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## Silent Data Waste in Public Laboratories: A Conceptual Framework for Sustainable Data-Driven Management

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### هدر البيانات الصامتة في المختبرات الطبية العامة: إطار مفاهيمي للإدارة المستدامة القائمة على البيانات

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#### Abstract

Public medical laboratories generate extensive volumes of routine operational data, including test workloads, turnaround times, quality control results, reagent consumption records, and equipment performance indicators. Despite this abundance, a substantial proportion of these data remains underutilized in managerial and strategic decision-making. This phenomenon is conceptualized in this paper as silent data waste, defined as the systematic loss of informational value arising not from data scarcity, but from weak governance, limited analytical capacity, and fragmented information systems.

This conceptual paper positions silent data waste as a managerial and organizational challenge rather than a purely technical limitation. Drawing on a focused and critical review of recent literature in laboratory management, health data governance, and sustainable healthcare systems, the study develops an integrated conceptual framework linking routine data utilization to quality performance and resource efficiency outcomes. Key operational indicators, such as turnaround time and specimen rejection rates, are used to illustrate how improved data utilization can support evidence-based management, reduce material and environmental waste, and enhance service reliability.

The proposed framework advances the discourse on sustainable laboratory management by reframing routine operational data as a strategic leadership asset. By strengthening data governance structures, analytical tools, and managerial data literacy, public laboratories can transition from reactive operations toward proactive, sustainable, and performance-oriented management aligned with relevant sustainable development goals.

**Keywords:** Data utilization, public laboratories, Silent data waste, Specimen rejection, Sustainable management, Turnaround time.

## المخلص

تنتج المختبرات الطبية العامة كميات هائلة من البيانات التشغيلية الروتينية، بما في ذلك أحجام عمل الاختبارات، ومدة إنجازها، ونتائج مراقبة الجودة، وسجلات استهلاك الكواشف، ومؤشرات أداء المعدات. وعلى الرغم من وفرة هذه البيانات، فإن نسبة كبيرة منها لا تزال غير مستغلة بالشكل الكافي في عمليات صنع القرار الإداري والاستراتيجي. ويتم في هذه الورقة النظر إلى هذه الظاهرة على أنها «هدر البيانات الصامت»، الذي يُعرّف بأنه فقدان المنهجي للقيمة المعلوماتية الناجم ليس عن ندرة البيانات، بل عن ضعف الحوكمة، ومحدودية القدرات التحليلية، وتجزئة أنظمة المعلومات.

تعتبر هذه الورقة النظرية هدر البيانات الصامت تحديًا إداريًا وتنظيميًا وليس مجرد قيد تقني بحت. وبالاعتماد على مراجعة مركزة ونقدية للأدبيات الحديثة في إدارة المختبرات، وحوكمة البيانات الصحية، وأنظمة الرعاية الصحية المستدامة، تُطور الدراسة إطارًا مفاهيميًا متكاملًا يربط بين استخدام البيانات الروتينية ونتائج الأداء الجيد وكفاءة الموارد. وتستخدم المؤشرات التشغيلية الرئيسية، مثل وقت الإنجاز ومعدلات رفض العينات، لتوضيح كيف يمكن للاستخدام المحسّن للبيانات أن يدعم الإدارة القائمة على الأدلة، ويقلل من الهدر المادي والبيئي، ويعزز موثوقية الخدمة.

يُعزز الإطار المقترح النقاش الدائر حول الإدارة المستدامة للمختبرات من خلال إعادة صياغة البيانات التشغيلية الروتينية باعتبارها أحد الأصول الاستراتيجية للقيادة. ومن خلال تعزيز هياكل حوكمة البيانات والأدوات التحليلية ومهارات التعامل مع البيانات على المستوى الإداري، يمكن للمختبرات العامة الانتقال من العمليات التفاعلية إلى إدارة استباقية ومستدامة وموجهة نحو الأداء، تتماشى مع أهداف التنمية المستدامة ذات الصلة.

**الكلمات المفتاحية:** استخدام البيانات، المختبرات العامة، هدر البيانات غير الملحوظ، رفض العينات، الإدارة المستدامة، مدة إنجاز العمل

**الكلمات الدالة:** تكتب هنا خمس كلمات مرتبة ابجديا بينها فواصل.

## 1. Introduction:

Public medical laboratories operate at the core of healthcare delivery systems and generate large volumes of routine operational data on an everyday basis. These data encompass indicators such as turnaround time (TAT), specimen rejection rates, workload distribution, quality control performance, and equipment utilization (Cai et al., 2025; Alhammad et al., 2023). Empirical reviews indicate that laboratories routinely collect more than 70–80% of the operational data required for performance monitoring, yet only a limited proportion of these data are systematically analyzed for managerial decision-making (Tuladhar et al., 2023).

Recent literature in healthcare management has described this underutilization as silent data waste, referring to the latent loss of informational value when routinely collected data are not translated into actionable managerial insights (Tuladhar et al., 2023; An et al., 2025). Studies on clinical data life cycles suggest that up to 30–50% of routinely generated health data remain underused due to governance gaps, limited analytical capacity, and system fragmentation (An et al., 2025).

From a sustainability perspective, effective data utilization is increasingly recognized as a critical enabler of resilient health systems. Data-driven decision-making supports the achievement of Sustainable Development Goal (SDG 3) by improving healthcare quality and (SDG 12) by promoting responsible resource use and waste reduction (Uçar, 2023). In laboratory settings, systematic analysis of operational data enables managers to identify bottlenecks, reduce unnecessary test repetition, and allocate resources based on actual service demand rather than assumptions.

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Despite these recognized benefits, significant gaps persist in the translation of routine laboratory data into managerial and strategic actions, particularly within public laboratory systems (Worku, 2025). Addressing these gaps is essential for improving both operational performance and sustainability outcomes.

**1. Problem Statement:**

In many public medical laboratories, routine operational data are systematically collected but inadequately incorporated into managerial decision-making. As a result, laboratories fail to detect and address process inefficiencies in a timely manner (Tuladhar et al., 2023). Published studies report median turnaround times exceeding recommended benchmarks by 20–40% in resource-constrained public laboratories, largely due to the absence of data-driven monitoring and feedback mechanisms (Cai et al., 2025).

**2. Significance of the Study:**

This study contributes to the growing body of literature on sustainable healthcare management by offering a structured conceptualization of silent data waste in public laboratory settings. By emphasizing managerial data utilization rather than data availability alone, the paper highlights an often-overlooked determinant of laboratory performance.

Strengthening the use of routine operational data supports evidence-based management, improves service timeliness, reduces material and environmental waste, and enhances accountability in public health institutions. The proposed framework provides laboratory leaders and policymakers with a theoretically grounded basis for integrating sustainability considerations into routine performance management practices.

**3. Aim and Objectives:**

**4.1 Aim:**

The aim of this paper is to develop a theoretically grounded conceptual framework that explains how improved utilization of routine operational laboratory data can enhance quality performance and resource efficiency within public medical laboratories.

**4.2 Objectives:**

- 4.2.1** To conceptualize silent data waste as a managerial challenge in public laboratory systems.
- 3.2.2** To identify routine operational data types with high managerial and sustainability relevance.
- 3.2.3** To examine key organizational and managerial barriers to effective data utilization.
- 3.2.4** To propose a conceptual framework linking data utilization to quality and sustainability outcomes.
- 3.2.5** To outline practical performance indicators that support data-driven and sustainable laboratory management

**4. Conceptualizing Silent Data Waste in Laboratories:**

Silent data waste in laboratory settings manifests in multiple interrelated forms. These include inaccessible data stored in fragmented or non-integrated systems, underutilized data that are available but not systematically analyzed, inconsistent data arising from variable recording practices, redundant data duplicated across platforms, and data lost due to inadequate archiving or backup procedures (An et al., 2025).

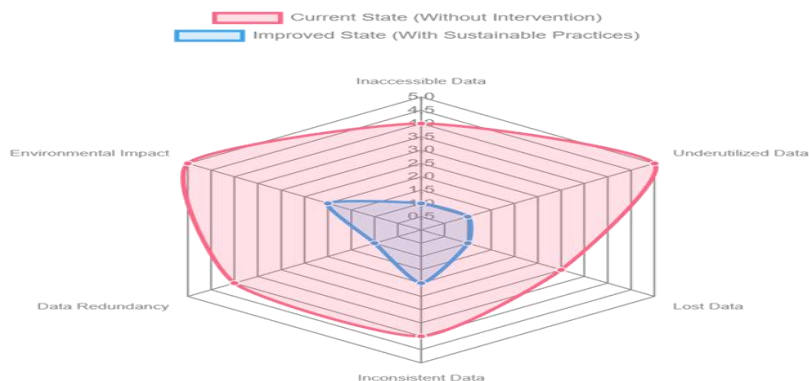
Systematic reviews of clinical data management indicate that data fragmentation and inconsistency can reduce the effective usability of routinely collected datasets by up to 40%, thereby limiting their value for longitudinal performance monitoring and strategic planning (An et al., 2025). Although often excluded from conventional sustainability audits, these forms of data waste collectively undermine operational efficiency, data reliability, and organizational learning capacity. Their cumulative

impact extends beyond managerial inconvenience to influence service quality, financial performance, and environmental sustainability outcomes in healthcare systems (Tuladhar et al., 2023; Uçar, 2023).

### 5.1. Forms and Impacts of Data Waste:

**5.1.1 Inaccessible Data:** Data frequently resides in disparate, unintegrated systems such as separate laboratory information management systems (LIMS), electronic lab notebooks (ELNs), or simple spreadsheets. Furthermore, data stored in legacy or proprietary formats can be difficult to access or interpret. This fragmentation often results from a lack of standardized data exchange protocols, leading to valuable information being siloed and effectively lost to broader analysis.

**5.1.2 Underutilized Data:** Even when data is accessible, it might remain underutilized. This occurs when collected data is not



systematically analyzed or integrated into decision-making processes. Reasons for this can include a lack of appropriate analytical tools, insufficient expertise among staff, or unclear protocols for data usage. This represents a significant missed opportunity for scientific breakthroughs and improved public health outcomes. (Tuladhar et al., 2023)

**5.1.3 Lost Data:** Poor archiving practices, inadequate backup strategies, and even physical degradation of storage media can lead to the complete data loss. This not only erodes the historical record but can also compromise longitudinal studies and the ability to track long-term trends essential for public health interventions.

**5.1.4 Inconsistent Data:** Variations in data entry, recording methodologies, and quality assurance procedures across different personnel or over time can lead to inconsistent datasets. Such inconsistencies compromise the reliability and integrity of the data, making it unsuitable for robust analysis and decision-making.

**Figure 1.** Conceptual framework linking data utilization with quality performance and resource efficiency outcomes

**5.1.5 Data Redundancy:** The duplication of data across multiple systems is a common issue. This not only consumes unnecessary storage space and processing power but also creates potential discrepancies, as updates in one system may not be reflected in another, leading to unreliable information. (An et al., 2025)

Figure 1 illustrates the proposed conceptual framework, using a radar chart to depict the relative impact of different forms of silent data waste and how improved data utilization and sustainable data management practices can reduce these effects across key laboratory performance outcomes, including environmental impact.

**Note:** (The radar chart uses a conceptual scale (1–5), where higher values indicate greater negative impact).

## 5. The Managerial Barriers to Data Utilization:

The persistence of silent data waste is closely linked to managerial and organizational constraints rather than technological limitations alone. Key barriers identified in the literature include limited analytical capacity among laboratory leaders, fragmentation between laboratory and hospital information systems, and the absence of standardized performance dashboards for routine monitoring (Worku, 2025; Cai et al., 2025).

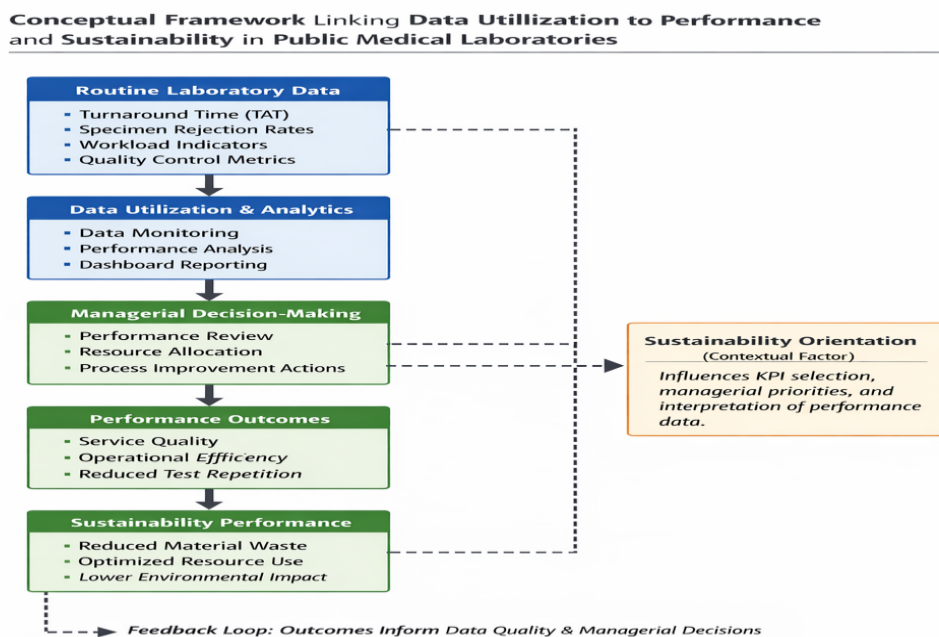
Without structured tools for data visualization and interpretation, routine performance indicators remain isolated data points rather than drivers of managerial action. Empirical and conceptual studies consistently emphasize that addressing these barriers is a prerequisite for embedding data-driven decision-making into sustainable laboratory management practices (An et al., 2025).

## 6. Methodological Approach:

This study adopts a conceptual analytical approach based on a structured and focused review of recent peer-reviewed literature published between 2020 and 2025. Sources were identified through leading academic journals and edited volumes in the fields of laboratory management, healthcare quality improvement, data governance, and sustainable health systems (Worku, 2025; An et al., 2025).

Rather than generating primary empirical data, the paper synthesizes existing theoretical frameworks, empirical findings, and best-practice guidelines to develop an integrating conceptual model. This approach is consistent with established methods for conceptual research in health management and sustainability studies (Tuladhar et al., 2023). Common laboratory performance indicators, such as turnaround time and specimen rejection rates, are used illustratively to demonstrate the practical relevance of improved data utilization for managerial decision-making (Cai et al., 2025; Uçar, 2023).

## 7. Conceptual Framework:



**Figure 2.** Conceptual framework illustrating how routine laboratory data utilization supports managerial decision-making, leading to improved performance outcomes and enhanced sustainability in public medical laboratories. The framework emphasizes a feedback mechanism through which performance outcomes inform continuous data quality improvement and future managerial actions.

The proposed conceptual framework positions data utilization as the central independent construct that influences two primary outcome domains: quality performance and resource efficiency. This conceptualization is grounded in management and health systems literature emphasizing the role of information use in organizational performance improvement (Tuladhar et al., 2023; Worku, 2025).

Data-driven management practices - including performance dashboards, real-time analytics, standardized indicators, and routine feedback mechanisms - act as mediating processes through which raw operational data are transformed into actionable managerial insights (Cai et al., 2025). Through these mechanisms, enhanced data utilization contributes to reduced turnaround times, lower specimen rejection rates, improved quality control compliance, and more efficient allocation of human and material resources (Uçar, 2023).

Continuous monitoring and feedback loops reinforce a cycle of proactive performance management, aligning laboratory operations with sustainability objectives and relevant Sustainable Development Goals (An et al., 2025).

#### 8. Key Performance Indicators for Sustainable Laboratory Management:

To operationalize the proposed framework, this paper highlights a set of widely accepted laboratory performance indicators with strong managerial and sustainability relevance. These include median turnaround time, specimen rejection rate, quality control compliance, and indicators related to material and environmental waste generation (Cai et al., 2025; Uçar, 2023).

**Table 1.** Quantitative Evidence Supporting Data-Driven Laboratory Management

Indicator	Reported Range / Impact	Context	Key Source
<b>Underutilized routine health data</b>	30–50% of collected data	Health information systems and laboratory operations	An et al., 2025
<b>Availability of routine operational data</b>	70–80% of required indicators routinely collected	Public and hospital laboratories	Tuladhar et al., 2023
<b>Median turnaround time deviation</b>	20–40% above benchmarks	Public laboratories	Cai et al., 2025
<b>Turnaround time reduction</b>	15–35% reduction	Data-driven process improvement	Cai et al., 2025
<b>Specimen rejection rate</b>	2–8%	Public laboratory settings	Uçar, 2023
<b>Rejection rate reduction</b>	30–50% reduction	Quality improvement initiatives	Uçar, 2023
<b>Environmental impact of rejected specimens</b>	12.3 tons CO <sub>2</sub> -eq; 3.7 tons medical waste	Tertiary laboratory (2 years)	BMC Health Services Research, 2025

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The quantitative evidence summarized in **Table 1** demonstrates that substantial performance and sustainability gains can be achieved when routine laboratory data are systematically analyzed and integrated into managerial decision-making processes.

## 9. Discussion:

The analysis underscores that routine operational data constitute a largely untapped strategic resource in public laboratory management. Evidence from the literature demonstrates that when such data are systematically utilized, laboratories can achieve substantial performance gains, including reductions in turnaround time of up to one-third and significant decreases in specimen rejection and repeat testing (Cai et al., 2025; Uçar, 2023).

From a sustainability perspective, improved data utilization contributes directly to reduced material consumption and lower environmental impact. Studies indicate that even modest reductions in rejection rates (e.g., 1–2 percentage points) can translate into meaningful decreases in medical waste volume and associated carbon emissions at the facility level (BMC Health Services Research, 2025). Embedding data utilization within routine managerial practices enables laboratories to transition from reactive problem-solving toward proactive performance optimization, a transition widely recognized as essential for sustainable health system strengthening (Tuladhar et al., 2023).

## 10. Recommendations:

Based on the proposed conceptual framework, the following recommendations are advanced to support sustainable, data-driven management in public medical laboratories:

- 11.1 Establish clear data governance structures that define responsibilities for data collection, validation, access, and use, in order to enhance the reliability of managerial decision-making.
- 11.2 Integrate laboratory information systems with broader hospital management platforms to minimize data fragmentation and improve the accessibility of routine operational indicators.
- 11.3 Implement standardized performance dashboards that enable regular managerial monitoring of key indicators such as turnaround time, specimen rejection, and workload trends, supporting timely and proactive intervention.
- 11.4 Strengthen managerial data literacy through targeted training initiatives focused on data interpretation, basic analytics, and the practical use of performance indicators in improvement planning.
- 11.5 Institutionalize routine data review cycles that are explicitly linked to quality improvement initiatives and sustainability-oriented performance management.

## 11. Conclusion:

Silent data waste represents a significant yet addressable challenge in public laboratory systems. The literature reviewed in this study consistently demonstrates that the problem lies not in data availability but in limited data utilization driven by managerial, organizational, and governance constraints (An et al., 2025; Worku, 2025).

By strengthening data governance, analytical capacity, and data-driven management practices, public laboratories can enhance quality performance, optimize resource use, and contribute effectively to sustainable healthcare development. The conceptual framework proposed in this paper provides a theoretically grounded foundation for future empirical research and practical implementation aimed at reducing silent data waste and improving laboratory sustainability outcomes (Tuladhar et al., 2023; Uçar, 2023).

## 12. References:

- 1- Tuladhar, S., Mwamelo, K., Manyama, C., Asefa, F., Soremekun, S., Worrall, S., Aagaard-Hansen, J, *Proceedings from the CIHLMU 2022 Symposium: Availability of and access to quality data in health. BMC Proceedings*, **17**(Suppl10), Article 21, 2023. <https://doi.org/10.1186/s12919-023-00271-1>

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- 2- Uçar, K. T, Examining the influence of sample rejection rates on the carbon footprint of clinical laboratories: A retrospective analysis. *Journal of Health Sciences and Medicine*, **6**(5), 993–997, 2023. <https://doi.org/10.32322/jhsm.1342155>
  - 3- Alhammad, L. A., Ainosah, T. K., Ahmad, A. M., Samarkandi, M. S., Jawi, N. H., Alharthi, M. A., Alsharif, A. M., Anazi, E. A. A., Aldugeshem, S. A., & Johali, F. Y, The impact of laboratory automation on efficiency and accuracy in healthcare settings. *International Journal of Community Medicine and Public Health*, **11**(1), 459–463, 2023. <https://doi.org/10.18203/2394-6040.ijcmph20233857>
  - 4- BMC Health Services Research, Sustainable care quality improvement: Performance measurement in lean healthcare implementations (Article 1452). *BMC Health Services Research*, **25**, 2025. <https://doi.org/10.1186/s12913-025-01452-3>
  - 5- An, D., Lim, M., & Lee, S, Challenges for data quality in the clinical data life cycle: Systematic review. *Journal of Medical Internet Research*, **27**, Article e60709, 2025. <https://doi.org/10.2196/60709>
  - 6- Cai, X., Lin, Y., Zhan, L., Lu, Q., Wu, Z., & Lin, X, Optimizing clinical laboratory efficiency through digital shadow and Lean Six Sigma integration: A real-time monitoring approach to reduce intra-laboratory turnaround time. *Digital Health*, **11**, 20552076251375939, 2025. <https://doi.org/10.1177/20552076251375939>
  - 7- Worku, A, Introduction to health care data analytics: An overview, In *Healthcare Data Analytics*, Springer, pp1–15, 2025. <https://doi.org/10.1007/s44250-025-00291-x>