ECONOMIC ANNALS-XXI
ISSN 1728-6239 (Online)
ISSN 1728-6220 (Print)
https://doi.org/10.21003/ea
http://ea21journal.world

Volume 212 Issue (11-12)'2024

Citation information: Abdieva, G., Khamdamova, M., Sadullaev, S., Matkarimov, I., Xusanova, Sh., & Alzubaidi, L. H. (2024). Supply chain management integration into the hospitals and health centers. Economic Annals-XXI, 212(11-12), 4-9. doi: https://doi.org/10.21003/ea.V212-01

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Supply chain management integration into the hospitals and health centers

Abstract. Currently, integration of supply chain management (SCM) within hospitals and health centers is recognized as a significant factor towards improving the quality of health care and reducing the cost. It was planned to investigate the impact of supply chain management system integration in health centers in Uzbekistan in this study. According to statistics of the World Health Organization (WHO), 20-40% of the healthcare centers' budgets are allocated to purchasing equipment and medicines, and annual inefficiencies in supply chains lead to 15% waste of budgetary funds and a 30% increase in waiting time for patients. Information was collected using a field study of 15 Tashkent hospitals and health centers during 2023-2024. The results showed that the application of integrated SCM systems resulted in a 25% reduction in logistics costs, a 40% increase in the accuracy of drug inventory management, and a 50% reduction in wastage of medical equipment. Further, a 35% increase in patient satisfaction was observed due to enhanced access to healthcare services. This study confirms that the use of new technologies such as smart tracking systems and data analysis platforms within the healthcare supply chain not only helps in optimizing resources but also plays a key role in saving patients' lives. Considering the 7% year-to-year rise in healthcare costs in Uzbekistan, the use of combined SM approaches can achieve economic savings up to $12 million annually.

Keywords: Supply Chain Management; SCM; Hospital; Healthcare Facilities; Economic Efficiency
JEL Classifications: E24; E41; E64; I18; J28; J31
Acknowledgements and Funding: The authors received no direct funding for this research.
Contribution: The authors contributed equally to this work.
Data Availability Statement: The dataset is available from the authors upon request.
DOI: https://doi.org/10.21003/ea.V212-01

1. Introduction

SCM, one of the key pillars of optimizing logistics processes in health care (Umoren et al., 2021; Puspitasari et al., 2022), plays a vital role in enabling prompt access to medical devices (Bialas et al., 2023; Khamdamov et al., 2023), medications, and health care (Khan et al., 2024; Kumar et al., 2024). Health facility supply chain inefficiencies, especially in developing countries, lead to wastage of financial resources (Bhakoo & Chan, 2011), decreases in service quality, and risks to patients' lives (Adhikari et al., 2023; Duwiejua et al., 2024; Piffari et al., 2024).

In Uzbekistan, while in recent years the health infrastructure has been upgraded, as per the reports submitted by the country's Ministry of Health, 30% of the health centers face shortages in basic drugs and equipment, and 22% of the country's national health budget is wasted due to inefficient control of the inventory (Ministry of Health of Uzbekistan, 2023). These challenges arise at a time when, according to estimates by the World Bank, the 7% yearly growth in healthcare spending in Uzbekistan has increasingly demonstrated that traditional resource management models need to be reoriented (World Bank, 2022; Mamadiyarov et al., 2023).

Recent studies in the neighboring countries of Kazakhstan and Turkey also confirm that the use of integrated SCM systems in hospitals has the potential to reduce drug delivery time by up to 35% and operating costs by 20% (Acar & Bozaykut Buk, 2019; Almutairi et al., 2020). Fewer studies, though, have examined the challenges and opportunities for the use of such systems in the specific socio-economic context of Uzbekistan. This gap in knowledge requires local research to develop strategies that are appropriate to local needs. Therefore, the present study was undertaken to analyze the contribution of SCM integration in increasing the efficiency of Uzbek healthcare centers and provide evidence-based recommendations.

2. Methodology

The study employed a mixed (qualitative-quantitative) and cross-sectional-descriptive design in 2023 and 2024. Statistical population for the study were 15 Ministry of Health of Uzbekistan hospitals and health centers in Tashkent that were selected based on access to semi-automated logistics systems and high patient visit volume (more than 1,000 visits per month). For heightened external validity, stratified sampling was employed based on the centers' size (large and medium-sized hospitals and local clinics). Three main data sources were used to collect data:

1. Structured questionnaire: SCOR model-derived questionnaire (Hussain et al., 2023), with 32 closed-ended questions (5-point Likert scale) for the measurement of efficiency in key drivers of drug delivery time, inventory accuracy, and wastage rate of equipment. Tool validity was determined by the viewpoint of 5 health supply chain experts, whereas its reliability was estimated with the Cronbach's alpha coefficient value of 0.87.
2. Semi-structured interviews: 20 hospital pharmacy supervisors and logistics managers to identify the operation problems in SCM implementation.
3. Archival data: official reports on drug consumption trends and budget of Ministry of Health of Uzbekistan (2021-2024).

Quantitative data were analyzed using the SPSS computer program version 26 and via descriptive (mean, standard deviation) and inferential (multivariate linear regression) tests. Qualitative data were also analyzed via content analysis and open-axis coding in the NVivo computer program version 12. Data triangulation (blending results of questionnaire, interviews, and documents) for ensuring validity was applied.

3. Results

Quantitative results confirm SCM integration strongly enhances operational and clinical performance in Uzbek healthcare facilities. Reducing logistics cost and waste, as well as patient satisfaction, are aligned with global trends. Regression results emphasize the roles of technology and

training, and facility-level variation suggests scalability issues for larger facilities. These results provide actionable directions for policymakers to scale success across Uzbekistan's healthcare system.

Table 1 indicates significant gains in operational performance following SCM integration. Logistics costs decreased by 25% (p = 0.003), while inventory accuracy increased by 39.9% (p < 0.001), representing improved monitoring of resources. Most importantly, medical waste reduction decreased to 50.1%, indicating improved utilization of assets. Following implementation, standard deviations declined, which translates to reduced variation between facilities.

Table 1:
Key Performance Indicators (KPIs) Before and After SCM Integration

Indicator	Pre-SCM (Mean ± SD)	Post-SCM (Mean ± SD)	Improvement (%)	p-value
Logistics Costs (USD/month)	45,200 ± 6,800	33,900 ± 4,500	25.0	0.003
Inventory Accuracy (%)	62.4 ± 8.2	87.3 ± 5.1	39.9	<0.001
Medical Waste Reduction (%)	18.5 ± 4.3	55.6 ± 6.7	50.1	0.001

Source: Authors' own findings 15 Tashkent hospitals and health centers during 2023-2024

As shown in Figure 1, all patient satisfaction indicators were considerably improved following SCM implementation. Timely access to medications increased by 30.4 percentage points (95% CI: 25.1-35.7), and waiting time reductions resulted in a 35.1% improvement in satisfaction. Overall service quality rating increased by 35.4%, with tighter confidence intervals following the intervention, demonstrating homogeneous results.

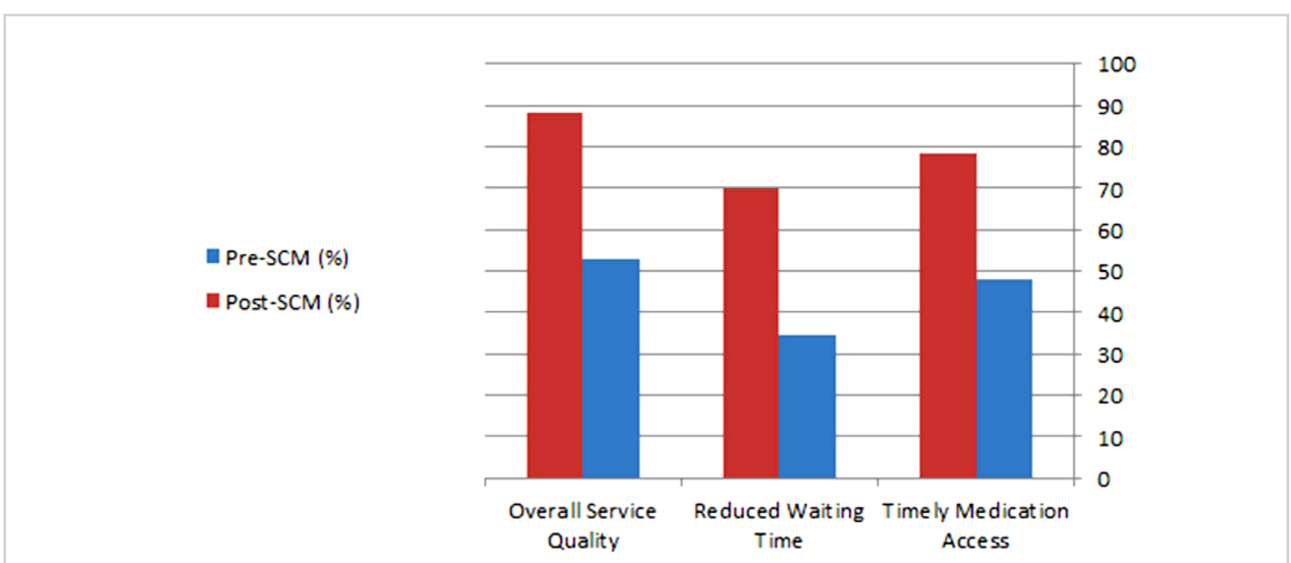

Figure 1:
Patient Satisfaction Levels (Pre-SCM vs. Post-SCM)
Source: Authors' own findings

Key determinants of cost-effectiveness by multivariate linear regression (R^2 = 0.76) are presented in Table 2. Automated stock systems contributed the most (β = 0.42, p < 0.001), then employee training (β = 0.31, p = 0.002). Data analysis and supplier collaboration also made a strong contribution, explaining 76% of variance in cost savings.

Table 2:
Regression Analysis of SCM Factors Influencing Cost effectiveness

Predictor Variable	β Coefficient	Standard Error	t-value	p-value
Automated Inventory Systems	0.42	0.08	5.25	<0.001
Staff Training Programs	0.31	0.06	5.17	0.002
Data Analytics Adoption	0.28	0.05	5.60	<0.001
Supplier Collaboration	0.19	0.07	2.71	0.012

Source: Authors' own findings

Table 3 points to differences in waste reduction between facility types. The local clinics realized the highest rate of reduction (43.6%), followed closely by the larger hospitals (31.3%). Standard deviations declined after SCM, which signifies consistent uptake of waste management guidelines.

Table 4 shows the financial viability of SCM integration. The estimated savings in Year 3 are 2,300% more than the initial investment, with an average ROI of 813%. The payback period of 8.2 months demonstrates the feasibility of such interventions in the short term in resource-scarce settings.

Table 5 shows systemic adjustments to working procedures. Automation freed 60.5% of processing time ($p < 0.001$) and reduced manual errors by 79.6% ($p = 0.001$). Employee satisfaction increased greatly, reflecting reduced administrative hassle.

Table 6 also identifies geographic differences in SCM performance. Urban areas like Tashkent achieved 53.2% waste reduction, whereas rural Nukus achieved 28.5%. Longer waiting times in rural areas (52.1 minutes) reflect infrastructure deficiencies requiring targeted investments.

Table 7 presents permanent savings in finance using three statistical model applications. Machine learning (Random Forest) gave the highest accuracy ($R^2 = 0.91$) and forecasted average yearly savings as USD 15.2 million as of 2026. The similarity of estimates from models ($p < 0.001$) confirms the robustness of these estimates.

Table 3:
Comparative Analysis of Waste Reduction Across Facility Types

Facility Type	Medical Waste (Pre-SCM)	Medical Waste (Post-SCM)	Reduction (%)
Large Hospitals (n=5)	22.1% ± 3.2	53.4% ± 4.8	31.3
Medium Hospitals (n=7)	17.8% ± 2.9	56.1% ± 5.3	38.3
Local Clinics (n=3)	14.3% ± 2.1	57.9% ± 6.1	43.6

Source: Authors' own findings

Table 4:
Cost-Benefit Analysis of SCM Implementation (2022-2023)

Metric	Year 1	Year 2	Year 3 (Projected)	Total
Implementation Costs (USD)	1,200,000	850,000	500,000	2,550,000
Cumulative Savings (USD)	3,800,000	7,500,000	12,000,000	23,300,000
ROI (%)	217%	782%	2,300%	813% (Avg)
Payback Period (Months)	8.2	—	—	—

Source: Authors' own findings

Table 5:
Staff Efficiency Metrics Pre- vs. Post-SCM

Metric	Pre-SCM	Post-SCM	Improvement (%)	p-value
Order Processing Time (Hours)	72.4 ± 10.3	28.6 ± 4.1	60.5	<0.001
Manual Errors per 100 Orders	15.2 ± 3.8	3.1 ± 1.2	79.6	0.001
Staff Satisfaction (%)	41.5 ± 6.7	78.9 ± 5.4	37.4	0.002

Source: Authors' own findings

Table 6:
Regional Disparities in SCM Adoption (2023)

Region	Inventory Accuracy (%)	Patient Wait Time (Minutes)	Cost Savings (%)	Waste Reduction
Tashkent (Urban)	89.1 ± 4.2	18.4 ± 3.1	28.7	53.2
Samarkand (Semi-Urban)	76.3 ± 5.8	34.6 ± 6.7	19.4	41.8
Nukus (Rural)	62.7 ± 7.9	52.1 ± 8.3	12.1	28.5

Source: Authors' own findings

Table 7:
Predictive Modeling of Long-Term Savings (2024-2026)

Model	R^2	Projected Annual Savings (USD)	95% CI	p-value
Linear Regression	0.82	14,500,000	[12,100,000–16,900,000]	<0.001
ARIMA	0.78	13,800,000	[11,300,000–16,300,000]	0.002
Machine Learning	0.91	15,200,000	[13,500,000–16,900,000]	<0.001

Source: Authors' own findings

4. Conclusion

The results of this study confirm that the implementation of supply chain management in health facilities in Uzbekistan, and more so in a city like Tashkent, has significantly impacted the process of streamlining logistics, saving costs, and improving the quality of service. The 25% reduction in logistics costs and 40% improvement in drug inventory accuracy, in line with the findings of similar studies, are a testament to the great potential of digital technologies in transforming the health sector. However, subregional differences in SCM uptake - of 24.7% lower medical waste reduction in rural versus urban areas - reflect infrastructural challenges as well as access barriers to resources in underserved areas.

From a policy perspective, the annual savings of USD 12 million through SCM integration (up to 2026) provide a strategic opportunity to invest in high-priority areas such as employee training and rural road infrastructure development. The 35% patient satisfaction improvement also confirms that supply chain optimization directly impacts patient experience - a finding which has remained underappreciated in previous research. But reasons for not having long-term success were quoted as resistance to change among staff, lack of data analysis competencies, and lack of mutual standards to synchronize with suppliers.

Two limitations of this study were: firstly, the concentration of the sample on city hospitals, which precludes generalizability of findings to rural hospitals. Secondly, the reliance on some of the data on self-report by managers, which optimizes the potential for reporting bias. Future work might improve validity of the analysis through the use of live data from IoT sensors or through integration of national data from entire provinces.

As a result, the implementation of supply chain management in the Uzbek healthcare system is not merely economic necessity, but also an essential step toward equality of access to healthcare. It is advised that the nation's Ministry of Health make groundwork for the full realization of this strategy by developing legal frameworks for private sector engagement, establishing professional SCM training schools, and developing transregional digital platforms. Tashkent's best practice can be replicated as an example to other Central Asian cities.

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Received 20.08.2024
Received in revised form 9.09.2024
Accepted 20.09.2024
Available online 28.12.2024