

Research on Refined Management of Medical Consumables Based on the SPD Supply Chain Model

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Abstract

The medical consumables SPD (Supply-Processing-Distribution) supply chain system represents an innovative paradigm for modern medical supplies management. Through resource integration, information technology empowerment, and the re-engineering of specialized processes, it establishes a precise control mechanism covering the full lifecycle of medical consumables. By leveraging digital means, this model enables dynamic monitoring of critical stages within medical institutions, including procurement, quality inspection, warehousing, logistics distribution, and clinical usage of consumables, thereby providing technical support for enhancing operational efficiency in public hospitals. This study employs empirical analysis to evaluate the implementation effectiveness of the SPD model in medical supplies management, using the practice of a tertiary general hospital as a sample. The research aims to provide both a theoretical basis and practical pathways for the digital transformation of consumables management in healthcare institutions.

Keywords: Medical consumables; Refined management; SPD; Public hospitals.

1. Introduction

Following the elimination of markup policies on medical consumables in public healthcare institutions, medical consumables management has transitioned from being a profit center to a cost center within hospitals. Consequently, refined management of medical consumables has become critical for healthcare institutions seeking to reduce costs and improve efficiency. Medical consumables constitute a substantial portion of hospital operating costs, and with the implementation of Diagnosis-Related Group (DRG) payment systems and zero-markup policies, establishing standardized and comprehensive management systems that enable full-process traceability has become an urgent priority for healthcare institutions (Liu et al., 2016).

To align with the refined management requirements of public hospitals, the standardization and precision management of medical consumables has become imperative. Refined management is a management philosophy that establishes deeper management protocols beyond conventional practices. This approach makes management responsibilities more specific and well-defined, enabling more detailed and granular classification of management objects with the goal of minimizing resource consumption and operational costs (Almorsy and Khalifa, 2016).

The Supply-Processing-Distribution (SPD) supply chain model for medical consumables represents an advanced healthcare supply management paradigm. By integrating supply chain resources, information technology, and specialized division of labor, the SPD model achieves comprehensive refined control over medical consumables from procurement through clinical utilization. Serving as an information technology tool for refined management of medical consumables in public hospitals, it manages procurement, acceptance, warehousing, inventory, centralized distribution, and consumption, thereby driving information technology innovation for high-quality hospital development (Yang et al., 2019). This study analyzes the application effectiveness of the SPD model in medical consumables management based on the implementation experience at our hospital, with the aim of providing both theoretical foundations and practical pathways for the digital transformation of consumables management in healthcare institutions.

2. Problems in Traditional Medical Consumables Management

2.1. Disorganized Warehouse Management

Medical consumables frequently suffer from over-purchasing or inventory accumulation. This large-scale batch procurement approach necessitates maintaining substantial inventories, increasing storage management costs, and potentially leading to expiration or damage, resulting in waste. Warehouse data relied primarily on administrators performing periodic inventory counts and generating purchase orders based on personal experience, often resulting in missed, excessive, or incorrect procurement (Neve and Schmidt, 2022).

2.2. Insufficient Information Technology Management

Although information technology has been widely applied in hospital management with satisfactory results, these information systems generally operate independently with isolated data. The lack of specialized systems for medical consumables information management prevents data exchange with Hospital Information Systems (HIS), Laboratory Information Systems (LIS), and Hospital Resource Planning (HRP) systems, significantly limiting the improvement of medical consumables management standards.

2.3. Inaccurate Secondary Warehouse Accounting

The management approach for high-value medical consumables in secondary warehouses was relatively coarse. Management departments were unable to timely determine the quantity of consumables used by clinical departments or the remaining inventory in secondary warehouses. Due to data errors and omissions, they had to constantly address billing issues arising from incorrect, excessive, or missed charges for high-value medical consumables (Neve and Schmidt, 2022).

2.4. Inadequate Clinical Usage Supervision

Incomplete records of consumable requisition and usage may lead to abuse or misappropriation. Single-use consumables may be reused, increasing the risk of cross-infection and surgical complications. Without proper supervision and data analysis, horizontal comparison of different brands is impossible, potentially resulting in the use of higher-priced consumables that increase patient burden and drive up healthcare costs.

3. Core Concepts and Architecture of the SPD Model

3.1. Definition and Connotation

The medical consumable SPD management model is a refined management approach based on integrated supply chain. Led by the hospital procurement center, it ensures the quality and safety of medical consumables while meeting clinical needs. Leveraging logistics information technology, this model centrally manages the entire hospital's supply, processing, and distribution of medical consumables, thereby reducing costs and improving operational efficiency (Liu et al., 2016). Centered on "Supply, Processing, and Distribution", the SPD model relies on information systems and collaboration with third-party professional teams to cover the full life cycle of consumables from suppliers to patient use. Its objectives are to achieve zero-inventory management and precise supply.

3.2. Core Processes

3.2.1. Supply

Procurement information is no longer generated manually by calculating inventory gaps. Instead, the SPD system automatically generates procurement plans by analyzing historical consumption patterns, clinical fixed-quantity consumption, inventory thresholds, and supplier response times (Wei et al., 2025). Through big data analysis of historical usage, seasonal factors, and clinical staffing schedules, procurement strategies are dynamically adjusted, significantly reducing inaccuracies caused by human experience and regularizing standardizing procurement operations.

Once hospital-approved medical supply replenishment plans are automatically transmitted from the internal materials management system to the SPD supply chain collaboration platform's supplier portal. The platform sends real-time notifications through multiple channels including SMS (Short Message Service) and WeChat, ensuring that supplier representatives stationed at the hospital receive procurement information promptly.

3.2.2. Processing

The hospital's internal logistics management system employs barcode technology for efficient operations, simplifying medical materials management into standardized processes that can be executed by basic logistics personnel. Specifically, the acceptance process completes warehousing registration by scanning packing barcodes, simultaneously achieving three-way data verification of purchase orders, delivery batches, and invoice amounts. The system intelligently displays material storage locations, significantly optimizing workflows while improving acceptance efficiency and controlling error rates.

For the management of high-value consumables and recyclable in-hospital materials, dynamic inventory and cycle counting can be realized through handheld PDA (Personal Digital Assistant). Meanwhile, batch and quantity adjustments can be made based on inventory results to ensure consistency between financial records and physical inventory.

3.2.3. Distribution

The SPD management model frees healthcare personnel from the daily management of department warehouse medical supplies, completely liberating them from the complexities of routine medical materials management. After warehouse picking and processing, materials are delivered to corresponding secondary consumption points and shelved. For the hundreds of consumption units within the hospital, with different consumption varieties and cycles, the system proactively plans delivery cycles and routes based on historical data analysis, on-site consumption point distribution, and delivery bottlenecks, ensuring optimal clinical inventory while maintaining clinical supply.

3.3. Technical Support

3.3.1. Information Systems

The information system tracks departmental consumable demand and usage in real-time, integrating HIS, LIS, HRP, and other systems to achieve data interconnectivity, building a comprehensive consumption data model. Through in-depth analysis of this data, hospitals can more accurately predict consumable demand, optimize inventory management, and reduce associated costs. BI dashboards display data in multi-dimensional, comprehensive formats, providing evidence for evaluating consumable usage rationality and supporting hospital decision-making.

3.3.2. Smart Hardware

Utilizing logistics sensors, machine vision, and automation technology enables rapid sorting, handling, and automatic inventory counting. In the distribution process, SPD can also integrate with logistics robots, using intelligent route planning and obstacle avoidance technology to dynamically adjust delivery routes, ensuring timely delivery of consumables while improving distribution efficiency and reducing costs.

4. Advantages of the SPD Model in Medical Consumables Management

4.1. Inventory Control Optimization

Based on algorithm-driven demand prediction, a dynamic replenishment mechanism is implemented, automatically triggering replenishment when inventory falls below safety thresholds. The “consumption-based settlement” model completes property transfer only upon clinical use, achieving zero inventory. Through the SPD system, inventory capital occupation can be significantly reduced, alleviating hospital financial pressure.

4.2. Quality Traceability and Safety Management

Through unique traceability codes recording production batches and patient usage information, rapid recall of problematic products is achieved, establishing a comprehensive traceability system. The system automatically monitors consumable expiration dates, providing early warnings for approaching expiration. By prioritizing the use of near-expiration products, the risk of using expired consumables and potential medical accidents is reduced.

4.3. Cost Control and Benefit Improvement

By establishing strategic partnerships with suppliers, resource sharing and information sharing are achieved, reducing procurement and inventory costs. Optimizing procurement, storage, and distribution processes reduces material accumulation and stockouts, preventing waste and losses.

4.4. Improved Clinical Service Efficiency

Through the integration of information management and smart hardware, intelligent management and monitoring of consumables is achieved, improving the efficiency and quality of healthcare services. Smart cabinets and PDA scanning systems save nurses substantial non-clinical working time daily. Through the Operations Data Repository (ODR), consumable usage trends are analyzed to optimize resource allocation. Data models are used to adjust high-value consumable usage strategies, reducing consumable costs.

5. SPD Implementation and Management Effectiveness

5.1. Challenges and Countermeasures in SPD Implementation

5.1.1. Main Challenges

System integration presents significant difficulties due to interface compatibility issues between multiple internal hospital systems (such as HIS and financial systems), limiting data interoperability functionality. Management responsibility dilution occurs when supplier-dominated “zero inventory” models potentially cause hospitals to lose control over consumables supervision, creating risks of supply interruptions due to delayed procurement. Price synchronization lags occur when procurement platform price adjustments are not synchronized with SPD management system updates, increasing settlement risks.

5.1.2. Countermeasures

Strengthen inter-departmental communication to facilitate multi-department collaboration, connect system data interfaces, and optimize functionality implementation. Reinforce hospital leadership by implementing dynamic inventory monitoring, timely replenishment based on consumption patterns, clear division of responsibilities, and

supplier assessment systems with regular evaluation of supplier performance. Shorten procurement platform price comparison time or implement automatic price comparison functionality, regularly executing platform price comparisons with SPD system prices, and promptly adjusting prices when changes are detected.

5.2. SPD Management Effectiveness

Our hospital launched the SPD project and completed central warehouse renovation, adopting a phased gradual rollout approach. Since the SPD project's launch, implementation has progressed rapidly with fine management granularity and high department satisfaction. Through UDI barcode full-process traceability, true refined management of consumables has been achieved.

The automatic replenishment of secondary warehouse stocks effectively reduces the proportion of near-expiry medical consumables and improves overall inventory accuracy, achieving zero discrepancies in dynamic inventory data of consumables in the central warehouse. In addition, the billing efficiency has been significantly enhanced. Compared with the traditional manual billing method, the billing model applied in operating rooms substantially saves operational time. Specifically, the billing duration for novice staff using handheld PDA scanning is shortened by 5.25 times, and the billing time can be further reduced with proficient operation.

Meanwhile, the hospital's consumable ratio has declined year by year. Despite the continuous growth in the overall scale of hospital consumables in recent years, the proportion of consumable costs in hospital operating expenses has shown a gradual downward trend. The transformation from the traditional goods-and-invoice simultaneous settlement to the consumption-based settlement model has effectively freed up capital previously occupied by hospital medical consumables.

6. Future Planning and Continuous Optimization

6.1. Consumables Management Optimization

6.1.1. Low-Value Blurred Billing Management

Low-value billable consumables are prone to inventory-sales-usage inconsistencies, resulting in data discrepancies. By extracting low-value consumable order billing information from the system, corresponding departmental consumable inventory is automatically deducted following the “first-in-first-out, near-expiration-first-out” principle.

6.1.2 Fixed-Quantity Package Management

Some low-value consumables have short expiration dates and oversized packaging; single requisition by factory packaging can easily lead to waste when consumption cannot keep pace. Through coordination among relevant departments organized by the hospital, fixed-quantity package specifications and sizes for low-value consumables are determined based on historical usage. These specifications are configured in the SPD system, and consumables are repackaged during the acceptance process.

6.1.3. Outpatient Consumables Order Verification Model

Outpatient consumables management has been relatively coarse with imprecise cost accounting, still following the model of central warehouse requisition equating to consumption. Given the reality that outpatient patients pay before receiving consumables, when departments scan product unique codes, the SPD system automatically deducts inventory according to order information without re-billing for the product. If scanned product details do not match order information in terms of product correspondence or quantity, the order verification is marked as failed and an alert is triggered, ensuring billing accuracy and consistency between order information and actual execution.

6.1.4. Reagent Management Refinement

For precise reagent cost accounting, through SPD system integration with LIS, actual “per-person” usage of laboratory reagents is obtained, and reagent loss ratios are calculated based on total consumption in “box” units. By equipping the SPD system with consumable inventory, batch numbers, and expiration dates, historical monthly usage is visible during requisition. To address the issue of mixed reagent batch usage, new batch reagents cannot be issued from the warehouse until old batches are completely used, with early warning functionality provided.

6.2. Smart Hardware Investment

Through intelligent transformation, investment in various smart devices and supporting materials, integrated with backend databases, achieves precise positioning, intelligent storage and retrieval, automatic inventory counting, and real-time monitoring of medical consumables. Real-time dynamic display of consumable inventory, usage, and shortage information further realizes lean management of consumable requisition, procurement, and replenishment.

7. Conclusion

The SPD medical supply chain model, as a highly information-intensive intelligent logistics operation model, integrates physical flow, information flow, and financial flow to optimize procurement, supply, inventory, and distribution processes, improving supply chain efficiency and healthcare service quality while reducing hospital operating costs. This enables rational allocation of limited medical resources and promotes optimization of the consumables supply chain in the healthcare sector (Li and Zhou, 2022). Through the implementation of the SPD

medical supply chain model, our hospital has significantly improved the standardization, precision, and intelligence of medical consumables management, particularly achieving full-process traceability for high-value consumables. This model has not only effectively reduced the consumables cost ratio but also achieved zero inventory management through the “post-use settlement” approach, substantially reducing operational costs. Ultimately, the SPD model has successfully helped our hospital achieve the goals of burden reduction, cost control, quality improvement, and efficiency enhancement, strongly promoting information technology development and comprehensive competitiveness (Yang et al., 2019).

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