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Implementing Digital Health Transformation in Zambia: A Case Study of Data Governance and Interoperability (2021–2025)

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Abstract

Digital health systems are central to achieving Universal Health Coverage in low- and middle-income countries, yet many national implementations remain fragmented, donor-driven, and weakly governed. This study examines Zambia's digital health transformation between 2021 and 2025, with a specific focus on interoperability and health data governance. Using a government-led case study approach, the research evaluated four core national platforms: SmartCare Pro, the National Health Insurance Management Authority system, the Zambia Medicines and Medical Supplies Agency system, and the National Data Warehouse. A convergent mixed-methods design combined system performance logs, interoperability testing, stakeholder surveys, document reviews, and governance compliance audits. Findings demonstrate a 78 percent national data exchange success rate, over 90 percent facility-level compliance with the Data Protection Act, and an average system usability score of 3.7 out of 5. The study shows that the implementation of a national Interoperability Architecture Framework and Health Data Governance Framework significantly improved system integration, accountability, and evidence-based decision-making. The results contribute practical implementation evidence for low- and middle-income countries seeking to transition from fragmented digital health investments to sustainable, government-owned, interoperable health information ecosystems.

Keywords: *Data Governance, Digital Health, Health Information Systems, Interoperability, SmartCare Pro, Zambia.*

Introduction

Digital transformation has become a strategic imperative for strengthening health systems globally, particularly in low- and middle-income countries (LMICs) where resource constraints, workforce shortages, and service delivery challenges persist. Digital health interventions including electronic health records, health information exchanges, analytics platforms, and digital registries are increasingly recognized as foundational enablers of Universal Health Coverage, health system resilience, and evidence-based policymaking. The COVID-19 pandemic further exposed the limitations of paper-based and fragmented digital systems, reinforcing the need for interoperable, secure, and real-time health information infrastructures.

Digital health is increasingly recognised as a catalyst for strengthening health systems by improving data availability, accountability, and evidence-based decision-making, particularly in low- and middle-income countries. [4] In sub-Saharan Africa, fragmented health information systems and limited interoperability have historically constrained the effective use of routine health data for planning, financing, and service delivery. [5] These systemic challenges provided the context within which Zambia embarked on a comprehensive digital health reform agenda

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focused on interoperability and data governance.

In many LMICs, digital health investments have evolved through vertical, donor-funded projects that prioritize program-specific reporting over system-wide integration. This approach has resulted in fragmented architectures, duplicated data collection, limited data reuse, and weak national ownership. Governance gaps particularly in data protection, accountability, and standards enforcement have further constrained the effective use of digital health systems for planning, financing, and performance management.

Zambia presents a distinctive and policy-relevant case of national digital health reform. Between 2021 and 2025, the Ministry of Health undertook a deliberate transition from donor-driven, siloed systems toward a government-led, standards-based digital health ecosystem. This transition was anchored in national policy instruments, legal reforms, and institutional governance mechanisms aligned with global best practices. Central to this reform agenda were the redevelopment of the SmartCare electronic health record into SmartCare Pro, the establishment of a national interoperability layer guided by open standards, and the operationalization of a comprehensive Health Data Governance Framework anchored in the Data Protection Act.

This study evaluates how these government-led interoperability and governance reforms influenced digital health system performance, regulatory compliance, usability, and decision-making across Zambia's public health sector. By documenting Zambia's experience through an implementation science lens, the study contributes empirical evidence to the global discourse on sustainable digital health transformation in LMICs. The conceptual and strategic alignment between global digital health principles, national policy instruments, and implementation outcomes guiding this study is illustrated in Figure 1.

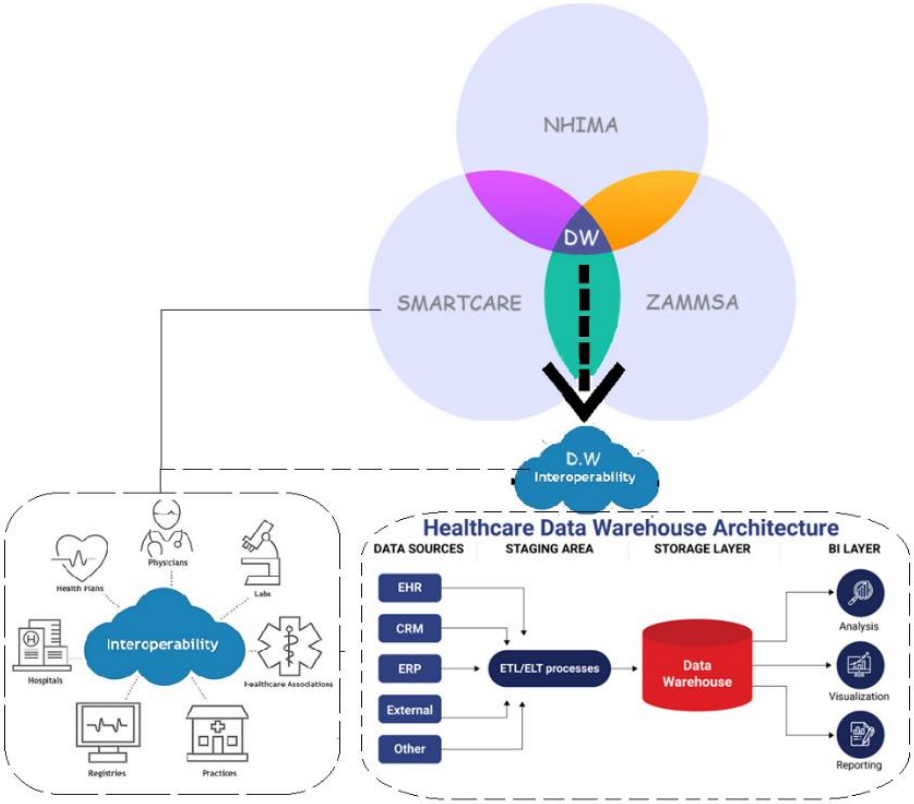

Figure 1. Conceptual and Strategic Framework for Digital Health Transformation in Zambia.

Methods

This study adopted a government-led case study design grounded in implementation science to evaluate Zambia's national digital health transformation between 2021 and 2025. The convergent mixed-methods design adopted in this study enabled integration of quantitative and qualitative findings in line with established mixed-methods research principles.[15] This design enabled triangulation of findings related to interoperability performance, governance compliance, and system usability across multiple data sources.

Study Design and Context

The case study focused on the Ministry of Health as the central coordinating authority for digital health implementation in Zambia. The reform period coincided with implementation of the Digital Health Strategy 2022–2026 and operationalization of the Interoperability Architecture Framework and Health Data Governance Framework. Four core national platforms underpinning Zambia's digital health ecosystem were examined: SmartCare Pro, the National Health Insurance Management Authority system, the Zambia Medicines and Medical Supplies Agency system, and the National Data Warehouse. The functional roles and data domains of these platforms within the national interoperability architecture are summarized in Table 1.

Table 1. Core National Digital Health Systems and their Primary Functions

Digital Health System	**Primary Function**	**Key Data Domains**	**Role in Interoperability Architecture**
SmartCare Pro	National electronic health record	Patient demographics, clinical encounters, diagnoses, treatments	Primary source of facility-level clinical data
NHIMA System	Health insurance claims management	Claims, provider accreditation, service utilization	Financial data exchange and reimbursement validation
ZAMSA System	Medical supply chain management	Medicines, commodities, inventory levels	Logistics and supply data integration
National Data Warehouse	National analytics and reporting	Aggregated clinical, financial, and logistics data	Central analytics, dashboards, and decision support

The standards-based interoperability architecture enabling data exchange across these platforms is presented in Figure 2.

Figure 2 illustrates the standards-based interoperability architecture underpinning Zambia's digital health systems. Clinical, financial, and supply chain platforms exchange data through a central interoperability services layer using HL7 FHIR and OpenHIE standards. The architecture enables secure messaging, authentication, mediation, and harmonised data flow into the National Data Warehouse to support analytics and decision support.

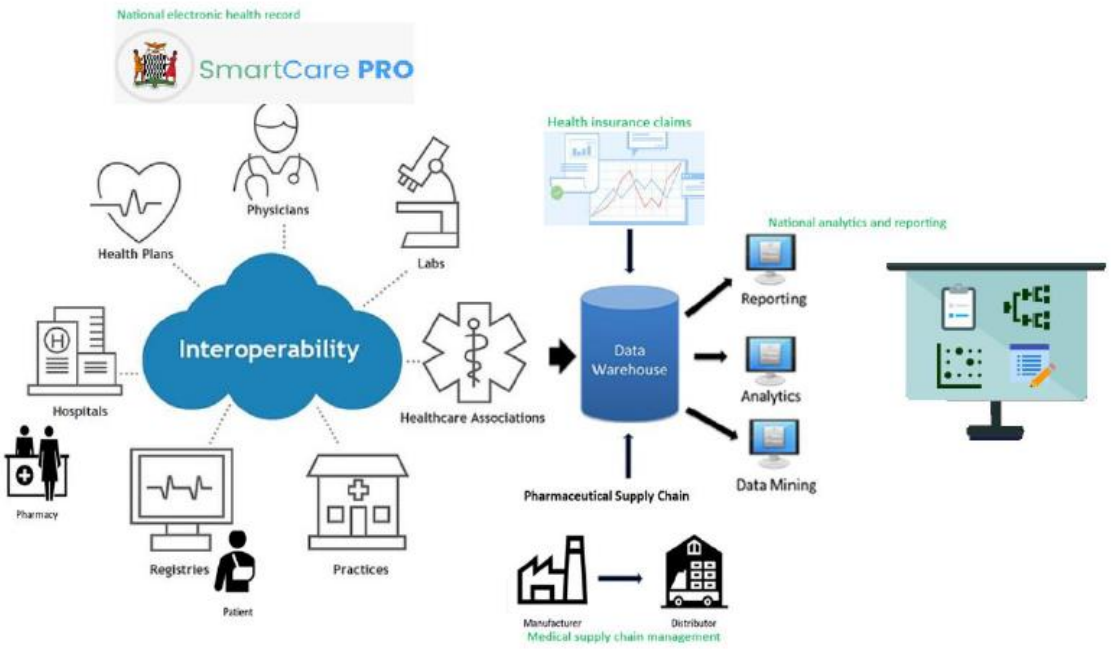

Figure 2. National Interoperability Architecture Framework.

Study Design and Context

The case study focused on the Ministry of Health as the central coordinating authority for digital health implementation in Zambia. The reform period coincided with implementation of the Digital Health Strategy 2022–2026 and operationalization of the Interoperability Architecture Framework and Health Data Governance Framework [9-11]. The study examined four core national platforms that collectively underpin Zambia's digital health ecosystem: SmartCare Pro, the National Health Insurance Management Authority system, the Zambia Medicines and Medical Supplies Agency system, and the National Data Warehouse.

These platforms were selected because they represent the primary clinical, financial, logistics, and analytics components of the national digital health architecture. Data exchange across these systems is enabled through a standards-based interoperability layer aligned with international health information exchange principles, including HL7 FHIR and OpenHIE architectural patterns [6, 13, 14]. The functional roles and data domains of these platforms within the national interoperability architecture are summarized in Table 1.

Data Sources

Data were collected from four primary sources. First, system logs and interoperability exchange reports were extracted from SmartCare Pro, the National Health Insurance Management Authority system, the Zambia Medicines and Medical Supplies Agency system, and the National Data Warehouse to quantify data exchange performance, completeness, and timeliness. Second, structured surveys were administered to healthcare workers, system administrators, and policy stakeholders across facility, district, and national levels to assess perceived usability, system effectiveness, and digital literacy. Third, key informant interviews were conducted with Ministry of Health officials, ICT specialists, and development partners to capture contextual insights on governance arrangements, implementation challenges, and institutional coordination mechanisms. Fourth, policy, legal, and technical documents including national strategies, interoperability standards, and governance compliance tools were

systematically reviewed to contextualize implementation processes and outcomes [9-11].

Data Analysis

Quantitative data were analyzed using descriptive statistics to assess interoperability success rates, governance compliance levels, and system usability scores. Interoperability performance indicators included successful message exchange rates, system availability, and data completeness, consistent with established digital health monitoring practices [1, 3]. Governance compliance was evaluated against statutory requirements and operational governance instruments derived from the Data Protection Act and national governance frameworks [9, 11].

System usability was assessed using standardized usability constructs commonly applied in health information systems research, drawing on established models of perceived usefulness and ease of use [16, 17]. Qualitative data from interviews and open-ended survey responses were thematically analyzed to contextualize quantitative findings, identify implementation barriers and enablers, and support interpretation of system performance within the broader institutional and policy environment.

Results

Table 2 presents a consolidated summary of interoperability performance, governance compliance, and system usability indicators observed across the core national digital health platforms during the study period.

Table 2. Summary of Interoperability Performance, Governance Compliance, and System Usability

Performance Domain	Indicator	Aggregate Result
Interoperability	Successful data exchange rate	78 percent
Governance	Facility-level compliance with Data Protection Act	>90 percent
Usability	Mean system usability score	3.7 / 5
Analytics	Availability of real-time dashboards	Implemented nationally
Decision Support	Use of data for planning and monitoring	Reported at facility, district, and national levels

Interoperability Performance

Interoperability testing demonstrated a 78 percent successful data exchange rate across core national platforms. Integration between SmartCare Pro and the National Data Warehouse enabled near real-time aggregation of clinical and programmatic data, reducing reporting delays and improving data availability for planning and monitoring.

Governance and Compliance

The alignment between technical interoperability mechanisms and data governance controls underpinning Zambia's digital health reforms is illustrated in Figure 3.

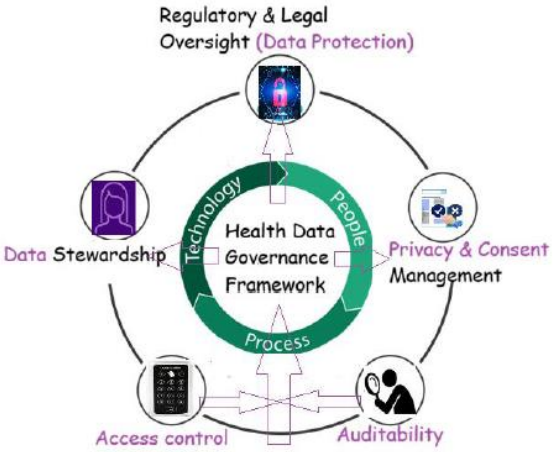

Figure 3. Alignment of Interoperability Architecture and Health Data Governance Frameworks.

This figure depicts the national health data governance framework guiding the ethical, secure, and accountable use of digital health data in Zambia. It highlights governance domains including data stewardship, access control, privacy protection, auditability, and regulatory oversight, aligned with national data protection requirements. Governance audits indicated over 90 percent compliance with key provisions of the Data Protection Act at facility level. introduction of formal data stewardship roles, access controls, and audit mechanisms strengthened accountability and reduced unauthorized data access.

System Usability

The mean system usability score across platforms was 3.7 out of 5. Facilities with stronger infrastructure and digital literacy reported better usability outcomes.

Decision-Making and Health Intelligence

The end-to-end pathway through which facility-level digital health data are transformed into analytics and policy decisions is summarized in Figure 4.

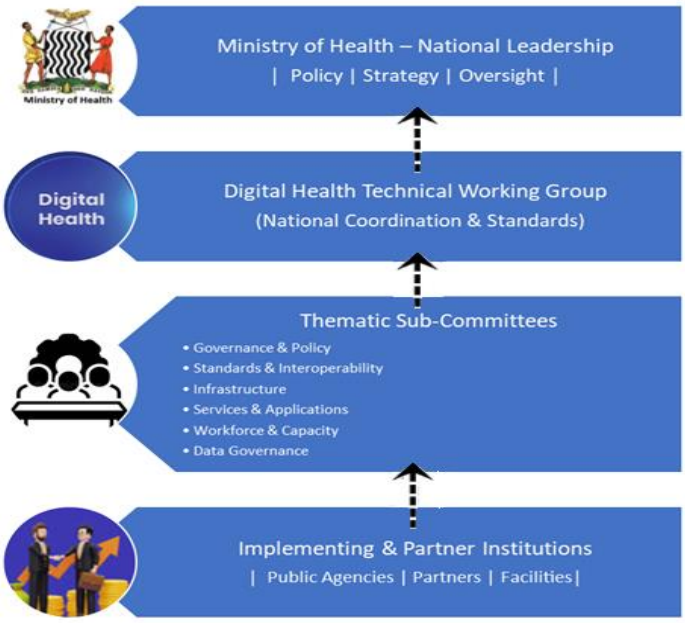

Figure 4. Digital Health Data-to-Decision Pathway Supporting Evidence-Based Decision-Making

This figure shows the institutional governance and coordination arrangements supporting digital health implementation in Zambia. It illustrates national leadership, technical coordination mechanisms, and stakeholder engagement structures that oversee interoperability, standards, compliance, and sustainability of digital health systems.

Top–Down Governance Flow

This figure answers "Who leads, who coordinates, and who implements digital health?"

It uses four levels only, with clear vertical authority and coordination lines.

Level 1 – Ministry of Health (National Leadership)

Single Point of Authority

1. Sets national digital health policy
2. Provides strategic direction
3. Ensures regulatory oversight.

Level 2 – Digital Health Technical Working Group (DHTWG)

Bridge between Policy and Practice

1. National coordination mechanism
2. Harmonises standards and investments
3. Oversees implementation alignment

Level 3 – Thematic Sub-Committees

Technical Depth Without Fragmentation

Each sub-committee focuses on a specific pillar of digital health:

1. Leadership, governance, investment & sustainability
2. Standards and interoperability
3. Infrastructure
4. Services and applications
5. Workforce and capacity development
6. Data governance

Level 4 – Implementing & Partner Institutions

Execution and Service Delivery Level

1. Government agencies
2. Health facilities
3. Cooperating and implementing partners

Discussion

This study examined Zambia's digital health transformation between 2021 and 2025, with emphasis on interoperability and data governance across national platforms. The findings indicate that deliberate, government-led reforms can improve system integration, governance compliance, and evidence-informed data use in low- and middle-income country contexts. Zambia's experience underscores the importance of aligning technical architecture with institutional and regulatory reforms to achieve sustainable digital health outcomes [1, 2, 9].

Interoperability as a Foundation for Health System Integration

The staged progression observed in Zambia's interoperability maturity is consistent with international digital health maturity models that emphasise incremental alignment of technical, organisational, and governance capabilities European Commission 2020 [7]. The establishment of a national interoperability architecture and supporting governance mechanisms positioned Zambia to progress along recognised digital health maturity pathways.

The observed improvements in data exchange across SmartCare Pro, the National Data Warehouse, insurance, and supply chain systems demonstrate the value of a nationally coordinated interoperability approach. Rather than relying on point-to-point integrations, Zambia's adoption of a structured interoperability architecture enabled multiple systems to exchange data through standardized interfaces, reducing fragmentation and improving coherence of the national health information ecosystem [3, 6, 10, 14].

Comparable experiences in other settings show that interoperability gains are more sustainable when embedded within national strategies and supported by formal governance

structures. Zambia's progress aligns with broader evidence that open standards, shared architectural patterns, and national coordination mechanisms are critical for scaling digital health solutions beyond individual programmes. [1, 3, 14, 20] Nonetheless, performance disparities between facility types suggest that infrastructure variability and workforce constraints continue to influence interoperability outcomes and should be addressed as part of scale-up. [2, 20] Regional implementation experiences further demonstrate that integration of DHIS2 and other national platforms is most successful when guided by national interoperability frameworks and institutional governance mechanisms [30].

Strengthening Data Governance and Trust

Effective data governance requires clearly defined stewardship roles, accountability mechanisms, and enforcement structures that extend beyond technical controls to organisational and institutional arrangements. [8] The findings indicate advances in governance maturity, particularly related to regulatory compliance, access control, and accountability mechanisms. Operationalization of national data protection requirements across core digital platforms improved clarity on roles, responsibilities, and data-sharing practices, contributing to institutional trust in digital systems and strengthening the enabling environment for secure data exchange [9, 11, 20].

However, governance implementation remains uneven, especially at lower levels of the health system. Similar patterns are reported in other LMIC contexts where governance frameworks exist but are not fully institutionalized due to capacity constraints, inconsistent supervision, or insufficient change management. [2, 20, 25] Zambia's experience suggests that governance reforms require sustained investments in capacity building, supportive supervision, and practical tools for compliance monitoring to ensure consistent application across all facilities [11, 20].

User Adoption and System Usability

Positive user perceptions of system usability reflect the benefits of designing digital platforms around end-user needs. Improvements in navigation, reporting, and modular functionality likely contributed to greater acceptance of SmartCare Pro compared to earlier system iterations. These findings are consistent with technology adoption literature, which emphasizes perceived usefulness and perceived ease of use as key determinants of sustained system utilization. [16, 17]. Patterns of system adoption observed across facilities align with diffusion of innovation theory, which highlights the roles of perceived advantage, compatibility, and organisational readiness in influencing technology uptake [18].

Despite these improvements, challenges related to system performance, infrastructure reliability, and user support highlight the limits of technical design alone. Without stable connectivity, power resilience, and responsive technical assistance, usability gains may not translate into consistent routine use. Variability in usability outcomes across facilities reflects broader differences in eHealth readiness, including infrastructure availability, human capacity, and institutional support. [19] This supports the need for integrated digital health strategies that treat infrastructure strengthening and workforce development as co-requisites for effective digital system adoption. [2, 20].

From Data Availability to Data Use

The increased availability of integrated data and analytics tools enhanced data use for planning and oversight, particularly at national and provincial levels. Consolidated dashboards supported more timely review of performance indicators and strengthened evidence-informed decision-making. This shift represents an important step toward data-driven health

system management and performance accountability [1, 2].

At facility level, data use remained variable, reflecting a common gap in LMIC health systems between data availability and data utilization. Organizational culture, feedback loops, supervisory expectations, and local decision space influence whether data are used routinely for improvement. Zambia's experience suggests that technical integration should be complemented by deliberate interventions to strengthen a culture of data use, including targeted training, routine review meetings, and leadership engagement [2, 20].

Implications for Digital Health Implementation in LMICs

Global benchmarking exercises indicate that countries with strong government stewardship, interoperable architectures, and enforceable governance frameworks consistently achieve higher levels of digital health maturity. [12] Zambia's digital health transformation yields several lessons for LMICs pursuing similar reforms. First, government leadership and ownership are critical for coordinating stakeholders and aligning digital investments to national priorities. [1, 2] Second, interoperability and data governance should be treated as foundational system functions rather than afterthoughts, supported by open standards and enforceable governance mechanisms. [3, 10, 11, 14] Third, sustained attention to infrastructure, workforce capacity, and change management is essential to translate technical integration into measurable health system improvements and consistent service-delivery benefits [2, 20].

Comparable national experiences from Kenya, Rwanda, and South Africa demonstrate that digital health transformation is most effective when anchored in government leadership, open standards, and sustainable financing mechanisms. [21-24] Global analyses of digital health systems similarly indicate that countries with well-defined governance frameworks and interoperability strategies consistently achieve higher levels of digital health maturity and system sustainability Global Digital Health Index 2022; Digital Square 2022.

Similar standards-based digital health architectures have been adopted in countries such as Bangladesh, India, Peru, and Brazil, reinforcing the global relevance of interoperability-led digital health reform [26-29] Cross-country case studies presented at global digital health forums highlight that interoperability, governance, and institutional capacity are recurring determinants of successful digital health transformation [31].

Conclusion

This study examined Zambia's digital health transformation between 2021 and 2025 through a national case study focused on interoperability and data governance. The findings demonstrate that deliberate, government-led reforms can improve the integration, governance, and use of digital health systems in low- and middle-income country settings [1, 2, 9].

Recent analyses of digital transformation in health systems emphasise that sustained value creation depends on aligning digital technologies with governance, organisational processes, and decision-making structures Shen et al. 2023 [32].

Zambia's experience shows that interoperability architectures and data governance frameworks are not merely technical instruments; they are core components of health system strengthening. When combined with institutional reforms, workforce development, and supportive infrastructure, these elements can enable more effective use of health information for planning, financing, monitoring, and service delivery [2, 10, 11, 20].

While challenges remain—particularly in extending governance maturity and routine data-use practices to all facility levels—the

progress achieved during the study period represents a substantial step toward a more coherent and resilient digital health ecosystem. The lessons documented in this article contribute to digital health implementation science and provide practical guidance for countries pursuing sustainable, interoperable, and secure digital health transformation [1, 2, 20].

Integrated dashboards and analytics platforms improved evidence-based decision-making at facility, district, and national levels. Decision-makers reported improved confidence in data reliability, timeliness, and analytical relevance.

Conflict of Interest

The author declares no conflict of interest.

Ethical Approval

Ethical approval for this study was obtained through relevant institutional and governmental review mechanisms within the Ministry of Health, Zambia.

Data Availability

Data supporting the findings of this study are available from the Ministry of Health, Zambia, subject to data protection regulations and reasonable request.

Author Contributions

The author conceptualized the study, led data collection and analysis, developed the interoperability and governance frameworks, and prepared the manuscript.

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