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Monitoring and Evaluation of a New Program to Modernize U.S. Public Health Surveillance through Data-entry Once and Creation of a One Health, Integrated Disease Surveillance and Response Health Information System

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Abstract

Monitoring and Evaluation of a New Program to Modernize U.S. Public Health Surveillance through Data-entry Once and Creation of a One Health, Integrated Disease Surveillance and Response Health Information System

By Liah Nguyen

The healthcare industry has relied on data-driven medical records, but many doctors still use pen and paper or store data in inaccessible external drives. Patients with severe disorders visit different clinicians without a uniform medical record system. While the electronic medical record (EMR) system has been introduced to address this issue, there are multiple EMRs with different designs and coding languages. The COVID-19 pandemic exposed shortcomings in the public health infrastructure, with delays and inaccuracies in data collection and analysis, and limitations in monitoring and evaluation frameworks. To address this, a team proposes the One Health Integrated Disease Surveillance and Response (IDSR) Health Information System (HIS) that enables healthcare providers to enter data only once. This feeds into the EMRs and the new HIS, with reportable public health data from other sources. The system aims to modernize public health surveillance (PHS) using AI and ML to predict and prevent diseases and standardize assessments. The purpose of this special studies thesis is to develop a monitoring and evaluation (M&E) plan for the One Health IDSR HIS pilot, including data collection plans and tools, to enable scientific evaluation and achieve program success. The investment in the IDSR system has the potential to be a long-lasting investment in US public health, saving lives by improving prevention, detection, and response to leading causes of illness, death, and disability.

Key Words: One Health Integrated Disease Surveillance and Response, Health Information Systems, Public Health Surveillance, Electronic Medical Record, Monitoring and Evaluation, Public Health

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Abbreviations

AI Artificial Intelligence
API Application Programming Interface
CDC Centers for Disease Control
DMI Data Modernization Initiative
EMR Electronic Medical Record
FHIR Fast Healthcare Interoperability Resources
GUI Graphical User Interface
IDSR Integrated Disease Surveillance and Response
HIS Health Information System
PHS Public Health Surveillance
LIMS Laboratory Information Medical Systems
M&E Monitoring and Evaluation
ML Machine Learning
RPA Robotic Process Automation

Chapter 1: Introduction and Background

1.1 Introduction and Rationale

In modern healthcare, medical records have been profoundly data-driven yet many doctors around the world still record via pen and paper or slowly load and store data in external drives that are not easily accessible.[1] And many patients diagnosed with severe disorders or diseases frequent different specialized clinicians without a uniform medical record system. [2,3]

The electronic medical record (EMR) system was introduced in 1992[4] and although many improvements have been made, there are multiple EMRs that work in parallel with each other in design, coding language, and coding platforms.[5] This issue in the United States was exacerbated during the COVID-19 pandemic, when many liabilities and shortcomings were discovered in the current public health infrastructure. It was hard to collect accurate and efficient data in a timely manner and the consequences impacted local, state, and national levels.

A team has proposed a data-entry once, One Health Integrated Disease Surveillance and Response (IDSR) Health Information System (HIS) to make Public Health Surveillance (PHS) data, information, and messages available to multiple partners in public health, when and where needed. This approach allows healthcare providers to easily fulfill their legal responsibility to officially record *reportable public health conditions* by entering data only once. That information will (as designed) feed the EMRs, plus concurrently and simultaneously feed the new One Health IDSR HIS. In addition, LIMS (Laboratory Information Medical Systems), Veterinary Record Systems,

pharmacists, extended-care workers, and the public will feed reportable public health data into the new HIS.

The project aims to modernize PHS through use of artificial intelligence (AI) and machine learning (ML) to predict and prevent expected cases plus maximizing efficiency and effectiveness. Public health managers and decision-makers can improve their detection and response to diseases, morbidity, and mortality. The overarching goal is to facilitate and standardize national-level assessments and create a new user-friendly process for public health professionals and healthcare personnel to support the next generation of PHS at the local, state, national and global level.

1.2 Problem Statement

The response to the COVID-19 pandemic in the United States has been inadequate due to many factors, including having limited public health data caused, in part, by the politicization of the origin, cause, and spread of the virus. The delays in data retrieval and analyses, coupled with limitations, only exacerbated the public's lack of trust of public health professionals. These could be avoided in future situations by a modernized PHS with One Health and IDSR. Currently there are no monitoring and evaluation (M&E) frameworks to assess new approaches, including an M&E framework to aid in achieving program success.

1.3 Purpose

This special studies thesis is to build a complete and comprehensive M&E plan for the data-entry once, One Health IDSR HIS pilot. It will include the full scope of existing IDSR with new elements that are added to the system that align with the North Star

Architecture.[6] The M&E plan will allow a careful scientific evaluation and include all elements and tools needed to implement an improved paradigm for PHS. By including key stakeholders throughout project development, this would ensure scientific fidelity to project goals and ensure the plan fits within the project capacity.

1.4 Objectives

- Create a comprehensive M&E framework for One Health Integrated Disease Surveillance and Response (IDSR) Health Information System (HIS). The M&E framework will function as a scientific reporting tool for the team to monitor progress and evaluate impacts.
- Develop all accompanying data collection plans and tools for indicators included within the M&E framework.

1.5 Significance

Reliable data are essential to perform the right public health actions and bolster trust in public health professionals. Accuracy improves perception of ongoing PHS activities while maintaining a high level of performance. The investment in an IDSR system has the potential to be a long-lasting investment in U.S. public health, as the ability to make informed, accurate decisions will save lives.

As seen during the COVID-19 pandemic, gathering information in a timely and effective way impacts how individuals behave and what policies are put into place. One Health IDSR HIS makes PHS data accessible, readable, and usable to public health decision-makers, thus improving prevention, detection, and response to leading causes of illness, death, and disability.

An M&E framework will allow close monitoring of project activities, outputs, and outcomes to ensure One Health IDSR HIS targets are met and allow for scientific review of the project's adequacy and effectiveness meeting its goals.

Chapter 2: Literature Review

2.1 Electronic Medical Record (EMR) Systems

To some degree, doctors and medical professionals around the world are still completing medical records via pen and pencil or loading and storing patient data offline which are not readily accessible, available, or safe.[7] Problems with this can be exacerbated when critical patients diagnosed with various additional disorders are overlooked due to inadequate record keeping.[8]

Patients with chronic diseases require a systematic medical history for proper diagnosis.[9] Their medical history can include frequent visits to various clinicians, laboratory reports, and prescriptions that become misplaced or stored at random without an account to time.[10] In these multifaceted cases, patients are unable to properly communicate their situations to new doctors, and doctors are unable to identify the root cause of various diagnoses. The ambivalent and muddled set of data may ultimately lead to avoidable mortalities.[10]

Since its introduction in 1992, the electronic medical record (EMR) system has revolutionized healthcare intelligence and enhanced user experience.[4] Over the past few decades, EMR has greatly evolved with the potential of saving trillions of dollars per year.[11] When innovative technologies like blockchain, artificial intelligence (AI), and 5G communication are utilized, opportunities increase.[12,13] There are many proprietary EMR systems that store sensitive data and operate in parallel, with similar coding language, platforms, and vary in design. However, some are web-based, while others are siloed that run on induvial, standalone computers or local networks.[5] In the United

States the infrastructure for PHS is out of date and fragmented with more than 120 siloed PHS in 2022.

The National Notifiable Diseases Surveillance System (NNDSS) Base System (NBS) aims to streamline the management of reportable data and facilitate communication among local, state, territorial public health departments, and the CDC by integrating information from EMRs. However, it is only utilized by 26 health departments, including 20 states, Washington, DC, CNMI, Guam, Puerto Rico, RMI, and the U.S. Virgin Islands.

The COVID-19 pandemic has highlighted numerous deficiencies and inadequacies in the current public health infrastructure and has put public health professionals under immense pressure to comprehend the spread of the disease while still maintaining PHS for various other preexisting ailments.[14] Functional and efficient PHS is vital for population health, as it captures data and generates information that public health practitioners and stakeholders can use to make better decisions and take more effective actions.[15]

However, the struggle to obtain accurate and timely data has resulted in a delay in data collection and analysis, putting a significant burden on public health workers at the local, state, and national levels. Although various technologies are available to improve PHS, constraints on the current system have hindered its transition into the 21st century. Despite being considered one of the best-prepared countries to handle a pandemic scenario, the United States struggled to contain the virus and became the epicenter of the pandemic due to a lack of preparedness and insufficient containment measures[16].

2.2 Integrated Disease Surveillance and Response (IDSR)

Public health struggles to provide timely and relevant information for action, which could potentially save lives. To address this, there is a need for a public health ecosystem that can effectively respond to crises and leverage successful public health programs, such as the Integrated Disease Surveillance and Response (IDSR) developed by the U.S. Centers for Disease Control and Prevention (CDC) in Africa.[17]

WHO African region adopted IDSR, and by 2017 94% of African countries implemented it. Lessons learned from the long-term implementation of IDSR emphasize the need for alignment at all levels of the HIS.[18] This extensively tested and proven PHS model proposes a more efficient and effective approach that can provide accurate, sensitive, specific, and timely data, information, and messages bypassing the limitations of the current system.[19,20.]

To achieve this, we propose an innovative and streamlined platform that integrates PHS. The short-term impact of this project would be improved PHS data for the pilot areas, which could encourage other health officials to adopt a similar approach. In the long-term, the project's impact includes better utilization of funding for PHS and the availability of widely accessible and accurate information that empowers health officials to make informed decisions and the public to have comprehensive health information.

The proposed conceptual framework aims to enhance PHS for the implementation of IDSR by utilizing an AI-based robotic automation process.[20] This framework not only promotes better coordination, communication, and collaboration but also includes an open-source tool that facilitates real-time reporting of public health information. The ultimate goal is to build a system that incorporates a middleware platform that allows for

singular data entry and efficient feed of public health information through concurrent reporting.

With the ongoing COVID-19 pandemic, the need for such a system is more evident than ever before. While many African countries have been able to repurpose their PHS to include immediate case notification and other types of PHS, the United States has struggled to keep up.[18]

To improve PHS, IDSR leverages the power of AI to push notifications through an interoperable tool that connects to EMRs and sends data to appropriate local, state, and national health officials in real-time.[16] However, the lack of interoperability between EMRs is a significant challenge that needs to be addressed. The proprietary nature of EMRs and their profit-driven development hinder data exchange between systems, making it difficult to capture information efficiently. To resolve this, creating a unique identifier for each individual or using a secure web-based platform that de-identifies the data as much as possible to ensure maximum privacy and HIPAA compliance.

The benefits of modernizing PHS outweighs the costs of an initial investment. The current system is outdated, inefficient, and unreliable, making it difficult to manage public health emergencies effectively. A modernized system would have been game-changing during the COVID-19 pandemic, allowing real-time monitoring of efforts to "flatten the curve" and early detection of the initial spread of the virus.[21] Clear communication and availability of data also help to build public trust and credibility in public health officials and the scientific process.

In summary, the proposed conceptual framework is a significant step towards transforming national-level PHS. By incorporating an AI-based robotic automation

process and an open-source tool, the framework promotes better coordination, communication, and collaboration facilitating real-time reporting of public health information. While there are challenges, such as the lack of interoperability between EMRs, the benefits of modernizing the system outweigh the costs. A modernized system would have been invaluable during the COVID-19 pandemic, and it would go a long way towards building public trust and credibility in public health officials and the scientific process.[22]

2.3 CDC Data Modernization Initiative and the North Star Architecture

CDC's Data Modernization Initiative (DMI) – launched in 2022 – is a comprehensive effort to modernize core data and PHS infrastructure across the federal and state public health landscape.[6] This multi-year, billion-plus dollar initiative is aimed to improve the speed and accuracy of insights gained from public health data, with a focus not just on technology, but also on people, processes, and policies.

The goal of the DMI is to move from siloed and brittle public health data systems to connected, resilient, adaptable, and sustainable 'response-ready' systems.[23] To achieve this, the DMI is utilizing several cutting-edge technologies, including North Star Architecture, Artificial Intelligence/Machine Learning, Vital Statistics Modernization Tools, Open Technology, and HL7 FHIR[23].

One of the key technologies being used by the DMI is the North Star Architecture, which is designed to make data available for decision-makers when they need it. [6] This framework will help systems speak the same language, reducing reporting data burden and increasing efficiency. The North Star Architecture is being developed iteratively and

human-centered design, where data flows and information systems are coordinated and interoperable across healthcare and public health at all levels of government.[6]

To test the North Star Architecture, CDC is currently piloting two use cases, viral hepatitis and PHS for Emerging Threats to Mothers and Babies Network (SET-NET).[6] These pilots are based on a health information exchange model (HIE), which poses certain risks to data integrity. In an HIE, data is duplicated and moved, and processes can be redundant, making it a cumbersome and potentially risk-prone solution where accuracy and trust in data may be questioned.

To address these and provide more accurate, sensitive, specific, and timely PHS data, information, and messages where they are needed, when they are needed, the team is proposing an innovative and streamlined platform called One Health Integrated Disease Surveillance and Response (IDSR) Cloud. This platform is based on several key approaches, including deep learning-based AI, a robotic automation process, and advanced data analytic techniques.

Through this platform, data are entered once by human or veterinary healthcare providers or laboratory personnel into a secure web-based portal that will be developed in React JavaScript. From here, data will be synchronously pushed in parallel to proprietary EMRs, laboratory information systems, and the One Health IDSR HIS. All of these will operate in a parallel, concurrent cloud infrastructure with existing EMRs, veterinarians, and human and veterinary laboratory reporting systems, the One Health IDSR HIS.

This approach avoids proprietary EMR impediments and provides a more effective, efficient, and secure mechanism of responding to outbreaks utilizing DHIS-2. It also

paves the way for the implementation of IDSR across the country, integrating all local, state, and national health departments while modernizing and updating U.S. PHS.

In summary, the DMI and the One Health IDSR Cloud are innovative and ambitious initiatives aimed at improving PHS in the United States. By utilizing cutting-edge technologies and adopting a human-centered design approach, these initiatives have the potential to revolutionize the way public health data are collected, analyzed, and shared, ultimately leading to better health outcomes for all.

Chapter 3: Monitor and Evaluation Plan

3.1 Program Overview

The One Health IDSR Cloud is built upon several essential strategies, such as data-entry once, a middleware platform, Application Programming Interface (APIs) integration, Oauth 2.0 authentication, robotic process automation, and the incorporation of IDSR. Additionally, the system leverages ML and AI to enhance its capabilities, as well as Fast Healthcare Interoperability Resources to facilitate the exchange of health information.

3.1.1 Data-entry Once

The proposed approach allows all users – including physicians, nurses, medical and veterinary laboratorians, pharmacists, and the public – to enter data only once. The data will automatically be fed into existing systems such as EMRs, LIMS, Veterinary Record Systems (VRS), and Laboratories, as well as the new One Health Integrated Disease Surveillance and Response (IDSR) Health Information System (HIS). A secure web platform developed in React JavaScript will be used for data entry, which provides fast, responsive, user-friendly applications that can be accessed from any device, including smartphones, tablets, laptops, and desktop computers. React JavaScript is the latest technology, secure, advanced, and has strong community support.

3.1.2 Middleware Platform

The secure web platform developed in React JavaScript will allow data to be entered only once by users, including physicians, nurses, medical and veterinary laboratorians, pharmacists, and the public. A middleware platform, developed in SpringBoot, will

receive the data from the secure web platform and simultaneously report them into the appropriate information systems, including EMRs, LIMS, Veterinary Record Systems and Laboratories, and the One Health IDSR HIS. The middleware will provide robust batch processing, flexible XML configurations, database transactions, easy workflow, and various tools for development. Data transfer between systems will be encrypted and authenticated using Oauth 2.0 and TLS cryptography algorithms, following ISO 27001 standards. Ultimately, this integration will feed data of public health importance into the One Health IDSR HIS.

The ISO 27001 standard comprises 14 domains, covering various aspects of information security. These domains include information security policies, organization of information security, human resource security, asset management, access control, cryptography, physical and environmental security, operations security, system acquisition, development, and maintenance, supplier relationship, information security incident management, information security aspects of business continuity management, and compliance.

The One Health Integrated Disease Surveillance and Response (IDSR) Health Information System (HIS) will facilitate the seamless integration of relevant public health data from multiple sources, providing stakeholders with sensitive, specific, and timely information using Artificial Intelligence/Machine Learning (AI/ML) algorithms. By enabling faster and more efficient responses to public health concerns, the system has the potential to significantly reduce costs and improve outcomes. Additionally, the middleware platform will utilize Robotic Process Automation (RPAs) tailored to individual EMRs, LIMS, Veterinary Medical Record Systems and Laboratories to

transfer data securely without modifying or interfering with the existing systems. The Middleware will ensure accurate, complete, and timely data entry into the EMRs and other information systems, enhancing the quality and reliability of public health data.

3.1.3 Application Programming Interface (APIs) and Oauth 2.0 Authentication

An Application Programming Interface (API) is a crucial software intermediary that facilitates communication between two different applications. Essentially, it acts as a bridge that enables various software systems to interact with each other seamlessly. APIs play a critical role in data extraction and sharing within and between organizations, providing a convenient and efficient way to access information. Nowadays, APIs are ubiquitous and deeply embedded in our daily lives. Whenever you use a ride-sharing app, make a mobile payment, or adjust the temperature on your thermostat through your smartphone, you're utilizing an API. As such, APIs are an integral part of modern software development and are essential in enabling seamless communication between applications.

OAuth 2.0 Authentication is a method of identity verification that eliminates the need for password data sharing between consumers and service providers. Instead, it employs authorization tokens as proof of identity. Essentially, OAuth is an authentication protocol that allows users to authorize one application to interact with another on their behalf without revealing their passwords. This approach enhances security and minimizes the risk of password compromise, while also providing a seamless user experience. With OAuth, users can confidently grant permission for applications to access their information and perform actions without having to disclose their sensitive login credentials.

3.1.4 Robotic Process Automation

Robotic Process Automation (RPA) is an innovative form of technology used for automating business processes. This technology is based on software robots or artificial intelligence that performs digital work. It is commonly known as software robotics, and it should not be confused with robot software. Traditional workflow automation tools require a software developer to create a list of actions to automate a task and then interface with the back-end system using APIs or dedicated scripting language. In contrast, RPA systems develop the action list by observing the user performing the task in the application's graphical user interface (GUI) and repeating those tasks directly in the GUI. This approach makes automation more accessible to products that do not feature APIs for this purpose, including proprietary EMRs and standalone applications.

In this program, RPAs will be developed separately for EMRs, LIMS, Vet Medical Record Systems, and Laboratories. UiPath, a leading RPA software, will be used to develop these RPAs. UiPath streamlines processes, identifies efficiencies, and provides insights that make the path to digital transformation faster and cost-effective. It leverages existing systems to minimize disruption.

Since different EMRs are being used, unique RPAs will be designed to interact with them. Once an RPA is developed for any EMR, it is much easier to replicate it for other EMRs. These RPAs will be used only to enter the initial data, including the patient information and initial diagnosis, which is sufficient for the One Health IDSR HIS to function. The hospital management can continue to use their respective EMRs as per their normal daily routine as this system will work silently in parallel with the EMRs and LIMS without interference.

3.1.5 Integrated Disease Surveillance and Response

The One Health IDSR HIS will be developed on the DHIS-2 platform, an internationally renowned HIS used in over 70 countries. This open-source software platform allows for reporting, analysis, and dissemination of data for all health programs, making it highly flexible. DHIS-2 is also used as a data warehouse for public health data in many countries. The One Health IDSR HIS will incorporate machine learning and artificial intelligence (AI) modules to detect, confirm, analyze, and report public health data.

The machine learning module will activate in the One Health IDSR HIS, and data will be checked against the already predefined state and national case definitions. Once a certain set of data is marked as data of public health importance by the ML algorithms, the One Health IDSR HIS will generate alerts through various means, including system alerts, dashboard pop-up alerts, email alerts, automated calls, and SMS. To benefit from the power of AI and ML, a set of historic data, such as NNDSS, will be requested to train the machine and test outcomes. It is important to build AI around identical national case definitions to ensure accurate and reliable results. The standard Rest protocol will be used to integrate with Machine Learning Models for the prediction of high-risk outbreak areas based on multiple variables of disease transmission rates.

3.1.6 Fast Healthcare Interoperability Resources (FHIR)

FHIR, which stands for Fast Healthcare Interoperability Resources, is a standard for exchanging electronic healthcare information. Health Level Seven International (HL7), an American National Standards Institute-accredited, not-for-profit organization that develops frameworks and standards for clinical health data and other electronic health information, created FHIR. FHIR was introduced in 2014 as a draft standard for trial use

in response to ongoing interoperability issues in health IT and electronic health records (EHRs).

Based on a resource-oriented architecture that enables developers to address clinical, administrative, and infrastructural issues by assembling modular components into working systems, FHIR provides resources and tools for software development and administrative concepts like patients, providers, organizations, and devices, as well as clinical concepts such as medications, problems, diagnostics, care plans, and financial issues. FHIR is designed specifically for the web, and unlike HL7's primary formal standard, FHIR leverages XML, JSON, HTTP, AToM, and OAuth structures. FHIR's modular design enables reuse of tools to improve interoperability, and it allows retrieval of the history of specific resources or versions.

3.2 Indicators

- Proportion of timely and complete reporting measures the percentage of health facilities or animal health clinics that report disease occurrence or outbreaks in a timely and complete manner, as per the established reporting guidelines and protocols.
- Timeliness of response to alerts measures the time taken by the One Health IDSR system to respond to alerts of potential disease outbreaks, from the time the alert is received to the time a response is initiated.
- Accuracy and completeness of data measures the accuracy and completeness of data collected by the One Health IDSR system, as determined by routine data quality assessments.

- Number of disease outbreaks detected measures the number of disease outbreaks that are detected by the One Health IDSR system, across multiple species (e.g., human, animal, and environmental).
- Number of cross-sectoral response actions taken measures the number of One Health response actions that are taken in response to a disease outbreak, across multiple sectors (e.g., human health, animal health, environmental health).
- Proportion of staff trained in One Health IDSR measures the percentage of One Health IDSR staff who have received training in One Health concepts and practices, as well as in data collection, analysis, and reporting across multiple species.
- Proportion of feedback and recommendations implemented measures the percentage of feedback and recommendations provided to One Health IDSR staff that are implemented to improve system performance and data quality.
- Cost-effectiveness of the One Health IDSR system measures the cost-effectiveness of the One Health IDSR system in terms of its ability to detect and respond to disease outbreaks across multiple species, compared to other disease surveillance systems.

3.3 Outcomes

The program has several key outcomes that are critical to its success, including but not limited to …

- reducing burden to healthcare professionals.
- supporting next generation PHS with the unique IDSR framework.

- aligning with the North Star architecture.
- connecting unrelated software (legacy and emerging) into a single user-friendly interface through the AWS platform, which reduces duplication (already used for financial services).
- providing a scalable solution that can become a future global standard.

3.4 Pilot program

A 6-month pilot project in Marion County, Indiana – in collaboration with the Fairbanks School of Public Health – aims to inform CDC's Data Modernization Initiative (DMI) by testing a modernization approach to healthcare data collection and analysis. The project will develop middleware technology using advanced analytics and APIs to integrate multiple data sources, reduce time and cost, and facilitate seamless information exchange. Participatory data collection methods will also be used to include patient and community member data in the analysis. The pilot aims to demonstrate the feasibility and impact of this approach to inform national-level policies in public health informatics.

Chapter 4: Discussion

4.1 Strengths

The One Health IDSR Cloud project is an innovative solution that seeks to improve the integration of health information systems. It boasts several strengths, such as the "data-entry once" strategy that allows users to enter data only once. The data is then automatically fed into existing systems such as Electronic Medical Records (EMRs), Laboratory Information Management Systems (LIMS), and Veterinary Record Systems (VRS). This is facilitated using a middleware platform that receives data from a secure web platform and reports it simultaneously into the appropriate information systems. Fast Healthcare Interoperability Resources (FHIR) integration also enhances the exchange of health information.

The project utilizes cutting-edge technologies like React JavaScript and SpringBoot, which provide secure and responsive web applications that can be accessed from various devices. Artificial Intelligence/Machine Learning (AI/ML) algorithms further enhance the system's capabilities, facilitating seamless integration of relevant public health data from multiple sources. Additionally, Robotic Process Automation (RPA) tailored to individual EMRs, LIMS, and Veterinary Medical Record Systems enhances data entry accuracy while minimizing interference with existing systems. Finally, the project's Application Programming Interface (APIs) and Oauth 2.0 Authentication methods enhance security and provide a seamless user experience.

The One Health IDSR Cloud project is an innovative solution that leverages the latest technologies to improve the integration of health information systems. It enhances the

quality and reliability of public health data and enables faster and more efficient responses to public health concerns.

4.2 Limitations

The quality and use of data generated through routine healthcare systems, which are the main source of PHS, remain a challenge in many countries. Factors such as limited skills among health workers, patient-load versus human resource availability, and inadequate resources contribute to weak case identification and incomplete data reporting. Data analysis and feedback are often lacking, and there is a shortage of skilled personnel and inadequate infrastructure for data management.[24]

However, some countries, like Uganda, have made progress in using routine data at sub-national levels.[25] Despite systemic challenges, Uganda has reported improvements in the implementation of PHS.[25] Overall, achieving IDSR requires a clear organizational structure and addressing human resource issues, not just technical aspects. Stronger coordination and communication, adequate resources, and reliable data sources are necessary to improve disease surveillance globally.

4.3 Recommendations

The One Health IDSR Cloud has the potential to revolutionize PHS and response globally, especially in low- and middle-income countries. To ensure successful implementation, there are key recommendations for implementation and future expansion.

First, there is a need for strong political commitment and leadership to support the establishment and maintenance of the One Health IDSR Cloud. Second, capacity

building efforts, including training programs for health workers and technical staff, should be prioritized. This training should focus on the use of the platform, data management, and analysis, as well as the interpretation and application of the data generated. It is crucial to engage all these individuals in the implementation process ensure that their needs and expectations are met, and their feedback is considered. Additionally, partnerships and collaborations between various stakeholders such as health ministries, international organizations, and academia should be fostered to enhance the sustainability and scalability of the system. Continuous support and supervision should be provided to users to ensure that the platform is being used effectively.

To ensure the sustainability of the One Health IDSR HIS, funding should be sourced from multiple stakeholders and partnerships should be established. Further, continuous evaluation and monitoring of the system's performance can help identify areas of improvement and ensure that the platform is functioning effectively.

In addition, it is essential to ensure the interoperability of different data sources and explore the use of innovative technologies to enhance the efficiency and accuracy of the system. Ongoing monitoring and evaluation should also be conducted to assess the effectiveness and impact of the One Health IDSR HIS on PHS and response.

Looking forward, the expansion of the One Health IDSR HIS should be considered, including the inclusion of other disease specific PHS and the adoption of a One Health approach. By following these recommendations, the One Health IDSR Cloud can become a powerful tool in advancing global health security and achieving the Sustainable Development Goals and a unified health system.

4.4 Implications

An improved One Health IDSR Cloud has the potential to revolutionize the way we monitor and respond to infectious diseases. By incorporating several essential strategies, such as data-entry once, a middleware platform, Application Programming Interface (APIs) integration, Oauth 2.0 authentication, robotic process automation, and the incorporation of IDSR, the system can bring about significant public health benefits.

The One Health IDSR Cloud will make it possible to collect and integrate data from multiple sources, such as health management information systems (HMIS), laboratory management information systems (LMIS), digital PHS, population-based surveys, and community-based surveillance initiatives, to name a few. This interoperability will allow for the efficient and effective use of community, facility, and research-based epidemiological information. The goal is to make data readily available and help speed up the detection and response to epidemics.

Furthermore, the system will foster improved utilization of PHS data for action and avoid delays in response to emergencies by linking health indicators with other information such as climate data that can add value to inform health risks accurately. Additionally, the use of big data and artificial intelligence will transform PHS and response and complement the existing traditional PHS to improve detection and response to epidemics. The One Health IDSR Cloud will provide decision-makers with real-time, actionable insights, enabling them to make informed decisions about public health policies, resource allocation, and emergency response planning.

An improved One Health IDSR Cloud, built upon several essential strategies, can have significant public health implications and impact public health across the world. By

integrating and analyzing data from multiple sources, the system can help detect and respond to infectious disease outbreaks quickly and efficiently. With improved utilization of PHS data and the incorporation of big data and artificial intelligence, decision-makers can make informed decisions that can save lives and prevent the spread of disease.

4.5 Conclusions

In conclusion, the development of an electronic platform that allows for the interoperability of multiple relevant databases can help address the challenges faced by the One Health IDSR system. This platform will enable the optimal use of community, facility, and research-based epidemiological information for evidence-based decision-making at different levels. Through this platform, composite and multi-sourced indicators can be generated, analyzed, and monitored to improve surveillance data utilization and prompt response to epidemics. Additionally, a multi-sectoral approach must be employed to develop a workforce that can support public health surveillance and response. By implementing these strategies, One Health IDSR can ensure efficient and effective monitoring and evaluation of disease outbreaks, leading to improved health outcomes for communities. This monitoring and evaluation plan provides tools to measure current progress and a framework to build on as program capacity and reach grow and improvements are made.

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