

Enhancing Healthcare Delivery through Integrated Data Analytics: Insights from Practical Applications in Zambia

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Abstract - The integration of data analytics into healthcare systems has the potential to revolutionize the delivery of health services, particularly in resource-limited settings. This paper explores the impact of data integration and analytics for the Zambian health sector, drawing on practical experiences from working at Zenysis Technologies and supporting the Ministry of Health (MoH). By analyzing challenges, solutions, and outcomes of implementing an integrated data platform, the paper highlights the transformative power of data-driven decision-making in improving healthcare outcomes.

Key words: Data integration, triangulation, analytics

I. INTRODUCTION

A. Background

In many developing countries, healthcare systems often suffer from fragmented data sources, making it difficult to make informed decisions that can lead to improved health outcomes. Different systems within the healthcare sector, from patient records to supply chain management, often operate in silos, preventing the effective use of data. This fragmentation leads to inefficiencies, such as duplicated efforts, wastage of resources, and delayed responses to health emergencies. [1]

The importance of data in healthcare cannot be overstated. Accurate, timely, and comprehensive data is crucial for healthcare providers to make informed decisions, allocate resources effectively, and track the progress of health interventions. However, the potential of data can only be realized when it is properly integrated and analysed, providing actionable insights that can drive improvements in healthcare delivery. [2]

The Zambia Ministry of Health through the National Malaria Elimination Programme (NMEP) has adopted Surveillance, Monitoring, Evaluation and Operations Research as a core intervention in its subnational elimination and control efforts. It

is therefore, important to have a comprehensive and integrated malaria information system that collates all programmatic data into one platform. However, the ministry has three systems that aggregate malaria data without allowing for data linkage. The Health Management Information System (HMIS) for

service and disease data, Electronic Logistic Management Information System (eLMIS) for commodity data and the Malaria Rapid Reporting System (MRRS) for community level data. [3][4]

B. Objectives

This paper aims to provide insights into the practical application of data integration and analytics for the Zambian health sector. Drawing from our experiences at Zenysis Technologies, where we supported the MOH in Zambia, the paper will discuss the challenges faced, the solutions implemented, and the outcomes achieved through the integration of various health data systems into a unified platform. The objective is to demonstrate how data-driven decision-making can enhance healthcare delivery in resource-limited settings.

C. Relevance

The relevance of this topic extends beyond Zambia, as many countries face similar challenges with fragmented health data systems. [5][6] The findings and insights presented in this paper align with global efforts to achieve the Sustainable Development Goals (SDGs), particularly Goal 3, which aims to ensure healthy lives and promote well-being for all at all ages. By improving data integration and analytics, healthcare systems can become more efficient, responsive, and equitable, ultimately leading to better health outcomes.

II. LITERATURE REVIEW

A. Data Integration In Healthcare

Data integration in healthcare has been the subject of extensive research, particularly in developed countries where sophisticated health information systems are more common. Integrated data systems allow for the consolidation of patient records, supply chain information, and epidemiological data, enabling healthcare providers to have a holistic view of the health landscape. [7]

In resource-limited settings, however, the implementation of such systems is limited with challenges. The literature highlights issues such as limited infrastructure, lack of trained personnel, and resistance to change as significant barriers to effective data integration. Despite these challenges, there have been successful case studies, such as in Rwanda and Kenya, where integrated health information systems have led to improved health outcomes.

B. Analytics for Health Outcomes

The use of data analytics in healthcare has proven to be a powerful tool for improving health outcomes. Predictive analytics, for example, can forecast disease outbreaks, enabling early intervention and potentially saving lives. Descriptive analytics can identify trends in health data, such as the prevalence of certain diseases or the effectiveness of interventions, which can inform policy decisions.

Globally, data analytics has been used to tackle a range of health issues, from managing chronic diseases to optimizing resource allocation in hospitals. However, the application of these technologies in developing countries remains limited, often due to the challenges associated with data integration. [8]

C. Gaps in Existing Research

While there is considerable research on data integration and analytics in healthcare, there is a lack of focus on the practical application of these technologies in resource-limited settings. Most studies concentrate on the theoretical benefits of integrated data systems, with few exploring the real-world challenges and solutions. This paper seeks to fill this gap by providing a detailed account of the implementation of a data integration platform in Zambia, offering insights that can be applied in similar contexts. [9]

III. METHODOLOGY

A. Project Design

The project involved designing and implementing a comprehensive data integration platform capable of integrating various health data sources. The platform utilized an open source Harmony data integration platform to store vast amounts of structured and unstructured data, enabling the MOH Malaria,

TB and Supply Chain teams to access and analyse data from multiple systems in one place.

To achieve this, an Extract, Transform, Load (ETL) process was established to standardize and integrate data from different sources. This included HMIS, ZAMMA's WMS, TB surveillance reports, Electronic Logistics Management Information System (eLMIS), Malaria data points for Long Lasting Insecticide Treated Nets (LLNIS), Malaria Rapid Reporting System (MRRS), Indoor residual spraying (IRS) and private sector family planning commodities. The integration was done in collaboration with MOH stakeholders, who provided valuable input on the data requirements and system functionality.

B. Data Sources

The data integrated into the platform came from several sources, each playing a critical role in the healthcare system. The MoH HMIS provided aggregate level data of diagnoses, treatments and outcomes including the Malaria DHIS2 instance used by the National Malaria Elimination Centre (MRRS). Supply chain data tracked the availability and distribution of medical supplies, while Malaria epidemiological data provided insights into disease trends and outbreaks.

By integrating these data sources into a single platform, the MoH could gain a holistic view of the health landscape, enabling more informed decision-making. The integration also allowed for the identification of data gaps and inconsistencies, which were addressed through the ETL process.

C. Stakeholder Involvement

Stakeholder involvement was crucial to the success of the project. From the outset, MOH officials, program officers, and IT officers were engaged in the planning and implementation phases. Regular consultations were held to ensure that the system met the needs of all users and that any concerns were addressed promptly.

This collaborative approach not only improved the functionality of the system but also fostered a sense of ownership among stakeholders. By involving them in the process, we ensured that the system was not only technically sound but also aligned with the needs and priorities of the MoH and stakeholders.

D. Training and Capacity Building

A key component of the project was training MoH staff to use the new system effectively. This involved creating training materials, including user manuals and video tutorials, as well as conducting workshops to demonstrate the system's capabilities.

The training was tailored to different user groups, from high-level decision-makers to on-the-ground healthcare providers. By equipping them with the skills needed to navigate the system and interpret the data, we ensured that the benefits of the platform were fully realized. [10]

IV. RESULTS AND PRACTICAL APPLICATIONS

The findings reviewed that the three systems were related and all vital for malaria programming but not integrated making it difficult to link malaria disease burden to malaria service and malaria commodity data without resorting to manual data manipulations. The coverage of these systems was at different organization unit level.

The eLMIS and the HMIS did not capture community level data. On the other hand, the MRRS collected community level data but was at 67% coverage. To that effect, the NMEP implemented an integrated platform that would house malaria data from the three systems. The Platform collated data from these systems using an Application Programming Interface facilitating holistic analysis.

This allowed and facilitated for data integration across multiple data collection systems from SQL databases to Excel without affecting the underlying source systems or creating additional data collection tools or data collection systems but rather a system for integration brought about efficiency in malaria analytics.



Figure 2: Decision making made easy

Data integration and triangulation enabled development of customized reports, dashboards and real-time analytics to guide decision making and action. Through this, the program was able to undertake a holistic analysis of malaria situation including linking disease burden with availability of malaria commodities and coverage of interventions bringing about efficiency and effectiveness through tailored approaches in addressing

bottlenecks hindering efforts towards malaria control and elimination.

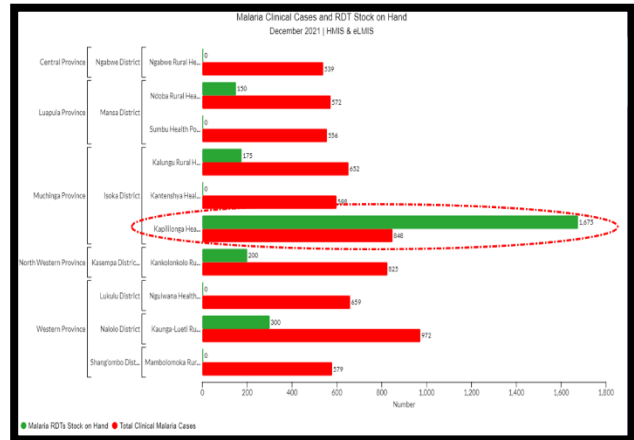


Figure 3: An example of analytics of clinical malaria cases and availability of RDTs from two different system sources (HMIS and eLMIS)

Data triangulation also helped identify data gaps by raising several questions ranging from data quality issues in reporting, data collection and reporting processes to possible gaps in service provision. The above analytics would bring a key question on the highlighted health facility. Why is the facility having clinical malaria cases when it has enough stock of RDTs? Key findings included; lack of understanding of clinical malaria cases, data capturing and entry errors, RDT's locked up at night and Clinical practices of prescribing AL in RDT negative results i.e. non-adherence to negative test result. [11]

V. CHALLENGES AND SOLUTIONS

A. Data Interoperability

One of the biggest challenges in integrating data from multiple sources was ensuring interoperability between different systems. The existing health data systems in Zambia have been developed independently of each other, using different data formats and standards.

To overcome this, we implemented a data mapping process that aligned the data from various sources with a common data model. This involved working closely with the developers and MoH of the existing systems to ensure compatibility and consistency in data formats. By standardizing the data, we were able to integrate it into the platform seamlessly, enabling comprehensive analysis.

B. Scalability

Scalability was another challenge, as the platform needed to accommodate the growing volume of health data in Zambia. To ensure the system could scale effectively, we designed it with a

modular architecture that allowed for the addition of new data sources and features without disrupting existing functionality.

The use of cloud-based infrastructure also played a critical role in achieving scalability. By leveraging cloud services, we ensured that the platform could handle increasing data volumes and user demand, while also providing flexibility for future expansion.

C. Data Security and Privacy

Data security and privacy were key considerations, given the sensitive nature of health data. We implemented robust security measures, including encryption, access controls, and audit trails, to protect the data from unauthorized access and breaches.

We also worked with the MoH to develop data governance policies that ensured compliance with national and international regulations. These policies outlined the responsibilities of users in handling data, as well as the procedures for reporting and addressing security incidents. [12]

VI. IMPACT AND OUTCOMES

A. Improved Decision-Making

The integration of data analytics into the MoH's operations significantly improved decision-making processes. With access to accurate, timely, and comprehensive data, MoH officials could make informed decisions on resource allocation, disease control, and policy development. This led to more effective health interventions and improved health outcomes across the country.

B. Increased Efficiency

By optimizing resource allocation and reducing inefficiencies, the data platform contributed to significant cost savings for the MoH. Health facilities reported fewer instances of stockouts and wastage, while healthcare providers could focus more on patient care rather than administrative tasks. This increased efficiency translated into better service delivery and higher patient satisfaction.

C. Enhanced Health Outcomes

Ultimately, the integration of data analytics had a positive impact on health outcomes in Zambia. The MoH was able to respond more effectively to disease outbreaks, improve the distribution of medical supplies, and make data-driven policy decisions that benefited the entire population. The platform's ability to provide actionable insights in real time was instrumental in achieving these outcomes.

VII. CONCLUSION AND RECOMMENDATIONS

A. Summary of practical experience

This paper has highlighted the importance of data integration and analytics in improving healthcare delivery, particularly in resource-limited settings like Zambia. The successful implementation of a comprehensive data platform at the MoH demonstrates the transformative potential of data-driven decision-making in the health sector.

Enhanced malaria surveillance is critical for malaria control and elimination as it informs malaria programme planning and implementation. It is therefore, important to have integrated information systems that improves data use culture and guide decision making by facilitating holistic analysis of data.

The NMEP in Zambia has made progress this far. However, a lot of effort is needed to roll out the eLMIS to community level and integrate the HMIS and MRRS. This will facilitate a seamless flow of data from the community to the national level, and ensure that all stakeholders have access to timely and accurate malaria. [13]

B. Recommendations for Policy and Practice

For policymakers, the success of this project underscores the importance of investing in data infrastructure and capacity building. Governments should prioritize the development of integrated health information systems that can support data-driven decision-making at all levels of the health system.

For practitioners, the key takeaway is the importance of stakeholder engagement and collaboration in implementing data integration projects. By involving all relevant parties from the outset, projects are more likely to succeed and deliver tangible benefits to the healthcare system. [14]

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