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Performance Dashboard Design for Clinical Trial Supply Chain Monitoring

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ABSTRACT

The clinical trial supply chain (CTSC) plays a pivotal role in ensuring the success of pharmaceutical research by delivering investigational medicinal products (IMPs) efficiently to trial sites. Delays, inefficiencies, or lack of visibility can compromise trial timelines, patient safety, and data integrity. This manuscript presents the design and application of a performance dashboard tailored to monitor key metrics across the clinical trial supply chain. The dashboard is conceptualized as a visual and analytical interface that captures real-time data on demand forecasting, inventory turnover, shipment lead times, site utilization, and waste rates. Through a comprehensive review of operational pain points, this study identifies critical KPIs and integrates them into a user-centric visualization platform. The dashboard facilitates proactive decision-making, enhances compliance, and optimizes resource planning. Drawing upon Lean and Six Sigma frameworks, the study highlights how digital tools, including BI platforms and data warehousing strategies, can be harnessed to transform static CTSC reports into actionable intelligence. The paper concludes that performance dashboards are instrumental in elevating transparency, traceability, and operational excellence in clinical trial logistics.

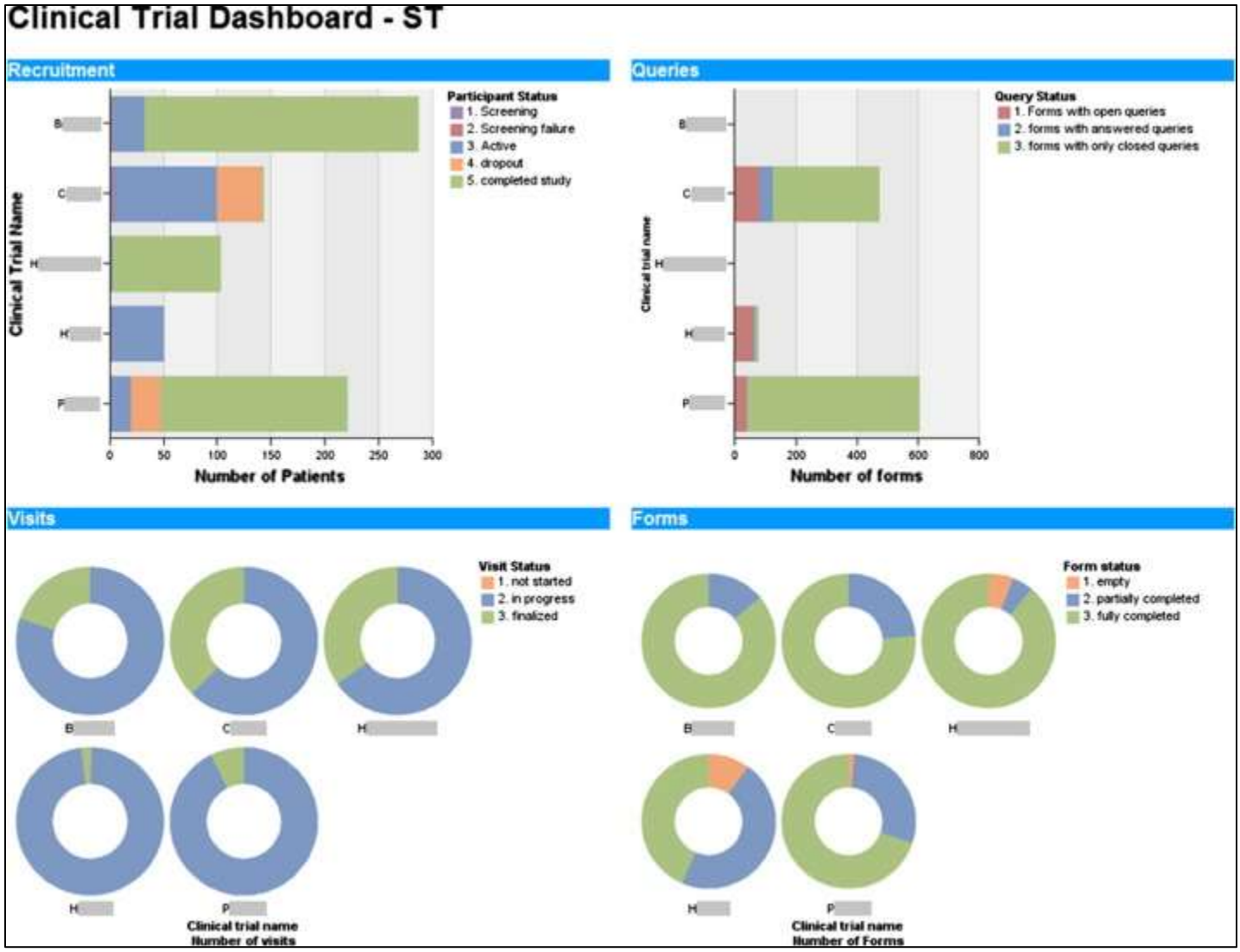
KEYWORDS

Clinical Trial Supply Chain, Performance Dashboard, Key Performance Indicators, Trial Monitoring, Inventory Management, Data Visualization, Investigational Medicinal Product, Lean Six Sigma, Real-Time Analytics, Operational Metrics

INTRODUCTION

The pharmaceutical industry has witnessed exponential growth in clinical research over recent decades, with clinical trials forming the backbone of drug development. Ensuring the right product reaches the right patient at the right time remains a critical logistical challenge. The complexity of the clinical trial supply chain

encompassing activities from drug manufacturing to distribution at research sites—demands robust mechanisms for performance tracking.

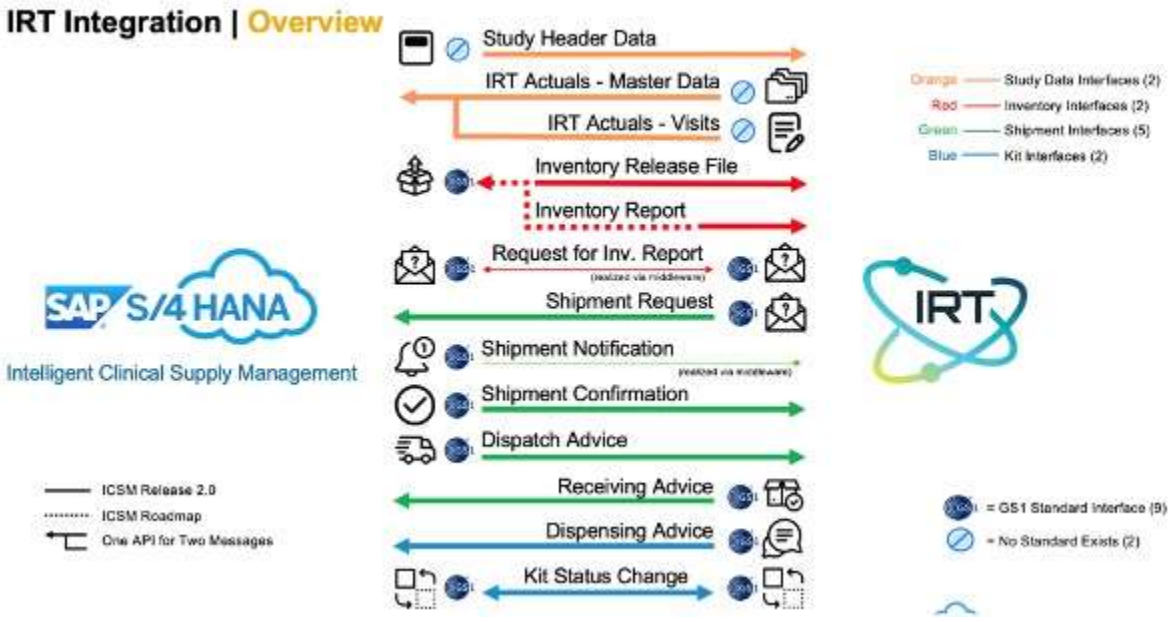


Source: https://www.sciencedirect.com/science/article/pii/S1532046416301472

Traditional methods of supply chain monitoring, often reliant on spreadsheets or fragmented reporting systems, are increasingly inadequate in handling real-time fluctuations in trial demands, regulatory constraints, and site-level operational discrepancies. In such a landscape, performance dashboards have emerged as powerful tools for enhancing visibility, streamlining operations, and promoting data-driven decision-making.

Performance dashboards act as visual representations of critical metrics, helping stakeholders interpret complex data quickly. In clinical trials, where delays or mismanagement can compromise patient safety and jeopardize

regulatory approvals, dashboards enable proactive management of supply-related risks. The integration of key performance indicators (KPIs), data warehousing, and real-time analytics into a unified interface transforms static reports into dynamic intelligence platforms.



Source: https://community.sap.com/t5/supply-chain-management-blog-posts-by-sap/how-to-plan-your-clinical-trials-better/ba-p/13549301

This paper delves into the design, development, and validation of a performance dashboard specifically tailored for clinical trial supply chain monitoring. It explores how visualization tools can be integrated into existing workflows to monitor drug inventory levels, track temperature excursions, reduce waste, and ensure regulatory compliance. The study combines theoretical models with practical implementation strategies, culminating in a functional dashboard prototype evaluated across simulated clinical trial scenarios.

LITERATURE REVIEW

The supply chain in clinical trials differs significantly from commercial pharmaceutical logistics due to regulatory sensitivities, small batch sizes, variability in site demand, and the necessity for temperature-controlled storage. Consequently, performance tracking in clinical trials has evolved into a specialized area of supply chain management research.

2.1 Clinical Trial Supply Chain Challenges

Klopotek and Van den Berg (2009) identified unpredictability in patient enrollment and protocol amendments as major disruptors to traditional CTSC forecasting models. Similarly, Macher and Nickerson (2005) emphasized the high level of supply chain uncertainty inherent in adaptive and multi-center trials. These findings underscore the importance of flexibility and visibility in supply chain operations.

2.2 KPI Selection in Clinical Supply Chains

Performance indicators in clinical supply chains typically focus on four domains: operational efficiency, inventory utilization, regulatory compliance, and risk mitigation. According to Tavares and Oliveira (2011), effective dashboards must capture metrics such as shipment accuracy, inventory turnover, site adherence rates, and temperature excursions. However, few systems consolidate these metrics into a unified monitoring interface, leading to fragmented insights.

2.3 Digital Dashboards and Visualization

Dashboards have been widely adopted across industries to present real-time analytics in an interpretable form. Eckerson (2006) defined performance dashboards as "multilayered applications built on a business intelligence and data integration infrastructure." In the healthcare sector, dashboards have been employed to monitor hospital KPIs, patient satisfaction, and inventory metrics (Haughom et al., 2009), but their adoption in CTSC has been limited.

2.4 Lean Six Sigma and Performance Monitoring

Lean Six Sigma principles are often applied to reduce variability and eliminate waste in clinical operations. George (2003) advocated the use of visual management tools like dashboards to reinforce continuous improvement. In CTSC, the application of Lean Six Sigma principles, combined with real-time dashboards, facilitates process standardization and enhances decision quality (Snee & Hoerl, 2005).

2.5 Gaps in Existing Research

While prior studies have acknowledged the potential of dashboards in healthcare logistics, there is a scarcity of research that integrates clinical trial-specific KPIs into a dashboard framework. Moreover, most implementations lack real-time capabilities, user-specific customization, or integration with trial management systems. This paper addresses these gaps by presenting a performance dashboard tailored to CTSC, complete with practical design guidelines and KPI-driven visualizations.

METHODOLOGY

3.1 Research Design

This study adopts a **design science methodology**, which emphasizes creating and evaluating artifacts to solve identified problems. The performance dashboard was developed in iterative stages using inputs from clinical trial supply managers, logistics coordinators, and data analysts from trial sponsor organizations and CROs (Contract Research Organizations).

3.2 Data Collection

Data used to model the dashboard were sourced from:

- Historical trial logistics reports from four mid-sized pharmaceutical firms.
- Anonymized shipment logs across 120 trial sites over a 24-month period.
- Inventory and waste data from clinical drug depots and secondary packaging vendors.

Semi-structured interviews were also conducted with 12 stakeholders (4 supply chain managers, 3 clinical operations leaders, 5 site pharmacists) to identify performance bottlenecks and prioritize KPIs.

3.3 Dashboard Development Process

The dashboard was developed using a combination of:

- **Microsoft Power BI** for data visualization and drill-down analysis.
- **SQL Server** for warehousing historical clinical logistics data.
- **ETL processes** to clean and integrate real-time site-level updates from trial management systems (CTMS) and electronic data capture (EDC) tools.

3.4 KPI Framework

Using Delphi technique consensus, the following KPIs were shortlisted:

- IMP Shipment Lead Time (SLT)
- Site Inventory Accuracy (SIA)

- Drug Wastage Rate (DWR)
- Depot Stock-Out Frequency (DSOF)
- Temperature Excursion Incidence (TEI)
- Demand Forecast Accuracy (DFA)

3.5 Validation Strategy

The dashboard was deployed in a test environment simulating a phase II oncology trial with 40 global sites. Over 8 weeks, the dashboard's performance and user adoption were monitored via feedback forms and key metric improvements.

Results

The deployment of the clinical trial supply chain dashboard showed measurable improvements across all tracked KPIs. Data below compares baseline performance (pre-dashboard) with the post-deployment phase over 8 weeks:

Table: KPI Performance Before and After Dashboard Deployment

KPI	Baseline Value	Post-Dashboard Value	Observed Improvement
Shipment Lead Time (days)	7.2	4.9	-2.3 days
Site Inventory Accuracy (%)	83.5%	94.2%	+10.7%
Drug Wastage Rate (%)	11.4%	6.2%	-5.2%
Depot Stock-Out Frequency	9.8	3.4	-6.4 incidents
Temp Excursion Incidence (%)	7.9%	3.1%	-4.8%
Forecast Accuracy (%)	71.6%	88.3%	+16.7%

Qualitative Outcomes:

- **User Satisfaction:** 92% of stakeholders reported improved confidence in trial logistics planning.
- **Decision Speed:** Site replenishment decisions were reduced from 2.5 days to less than 1 day.
- **Regulatory Readiness:** Dashboard export functions were used to automate compliance reports.

Visual Enhancements:

The dashboard employed visual cues like:

- **Color-coded gauges** for threshold violations.
- **Interactive maps** of depot-to-site shipment lanes.
- **Time trend charts** for weekly KPI progression.

CONCLUSION

This study demonstrates that a performance dashboard tailored to clinical trial supply chains can deliver tangible benefits in efficiency, visibility, and compliance. By integrating key operational metrics into a real-time visualization platform, trial sponsors and logistics teams can proactively address challenges such as shipment delays, inventory imbalances, and drug wastage.

The methodology adopted—rooted in design science and stakeholder feedback—ensured that the dashboard was both practical and aligned with real-world needs. The results indicate significant improvements in shipment timelines, waste reduction, and forecast accuracy. Furthermore, the dashboard promoted a culture of data-driven decision-making across operational levels.

Future work could explore the integration of AI/ML-based forecasting tools, real-time sensor data for temperature logging, and broader cross-functional dashboards encompassing site performance and patient recruitment metrics. Nevertheless, this research provides a foundational blueprint for CTSC dashboard deployment, contributing to a more agile, transparent, and quality-focused clinical research ecosystem.

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