administrative and organizational frameworks and requires a supportive environment that fosters sound policy implementation. Equally essential are key human elements—skilled and knowledgeable health workers, personal motivation, strong leadership, and collaboration among various stakeholders. This overview aims to delve into some of the fundamental challenges facing DHIS 2 implementation in Bangladesh, exploring ways to refine and elevate DHIS 2 to meet the health needs of the nation.

Keywords: Health data, DHIS2, Policy, Implementation, SDG.

INTRODUCTION

In Bangladesh, the development of Health Information Systems (HIS) and e-health has flourished through the steadfast support of development partners such as UNICEF, WHO, UNFPA, Save the Children, and ICDDRB. These systems undergo updates at least annually, introducing enhanced functionalities to meet evolving health needs. The HIS team receives robust support to build capacity, ensuring they can operate the systems independently. Over time, these responsibilities are gradually transitioned to the Ministry of Health and Family Welfare (MOHFW), fostering a sustainable, nationally-led approach to health information management. The Health Metrics Network (HMN), launched under the auspices of the World Health Organization (WHO), pioneered a global movement to elevate Health Information Systems (HIS) in developing countries. From this visionary initiative, the DHIS-2 was born—a tool crafted to deliver a holistic perspective on the core strengths and gaps within critical health system components. DHIS-2 encompasses data sources and collection methods, analytical capabilities, and the strategic application of information to inform policymaking and governance, all while aligning closely with the aspirations of the Sustainable Development Goals (SDGs) [1]. The Sustainable Development Goals seek to decrease neonatal death to fewer than 12 per 1,000 live births, stillbirths to fewer than 12 per 1,000 total births, and the global maternal mortality ratio to below 70 per 100,000 live births by 2030 [2]. This is an ambitious aim since "those delivering care and those responsible" are among the possible health data users. HIS also involves recognizing needs and issues, following development, assessing the effectiveness of treatments, and basing decisions on evidence on health

policy, program design, and resource allocation [3]. With the development of the DHIS-2 and constant technological progress, such elusive ambitions are finally being realized, albeit the actualization rate has slowed down due to some significant barriers. This article attempts to dissect and analyze the main roadblocks and proposes alternatives to bypass them and fast-track health progress. It advocates the endorsement of strong building blocks for strengthening health systems since it understands they are needed in this regard. These include standards and interoperability; infrastructure; leadership and governance; services and applications; legislation, policy, and compliance; workforce and strategy and investment. Their importance is vital in helping the ecosystem to grow and in realizing that there is always a balance to be struck between responsibility, supply, demand, quality, and cost [4]. In order to understand the critical challenges that the country faces during the implementation of DHIS-2, a brief outline of the key successes of the system is necessary. With the implementation of the open-source District Health Information Software 2 (DHIS2), the country now has a national public sector health data warehouse." Data exchange for health information systems and decision-making is made possible by the unification of information from once fragmented data systems in a common data repository. Work is in progress to produce lifetime electronic health records for every person able to be transmitted between medical institutions. Extensive customization of open-source software has set the groundwork for a national digital networking system [5].

The DHIS-2

The bar chart below shows the exponential rate of increase in data reporting via DHIS-2 in the last decade (Figure 1).

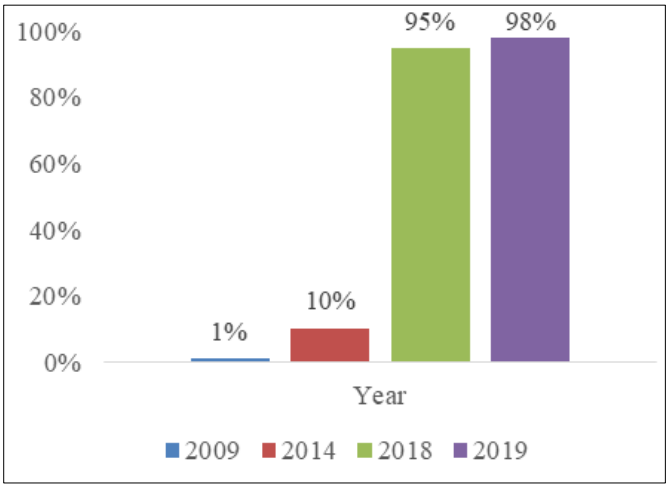

Figure 1: Percentage of Data Reporting via DHIS-2

In different areas, the Directorate General of Health Services (DGHS) has shown excellence in using ICT. DGHS has already built, for regular health information (both for facilities and communities), a COVID-19 surveillance and lab report system, and a Cervical and Breast Cancer screening program both based on the DHIS2 system. Moreover, they built an online-based Human Resource Information System (HRIS) to record health workforce data. This is relevant for every Directorate under the Ministry of Health and Family Welfare (MOHFW) [4].

Directorate General of Family Planning (DGFP) has made amazing developments in implementing web-based monitoring tools and electronic systems that are easily accessible for managers at the district, Upazila and central levels. DGFP is using the Management information system (MIS) for population registration, couples' eligible couple registration, pregnant women under planned visits, ANC and PNC services, and task attainment described in the work plan. FP-DHIS2 is additionally used for gathering, validation, analysis, and display of aggregated client-based statistical data [4].

There are shortcomings though on all levels of the health systems, in terms of quality, analysis, interpretation and use of data and indicators. It is noteworthy that a sizable fraction of health services are provided by the private sector, and yet private sector performance data is lacking. It represents a blind area in terms of knowledge of health services delivery. Interoperability presents still difficulties for both public and commercial sectors. There are now as many as 28 health monitoring dashboards, but their optimal usage especially for management decision support and at the level of data collecting may be limited [4].

Getting a full picture of Bangladesh's Reproductive maternal, newborn, child and adolescent health (RMNCAH) status is made difficult by the omission of statistics from the country's sizable private health sector. Effective implementation of DHIS2 is hampered by slow Internet connectivity, certain

healthcare workers' defensive attitudes towards an electronic system, and limited utilization of data for local-level decision-making [6].

HMIS must operate with integrity depending on strong data governance. Data governance practices could guarantee that data collecting, management, and use are ethical and fair, do not hurt vulnerable people, and assist in improving decision-making in the health sector by employing appropriate rules and laws. One must first raise the quality and protection of data, the interoperability of systems, and data sharing among institutions if one is to realize this promise. Once all these criteria are satisfied, HMIS could be critically important in anti-corruption initiatives in the medical field [7].

Proper management and distribution of health data transforms it into an analytical instrument available for use in improved policy decisions, therefore influencing the outcome of public health. Particularly facilitating decision-making procedures of health institutions and organizations is the data from health management information systems (HMIS). Governments exploit this information in ways that reinforce their political agendas.

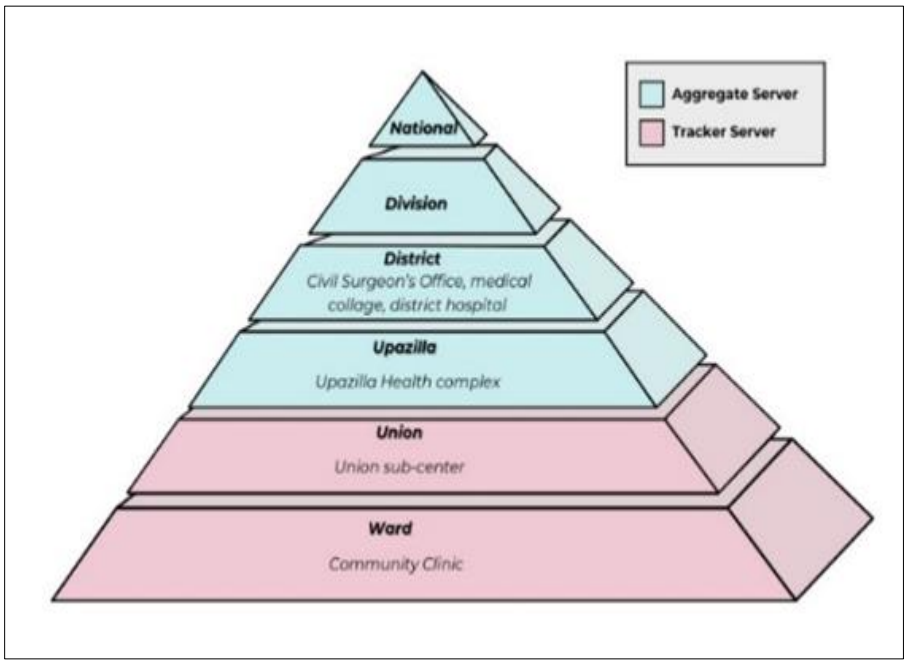

Figure 2: MIS Dataflow under the DGHS

The following discusses each of the principal bottlenecks that plague the system in Bangladesh and discusses potential solutions to solve them.

Data Flow, Collection and Quality

While the Data reporting rate is 98% as of February 2019 [2]. The issue of data quality never gets direct answers. Using data audit and validation, DHIS-2 makes enormous efforts to raise data quality. It specifies minimum and maximum values for particular fields that set off alarms when data input falls. Inbuilt data validation features of DHIS2 also aid in raising report completeness. Before a report can be sent to the server, the required data entry fields have to be finished [5].

Yet the data quality remains poor still and will continue to stay poor as long as the burdens and incentives around data collecting remain unresolved. The main cause of inadequate data quality is the scarcity of qualified people, especially those in charge of service delivery. Eg-Doctor, Nurse, Statistically [3]. The DHIS 2 module itself has the option to "SKIP" for all indicators, which results in even more incomplete data Retrieving accurate results from DHIS 2 is challenging with partial data. Their cell phone numbers are tracked rather than their original health identification numbers. Searching the database with a cell phone number might be time-consuming and challenging though. To get around this, CHCPs would rather register follow-up patients as new ones. This creates a data quality problem since system identification of recurrent customers marks them as new consumers [8].

Solution:

- Establishing easily available feedback systems for employees and members of the community will motivate them to gather better data right away. This approach allows one community to ask questions or highlight any discrepancies in data given by another. Remember that these possible data validation techniques will help you find sources of incorrect data. The system lacks any review system or staff red flagging mechanism, so implementing them will

function as automatic quality control on top of the currently used procedures.

- Policies, guidelines, and checklists help to establish institutionalization and decentralization of data quality as well as periodic assessment and review can also help to enhance many other areas [9]. Timeliness, completeness, and consistency of facility reporting should all form assessment benchmarks [2].

Data Analysis

One of the poorest areas in Bangladesh turned out to be data analysis [9]. Every sub-district, district, and divisional health manager hosts regular monthly meetings where the produced summary reports utilizing DHIS 2 are reviewed. Reproductive mother, newborn, child, and adolescent health (RMNCAH) -related data observation, monitoring, and quick planning for the next weeks are discussed here. Usually, statisticians were tasked to compile the data from DHIS 2 and distribute the produced summary reports to district and divisional health managers. Results were addressed in front of field staff (e.g., CHCPs, health inspectors, EPI supervisor, and other staff members) at meetings. However, this imposes a tremendous burden on the statisticians who are prone to make mistakes and provide poor analysis on account of being exhausted and overworked. Lack of automated computation for aggregated data is not provided raising the likelihood of data discrepancy and error generation [8].

Solution:

- Establish policies for data analysis; let data to be freely available for research and analysis; enhance interaction with local Bangladeshi universities, such as the University of Dhaka; and apply interventions to change the organizational culture connected with data analysis [9].
- Moreover, help should be given to analysts now using DHIS2 data for most common data problems thereby enabling analysts to generate accurate studies using current data for use by national governments [1].

Data Utilization and Integration

Those who provide or oversee local health services now hardly use the health information system since their training is limited to data collecting. Users far distant from the actual delivery of health services decide the data gathered. From those at the bottom collecting to those higher up the chain of command, data moves one way [3]. The requirements of those delivering health care are disregarded and most policymakers see the information system mostly as a tool for gathering and storing data for the benefit of managers, analysts, funders, and others [5].

People in the health system are seen as mere data providers rather than as information consumers or active managers of their different roles and activities [3]. Although they may indirectly benefit from data analysis undertaken elsewhere, the potential for DHIS-2 to directly enhance the effectiveness and efficiency of service delivery is often neglected.

In 2017, DHIS2 was enhanced to display real-time data for emergency response, encompassing information on floods, dengue incidence rates throughout Bangladesh, and significant events such as the cold wave from 1 November 2017 to 13 March 2018, which resulted in low temperatures and subsequent health complications including ARI, diarrhoea, and COPD**.** However actual utilization of this update to increase emergency response capacity remains subpar [5].

***Solution*:**

- Develop **relevant, actionable, trending Indicators.** Involve local healthcare providers in the process of determining which indicators are to be collected. Deciding what data to collect might be hard, but the effort is worth it. This ensures that the data is more relevant, current and useful for actual service delivery improvements and not taken solely for donor reporting.
- **Bi-directional Data Flow must be introduced** allowing data to flow not only upwards to central authorities but also back to local facilities in the form of feedback reports or dashboards. This way, healthcare providers can compare their performance with similar facilities and identify areas for improvement.
- Assess the extent of routine health information utilization through five fundamental indicators: (i) availability of feedback from department heads to health personnel, (ii) documentation of information utilization for decision-making, (iii) key performance indicators, (iv) evidence of health coverage, and (v) attainment of targets[10].
- Unique identification numbers (UID), Electronic Medical Records (EMR), appointment scheduling and reminders, facility operational capabilities (laboratory, pharmacy, etc.), and investigation profiles should be readily accessible across all tiers of the service delivery network to significantly enhance utilization. If a Health Information System directly benefits its data collectors, it will yield superior-quality data and is more likely to endure. When an assistant arranges a referral or follow-up consultation, the system will autonomously recommend a facility, physician, and appointment time depending on many parameters, including the proximity of the

patient's residence to the healthcare facility and the earliest available time slot.

Data Security

An electronic health record (EHR) is a technology that facilitates the management of health information. It maintains digital records for many healthcare organizations. Records are transmitted through comprehensive data systems and various networking technologies and exchanges. Contemporary patients anticipate prompt access to their health information.

Nevertheless, despite the health sector's instant access to data, concerns regarding the privacy and security of patients' medical records are inevitable. Prioritize the safeguarding of individuals' privacy in open data governance policies. Not all data should be disseminated, particularly when such actions may subject vulnerable populations—such as women, LGBTQ individuals, economically disadvantaged groups, and children—to discrimination [7]. The healthcare system is vulnerable across many medical services due to delays in data availability and the risk of data breaches. Hospital records may be archived without the patient's awareness [11].

Solution:

- Implement a legal framework to safeguard the data security, privacy, and confidentiality of persons, health professionals, and health workers within the digital health sector, thereby ensuring accountability commensurate with each individual's scope of obligation, referred to as the Digital Health Act. Guarantee that any digital systems developed, implemented, or utilized in Bangladesh are secure, protected, and compliant [4].
- Decentralization, security, anonymity, and resilience via cryptographic algorithms are components of block chain that can address current challenges in the healthcare sector.

A block chain-based system can aid in addressing this issue. A block chain is a decentralized network employing peer-to-peer (P2P) technology to monitor all transactions. It is devoid of a centralized authority or a singular point of contact. It is, instead, a collection of nodes that maintain the system's operation. Every transaction is highly secure due to the network's nodes. Encryption enhances the security of the connection. The digital record is replicated at each node inside the system. Every node must validate the authenticity of a transaction before reintegration. The block chain possesses the capability to surpass the traditional centralized system, which is plagued by significant accessibility deficiencies. This decentralized technology has just been introduced to offer a novel perspective on data security and system efficiency. Assurance of patient information rights, integrity, privacy, security, confidentiality, and anonymity by evolving public health access requirements utilizing block chain technology [11].

Interoperability

The absence of interoperability hinders the digital transformation of healthcare [12]. The DHis-2 system has great interoperability. The exchange of electronic records calls for a standard (yet dynamic) design and interoperability framework. It calls for an underpinning infrastructure of networks allowing all the facilities and people rendering health care to interact. This allows one to offer data warehouse and aggregation services, thus enabling data analytics to offer extra value and insights, so bottlenecking the digital transformation of healthcare [4]. Nevertheless, the other several separate health systems that exist in Bangladesh are still not completely integrated with it, which limits the capacity to use data from several sources to improve the operations' efficiency or the sophistication of analysis and decision making. Unverifiable birth registration (220 million registrations for 160 million people); most systems lack interoperability; insufficient interoperability advice or Standard Operating Procedures; inefficient shared record systems are challenges to enhanced interoperability [9].

Solution:

- Enforce private health clinics' signed data-sharing agreements to promote knowledge development at several levels to support data and service interoperation.
- Create digital object-shared vocabularies, metadata templates, and other tools to simplify the interaction of DHIS-2 with other systems. This acts to generate horizontal interoperability since the system itself is interoperable by design.
- Make sure such data is curated and AI-ready, therefore accelerating the availability of inclusive, quality data pipelines improving the use of machine learning and future artificial intelligence to find significant trends in an epidemic outbreak [12].

Resource and Workforce Capacity

A. Shortage:

Globalization keeps trained expertise lost from health systems catering to the underprivileged. Not only are doctors and nurses in underdeveloped nations drawn to cities, but they also find Europe or North America particularly appealing as employment in medicine as typical non-medical salaries are far higher than in their own country. Analysis of doctors in the US, the UK, Canada, and Australia reveals that 40–75% of international doctors are from low-income countries and 23–28% of the doctors in those nations are international medical graduates. Driving investment in technologies that allow non-physician health care providers including nurses, midwives, community health care providers

CHCP, etc. to execute more advanced responsibilities, the Bangladesh Government accomplished an outstanding job. It succeeded in motivating the adoption of HIS or equivalent systems and infrastructure down the health system hierarchy to reach these lower-level health workers and enable them to generate and distribute data**.** Supported financially by ICDDR-B UNICEF and HISP Bangladesh, an online e-learning platform for DHIS2 was launched in 2017. Six-month courses for the community healthcare practitioners housed at the local clinics are offered [5]. However, the shortage remains. Chronic shortages, unsuitable skill combinations, and an unfair allocation across services define Bangladesh's health workforce. At the central level, a health staff with creative ideas, who are trained not just in IT knowledge but also in public health knowledge and experience in DHIS2, is much needed. Challenges to data utilization at the district and sub-district levels include deficiencies in the health professionals accessible to enter data, especially local-level qualified statisticians lacking in presence. Often office clerks or nurses—who lack statistical analysis knowledge—have filled in for the statistician. Not enough personnel exists at the national and divisional levels to monitor, evaluate, and assist decentralized levels [8].

***Solution*:**

- Further Training is of utmost importance. Training Period should be increased to one year to ensure adequate quality of data. The training of national staff was crucial to ensure there are DHIS2 experts on the ground and that the Government is not reliant on external support [5].
- Instead of relying solely on the Ministry of Health to conduct training programs in district and rural areas, local site managers and community leaders could adopt a Training of Trainers (ToT) [13]**,** approach to quickly build a skilled workforce. By empowering local trainers, the training program can create a "snowball effect," where each trained individual can train others, rapidly expanding the reach and impact of the program. This approach minimizes delays, as it allows training to proceed without needing continuous approval or oversight from line directors or higher officials.
- Local trainers can tailor the content to community needs, ensuring that training is relevant, accessible, and effective, while also fostering a sense of ownership and motivation within the community. This method is especially beneficial in resource-limited settings, where timely and scalable training is crucial for addressing public health challenges.

B. Behavioral:

Trained personnel is desperately lacking at all levels. Everyone that exists locally is traditional and quite resistant to habit modification. Complicating matters even further is the lack of responsibility and oversight in follow-up following training. The biggest difference in data quality comes from inadequate role definition at the level of the health facility and hardware and software shortage at the community level.

Solution:

- Using your local skills and building local expertise can help you maintain and control the HIS, including its technical elements. Zanzibar's first experience, which concentrated on delivery under foreign advisors, came back short. But in the later effort after including local staff, the DHIS2 was effectively applied [13].
- Engaging all stakeholders in the country should be ensured. Committing to long-term capacity building with monitoring and accountability. Improving the analytical skills and interests of health managers and other decision-makers will yield progressive results.
- Providing more knowledge and skills to the health workforce by Pushing role delineation and accountability will result in better data quality.
- Improved quality yields better utilization and with the Introduction of new scorecards, dashboards and software such as Machine Learning module integration, Real-time charts, visual teaching aids and effective action recommendations will be available in DHIS-2 allowing behavioral change in all sectors.

Corruption and Accountability

Supervision and responsibility are severely lacking in DHIS2, they can help to prevent and lessen corruption. Although seminars on data quality and usage are valuable, health managers sometimes return to their old practices without constant follow-up and monitoring of the improvements brought about by the training [7].

Solution:

- Adopting a decentralized approach to health development would allow local groups, NGOs, and international donors to have a bigger impact on healthcare delivery. By configuring DHIS-2 to identify fraud and misuse through data analysis, it could improve the tracking of public spending and boost accountability, with more citizen involvement. This way, DHIS-2 could support stronger anti-corruption efforts in the health sector, ultimately leading to better public health results.
- Absenteeism and Ghost worker Problem can be solved by adding E-recruitment Interface and Attendance System to the platform.
- Bid rigging and procurement-related corruption of Medical products, vaccines and technologies

can be solved by adding an E-Procurement Interface.

- Health service delivery-related corruption Bribery can be solved by E-Whistle Blowing Interface [7].

Private Sectors

With four main players defining the structure and operation of the system—government, private sector, nongovernmental organizations (NGOs) and donor agencies— Bangladesh's health system is pluralistic [5]. Almost all government-run health services have either fully or partially adopted DHIS2 ten years after the first actions were taken, and nongovernmental organizations are advancing.

Many NGOs (23 now) including Population Services International, Médecins Sans Frontières, International Rescue Committee, IMA World Health, MSH, Engender Health, Caribbean Epidemiology Centre, Family Health International, ICAP, IntraHealth, CHAI, and BEMFAM run DHIS2. Several worldwide/regional/international organizations including WHO (malaria program, DQA tool), UNICEF-HQ/Zambia/DRC, Economic Community of West African State, East African Community, PEPFAR - Headquarters, USAID - Nigeria, CDC - Global Health Security use it [14].

In Bangladesh, the private sector provides over 70 per cent of health services [5], The commercial sector in Bangladesh still finds great difficulty embracing DHIS-2. HIS providing just public health services leaves out private health data, which causes under-reporting of information on families [3]. Among the highest in the world, out-of-pocket expenses account for 74% of total health expenditure in Bangladesh, mostly for outpatient treatment and medicine [15].

Getting thorough health data depends critically on DHIS-2 being integrated with the commercial sector. The private health sector is thus already cautious about the integration. Under the pretense of data protection, every corporation runs its information system with 0% interoperability.

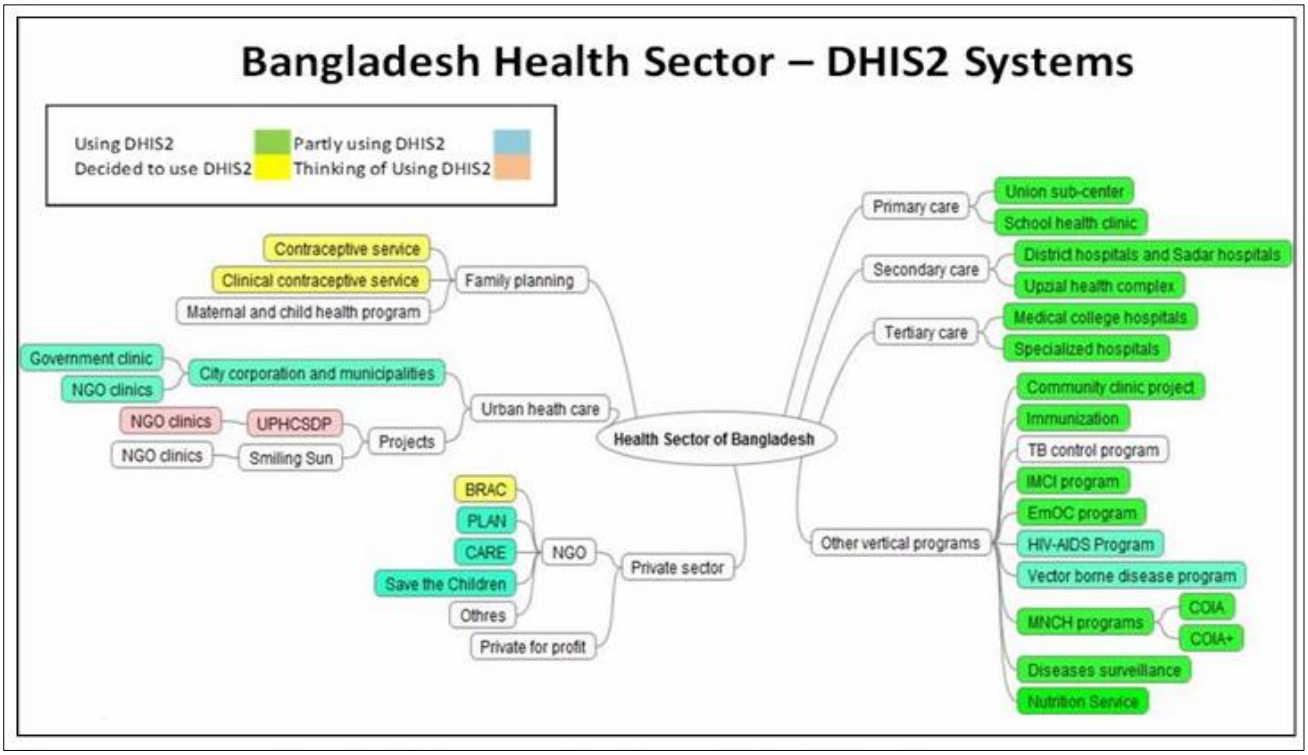

Figure 2: Status of DHIS-2 in the Health Sector

***Solution*:**

- The establishment of a mandated health insurance system lets one bridge this private data contradiction. One of the lowest rates among Asian nations, Bangladesh's total insurance penetration is 0.6% [15]. Public or private, insurance companies have a significant role to fulfil since they have a strong vested interest in acquiring correct data on health system performance to support actuarial calculations underneath the economics of all insurance. Furthermore, these public or private insurers, who reimburse private providers, are specially qualified to demand data on services performed in the line of payment [3].
- Priority will be given to the development of Public-Private Partnerships (PPRs), coordination and cooperation between the

Government, cooperating partners, and stakeholders at various levels to enable integration of digital technology in important functions of society in order to guarantee the sustainability of digital health programs and projects [4].

- Private practitioners, clinics, and hospitals without operational integrated HMIS systems must employ ePrescription whenever practical to guarantee greater access to prescription and drug information [4]. These can later be integrated with DHIS-2 when infrastructure is available.

Changing Disease Profile

Bangladesh is in an epidemiological transition, and rising non-communicative diseases(NCD) including diabetes and heart disease will call for more resources in an already taxed medical system [5]. Economic growth is shifting the nature of illness concerns. With a few notable exceptions, the link between poverty and sickness is usually seen as a two-way street: poor generates conditions that make individuals more susceptible to disease, while disease stunts growth [14]. As populations grow wealthier, their disease profile changes. Major communicative illnesses such as malaria, TB, HIV, cholera, and diarrhoea used to be a top priority in underdeveloped nations including Bangladesh. Over time, advancements against these diseases produced a higher prevalence of chronic diseases. This change in emphasis towards longitudinal health management implies that the DHIS-2 now needs to be able to monitor individual patients effectively and provide ongoing treatment over a long time. Still, the possibility of broad use of electronic records for individual patients in public hospitals remains low, mostly due to a continuous influx of patients, paucity of medical staff and lack of ICT resources. Given doctors have, at best, five minutes to spend with every patient, outpatient service is especially difficult [3]. The platform shows that service data from facilities was not updated to integrate the NCD data. For example, current information from the Community Clinic at DHIS2 shows the number of patients getting blood pressure measuring services but it does not status related to hypertension control [10].

Solution:

- Utilize DHIS-2 to address emerging disease threats while concurrently managing infectious diseases. The anticipation of imminent dangers and the evolving trend in data input, with a focus on individual longitudinal tracking, is of paramount importance, as these changes must be integrated immediately to obtain a competitive advantage in data gathering against the forthcoming non-communicable illness threat [15].
- An extended database allows accurate estimation of the chronic medication needs of a country as proper drug dispersal. Training and enforcing medical assistants and other non-physician health workers to perform pre and post-visit record keeping, taking vitals and a brief history allows those 5 minutes to be used efficiently.

Lack of Urban Data and Health System Data

The ongoing initiatives to get data on routine health and family planning service coverage predominantly focus on rural regions. Twenty-seven per cent of the nation's population resides in urban regions and is not included in the current regular Management Information System [14]. Also, while the data collection reporting is 98% on paper, this only includes patient data. Data regarding health systems, such as the number of health workers, capacity, and services, has frequently not been recorded within DHIS2, despite its potential utility as a national health statistic [1].

Solution:

- Including data on health system capacity—such as staffing levels, facility capacity, and service availability—within DHIS-2 would enable more informed planning and resource allocation.
- Digitalizing data reporting to transition from paper to electronic records could further streamline the process, ensuring timely, consistent, and comprehensive data collection across all regions. Implementing these measures would enhance data quality, support urban health initiatives, and improve overall health system resilience.

Environmental

The system often omits important potential data sources such as disease response systems, or environmental data such as water or air quality data, which are particularly important in an age of fast-moving epidemics. Dhaka, the capital of Bangladesh is one of the most polluted cities in the world, yet so far there is no attempt to collect any environmental data using this system. One of the principal reasons is that data collection is mainly employed at the rural level where air quality is pristine.

Solution:

Set up district or division-wise environmental data collection centers to be input to the software which then compares it against health norms.

Software Access

The Module is currently only available to those involved in giving health services and higher management. Citizens who receive care have no way to track/Produce/Utilize data. Not only are the patients unaware of the data being collected, they are also unable to cross-check the veracity of said data. Moreover, it was pointed out that workers generally assumed DHIS-2 data

would be utilized exclusively at the ministry level, where decision-making occurs [16].

Solution:

- Enable individuals to acquire knowledge on reproductive health and family planning; adolescent health concerns; healthy behaviors and lifestyles; mental health; non-communicable diseases (NCDs) and communicable diseases (CDs); disease outbreaks; and health events, and provide them with information via DHIS-2 to guide their actions [4].
- Facilitate patients and consumers' access to their health information at any time via internet platforms and mobile applications [4].

Infrastructure and Connectivity

DHIS-2 is a web-based platform. This requires access to high-speed internet throughout the day. This can be difficult, as rural regions seldom possess cellular networks. Moreover, during the monsoon season, the vulnerable regions frequently experience flooding and other natural calamities, rendering continuous electronic record-keeping nearly unfeasible. At the first implementation of DHIS2 in Bangladesh. Only 2G connectivity was limited to certain regions. Subsequently, 3G was introduced. Numerous regions in the country possess 4G connectivity [5].

Solution:

- All public health facilities should be linked through high-speed, secure networks with backup systems, while private health providers and independent practitioners should also be encouraged and regulated to connect via secure, high-speed internet.
- Health data should be stored within Bangladesh's borders to ensure local control.
- Additionally, a policy is needed to provide both public and private field health workers with secure, internet-enabled devices and relevant training, along with certification to maintain secure network connections. An example is Starlink's Satellite Internet System, which uses low-Earth orbit satellites to deliver continuous internet access. The Ministry of Health should work with the Bangladesh Telecommunication Regulatory Commission to quickly set up infrastructure in low-connectivity regions.
- With Bangladesh's growing digital framework, including the Bangabandhu Satellite-1 and plans for a second, Starlink's presence could open a new chapter in national internet coverage, particularly benefiting remote communities.

Big Data

Healthcare systems generate what's known as "Big Data," a relatively new term, though analyzing large datasets is a long-standing practice. Hospitals gather massive amounts of information for each patient, including datasets like MRI scans or gene microarrays. Big Data has four key features: Volume, which is the total size of the data; Velocity, or the rate at which new data is created; Variety, which refers to the different types of data; and Veracity, which is the data's reliability. By 2011, healthcare organizations had already generated over 150 Exabyte of data (where one Exabyte equals 1,000 petabytes). To enhance healthcare services, clinical data warehousing and analyzing these data collections in medical informatics are essential. Today, developed countries like the USA and Canada use this data mining in health informatics to offer better treatment, access patients' medical histories, and support disease prediction and prevention [17]. The DHIS-2 implemented in Bangladesh has yet to do so.

Solution:

- Bangladesh's government will build a Big Data and Analytics platform to enable the use of data for decision-making and to proactively disclose depersonalized data through an open data platform for peoples' participation in monitoring of health system and fostering innovation [4].
- Public Health Informatics focuses on analyzing data at the population level to improve the accuracy of medical assessments. This data, gathered from sources like social media, surveys, hospitals, doctors, and clinics, is characterized by its large volume, rapid growth, and diverse types. To effectively analyze such Big Data, machine learning is essential. Although DHIS-2 hasn't yet integrated machine learning, the rise of artificial intelligence in recent years suggests that predictive analytics and machine learning could significantly enhance productivity in healthcare [4].

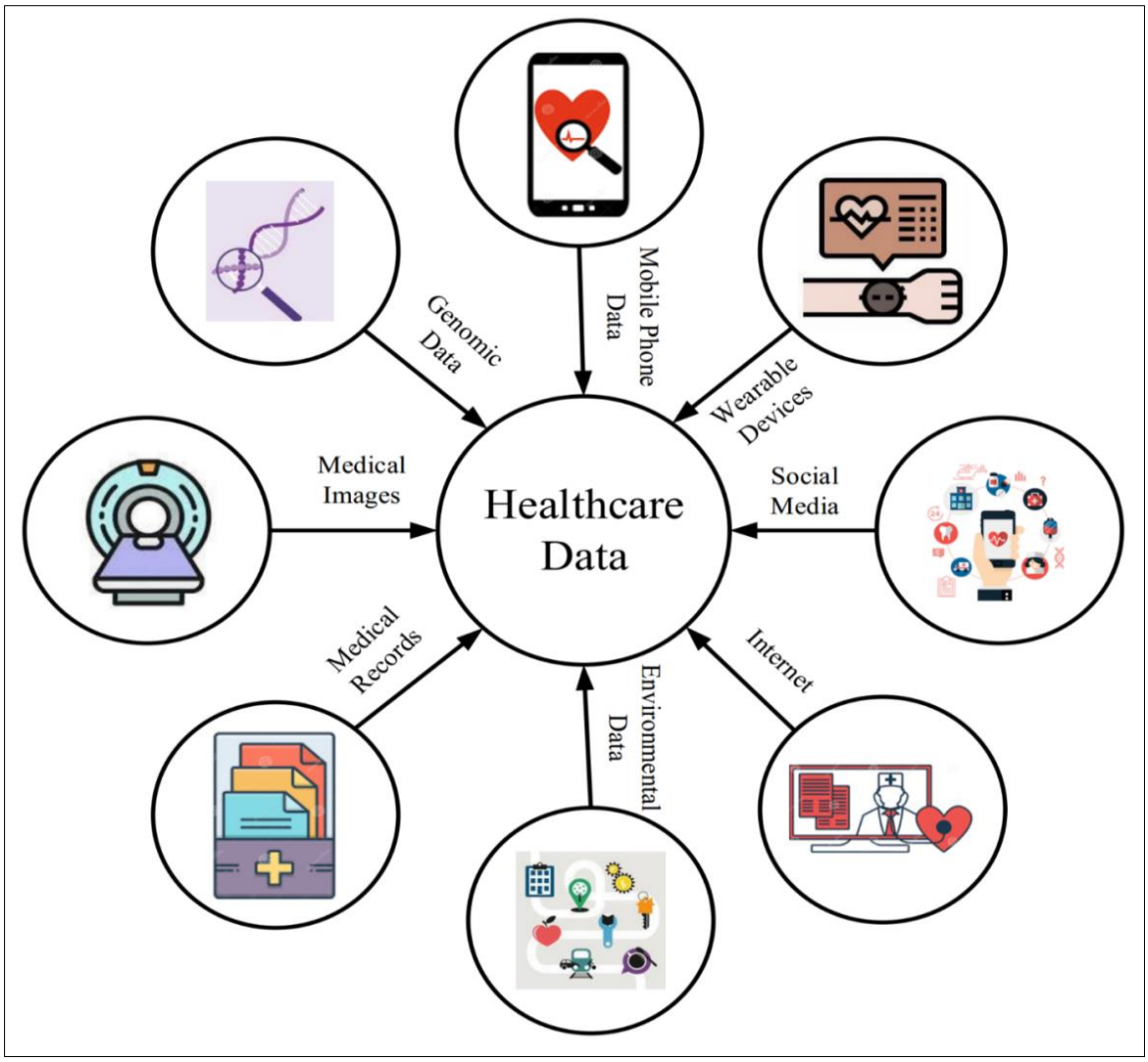

Figure 3: Some examples of Big Data in Healthcare

Lack of Machine Learning and Robotics

The eHealth program's rapid growth has led to an enormous amount of data accumulating in the DGHS's central repository. Now, DGHS is exploring how to leverage this data to enhance healthcare delivery through big data analytics, artificial intelligence, and machine learning. DGHS is also open to partnerships in this emerging field. In February 2019, the Ministry of Health and Family Welfare hosted an international conference in Dhaka focused on big data for health. This event brought together local and international experts to discuss (i) global examples of big data applications that have improved health outcomes; (ii) current and potential sources of big data for healthcare applications in Bangladesh; and (iii) ways to build capacity for developing big data tools for health. For instance, Bangladesh's public healthcare sector faces significant human resource shortages, with heavy workloads for existing staff. Studies indicate that even filling vacant positions would still leave staffing gaps relative to the demand across most facilities [9]. Hence Machine Learning is the only viable option.

Solution:

- Machine Learning (ML) is used in areas like surveillance and protection by gathering data from various sources to track disease spread, enabling predictive analytics to forecast future outbreaks. For population risk management, AI and inference tools help assess risk levels across different population groups, allowing for a more accurate projection of healthcare needs. In terms of intervention selection, AI can analyze the characteristics of specific populations and regions, identifying high-risk areas and suggesting the most effective interventions. For example, in South Africa, ML is utilized for human resource planning, predicting how long healthcare workers may remain in public service and assisting in strategic workforce planning [18].
- In a study conducted in São Paulo, Brazil, researchers developed five machine learning models to predict mortality risk utilizing routine data. They discovered that machine learning algorithms had exceptional prediction accuracy

in assessing the neonatal mortality risk of newborns.

- A comparable study was conducted in Tanzania to ensure the preservation of optimum vaccinations in healthcare facilities. Their machine learning methodology precisely forecasted bi-weekly vaccination usage at the specific healthcare facility level. They attained a forecasting fraction error of under two for around 45% of regional health institutions in Tanzanian regions.

Suggestion:

An application will operate on the DHIS2 core, featuring a user interface for data presentation. Users will engage with the application to transmit data to a machine learning process, which will analyze the data for predictive outcomes and relay feedback to the application for result display, report generation, pictogram and chart creation, or notification dispatch[18].

Other Opportunities of Machine Learning:

A) Forecasting:

Forecasting provides insights into the feasibility of achieving a goal based on the trends observed in historical data. This can then facilitate interventions or policy modifications.

B) Anomaly Detections:

The metrics in the DQR framework utilize z-scores to identify outliers. Z-scores identify outliers by measuring the distance of a data point from the mean within a dataset. M-learning offers a distinctive potential for anomaly detection by analyzing correlations among indicators and employing data fragmentation and re-assimilation, which is absent in the DQR framework metrics.

C) Disease Predictions:

Data in DHIS2 can also be combined with other data such as climate, weather etc. to predict disease outbreaks [18].

Equity

In 2017, the equity-based instrument known as The Equitable Impact Sensitive Tool (EQUIST) was launched, utilizing DHIS2 data. Health issue interventions advocated by the Lancet are accessible via the EQUIST tool, derived from published materials over the last two decades. EQUIST for decision-making is a robust framework. The EQUIST was created to rectify the shortcomings of conventional cost-effectiveness analysis (CEA) in global health, which frequently neglected equity factors. The major objective was to enhance the effectiveness and efficiency of health systems by openly integrating equity as a fundamental factor in health policy decisions [19]. Bangladesh is the first nation to utilize DHIS2 data for equity-based planning. Yet Bangladesh has yet to use this tool to enforce equity [5].

Solution:

- Employ EQUIST to address the unequal allocation of resources among different districts. EQUIST has demonstrated its efficacy as a valuable instrument in formulating health policies that are both economically viable and equitable.
- REQUEST can be utilized to directly impact national health policy and resource distribution, identifying impediments and formulating priority measures to resolve them.
- Integrate the Pathways to Survival (PATHS) tool with EQUIST as a valuable enhancement. PATHS uses an epidemiological model based on decision trees, existing evidence, and expert insights to map out the "architecture" of mortality within a population. By identifying areas where health systems are weakest, PATHS can pinpoint where improvements are most necessary [19].

Lack of Decentralization

The system is primarily centralized, with the Ministry of Health and Family Welfare (MOHFW) tasked with the oversight, management, and regulation of health, family planning, and nutrition programs nationwide. The Ministry of Health and Family Welfare (MOHFW) comprises two Directorates: the Directorate General of Health Services (DGHS) and the Directorate General of Family Planning (DGFP). Family planning services are frequently administered and provided independently from DGHS services, and there is no information exchange between these two agencies through DHIS. Datasets from these programs cannot move to DHIS2, leading to data mismanagement. Furthermore, data retrieval from the DHIS 2 platform is not the standard procedure for the RMNCAH line directorates; similar to other directorates, they depend on their own reporting formats [8].

Solution:

- While the DGFP has repeatedly indicated its intention to utilize DHIS2 as a comprehensive platform for routine data collection, this initiative has yet been implemented at the national level**.** Ensuring the integration of DGFP with DHIS-2 and with DGHS will lead to proper data flow and mitigate double data recording [5].

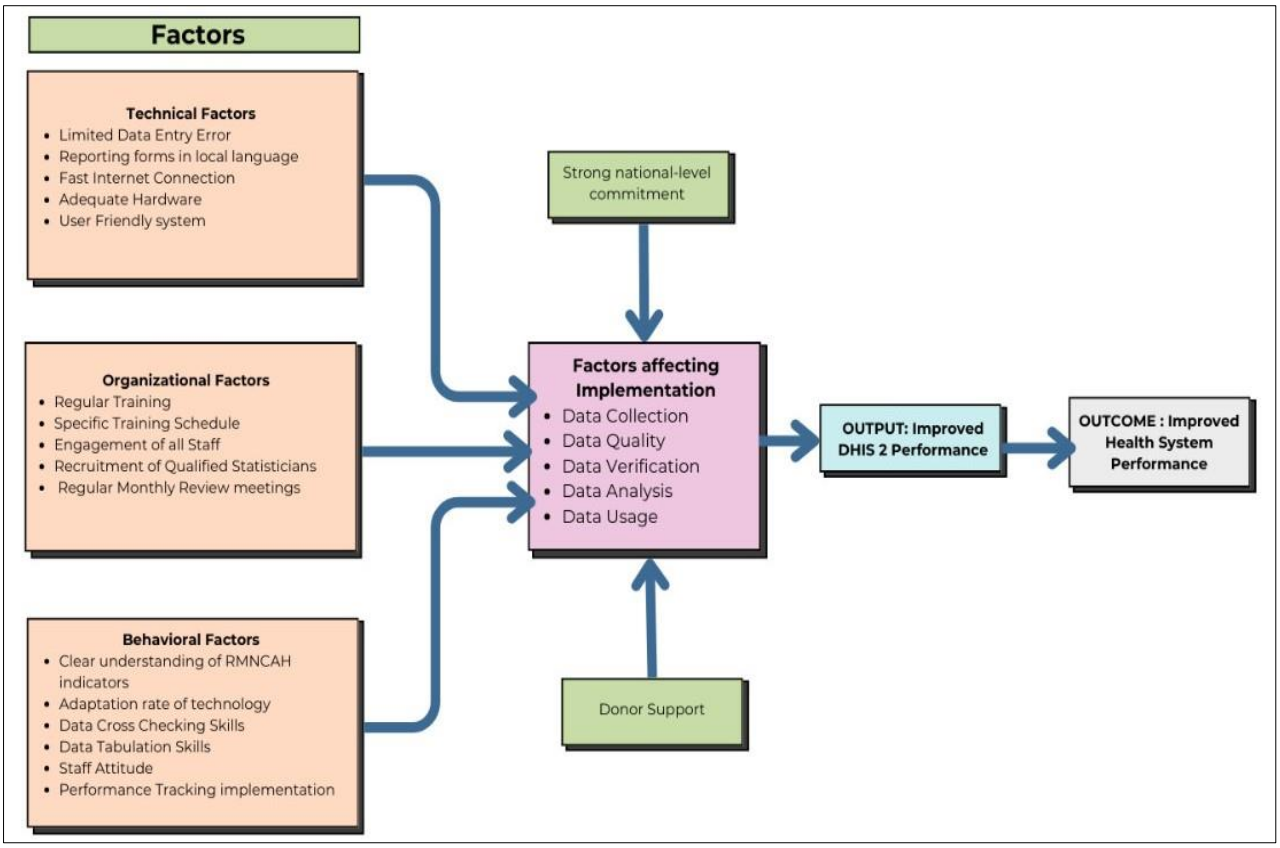

Figure 4: Factors affecting DHIS-2 Performances that should be addressed

Patient Tracking

In 2013, UNICEF helped GIZ upgrade DHIS2 to version 2.12, which introduced a "patient tracker" feature. This function allows details from patient appointments to be recorded and later accessed. Patients can also be tracked over time, with the system sending automatic text reminders if they miss an appointment or are due for a vaccination. Although the tracker feature enables a patient's electronic health record to be transferred to a new facility, recording individual data at the sub-district level is often difficult. Challenges include slow internet speeds and limited time for data entry. Additionally, at the community level, internet speed issues can make it hard to retrieve previously entered information, leading to duplicate patient records.

Solution:

There is yet to be established a unique identification number for accurate patient tracking. If the National Identification Database (NID) number was used and integrated into the DHIS-2, duplication of records would no longer be possible. Furthermore using the NID number allows all health data of the patient to be accessible from anywhere in the country by any healthcare provider.

Screening

A specialized DHIS2 module was created to manage data from the national cervical cancer screening program in Bangladesh. A training program for trainers was established to continuously educate data managers. The system has been employed to gather cumulative cancer screening performance data since 2018. Nonetheless, the system has not yet integrated colposcopy data. The colposcopy clinic at BSMMU has an independent computerized record system that is not yet integrated with [20].

Solution:

- Expanding DHIS-2 to collect data on all cancer screenings—not just cervical cancer—can significantly enhance Bangladesh's cancer surveillance and early detection efforts. By integrating screening data for breast, colorectal, prostate, and other prevalent cancers into the DHIS-2 system, health authorities can monitor and address broader cancer trends, optimize resource allocation, and target interventions more effectively.
- This comprehensive approach would support a more inclusive national cancer control strategy, ultimately improving patient outcomes and aligning with Sustainable Development Goals related to non-communicable diseases and universal health coverage.

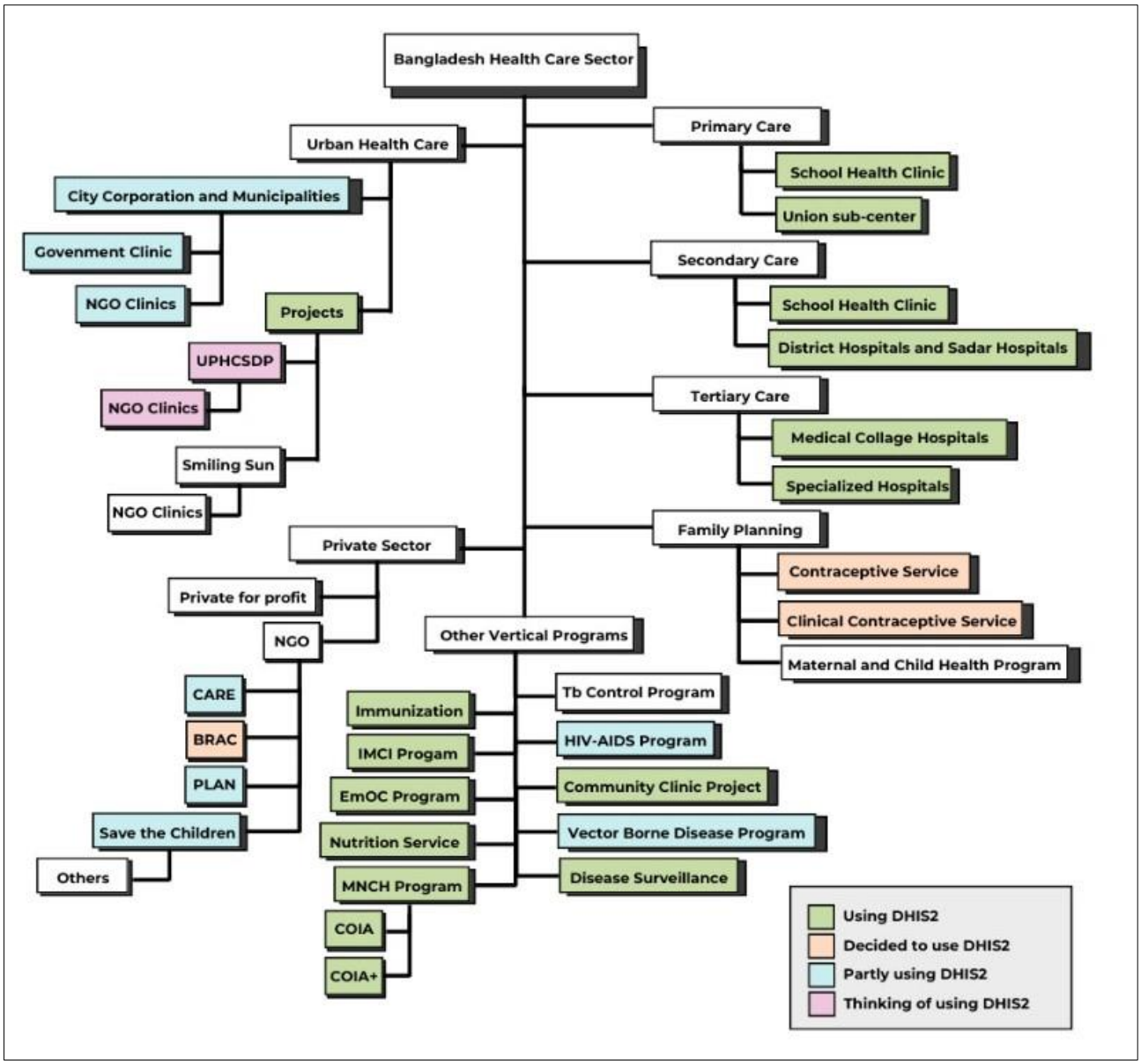

Figure 5: Implementation of DHIS-2 in the Health Sector

Antimicrobial Resistance Tracking

Bangladesh is notoriously known for its lack of policies regarding antibiotic misuse. The unregulated availability of antibiotics and a lack of awareness about proper usage have led to widespread misuse, including self-medication, incomplete treatment courses, and over-prescription. Bangladesh has a significant deficiency in One Health (OH) surveillance and reporting systems for antimicrobial resistance (AMR). DHIS-2 has not yet been extensively employed for AMR data. The efficacy of containing the local, national, and worldwide proliferation of AMR is predominantly reliant on a technically proficient, prompt, and cohesive surveillance system. A robust surveillance system is essential to provide the necessary data for all facets of antimicrobial resistance (AMR), including the efficacy of antibiotic medicines, stewardship programs, and programmatic interventions across diverse settings [21].

Solution:

- Incorporating a module into DHIS-2 to collect antimicrobial resistance (AMR) data could greatly enhance its effectiveness. When implemented with an interdisciplinary approach, this surveillance platform can facilitate easy and flexible archiving, analysis, and sharing of AMR data. There are already initiatives underway to improve interoperability and data integration between DHIS-2 and other commonly used AMR tools like WHONET [21]. WHONET is a free desktop software created and maintained by the WHO Collaborating Centre for Surveillance of Antimicrobial Resistance in Boston, USA. Establishing a dedicated DHIS-2 server for antimicrobial resistance (AMR) data—both confidential and non-confidential—is crucial

for effective operations. This server would enable automated file transfers and synchronization between WHONET and DHIS-2 backend databases. Such integration is essential for supporting the development, implementation, monitoring, and real-time evaluation of national strategies aimed at containing AMR [22].

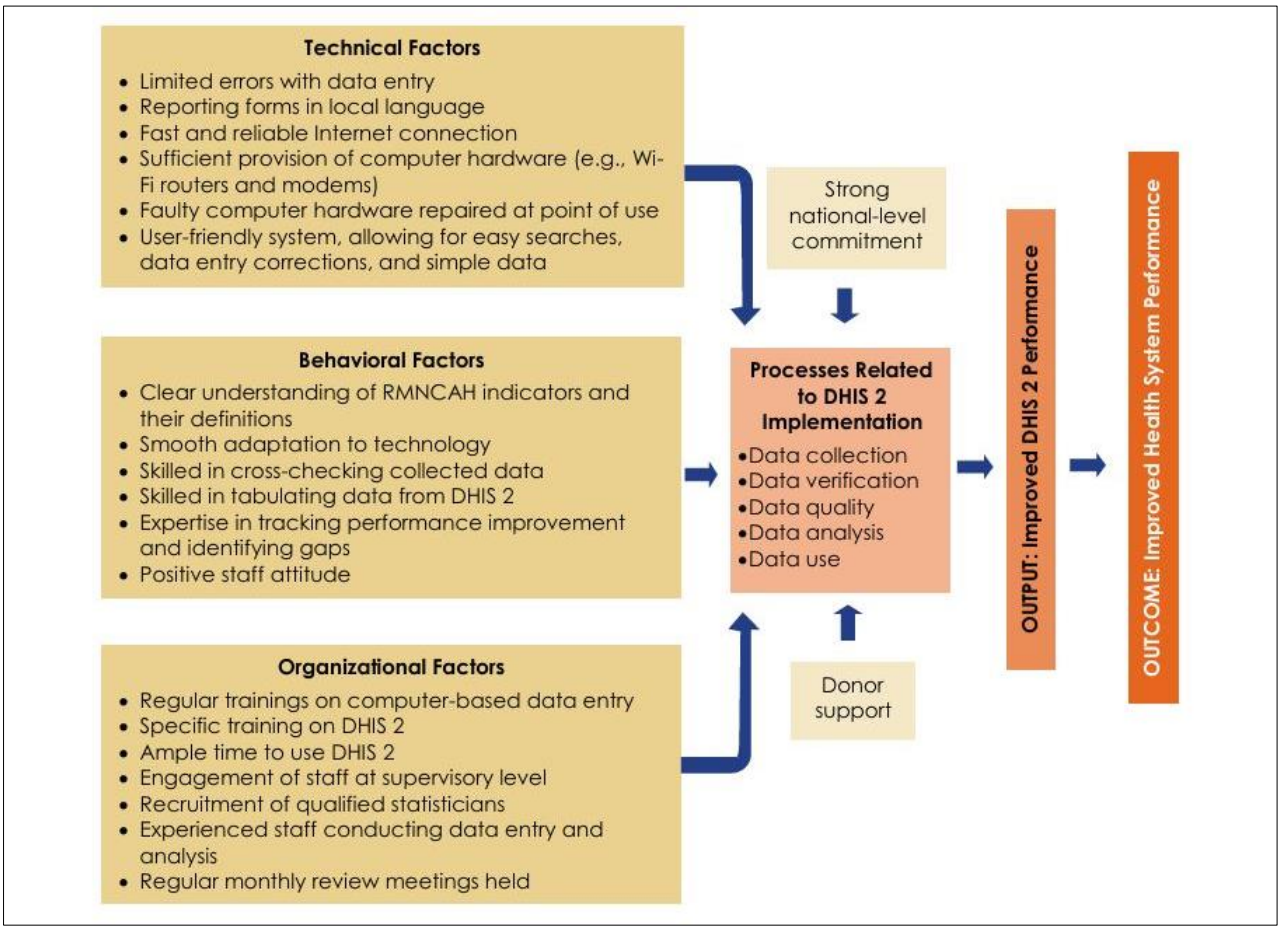

Figure 6: Key Bottlenecks while applying DHIS-2

Miscellaneous Data Gaps

Routine health data entered into DHIS2, along with survey data, is utilized at the national level to monitor health-related SDG indicators, encompassing maternal mortality, neonatal and child mortality, communicable diseases, mental health, substance abuse, road traffic injuries, sexual and reproductive health, and universal health coverage (UHC). A dashboard has been developed to visualize data from over 14,000 public health clinics in Bangladesh [5]. Nevertheless, various additional forms of data remain to be collected. There is a persistent deficiency of statistics about elder abuse, domestic violence, heat waves, and orphan demography. Data collecting must commence immediately and be mandated at all levels throughout the country. Bangladesh possesses a wealth of significant data concerning neglected tropical diseases, including Lymphatic filariasis. Nonetheless, there exists no data-gathering initiative for the post-elimination surveillance protocol. No indicators have been added in DHIS-2 to facilitate the long-term reporting of new instances and patient access to care, specifically lymphoedema management and hydrocele surgery, by health facilities [23].

Associated Challenges

Research revealed a prevalent deficiency in health workers' comprehension of the significance of the data being gathered, resulting in incomplete or substandard data. Additionally, another study indicated data falsification occurred in the absence of supervision or feedback for lower-level healthcare professionals. Enhanced education of the purpose and applications of the data, especially among lower-level employees, could augment completeness. Behavioral variables significantly contributed to data transmission problems, mostly resulting from inadequate staff motivation. Despite receiving feedback, health workers frequently had challenges in comprehending the information from central reports, resulting in misconceptions and delays in rectifying errors [16].

CONCLUSION

Citizens can conveniently access health services according to their needs and preferences; providing data for informed decision-making and enhanced governance; equipping service providers and health professionals with knowledge and digital tools to deliver quality health services to the citizens of Bangladesh. This will enable the nation to achieve Sustainable Development Goals (SDGs). There is a persistent redundancy of indicators in the register and program, along with insufficient coordination, deficiencies in capacity development, and inadequate use**.** It is important to leverage innovative technologies as a means to strengthen systems. New technological advancements may provide possibilities for managing individual-level data, sharing data across systems, and developing innovative ways in which to visualize and disseminate data. However, leveraging the potential of innovative technologies is a complex process and this requires significant time and resources with appropriate government support. Regular refresher training and incentives for increased performance can help to make systems more user-friendly. A national electronic health strategy and implementation framework can create the practice of using DHIS2 data for planning, setting priorities, and decision-making among stakeholder groups and monitoring of measurement and data entry process and lacking infrastructures were the key challenges of routine health information.

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