Nanotechnology Perceptions
ISSN 1660-6795
www.nano-ntp.com

Challenges and Innovations in Vaccine Data Collection: Designing a Framework for Enhanced Immunization Effectiveness in the Bicol Region

Marilou Benoza-Lansangan, Thelma Palaoag

[1]*College Dean, Information Technology, Infotech Development Systems Colleges, Inc, Ligao City, Philippines*
[2]*Associate Professor, Information Technology, University of the Cordilleras, Baguio City, Philippines*
Email: mvjc88@yahoo.com

Improving vaccine data collection is a significant concern in the health sector. Despite putting in place various strategies, there is still data collected depicts failures that leads to untimely provision of immunization programs for children. The study sought to investigate the challenges that the immunization program personnel were encountering in their course of carrying out in data collection, assess the level of effectiveness of current practices, and recommend solutions from the identified problems and recommendations to improve data collection. The findings of this study are salient findings to policy and health providers within the Bicol Region, strategically serving them as blueprint in identifying key areas of improvements in relation to data collection. Such guidance is important for bringing into effect successful improvements in vaccine management practices. An exploratory analysis was conducted though a survey. The results suggest that while the child immunization data collection is considered effective, several challenges prevail, including lack of interoperability between data systems, data privacy and security concerns, especially in private clinics, inadequate training on data entry and management, insufficient resources for timely data entry and analysis, poor internet connectivity, and inadequate IT equipment. Hypothesis testing using Pearson R indicated a statistical correlation that was significant at $p < 0.05$ between the level of effectiveness and the identified challenges. Based on these findings, a framework for a Vaccine Data Management System (VDMS) is proposed that has the potential to play a vital role in offering effective outcomes related to the management of vaccine data. This framework includes training and human resource management, technology deployment and infrastructure, data handling and reporting mechanisms, data transparency and accessibility, collaborative work environment, end-user centricity, security and interoperability, and continuous improvement, and adaptability.

Keywords: vaccine data collection, child immunization programs, data management challenges, Bicol region, health sector, challenges, framework, innovation exploratory research, thematic

analysis.

1. Introduction

In the contemporary landscape of public health, the effective management of vaccine-related data is paramount. One of the most daunting public health objectives is to maintain an optimal performance of an immunization program. [1] As global health systems manage with endemic diseases and periodic health crises, the role of robust vaccine data collection and distribution systems becomes dominant. These are important systems in planning, executing, and monitoring of programs for immunization with the protection of populations from diseases or outbreaks. Quality and timely data on immunization are very vital in the prevention and control of disease among people within local, national, and global perspective. This includes the decision of better ways to reach children, introducing new vaccines successfully, impact documentation, monitoring and improving program performance of the immunization system, prioritizing resources and activities, and engaging in performance improvement. [2]

Child immunization programs are particularly sensitive to the pitfalls of inadequate data management. Challenges in immunization data collection and poor data recording practices frequently undermine the accuracy of immunization coverage estimates. [3] Timely and accurate administration of vaccines is important for preventing diseases in this susceptible population sector. Nonetheless, the effectiveness of these programs is often hindered by systemic data collection and management deficiencies, which can lead to missed vaccination opportunities and increased susceptibility to preventable diseases. The WHO Strategic Advisory Group of Experts (SAGE) on Immunization highlighted the crucial role of high-quality data in enhancing performance and monitoring. Reliable data enables managers and health workers to make timely decisions, thereby optimizing the effectiveness and impact of immunization programs. [2]

However, various challenges endure in the vaccine data management sector even though there are significant advances in medical technology and health informatics. Challenges such as data accuracy, timeliness, and relevance, as well as inadequate internet connectivity in certain regions, technical difficulties, and resistance to change among healthcare providers, are critical obstacles that hinder informed decision-making in public health. [4] Delays in response times and, subsequently, suboptimal health outcomes, particularly in urgent scenarios is due to failures in effectively collecting vaccine data.

In the Bicol Region, a Routine Immunization Reporting Tool is being utilized as part of its data collection procedure, which is a digitalized mechanism designed to collect child immunization records, including demographics and vaccine specifics. However, the region were identified to be consistently among the five regions with lowest coverages across all vaccines based on the FHSIS 2022 Annual Report, [5]. According to NIP Coordinator of the region, despite the tool's automated capabilities, the process of report submission to the Central Office remains unofficial and consistently incomplete, with submission rates declining below 100%. This issue leads to the underreporting of vaccine utilization on national records, which

impedes accurate tracking and effective management of vaccine supplies.

This paper aims to investigate deeply into the specific challenges faced by immunization program personnel in the area of data collection. It evaluates the effectiveness of current practices and aims to develop strategic solutions based on identified issues and recommendations. The ultimate goal is to enhance the efficiency and accuracy of vaccine data collection processes.

This research is significant for healthcare providers, specifically policymakers. The study will serve as a strategic guide to improving vaccine data management practices, potentially influencing policy decisions and operational approaches by providing a detailed analysis of the challenges and proposing a framework for improvement.

2. Methodology

This study employed the exploratory research approach to explore strategies for enhancing vaccine data collection and distribution. The researcher utilized a survey questionnaire administered through Google Form, the respondents were requested to assess the level of effectiveness of current data collection procedure and identify any challenges faced. This methodological approach provides a comprehensive insight into the practical challenges and obstacles that respondents face daily. The survey was distributed to a total of 8634 targeted participants, but only 382 responses were collected. The research foregoes the potential size using a confidence level of 95% and margin of error of 5%.

The data was analyzed using percentage, weighted mean, and standard deviation. The study employed the Pearson R statistical method to determine the relationship between variables. Refer to (1). The challenges were categorized and then assigned a numerical value based on the number of formulated categories. The numerical value of effectiveness was determined using the 5-point Likert scale. The questionnaire utilized a 5-point Likert scale along with open-ended questions. Refer to Table I.

$$r = \frac{\sum(x_i-\bar{x})(y_i-\bar{y})}{\sqrt{\sum(x_i-\bar{x})^2\sum(y_i-\bar{y})^2}} \qquad (1)$$

Moreover, the researchers employed thematic analysis to provide potential recommendations to improve data collection in the Bicol Region. Thematic analysis entails identifying recurring patterns or themes within qualitative data. Its goal is to uncover significant or noteworthy patterns, referred to as themes, and use these to explore the research topic or draw conclusions about a specific issue. A well-executed thematic analysis does more than just summarize the data; it interprets and provides a deeper understanding of the information. [6].

TABLE I. 5-POINT LIKERT SCALE FOR THE LEVEL OF EFFECTIVENESS OF DATA COLLECTION

Point Score	Range Interval	Descriptive Rating
		Level of Effectiveness
1	1:00-1.79	Very Ineffective
2	1.80-2.59	Ineffective

3	2.60-3.39	Neutral
4	3.40-4.19	Effective
5	4.20-5.00	Very Effective

The analysis generated four (4) themes, as recommended by the respondents. These themes encompassed technology and digital infrastructure, training and human resources, efficiency and data management, and coordination and cooperation. Fig. 1 displays the flowchart outlining the research process.

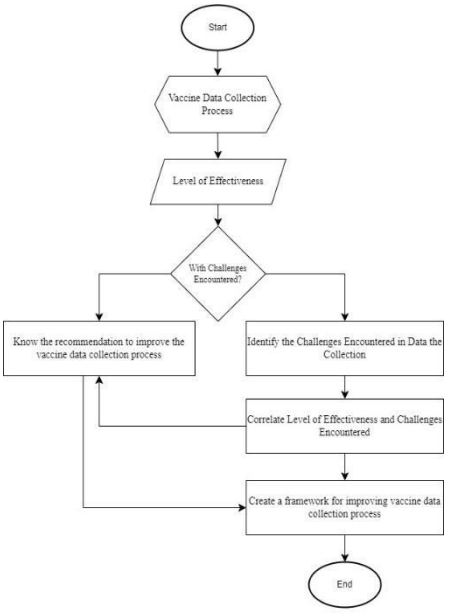

Fig 1. Research Process Flowchart

The researcher conveniently accessed the instruments through a Google Form. The responses were analyzed through a process such collecting, synthesizing, tabulating, and interpreting their meaning and relevance. Data visualization techniques such as tables, and graphs were employed to present visually the gathered data. The data analysis was conducted with Python, Microsoft Excel, and the Social Science Statistics Calculator. Descriptive analysis involves calculating the mean, standard deviation, frequency, percentage, and correlation.

3. Results and Discussion

In Fig. 2 displays the total number of respondents who responded the survey. The healthcare provider category received the most responses, accounting for 64.7%, followed by logistics (17.6%). The administration has 11.8%, while the NIP Coordinator has 5.9%.

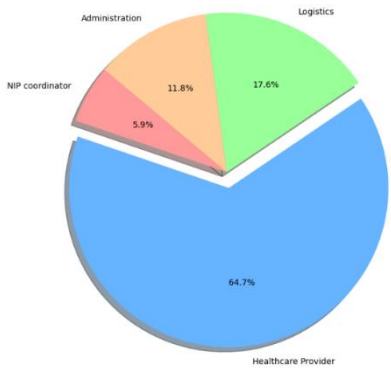

Fig. 2. Respondents of the study

A. Level of Effectiveness

Fig. 3 below displays the level of effectiveness of child immunization current data collection as perceived by the respondents. Effective category, holds 35.08% of responses, stands out as the most prominent, indicating a strong positive assessment of immunization data collection's effectiveness. Next is the Neutral category represents nearly a third of the responses at 29.58%, suggesting that many respondents are neither satisfied nor dissatisfied, highlighting an area for potential improvement. Very Effective follows with 23.82% of responses, demonstrating that a considerable portion views the data collection efforts as highly effective. The lowest percentages are shared by the Ineffective and Very Ineffective categories, each at 5.76%, showing that a smaller fraction of respondents view the efforts as lacking.

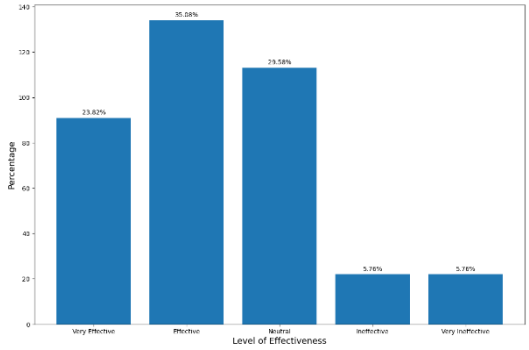

Fig. 3. Level of Effectiveness of Child Immunization Current Data Collection

The data means that the prevalence of the effective category is positive, implying that most data gathering initiatives are meeting its objectives successfully. However, the total number of effective and very effective responses does not constitute an overwhelming majority, showing that there is still opportunity for improvement in data gathering to shift neutral responses toward more favorable outcomes. The low percentages in the ineffective and very ineffective categories, on the other hand, are promising, but highlight the significance of addressing these areas and investigating the underlying causes of ineffectiveness.

B. Challeges Encountered in the Current Data Collection process

Table II shows the challenges encountered by the respondents in the current process of data collection. Inadequate training on data entry and management is the most significant challenge at 70.60%, followed closely by insufficient resources for timely data entry and analysis at 64.70%. The lack of interoperability between data systems is next, with a notable 41.20%. Data privacy and security concerns are also significant at 35.30%. Lastly, both data privacy for private clinics and poor internet connection, along with inadequate IT equipment, are the least reported challenges, each at 5.90%.

TABLE II. CHALLENGES ENCOUNTERED IN THE CURRENT DATA COLLECTION PROCESS

Data Collection Challenges	Percentage
Lack of interoperability between data systems	41.20
Data privacy and security concerns	35.30
Inadequate training on data entry and management	70.60
Insufficient resources for timely data entry and analysis	64.70
Data privacy for private clinics	5.90
Poor internet connection. Inadequate IT equipped	5.90

The finding highlights significant areas where data collection approaches expect improvement. The highest percentage, indicative of inadequate training in data input and management, reveals a significant gap. This suggests that personnel involved in the immunization program lack the necessary skills or expertise for effective data management. This gap is likely to cause errors and inefficiencies in data handling. The collected data is frequently of low quality, with a high amount of missing information. [7] This is partly due to delays in data recording. [8] as well as insufficient training and support for health facility staff. [9] Similarly, the difficulty of limited resources indicates potential delays and inefficiencies in data gathering and processing due to a lack of appropriate equipment or personnel. [10 Furthermore, the main barriers to maintaining high-quality immunization data included the lack of guidelines, a shortage of data recording tools, vertical reporting structures, and limited supportive supervision from higher levels. Respondents also mentioned that they used to multitask and that their facility has no designated personnel for data collection and reporting. In the study of Saidu, et. al. [3], a significant obstacle to achieving universal immunization coverage is the lack of timely and high-quality data. This issue arises, in part, because frontline immunization staff in this region often juggle numerous data-related tasks alongside their primary clinical responsibilities. This could certainly impact their data collection practices, leading to the noted deficiencies.

Moreover, respondents highlight significant interoperability issues, pointing out challenges in integrating systems and seamlessly transmitting data across healthcare infrastructure components like hospitals, logistics, and healthcare facilities. As a result, immunization records are often dispersed across various locations, risking that providers make immunization decisions based on incomplete information.[11] These challenges often result in data silos that hinder comprehensive data analysis. Additionally, lack of interoperability also results to difficulties in collecting specific data, such as records of vaccines administered to children from other healthcare facilities, and in identifying available vaccines within logistics systems

for vaccine monitoring. These difficulties also are compounded by security concerns at various healthcare sites, including clinics and hospitals. The core of these challenges lies in the need to protect sensitive information, such as details about children and their immunization records. The restricted data exchange leads to numerous challenges. These obstacles compromise the efficiency and reliability of health data management across different regions and systems. [12]

Although less experienced, technical issues such as poor internet connectivity and inadequate IT equipment are critical because they may compromise the quality and reliability of data collecting in certain contexts. Rahmadhan, et.al. further explained that connectivity poses a significant challenge for online health information systems. In response, many countries are enhancing connectivity through national eHealth strategies, which include policies to improve digital infrastructure in the health sector. This upgrade is crucial for enabling effective data exchange and communication across healthcare services. [12] Addressing these issues is critical to ensuring efficient, secure, and effective data collecting, which provides accurate insights needed for informed decision-making.

C. Correlation between Level of Effectiveness and Challenges in the Data Collection

Fig. 4 depicts the correlation between the level of efficiency and the challenges encountered in current data collection in Bicol Region. After assessing the degree of efficacy and the drawbacks in current data collection, the researchers examined their relationship to determine if there was a connection between the respondent's perceived effectiveness and the challenges identified in existing data collection practices.

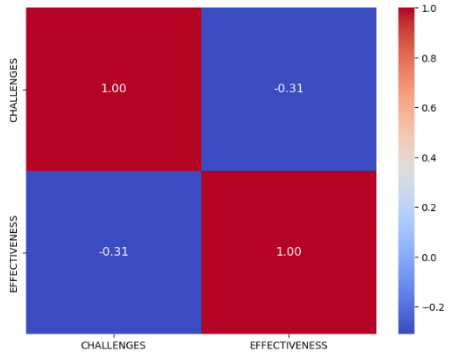

Fig. 4. Correlation between the Level of Effectiveness and Challenges

The data indicates a weak negative correlation between the variables, with $r = -0.31$. The p-value is less than .00001, making the result significant at $p < 0.05$. Based on standard criteria, this association is considered statistically significant.

According to the research, regardless of the challenges encountered in the data collection, it has no effect on the data collection process. However, since the correlation is significant, addressing these challenges could still lead to improvements in the data collection process, even if the impact may be moderate. This suggests that there is room for optimization and that by mitigating challenges, there could be a meaningful increase in the efficiency or quality of the data collection. One of the health workers mentioned that to create reports and easily

facilitate data concern for submission they tend to create their own strategies such as creating forms in Excel to input, save, and retrieve data. This resiliency is a positive act, but they still find difficulty in the current process, specifically in the accuracy of the data entry and efficiency of submitting reports. Another healthcare provider mentioned that they need to submit quarterly reports containing the same record. This could lead to either under-reporting or over-reporting of vaccinated children, resulting in poor data quality. This could subsequently impact both in-country and external investments, hindering efforts to reach zero-dose and under-immunized children. This emphasizes the necessity for enhancing staff capacity, providing supportive supervision, and standardizing data recording processes. [3]

D. Recommendation to Improve the Vaccine Data Collection

Fig. 5 presents the recommendation to improve the vaccine data collection as perceived by the respondents. The researcher employs thematic analysis to examine the results. The analysis, based on the respondents' recommendations, identified four (4) key themes, which include technology and digital infrastructure, training and human resources, efficiency and data management, and coordination and cooperation. Among the themes, technology and digital infrastructure got the highest percentage of 35%, followed by efficiency and data management with 25%, while training and human resources is 20%, and coordination and cooperation, and resource allocation both received 10%.

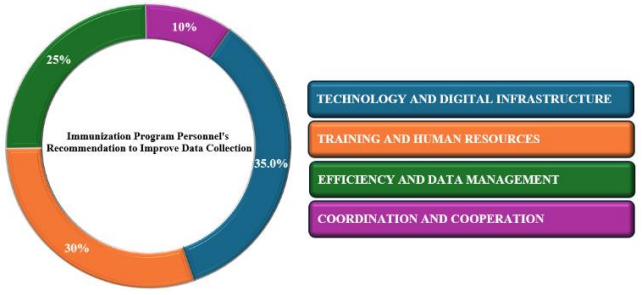

Fig. 5. Recommendation to Improve Vaccine Data Collection

1.) Technology and Digital Infrastructure. The transformative potential of digital vaccine registries in refining the processes of data collection and reporting was underlined by the healthcare provider respondents. Respondents also highlighted that leveraging digital vaccine registries and maximizing the use of technology with a stable internet connection would ensure the accuracy of data in real-time, which is crucial for the success of immunization programs. Fast and reliable internet connections for data sharing and communication would be beneficial for accurate and efficient data collection process. Some of the responses related to this theme include: “Full digitalization with the support of the Department of Health (DOH) in providing IT equipment, including satellite internet connection (Starlink).”, “Enhancing online reporting systems to be more reliable ("should not bug down"), and “Leveraging digital vaccine registries and scheduling systems for better data management”.

2.) Training and Human Resource. Respondents emphasized the need to train and to have effective human resource management for immunization health personnel. According to them it is essential to equip healthcare workers with necessary knowledge and skills to accurately

input then manage data. Training should cover all aspects of data handling, from initial data entry to advanced data management techniques. Health workers involved in reporting and administrative tasks must receive targeted training that emphasizes the importance of accuracy and timeliness in reporting health data. They further suggest that DOH must designate personnel for data management concern to avoid multitasking of the healthcare personnel. Specific of the responses in this theme comprise: "Providing adequate training for healthcare workers in data entry and management.", "Conducting more trainings and seminars, especially for public health workers.", "Proper training for health workers involved in reporting and administration.", "Designating staff specifically for the task of reporting to avoid multitasking."

3.) Efficiency and Data Management. Health personnel are advocating for several enhancements to streamline vaccine data management. They recommend establishing protocols for the timely collection of data to ensure that information is up-to-date and accurately reflects recent vaccine administrations, thus facilitating real-time tracking and management. Additionally, they suggest implementing an online system for the reporting of vaccine accomplishments, allowing local health offices to promptly update city health authorities. This digital approach would enhance transparency and enable faster response to public health needs. Moreover, to complement traditional hard copy submissions, health personnel propose prioritizing online report submissions, which can streamline processes and reduce delays in data communication between healthcare providers and oversight agencies. Responses related to this theme contain: "Timely collection of data.", "Online reporting of vaccine accomplishments from local to city health offices.", "Online submission of reports in addition to hard copies.", "Online registration for tracking children's immunization schedules."

4.) Coordination and Cooperation. Health personnel are emphasizing the importance of fostering coordination and cooperation among healthcare workers and facilities to enhance the effectiveness of health services. They stress that improved collaboration can lead to more efficient healthcare delivery and better patient outcomes. Additionally, there is a strong push for implementing transparent data sharing practices. By maintaining open lines of communication and sharing data freely between different healthcare entities, trust and accountability can be upheld, which are crucial for maintaining public confidence in health systems. This transparency is particularly important in sensitive areas such as vaccine distribution and patient data handling, where privacy and accuracy are paramount. Together, these initiatives are aimed at building a more robust and reliable healthcare infrastructure. Under this theme, responses include: "Encouraging coordination and cooperation among healthcare workers and facilities.", "Transparent data sharing practices to maintain public trust and accountability."

E. Framework to Improve the Vaccine Data Collection

Based on the challenges identified and the recommendations provided by respondents, the researchers developed a comprehensive framework intended to mitigate these issues and enhance the vaccine data management process. This framework, detailed in Fig. 6, is built around eight (8) contributing factors that are essential for its successful implementation. These

factors are depicted as influencing and supporting the VDMS, highlighting their integral roles in ensuring the efficacy and efficiency of the framework. Each factor is designed to address specific challenges and incorporates the proposed improvements such as include training on data management and effective human resource management for healthcare personnel, streamlined data reporting mechanisms, and enhanced transparency and accessibility to maintain public trust. It also emphasizes secured and seamless system integration, improved coordination among healthcare facilities, and the deployment of robust technology and infrastructure. Additionally, the framework focuses on end-user centricity to ensure the systems are intuitive and meet direct user needs, alongside principles of continuous improvement and adaptability to evolve with changing healthcare landscapes and technological advancements. By integrating these elements, the framework aims to provide a robust structure for managing vaccine data that addresses current inefficiencies and sets a standard for future healthcare data management practices.

1.) Training and human resource management. Developing the ability to plan and execute data management tasks is crucial for both individuals and institutions. Educating people on data literacy skills can also help reduce the impact of data overload and other challenges associated with being inundated by information.[13]

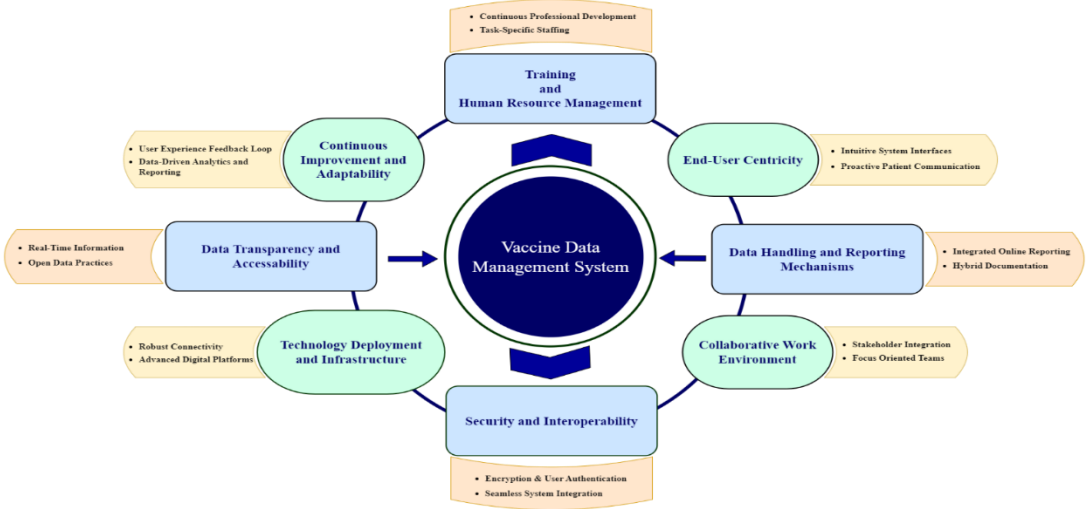

Fig. 6. Proposed Framework to Improve Vaccine Data Collection.

Capacity building improves health professionals' knowledge, attitudes, and competency levels in data management. Essential measures to enhance data management practices include continuous supportive supervision, designing user-friendly data management formats, and providing comprehensive training. [14] Dougherty, et.al., [15] also stated that various activities like adult learning, behavior change strategies, social learning, and quality improvement approaches can improve data utilization.

2.) Technology deployment and infrastructure. Digital solutions for data collection and management can streamline vaccination activities and provide valuable insights for tailoring immunization programs.[1] Electronic Immunization Registries enhance data collection by

reducing the time needed to gather information and generate reports. This approach allows data to be recorded only once, rather than on multiple forms, and enables a more dynamic workflow, allowing healthcare workers to move with the patient instead of remaining seated behind a desk. [16] It can also help address accuracy issues stemming from poor recording practices and detect inaccuracies at the point of data collection. [16] [17] Additionally, EIRs can enhance vaccine coverage by enabling the tracking of new, more specific measures to improve vaccine program management. These measures can be quickly calculated, allowing programs to act on their data more efficiently and at the right time. This system also facilitates the efficient collection and access to children's vaccination dates and birth dates. [17]

Data is pivotal for the success of mass immunization campaigns, as it allows for effective reach to millions of individuals. [18] Data-driven management systems are instrumental for healthcare providers, helping to optimize resource use, control costs, improve patient outcomes, identify improvement areas, track and measure progress. [19] [20] Specific data-driven strategies like predictive analytics and machine learning can be particularly beneficial in optimizing vaccine utilization and reducing wastage.

Furthermore, enhancing data collection in health registries can be significantly advanced through the adoption of technologies like Starlink, which provides wide-reaching, high-speed internet access, and private 5G networks, which offer secure, local connectivity. Innovations like Starlink and private 5G networks are proving to be vital in addressing these gaps. Starlink, utilizing a network of low-earth orbit satellites, provides global high-speed internet access with the benefits of low latency and easy setup, making it ideal for remote regions. On the other hand, private 5G networks offer customizable, high-speed, low-latency wireless connectivity, enhancing local network capabilities and security for various applications, including IoT and real-time operations. By integrating Starlink with private 5G networks, a comprehensive connectivity solution for remote areas is created. Starlink acts as the primary internet source, while private 5G networks extend this connectivity locally, ensuring seamless coverage and high performance across devices and infrastructure. This synergy not only bridges the connectivity divide but also supports a wide range of modern digital requirements, making it a transformative solution for remote connectivity. [21][22] Together, these technologies ensure a comprehensive and reliable data management system across healthcare platforms.

3.) Data handling and reporting mechanisms. The Vaccine Data Management framework includes a critical component focused on Data Handling and Reporting Mechanisms to streamline and secure vaccine data processing. A key feature is Integrated Online Reporting, which allows vaccination sites to report data directly to health offices through an online system. The integration of real-time data processing and online reporting in healthcare significantly enhances management efficiency and patient care. These systems streamline administrative tasks, allowing healthcare providers more time for direct patient interaction. By enabling efficient and accurate documentation of patient encounters, and updating patient data promptly, these technologies reduce errors and improve data accessibility. Healthcare providers can effectively track and analyze a broad range of KPIs and metrics, making data actionable for better decision-making. This adoption of business intelligence in healthcare leads to improved strategic planning and resource management, ultimately enhancing patient

care and institutional performance. This underscores the critical role of technology in advancing healthcare efficiency and quality. [23] [24]

Additionally, the framework employs a Dual Documentation Mode, blending traditional hard copy record-keeping with digital submissions. This hybrid approach ensures data integrity and provides a reliable method for data verification, enhancing the overall trustworthiness and robustness of the vaccine data management system. These strategies are designed to optimize data handling processes, ensuring data is both accurate and secure. Hybrid systems, which combine paper-based and electronic records, provide several benefits including flexibility, convenience, and a smoother transition from paper to digital formats. These systems can accommodate various record types and formats, reducing the risk of record loss or damage. However, they also present challenges such as potential duplication and inconsistency, increased management complexity, higher costs, and difficulties in integration and synchronization. Despite these issues, organizations that need to manage both paper and digital records may find hybrid systems advantageous. The trend in record management is increasingly leaning towards more advanced technological solutions, including specialized document management software and hybrid systems that integrate paper and digital records effectively. [25]

4.) Data transparency and accessibility. Data accessibility and transparency in healthcare are transforming patient care by empowering individuals with direct, convenient access to their own health information through digital means. This empowerment allows patients to actively participate in their healthcare decisions, better manage their conditions, and prevent the escalation of chronic diseases by making informed choices based on a comprehensive view of their medical records, clinical notes, and data from connected devices like smartwatches and fitness trackers. The recent interoperability rules further enhance this by enabling digital health companies and app developers to access patient data, fostering innovation and improving patient engagement, health literacy, and outcomes. This shift towards greater transparency and patient-centered care not only reduces medical errors but also enhances the overall healthcare experience by promoting deeper patient involvement and collaboration in their health management. [26]

5.) Collaborative work environment. A successful implementation of electronic immunization data collection requires care providers and policymakers to appreciate and commit to shared surveillance resources. [27] Also, healthcare reform that emphasizes better collaboration can significantly improve patient outcomes and provider well-being. Embracing a collaborative mindset fosters the creation of effective team-based healthcare. Enhanced healthcare coordination can reduce adverse drug reactions, optimize prescription dosages, and decrease morbidity and mortality, making medical care more effective. Furthermore, interprofessional collaboration is vital in creating a supportive work environment that encourages conflict management, innovation, and boosts confidence, while simultaneously reducing emotional exhaustion. This type of teamwork not only eases the workload but also increases job satisfaction among healthcare providers. By improving communication and decision-making in high-stress environments, it guarantees that the contributions of all disciplines are valued and integrated, preceding to more efficient and effective patient care.

[28] [29] [30]

6.) End-user centricity. Designing user-friendly digital interfaces ensures that healthcare workers can navigate systems easily and efficiently, enhancing their ability to manage vaccine data effectively. Zheng, et. al., mentioned that intuitive user interafce (UI) enhances the usability and efficiency. [31] Intuitive design not only simplifies complex processes but also fosters a more transparent and collaborative relationship between patients and healthcare providers. As technology continues to advance, the integration of UI/UX principles will play a pivotal role in shaping the future of healthcare, ultimately enhancing patient experiences and improving health outcomes. [32] Additionally, implementing electronic systems for scheduling and reminders plays a pivotal role in improving patient compliance and overall experience. These systems facilitate timely communication with patients about their vaccination schedules and any necessary follow-ups, which not only streamlines the vaccination process but also boosts patient engagement and satisfaction. stated that new IT scheduling tools that send automated SMS appointment reminders, allowing patients to confirm or cancel appointments via SMS, can enhance primary care clinics' capacity to care for more patients without requiring additional staff or resources. [33] Text-message reminders are as effective as telephone reminders in reducing missed appointments in an academic primary care clinic and are more cost-effective particularly in low-resource settings. [34] [35] Together, these factors contribute to a more effective and user-centric vaccine data management strategy.

7.) Security and interoperability. It is essential to incorporate two critical components to ensure its efficacy and security. First, enhanced security protocols should be a cornerstone of the framework. This involves integrating strong encryption and robust user authentication methods to protect sensitive health data against unauthorized access and potential breaches. Such security measures are crucial in maintaining the confidentiality and integrity of health information. To protect health information (PHI), a set of technological safeguards known as the HIPAA Security Rules has been devised. These regulations specify the methods for authentication, access control, integrity, and auditing, as well as how organizations should handle, transfer, and keep PHI in a safe manner. To avoid breaches and guarantee adherence to these requirements, conventional security solutions like firewalls, multi-factor authentication, antivirus software, and data encryption must be put into place. [36] Second, the framework should include seamless system integration, designed to enable the VDMS to interoperate effectively with existing healthcare IT systems. By adhering to industry standards, this integration ensures that the VDMS can seamlessly communicate and function within the broader health information ecosystem, facilitating a more efficient and error-free data exchange. Together, these components not only enhance the security and functionality of the VDMS but also support a more robust and reliable infrastructure for managing vaccine data. The Health Level 7 (HL7) Fast Healthcare Interoperability Resources (FHIR) is a widely recognized standard for ensuring interoperability in healthcare IT systems. HL7 FHIR allows health information to be exchanged efficiently across different systems by structuring data into discrete components known as "resources." This modular approach facilitates the extraction and reuse of specific data elements, making FHIR adaptable for internet-based technologies

and mobile applications. Moreover, it supports various data formats like JSON, XML, or RDF, enhancing its flexibility. Implementing HL7 FHIR, particularly between Vaccine Information Systems (VIS) and other health organizations, has been proven to increase the quality of immunization records and streamline processes, making them more efficient. [12]

8.) Continuous improvement, and adaptability. In the proposed vaccine data management framework, emphasizing continuous improvement and adaptability is crucial for evolving with the dynamic healthcare landscape. Integrating a user experience feedback loop is fundamental; this mechanism collects and analyzes feedback from system users to inform necessary updates and modifications, ensuring the system remains user-centric and effective. Feedback loop improve patient care and administrative efficiency. Patient input must be collected, analyzed, and addressed. Medical practices can identify strengths and weaknesses by gathering feedback through questionnaires, evaluations, or direct conversation. Analyzing this input helps practices make data-driven decisions by revealing hidden patterns and challenges. Finally, changing processes or resolving problems in response to feedback helps practices satisfy patient requirements. Modern medical practice management relies on the feedback loop to improve patient satisfaction and treatment. [37] Good patient feedback software improves healthcare. It streamlines patient survey design and distribution across media, helping medical providers collect feedback. This input is essential for monitoring patient satisfaction and finding areas for improvement, improving the patient experience. Healthcare professionals may directly meet patient needs and expectations with this technology, improving results and satisfaction. [38] Additionally, incorporating data-driven analytics and reporting is essential. This element employs advanced analytics to derive actionable insights from the data, facilitating real-time informed decision-making. Together, these strategies ensure the vaccine data management system is not only responsive to current needs but also adaptable to future changes, enhancing overall efficiency and effectiveness in vaccine administration and monitoring.

4. Conclusion

Despite the existing child immunization programs, issues such as data interoperability, privacy concerns, inadequate training, and poor technical infrastructure limit their success. The study employs an exploratory survey to gauge the effectiveness of current practices and identifies substantial challenges that hinder efficient data management and immunization coverage.

Based on the survey findings, the paper argues that enhancing data management requires a holistic approach involving technology upgrades, better training, and improved resource allocation. The proposed Vaccine Data Management System (VDMS) Framework aims to address these challenges by incorporating training, better technology, efficient data handling, and improved interoperability among other strategies.

The study is significant for policymakers and healthcare providers, serving as a strategic guide to reform data collection processes and improve vaccination rates. This framework, if implemented, could lead to more informed decision-making and better healthcare outcomes,

not just in the Bicol Region but in similar settings globally, thus showcasing a vital step toward enhancing public health infrastructure through better data management.

The investigation was conducted in Bicol Region, but the researchers recommend extending the research to other regions with similar socio-economic backgrounds to compare the effectiveness of the Vaccine Data Management System (VDMS) framework. Additionally, conduct an in-depth study on the direct correlation between improvements in vaccine data management and health outcomes, as well as the cost-benefit analysis to support the financial implications and potential returns of implementing the VDMS.

ACKNOWLEDGEMENT

The authors are grateful to God Almighty for making everything possible. They thank the respondents, NIP Unit personnel; Dr. Desiree Bricenio and Kendall Louise Luna, IDS Colleges, Inc. and DIT colleague Dr. Florivel D. Villacorta, Kennedy Cuya, Mary Joy Canon, Jocelle Monreal, and Ramona Mic Magtangob for their inputs, ideas and assistance. Similarly, to the expert panel members who contributed insightful feedback and considerable time to improve the study. The researchers also express gratitude to their colleagues and family, especially Luna and Lance, for their motivation and inspiration.

References

1. AE. Tozzi, F. Gesualdo, A. D'Ambrosio, E. Pandolfi, E. Agricola and P. Lopalco, (2016) Can Digital Tools Be Used for Improving Immunization Programs? Front. Public Health 4:36. doi: 10.3389/fpubh.2016.00036
2. Innovations in Immunization Data Management, Use, and Improved Process Efficiency (Round 21), 2018
3. Y. Saidu, J, Gu. BM, Ngenge, SC. Nchinjoh, A. Adidja, NE. Nnang, NJ. Muteh, VM. Zambou, C, Mbanga, VN, Agbor, D, Ousmane, AA, Njoh, J, Flegere, D. Diack, O. Wiwa, E. Montomoli, SAC. Clemens, R. Clemens, (2023) Assessment of immunization data management practices in Cameroon: unveiling potential barriers to immunization data quality. BMC Health Serv Res. 2023 Sep 27;23(1):1033. doi: 10.1186/s12913-023-09965-9. PMID: 37759205; PMCID: PMC10537541.
4. AC, C. Reyna, "Assessment of Online Maternal and Newborn Immunization Schedule Records Management System," International Research Journal of Advanced Engineering and Science, Volume 8, Issue 2, pp. 98-102, 2023.
5. Field Health Service Information System Annual 2022. (2022). Legazpi City, Albay, Philippines, page 30.
6. V. Clarke and V. Braun, (2013) Teaching thematic analysis: Overcoming challenges and developing strategies for effective learning. The Psychologist, 26(2), 120-123.
7. K. Ward, K. Mugenyi, A. Benke, H. Luzze, C. Kyozira, A. Immaculate, A. MacNeil, (2017). Enhancing Workforce Capacity to Improve Vaccination Data Quality, Uganda. Emerging Infectious Diseases, 23(Suppl 1), S85. https://doi.org/10.3201/EID2313.170627
8. J. Mckibben, & M. Barber, (2012). Defining Functional Requirements for Immunization Information Systems. Retrieved from https://www.phii.org/sites/default/files/resource/pdfs/IIS FINAL 10302012.pd
9. A. Q. Ford, N. Touchette, B. Fenton Hall, A. Hwang, & J. Hombach, (2018). Meeting report: Global vaccine immunization research forum. Vaccine, 36(7), 915–920.

10. B. Kefiyalew1, S. Abay, W. Mamo, B. Abate, M. A. Chanyalew, Y. Ayalew, A. Necho, Z.A. Mekonnen, A. Teklu, A. Shahabuddin, B. Tilahun, Assessment of immunization data management practices, facilitators, and barriers to immunization data quality in the health facilities of Tach Gayint district, Northwest Ethiopia Ethiop. J. Health Dev. 2021;35 (SI-3)
11. A. R., Bryant, "Electronic Health Records and Immunization Information Systems Interoperability: Measuring Impact on Immunization Outcomes." Thesis, Georgia State University, 2016. doi: https://doi.org/10.57709/7934207
12. M. A. W. P. Rahmadhan, & P. W. Handayani, (2023). Challenges ofvaccination information system implementation: A systematic literature review. Human Vaccines & Immunotherapeutics, 19(2). https://doi.org/10.1080/21645515.2023.2257054
13. C-Y. Hou, & H. Soyka, & V. Hutchison, & I. Sema, & C. Allen, & A. Budden, (2017). Evaluating the Effectiveness of Data Management Training: DataONE's Survey Instrument. International Journal of Digital Curation. 12. 47-60. 10.2218/ijdc.v12i2.508.
14. H. S. Ngusie, A. M. Shiferaw, A. D. Bogale, M. H. Ahmed, (2021) Health Data Management Practice and Associated Factors Among Health Professionals Working at Public Health Facilities in Resource Limited Settings. Adv Med Educ Pract. 2021 Aug 7;12:855-862. doi: 10.2147/AMEP.S320769. PMID: 34393540; PMCID: PMC8357531.
15. L. Dougherty, A. Makulec, B. Knittel, & A. Lafond, J. Snow, Inc. Literature Review on Improving Data Quality & Promoting the Use of Data for Decision Making, Better Immunization Data Initiative, January 24, 2014
16. L. Werner, D. Seymour, C. Puta, S. Gilbert, (2019). Three waves of data use among healthcare workers: the experience of the Better Immunization Data Iniative in Tanzania and Zambia. Global Health: Science and Practice 7(3): 447-456. Retrieved from: https://www.ghspjournal.org/content/ghsp/7/3/447.full.pdf
17. S.B. Dolan, E. Carnahan, J. Shearer, E. Beylerian, J. Thompson, S. Gilbert, L. Werner, and T. Ryman, (2019). Redefiing vaccination coverage and timelienss measures using electronic immunization registry data in low- and middle-income countries. Vaccine, 37,(1859-1867). Retrieved from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6420680/pdf/main.pdf
18. Fast Data: The Key to Efficient Vaccine Delivery UNICEF's RT-VaMA tool provides real-time data on vaccine rollouts. This data improves vaccine distribution and saves lives. UNICEF. 18 April 2024, [Online]. Available: https://www.unicef.org/innovation/stories/fast-data-key-efficient-vaccine-delivery
19. Data-driven healthcare: How analytics and BI are revolutionizing the industry. (2019). Retrieved from American Hospital Association: [Online]. Available: https://www.aha.org/system/files/2019-09/Data-Driven-Healthcare.pdfh
20. Y. Wang, & Y. Huang, (2018). Data-driven healthcare: Concepts, challenges, and oppotunities. Journal of Healthcare Engineering. Retrieved from https://www.hindawi.com/journals/jhe/2018/7820182
21. Combining Private 5G With Starlink For Remote Connectivity, Blog, Business Insights. 18 July 2023, Available: https://www.clarus-networks.com/2023/07/18/combining-private-5g-with-starlink-for-remote-connectivity/
22. K. E. Georgiou, E. Georgiou, R. M. Satava, (2021), 5G Use in Healthcare: The Future is Present. JSLS. 2021 Oct-Dec;25(4):e2021.00064. doi: 10.4293/JSLS.2021.00064. PMID: 35087266; PMCID: PMC8764898.
23. B. Calzon, (2023). How To Improve Your Facility Management With Healthcare Reports. 28 April 2024, [Online] Available: https://www.datapine.com/blog/healthcare-report-benefits-and-examples/
24. L. Maas, & M. Geurtsen, & F. Nouwt, & S. Stefan & R. Van de Water, & A. M. Dulmen & F. Dalpiaz & K. Van Deemter, & S. Brinkkemper, (2020). The Care2Report System: Automated Medical Reporting as an Integrated Solution to Reduce Administrative Burden

in Healthcare. 10.24251/HICSS.2020.442.

25. C. Hockey, What are the different types of records management systems?, 28 April 2024 [Online]. Available: https://www.linkedin.com/advice/0/what-different-types-records-management
26. J. Poe, (n.d). Data Transparency in Healthcare Matters to Every Patient, 28 April 2024 [Online]. Available: https://skypoint.ai/blog/data-transparency-in-healthcare/
27. C. L. Heidebrecht, J. C. Kwong, M. Finkelstein, S. D. Quan, J. A Pereira, S. Quach and S. L. Deeks, H. et al. Electronic immunization data collection systems: application of an evaluation framework, BMC Medical Informatics and Decision Making 2014, 14:5, http://www.biomedcentral.com/1472-6947/14/5
28. B. Bosch, & H. Mansell, (2015). Interprofessional collaboration in health care: Lessons to be learned from competitive sports. Canadian pharmacists journal : CPJ = Revue des pharmaciens du Canada : RPC, 148(4), 176–179. Retrieved from https://doi.org/10.1177/1715163515588106
29. The Importance of Interprofessional Collaboration in Healthcare, (2023). 11 September 2023, [Online]. Available: https://nursing.jnj.com/getting-real-nursing-today/the-importance-of-interprofessional-collaboration-in-healthcare
30. T. A., James, Teamwork as a Core Value in Health Care, (2021). 6 August 2021, [Online]. Available: https://postgraduateeducation.hms.harvard.edu/trends-medicine/teamwork-core-value-health-care
31. K. Zheng, R. Padman, M. P. Johnson, & H. S. Diamond, (2009). An interface-driven analysis of user interactions with an electronic health records system. Journal of the American Medical Informatics Association : JAMIA, 16(2), 228–237. Retrieved from https://doi.org/10.1197/jamia.M2852
32. K. Vadhadia, (2023). UI/UX in Healthcare: Enhancing Patient Experiences through Intuitive Design, 18 December 2023, [Online] Available: https://bootcamp.uxdesign.cc/ui-ux-in-healthcare-enhancing-patient-experiences-through-intuitive-design-a86589a2e1ba
33. C. E. Boone, P. Celhay, P. Gertler, T. Gracner, J. Rodriguez, (2022). How scheduling systems with automated appointment reminders improve health clinic efficiency, Journal of Health Economics, Volume 82, 2022, 102598, ISSN 0167-6296, Retrieved from https://doi.org/10.1016/j.jhealeco.2022.102598, https://www.sciencedirect.com/science/article/pii/S0167629622000182
34. N. Junod Perron, M. D. Dao, N.C. Righini, J. P. Humair, B. Broers, F. Narring, D. M. Haller, & J. M. Gaspoz, (2013). Text-messaging versus telephone reminders to reduce missed appointments in an academic primary care clinic: a randomized controlled trial. BMC health services research, 13, 125. Retrieved from https://doi.org/10.1186/1472-6963-13-125
35. Q. Liu, K. Abba, M. M. Alejandria, D. Sinclair, V. M. Balanag, & M. A. Lansang, (2014). Reminder systems to improve patient adherence to tuberculosis clinic appointments for diagnosis and treatment. The Cochrane database of systematic reviews, 2014(11), CD006594.
36. S. Dash, S. K. Shakyawar, M. Sharma, et al. (2019). Big data in healthcare: management, analysis, and future prospects. J Big Data 6, 54 (2019). Retrieved from https://doi.org/10.1186/s40537-019-0217-0
37. Leveraging the Feedback Loop to Grow Your Medical Practice: Enhancing Patient Experience for Success, Vizium360, 19 January 2024, [Online] Available: https://www.linkedin.com/pulse/leveraging-feedback-loop-grow-your-medical-practice-enhancing-ea2hc/
38. N. Dawer, (2024) Patient Feedback: Improving the Quality of Care and Healthcare Services, 24 April 2024, [Online] Available: https://www.zonkafeedback.com/blog/patient-feedback