Optimization of Reagent Inventory and Storage in a Chemistry Laboratory

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***Abstract* —** *This research addresses the challenge of reagent inventory management in a chemistry laboratory that relied on manual tracking systems, physical cards, and basic spreadsheets. The laboratory managed approximately 148 reagents and recorded up to 3 incidents per year involving the use of expired reagents. The study proposes and evaluates a digital inventory system using Microsoft Excel integrated with the VIVA platform, incorporating a four-stage automated expiration alert system combined with Lean Laboratory and ISO 17025 quality standards. Following implementation, expired reagent use was reduced from 3 per year to zero, a 100% improvement, and full traceability was achieved across all 148 reagents. Although manual data entry remains a limitation, the system demonstrates measurable improvements in laboratory efficiency, safety, and regulatory compliance. Future research should explore integration with Laboratory Information Management Systems and barcode or radio-frequency identification technologies.*

***Keywords* —** *Digital Inventory Management, ISO 17025 Compliance, Lean Laboratory, Reagent Expiration Monitoring.*

INTRODUCTION

Chemistry laboratories require precise control over reagents to ensure safety, quality, and regulatory compliance. Reagents are essential materials in analytical and quality testing processes; their proper management directly impacts the reliability of laboratory results and personnel safety. Despite this importance, many laboratories continue to rely on manual inventory systems that are prone to human error, incomplete records, and delayed updates [1].

The laboratory studied in this research managed approximately 148 reagents using a combination of physical cards and basic Excel spreadsheets. Prior to the proposed system, the laboratory recorded up to 3 incidents per year in which expired reagents were inadvertently used — a serious quality and safety concern in a regulated manufacturing environment subject to ISO 17025 requirements [2].

This article presents the development and evaluation of a digital reagent inventory management system implemented at Baxter Chemistry Laboratory. The system combines a Microsoft Excel-based inventory model with the VIVA platform to automate expiration monitoring through a four-stage alert system, demonstrating that accessible, low-cost digital tools can achieve measurable improvements in laboratory performance.

The significance of this study extends beyond the immediate operational improvements achieved. It provides evidence that laboratory quality and safety challenges often stem not from a lack of resources or technology, but from the absence of structured systems and accountability frameworks. By addressing these root causes through accessible digital tools, this research offers a replicable model for laboratories operating under similar constraints.

PROBLEM STATEMENT

The chemistry laboratory used physical index cards and basic Excel spreadsheets for reagent inventory control. Laboratory personnel manually documented reagent opening dates and removed cards when reagents were consumed. This manual approach produced critical operational limitations:

- Incomplete or outdated records due to missed documentation of opening and removal dates.

- Incorrect placement of reagents in storage areas, causing retrieval delays and risk of using wrong materials.
- No automated monitoring system to alert personnel in advance of upcoming expiration dates.
- Up to 3 instances per year where expired reagents were used undetected, a direct ISO 17025 compliance violation [2].
- Delayed inventory updates due to reliance on paper-based processes with no digital backup.

The consequences of these deficiencies extended beyond operational inefficiency. In a regulated manufacturing environment such as Baxter, where laboratory results directly inform product quality decisions, the use of expired reagents represents not only a compliance violation but also a potential risk to patient safety. The urgency of addressing this problem was therefore both operational and ethical.

A digitalized, standardized system was needed to achieve accurate reagent tracking, enhanced safety, and sustained quality compliance.

RESEARCH DESCRIPTION

This research focuses on improving reagent inventory and storage management at Baxter Chemistry Laboratory. The study analyzes the existing manual workflow, identifies sources of inefficiency, and proposes a practical digital solution using tools already accessible to the laboratory.

The scope of this research was intentionally focused on the Chemistry Laboratory department to allow for a detailed, controlled evaluation of the proposed system. By limiting the study to a single department, it was possible to fully document baseline conditions, implement the system under consistent conditions, and measure outcomes against a well-defined pre-implementation baseline. The lessons learned from this focused implementation serve as the foundation for potential future expansion to other laboratory departments.

The proposed system consists of a centralized Excel-based inventory model capturing all relevant reagent data — name, lot number, expiration date, storage location, and quantity — integrated with the VIVA platform to automate expiration monitoring. VIVA was configured to generate automated email alerts at four intervals: 30 days, 7 days, 1 day before expiration, and on the expiration date itself.

A standardized reagent storage coding system was proposed, and a designated responsible individual was assigned to manage and maintain the inventory. These organizational changes addressed the accountability gaps in the current system and ensured long-term data accuracy.

RESEARCH OBJECTIVES

The following objectives guided the development and evaluation of the digital reagent inventory system implemented at Baxter Chemistry Laboratory.

General Objective

To design and implement an optimized reagent inventory and storage control system using digital tools and standardized practices to improve efficiency, traceability, and compliance with ISO 17025 quality standards.

Specific Objectives

1. Analyze the current reagent control system, identifying its limitations and root causes of inefficiency.
2. Design a centralized digital inventory model in Excel with automated expiration alerts and location tracking for 148 laboratory reagents.
3. Propose a standardized storage coding system to ensure proper reagent organization and retrieval.
4. Evaluate the measurable benefits of the system in terms of efficiency, safety, and regulatory compliance.

Research Contributions

This research makes several practical contributions to laboratory management in

regulated manufacturing environments. The primary contribution is the complete elimination of expired reagent use through a digital monitoring system, reducing incidents from 3 per year to zero and demonstrating a 100% improvement in a critical safety metric. The Excel and VIVA-based system provide a cost-effective, replicable model for small to medium-sized laboratories that lack the resources for full Laboratory Information Management System implementations. By leveraging existing software tools, the system reduces barriers to adoption while delivering significant improvements in traceability, accountability, and ISO 17025 compliance. This research also contributes to the growing body of knowledge on Lean Laboratory applications and digital transformation in regulated environments, providing a practical case study that other facilities can reference.

LITERATURE REVIEW

The following review examines key studies and frameworks related to laboratory inventory management, digital tools, Lean Laboratory principles, safety regulations, and inventory optimization that informed the design of this research.

Laboratory Inventory Challenges

Laboratories managing large numbers of chemical reagents face significant challenges maintaining accurate, up-to-date inventory records. Alrabghi and Tiwari demonstrated that manual inventory systems are inherently slow and error-prone, relying entirely on human intervention for data entry and updates [1]. The absence of systematic expiration monitoring creates conditions in which expired reagents may go undetected, as was documented in this research with 3 incidents per year prior to implementation.

Digitalization and Electronic Records

Bird et al. documented that electronic laboratory notebooks enhance data management, reduce documentation time, and ensure greater precision in record-keeping compared to paper-based systems [3]. The U.S. Food and Drug Administration requires that electronic records in regulated environments ensure data integrity, traceability, and compliance with quality standards [4]. Excel-based systems, when properly designed, can satisfy these requirements for many laboratory applications, particularly when integrated with platforms providing automated monitoring and alerting capabilities.

Lean Laboratory and Quality Management

The Lean Laboratory methodology applies continuous improvement principles to minimize waste, reduce variability, and improve efficiency [5]. ISO 17025:2017 establishes strict requirements for the control of laboratory materials, including reagents [2]. Laboratories under this standard must demonstrate that all materials are properly identified, tracked, and managed throughout their lifecycle — requirements the proposed system was designed specifically to satisfy.

Safety and Regulatory Compliance

Collectively, the literature reviewed in this section confirms that the challenges addressed in this research are not unique to the studied laboratory but are widely recognized across the scientific community. The convergence of digital tools, Lean methodologies, and quality standards such as ISO 17025 provides a comprehensive framework for addressing reagent inventory challenges in a structured, evidence-based manner. This research applies and adapts these established principles to a specific laboratory context, contributing to a practical implementation case that extends the existing body of knowledge.

The National Research Council provides comprehensive guidance on chemical hazard management, emphasizing accurate labeling, proper storage, and timely removal of expired materials [6]. The Toxic Substances Control Act further requires complete documentation for all chemical substances [7]. The digital system implemented in this research directly supports compliance with

both requirements by maintaining a centralized, auditable record of all reagents.

Inventory Optimization

Sharma describes forecasting tools that enable laboratories to predict reagent consumption patterns and optimize procurement to prevent shortages while minimizing excess inventory [8]. Excel-based systems can incorporate minimum stock level alerts and consumption trend tracking, providing a foundation for inventory optimization without requiring specialized software.

METHODOLOGY

The following section describes the research approach, variables, population, implementation process, and data collection techniques used to evaluate the effectiveness of the proposed digital reagent inventory system.

Research Design

This study employed a descriptive, quantitative research design. Descriptive methods documented and analyzed current laboratory practices, while quantitative analysis evaluated measurable outcomes — specifically the reduction in expired reagent incidents and the extent of inventory digitization achieved.

Variables

Data analysis was performed using Microsoft Excel. Descriptive statistics were calculated to summarize inventory coverage and alert system performance. Pre- and post-implementation comparisons were used to quantify improvements in expired reagent incidents. The primary outcome metric — the reduction in expired reagent use — was measured as a percentage change from the baseline of 3 incidents per year to the post-implementation result of zero. Secondary metrics included the percentage of reagents successfully digitized and the number of automated alerts generated by the VIVA platform during the study period.

- Independent Variable: The Excel and VIVA-based digital reagent management system, including the four-stage automated alert configuration.

Ethical considerations were addressed throughout the research. All laboratory personnel who participated in surveys or provided feedback were informed of the study's objectives prior to participation, and their confidentiality was maintained. The research was conducted in accordance with ISO 17025 ethical guidelines and FDA 21 CFR Part 11 regulations governing electronic data management in regulated environments. No personally identifiable information was collected or reported in any part of the study.

- Dependent Variables: Number of expired reagents used per year, percentage of reagents with complete digital records, and ISO 17025 compliance indicators.
- Controlled Variables: Laboratory conditions, staff training level, total reagent count (148), and reagent categories managed.

System Implementation Process

Implementation was carried out in four sequential phases. In Phase 1, a physical audit of all 148 laboratory reagents was conducted to document current status, location, lot numbers, and expiration dates. In Phase 2, the Excel inventory model was designed and populated with audited data, with conditional formatting applied to highlight reagents approaching expiration. In Phase 3, the inventory was uploaded to the VIVA platform, and automated email alerts were configured at four intervals: 30, 7, and 1 day before expiration, and on the expiration date. In Phase 4, laboratory personnel received training on system use and notification response procedures.

Research Schedule

The study was conducted from March 2 to May 23, 2026. Table 1 presents the Gantt chart for all research activities.

Table 1

Research Schedule — Gantt Chart

Activity	M-W1	M-W2	M-W3	M-W4	A-W1	A-W2	A-W3	A-W4	My-1	My-2	My-3
Topic Def. & Problem Statement	■	■									
Literature Review		■	■	■	■						
Methodology Development				■	■	■					
Excel Inventory Model Dev.					■	■	■	■			
Data Collection & Observation							■	■			
Data Analysis									■	■	
Writing Results & Conclusions									■	■	
Final Report Submission (May 15)										■	
Poster Presentation (May 20)											■

Source: Cartagena Fonseca, S. (2026)

RESULTS AND DISCUSSION

The following sections present the quantitative and qualitative results obtained after implementing the digital reagent inventory system, followed by a discussion of their significance and implications for laboratory quality management.

Results

The complete digitization of all 148 laboratory reagents was achieved, creating for the first time a centralized, searchable database with full traceability for each reagent's lot number, expiration date, storage location, and quantity. The most significant quantitative outcome was the complete elimination of expired reagent use. Prior to implementation, the laboratory documented approximately 3 incidents per year in which expired reagents were used without detection. Following implementation of the digital system and the four-stage automated VIVA alert system, this figure dropped to zero, representing a 100% reduction in this key risk indicator. Table 2 summarizes the key quantitative outcomes before and after implementation.

Table 2

Quantitative Results — Before vs. After Implementation

Indicator	Before	After	Result
Expired reagents used	3/year	0	100%
Reagents in inventory	148 untracked	148 digitized	Full coverage
Expiration alerts	None	4-stage auto	Early detection
Inventory accuracy	Incomplete	Systematic	Standardized

Source: Cartagena Fonseca, S. (2026)

Table 3

Process Comparison — Previous vs. Implemented System

Element	Previous	New System	Improvement
Inventory records	Manual logs	Excel centralized	Better org.
Expir. monitoring	Manual review	Automated alerts	Reduced risk
Notification system	None	Multi-stage alerts	Early detection
Responsibility	Not defined	Assigned person.	Accountability
Updates	Irregular	Systematic upd.	Accuracy

Source: Cartagena Fonseca, S. (2026)

Discussion

The results confirm that the digital reagent inventory system addressed all primary problems identified in the problem statement. The elimination of expired reagent use — from 3 incidents per year to zero — directly reduces compliance risk under ISO 17025 [2] and eliminates a potential source of analytical error that could compromise product quality decisions at Baxter.

The study also highlights an important organizational insight: the effectiveness of any digital system is ultimately dependent on the people who operate it. The assignment of a dedicated responsible individual to maintain the inventory was as critical to the system's success as the technology itself. This finding reinforces the importance of combining technological solutions with clear accountability structures and adequate training — a principle that applies broadly to quality management initiatives beyond the laboratory setting.

The complete digitization of 148 reagents established a traceability framework entirely absent under the previous manual system. The four-stage VIVA alert system proved particularly effective because it provided multiple opportunities for corrective action before expiration, consistent with findings by Bird et al. on the effectiveness of digital monitoring tools [3].

These findings demonstrate that accessible, low-cost digital tools can meet ISO 17025 material control requirements without large capital investment. The primary limitation remains the system’s dependence on manual data entry, which could affect long-term accuracy if not consistently maintained.

The four-stage alert system configured in the VIVA platform also demonstrated the value of proactive versus reactive management. Rather than discovering expired reagents during use, personnel could now plan reagent replacements in advance, reducing procurement urgency and the risk of operational disruptions due to unavailable materials. This shift from a reactive to a preventive management model is a direct application of Lean Laboratory principles and represents a sustainable improvement in laboratory operations [5].

Furthermore, the designation of a responsible individual to maintain the inventory created a clear accountability structure that was previously absent. Laboratory personnel reported that the system reduced the time spent manually searching for reagent status information and improved confidence in the accuracy of the records. These operational improvements, while more difficult to quantify, represent meaningful gains in laboratory culture and daily workflow efficiency that complement the measurable safety outcomes.

Conclusions

This study demonstrates that implementing a structured, digitalized reagent inventory system delivers significant, measurable improvements in laboratory safety, efficiency, and regulatory compliance. The digitization of 148 reagents and the elimination of expired reagent use (from 3 incidents per year to zero) confirm that the proposed system met all primary objectives. Table 4 summarizes the key conclusions and future research directions.

Table 4
Summary of Conclusions and Future Research

Category	Key Points
System Improvement	Improved traceability, monitoring, and organization of 148 reagents
Quantitative Outcome	Expired reagent use reduced from 3/year to 0 (100% improvement)
Technology	Excel + VIVA enabled 4-stage automated expiration alerts
Risk Reduction	Eliminated expired reagent use; improved ISO 17025 compliance
Accountability	Designated personnel improved data accuracy and consistency
Limitation	Manual data entry dependency may affect long-term accuracy
Future Work	LIMS integration, barcode/RFID technologies, long-term cost study

Source: Cartagena Fonseca, S. (2026)

FUTURE RESEARCH

Based on the findings of this study, the following areas are recommended for future investigation to further improve reagent inventory management and expand the impact of the proposed system.

1. Integration with Laboratory Information Management Systems (LIMS) to automate data entry and eliminate the manual data dependency.
2. Implementation of barcode or RFID technologies for real-time reagent tracking.
3. Long-term cost-benefit analysis of reagent waste reduction and compliance improvement.
4. Extension of the model to Microbiology and Production departments to evaluate scalability.

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