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Warehousing and inventory management performance after HCMIS implementation in Tikur Anbessa Specialized Hospital, Addis Ababa, Ethiopia

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Abstract
The health commodity management information system (HCMIS) has been implemented in Ethiopia to serve the country's public health commodity supply chain management since 2009. But Tikur Anbessa Specialized Hospital (TASH) implemented since 2017. However, there is no evidence thus far on changes in the performance of the warehouse and inventory management practices since the implementation of the HCMIS. Therefore the purpose of study was to assess warehousing and inventory management performance after HCMIS implementation. A quantitative method research design using facility based retrospective technique was applied to survey data for the years (2015/2016 and 2017/2018). The collected data was entered and analyzed using Microsoft excel and statistical package for social sciences (SPSS) version 20 computer software. The current study revealed a significant improvement in order fill rate, line fill rate, inventory turnover rate, stock wastage amount and rate, and order turnaround time with percentage improvements of 14.06%, 4.48%, 42.85%, 50%, 1.25%, and 26.1% respectively following HCMIS implementation. HCMIS has improved the warehousing and inventory management of TASH. However the system needs to be linked to the pharmacy units and fully controlled and managed by the hospital in order to reap the full benefit of the system.

Keywords: HCMIS, inventory management, performance, warehousing management, TASH

Introduction
Inventory management is the heart of the pharmaceutical supply system. It informs health facilities when to order or issue, how much to order or issue, and how to maintain an appropriate stock level of all products. All these activities are tracked with appropriate documentation, thus good record-keeping is critical. Generally a good inventory control system result in minimized inventory investment, appropriate customer service level, balanced supply and demand, minimized ordering cost and holding cost; also preservation of inventory control system [1] while poor inventory management leads to wastage of financial resources, overstock of pharmaceuticals, shortage of essential medicines, and a decrease in the quality of patient care [2].

It has been recognized as one of the most important functions that has huge impact on the overall performance [3]. In hospital the second largest expense after employment cost to health care provider is inventories, which usually estimated to consume one fifth of the income from patients [4]. Therefore inventory management constitutes the key lever to realize efficiency improvements (e.g. reduce costs, waste and the risk of product obsolescence) while satisfying healthcare service levels [5].

Warehouse management comprises the physical movement of a stock in to, through, or out of a warehouse. Regardless of storage facility size- from a small health center to a central warehouse the main operational activities for storage are very similar which include receiving, put away, storage, picking and packing, and shipping. Warehouse management should insure productivity, timeliness, use of resource, and safety. As a result, pharmaceutical cost decreased and service level improved.

The health commodity management information system (HCMIS) in Ethiopia is an open source, custom software solution; it was developed in Ethiopia for the country's health commodity supply chain by USAID | DELIVER PROJECT. First developed and deployed in 2009 to manage inventories in health facility pharmaceutical stores [6]. As of 2017, the HCMIS plat form has been implemented in more than 700 health facilities that account approximately 80% of PFSA's distribution [7].

The HCMIS Facility contains the essential data required to manage and account for all health commodities managed by facilities, including donated items and the commodities purchased with the Revolving Drug Fund (RDF). Its analytical tools provide users and managers with reports on cost, price only (value per batch to determine charge to the patient), as well as value of inventory, expiries, and near expiries [6]. HCMIS is helping health facilities to improve commodity management, data visibility, and overall performance. Users with various backgrounds; Ranging from those with limited computing experience to advanced users and experts can use HCMIS due to its user-friendly interface [6]. Camp *et al*. provide several strategies to improve the healthcare supply chain performance, such as the degree of standardization, inventory control, waste reduction, and data analysis, all of them required a supply chain innovation (SCI) [8]. Also it defined SCI 'It combines developments in information and related technologies with new logistic and marketing procedures to improve operational efficiency and enhance service effectiveness [9].' The adoption and use of innovative technological solutions for solving business problems have been arguably slow within the healthcare industry [10]. However, since the 90s, the health care sector has changed rapidly. Due to increased competition, a growing influence of patients and a stronger necessity to deliver health services in a more efficient and effective way, many health care organizations have started projects in the area of service quality, clinical pathways, information systems and patient logistics, and innovative supply chain strategies [11]. One of the biggest challenges in healthcare supply chain management is balancing costs with the right amount of inventory to sustain quality and timely patient care [12]. Moreover in a hospital, the consequence of a stock-out is far more severe (e.g. endanger patient's life) compared to other industries where a stock-out typically results in lost revenue [13]. Thus warehousing and inventory management impacts the bottom line to this, as it ensures cost containment, supply chain efficiencies and customer satisfaction [8].

Study conducted in India's biggest retail company, which has developed expertise in Supply Chain Management of consumer product categories such as Fashion, Food and General Merchandise, warehouses with manually run had a high cycle time process of 773 minute [14].

The study also pointed the receipt of order; picking and dispatching was tedious to carry out in a manually operated warehouse.

To the best of evidences at hand there is no study conducted on the performance of manual warehousing and inventory management using key performance indicators in TASH and as well as in Ethiopia. However considering the high amount of processed order lines and amount of stock keeping units, in this nationwide, specialized teaching hospital the burden of using manual method was paramount. To tackle these challenges and to increase efficiency and effectiveness TASH embarked on supply chain innovations. As, such challenges require a reliable, agile, scalable supply chain with the capacity to adapt timely and efficiently to different types of requirements [15]. Among supply chain innovations TASH adopted is the technological software called HCMIS in 2017, because information technology facilitated information sharing between parties [16]. It is also agreed that information exchange capabilities are a positive antecedent for successful supply chain innovation too [17]. New technologies and automation can help healthcare providers overcome the biggest inventory and distribution management barriers of product variability, inaccuracies, and complicated workflows [2]. Furthermore, there is a growing need for technologies that provide end-to-end supply chain visibility, resulting in lower inventory and cost, improved patient service, improved tracking, shorter delivery times, and lean and proactive supply chain partners [18].

Despite those encouraging progresses, it has been seen that frequent stock depletions and shortages of health commodities at the service delivery point, and clients complain about the service in TASH. The focus of this research project, therefore, was to understand systematically the impact of HCMIS as a transformative technology to address cost, safety, and quality problems in this ever-important health care industry. To narrow our scope, this research focuses on the use of HCMIS within a bounded set of activities and work processes in the healthcare industry. Namely, this study focused on warehousing and inventory management processes that support the delivery of a particular type of healthcare service. To achieve the intended objectives, this study intended to answer the following questions: Does automation of logistic information management system result in improved warehousing and inventory management performance?

Methods

A quantitative method research design that involves retrospective facility based survey was used to assess warehousing and inventory management performance in TASH. All health commodities found in TASH warehouse and all documents that were used to manage the pharmaceuticals supply chain are the source data for quantitative method. All RDF, and program medicines, found in the warehouse was the study population for quantitative method.

All RDF and program medicines flows in TASH for the years (2015/2016 and 2017/2018) were selected for study due to their full integration into the system.

In TASH, there are more than 14 pharmacy outlets other than the different hospital's units, and catchment setting supplied by the warehouse. But the study included 10 pharmacy outlets, since the rest four pharmacies opened soon after HCMIS implementation. A one year data from [Meskerem 1, 2008 – Sene, 30, 2008 E.C (September, 12, 2015 - July, 7, 2016 G.C) before HCMIS and, Nehase, 1, 2009 - Sene, 30, 2010 E.C (August, 7, 2017- July, 7, 2018 G.C) after HCMIS implementation] were included in the study. Data like; items and quantity ordered and/ received, cost and quantity of items expired or damaged, cost of the products, and number of days to process the orders before the implementation was abstracted from internal facility report and requisition (IFRR) form, Disposal Report, Bin Card, and goods receiving voucher (GRV) (Model 19) and goods issuing voucher (Model 22). However, HCMIS with cross checking to above listed documents were used to abstract a data after the implementation. In this standardized Ethiopian pharmaceutical supply chain management system monitoring and evaluation quantitative data collection tools were used to analyze the performance using order fill rate, line fill rate, wastage rate, stock wastage, inventory turnover rate, and order turnaround time indicators [19]. The uses of a data starting from Meskerem (September) instead of Hamle (July) before HCMIS, and Nehase (August) instead of Hamle (July) after HCMIS were due to the delay in the time that pharmaceuticals transaction started for the year which is

related to the long duration by the physical inventory.

The data was collected by eight trained pharmacist in TASH. To control bias of those pharmacists each of them were allocated to abstract a data at different time. Thus each data collected was checked on the time of the data collection for completeness of information. Moreover, data quality was checked up for completeness before data entry.

Data collection was carried out from December, 2018 – March, 2019. After the quantitative data was collected, it was entered and performance measurement metrics were analyzed using Microsoft (Ms) Excel. Statistical Package for Social Sciences (SPSS) version 20 computer software was used to test the association between HCMIS and each indicator using multivariate tests, to test Correlation between indicators using Pearson correlation coefficient, and to test for two dependent sample means using paired sample T-test. The quantitative data collection tool used, standardized Ethiopian pharmaceutical supply chain management system monitoring and evaluation data abstraction tool [19]. Training and briefing was done to data collectors by the principal investigator. Data completeness and consistency was checked by the investigator. The principal investigator discussed with the project advisor on regular basis and reviews the collected data for completeness. The collected data was summarized on the same day of the data collection. Data cleaning and editing was taken on regular basis electronically.

Ethical approval was obtained from the ethics review committee of School of Pharmacy, College of Health Science, Addis Ababa University with reference number ERB/SOP/45/12/2018 and support letter written from the Department of Pharmaceutics and Social Pharmacy to hospital management.

Results

Pharmaceutical warehousing and Inventory management performance measurement

The warehousing and inventory management performance were measured by selected indicators considering the cost, service coverage, and time. For the study all of the medications revolved were considered. Since pharmaceuticals in TASH are received through different channels and managed in the warehouse as RDF and program medicines, the findings of this study are presented accordingly considering the pharmacy units within the hospital.

Before the implementation of HCMIS the total cost of items distributed within a year was found to be 102,558,281.54 ETB (USD 4,784,974.92). From this, the items procured by hospital cost were 82,605,065.89 ETB (USD 3,854,034.63) RDF pharmaceuticals and 19,953,215.65 ETB (USD 930, 940.29) cost items were funded through program (program pharmaceuticals). Whereas after the implementation of HCMIS the total cost of items distributed within a year was 129, 357, 715.29 ETB (USD 5,205,814.21). From this, the items procured by hospital were cost to 107,701,854.94 ETB (USD 4,334,305.42) (RDF pharmaceuticals) and 21,655,860.35 ETB (USD 871,508.79) cost items were funded through program (program pharmaceuticals).

An increasing trend observed in order and line fill rate and inventory turnover rate for both program and RDF medicines, however a decreasing trend was seen in wastage amount and rate, and order turnaround time both for program and RDF medicines after the implementation of HCMIS than before the implementation of the software (Table 1).

Table 1: Combined RDF and program medicines performance measurement and percentage improvement before and after HCMIS in TASH warehouse, Addis Ababa, Ethiopia. 2019.

HCMIS	Performance indictors					
	Order fill rate (%)	Line fill rate (%)	Inventory Turnover rate	Wastage rate	Wastage amount (%)	Order turnaround time (days)
Before implementation	70.56	82.38	3.78	0.058	3.85%	3.45
After implementation	84.62	86.86	5.4	0.029	2.60%	2.55
% improvement	14.06 %	4.48%	42.85%	50%	1.25%	26.1%

It was observed that also except line fill rate to ART (Anti-retroviral therapy) pharmacy, an increased in line fill rate and order fill rate in all pharmacy outlets with varying degree of increment was found. The decrease to ART pharmacy was found due to program interruption and intermittent supply of medicines. Also finding showed improvement in the time required to process orders from different pharmacy outlets (Table 2).

Table 2: Combined RDF and program medicines change in performance after HCMIS implementation of 10 selected pharmacy outlets in TASH, Addis Ababa, Ethiopia. 2019

Pharmacy outlets	Change in the performance indicators (Δ before and after HCMIS implementation)		
	Line fill rate (%)	Order fill rate (%)	Order turnaround time (days)
A5 pharmacy	1.21	13.33	0.79
Adult Emergency pharmacy y	2.63	21	0.52
Adult Oncology pharmacy	1.86	5.95	0.88
ART pharmacy	-5.19	13.89	0.89
DM pharmacy	4.31	7.73	1.66
ICU pharmacy	5.8	14.77	1.36
OPD pharmacy	2.51	14.98	0.13
OR pharmacy	0.43	10	0.47
Orthopedics pharmacy	10.14	21.42	1.26
Pediatric Emergency pharmacy	5.08	17.5	1.11

The assumption of independence and scale of measurement met because the data was independently and randomly sampled and the dependent (outcome) variables was on a continuous scale.

After test for the basic assumptions of paired sample T-test including normality test through skewness, kurtosis, and histogram check and kolomogorov-smirnov and Shapiro wilk test, and homogeneity of variance by levene's test was conducted, it's found that a one-tailed paired sample T-test revealed that warehousing and inventory management performance has improvement after HCMIS implementation when compared to before the implementation of HCMIS in TASH (Table 3).

Table 3: Paired sample T-test result of RDF and Program medicines at TASH warehouse, Addis Ababa, Ethiopia. 2019

Indicators	Mean(m)	Standard deviation (S)	t	Df	p-value
Order fill rate after HCMIS	84.62	4.85			
Order fill rate before HCMIS	70.56	4.47	8.637	9	<.0005
Line fill rate after HCMIS	83.928	1.73	2.281	9	.024
Line fill rate before HCMIS	81.05	4.15			
Order turnaround time after HCMIS	2.547	.401	-6.247	9	<.0005
Order turnaround time before	3.45	.427			
HCMIS					
Inventory turnover rate after	.9012	.0402	10.089	5	<.0005
HCMIS					
Inventory turnover rate before	.633	.0344			
HCMIS					
Wastage rate after HCMIS	.0049	.00190	-2.613	5	.024
Wastage rate before HCMIS	.0098	.00545			
Wastage amount after HCMIS	.4398	.096	-5.385	5	.0015
Wastage amount before HCMIS	.6384	.048			

After basic assumption for Pearson's correlation analysis including normality test through skewness, kurtosis, and histogram check was conducted, it was found that a Pearson's r data analysis revealed a strong positive relationship (r= 0.87) between order fill rate (mean = 77.59, SD = 8.52) and inventory turnover rate (mean = 0.77, SD = 0.14). This expressed as the higher order fill rate to different pharmacy outlets reported the higher level of inventory turnover rate and low inventory holding days by the warehouse.

On the other hand a Pearson's r data analysis revealed a strong negative relationship (r= - 0.79) between order fill rate (mean = 77.59, SD = 8.52) and wastage amount (mean = 0.54, SD = 0.13). This means that the higher order fill rate to different pharmacy outlets reported the lower level of wastage amount.

It was also found that a moderate negative relationship between order turnaround time (mean = 3, SD = 0.62) and inventory turnover rate (mean = 0.76, SD = 0.14). With a Pearson' r= - 0.61. This described as the higher order turnaround time to different pharmacy outlets reported the lower level of inventory turnover rate and higher inventory holding days by the warehouse.

After test for the basic assumptions of multivariate statistical analysis, including linearity of the dependent variables by Pearson's r, multivariate normality by kurtosis, skewness, and histogram check, multivariate homogeneity of variance between groups by levene's test, and multivariate homogeneity of covariance between group by Box M test was conducted it was found that there was a significant difference between before HCMIS and after HCMIS implementation when considered jointly on the variables order fill rate, line fill rate, order turnaround time, inventory turnover rate, wastage rate, and wastage amount, wilk's ^ 0.027, F(6, 13) = 77.1, p = < 0.001, Partial Eta square 0.97.

However when considered separately with each variables at an alpha level of 0.025. There was significant difference between before and after HCMIS on order fill rate, F (1, 18) = 45.34, p = < 0.001, partial Eta square = 0.72, with after HCMIS (M = 84.62) scoring higher than before HCMIS (M = 70.56).

Whereas on order turnaround time F (1, 18) = 23.95, p = < 0.001, partial Eta square = 0.57, with before HCMIS (M = 3.45) scoring higher than after HCMIS (M = 2.54). Also the study revealed on inventory turnover rate F (1, 18) = 275.4, p = < 0.001, partial Eta square = 0.94, with after HCMIS (M = 0.9) scoring higher than before HCMIS (M = 0.64)

Additional investigation on wastage rate revealed F (1, 18) = 6.96, p = 0.017, partial Eta square = 0.28, with before HCMIS (M = 0.011) scoring higher than after HCMIS (M = 0.006), and on wastage amount F (1, 18) = 44.23, p = < 0.001, partial Eta square = 0.7, with before HCMIS (M = 0.65) scoring higher than after HCMIS (M = 0.43). However the study found out that there was not a significance difference between before and after HCMIS on line fill rate, F(1, 18) = 00, p = 0.99, partial Eta square = 0.00.

Discussion

In the present study, overall TASH warehousing and inventory management performance measurement indicators were determined both before and after the implementation of HCMIS. On top of that finding also describe majorly as a decreased wastage and order turnaround time, and increased pharmaceuticals turnover rate, order fill and line fill rate following HCMIS implementation. Additionally a strong positive relationship existed between order fill rate and inventory turnover rate, and a strong negative relationship existed between order fill rate and wastage amount in the warehouse.

Pharmaceutical warehousing and inventory management performance

The study found a significant decrement from a wastage value costing of 2,870,413.89 ETB (with wastage rate of 0.029) to a value costing 4,831,847.16 ETB (with wastage rate of 0.058) after HCMIS implementation which is utmost to TASH, because it is explained as; apart from hampering therapeutic benefits, the financial burden resulting from medicines wastage (expiry) is very huge [21]. It is still important to decrease further medicines expiry to optimize overall financial loss incurred and to compromise frequent stock out of pharmaceuticals in the TASH which in turn would have a positive implication for the achievement of Health System

Transformation Plan (HSTP) target of below 2% average rate of medicine wastage in Ethiopia [22].

after the From the study also a significant decrement from 96.38 holding days (with inventory turnover rate of 3.78) to 67.59 holding days (with inventory turnover rate of 5.4) was found implementation of HCMIS. This is supported in study conducted by Rossettti presented a large amount of inventory in a traditional healthcare supply chain, resulting in a relatively small number of deliveries and consequently low transportation and ordering cost but high inventory holding cost [23]. It also concluded by Junaid, Shiming and Muhammad that the annual inventory turnover of the firms forecast future inventory management performance [24].

Even though there is no previous study conducted on filling rate of pharmaceutical warehouse within the facilities and no standard set nationally for facility filling rate to the units, its fact that the facilities must utilize the medicine acquired, because according to Yurtkuran and Emel inside hospital pharmacy delivery systems have a key role in hospital service quality [25].

The study revealed that statistically significant decrement from 3.45 to 2.55 days after HCMIS implementation. This is in line with study conducted by Hui Nee Au Yong (2009) that warehouse management system (WMS) provided better workload control for view of completed and upcoming activities [26]. An average incoming cycle has been reduced from average 3.71 days to 1.02 days which was observed that the lead-time has been reduced by 73% in the period. Such improvement has impact on the quality service rendered by the hospital, Chiang *et al*. expressed the capability of the organization, internally, and in conjunction with its key suppliers and customers, to adapt or respond in a speedy manner to a changing demand contributing to agility of supply chain and service quality improvement [27].

It was found that the higher order fill rate to different pharmacy outlets reported the higher level of inventory turnover rate and low inventory holding days by the warehouse r= 0.87. This supported by study conducted in Belgium, efficient supply ability of firms correlated with increase turnover rate and decreased holding days and minimizes associated holding costs [2].

It was also found that the higher order fill rate to different pharmacy outlets reported the lower level of wastage amount r= - 0.79. And the lower order turnaround time to different pharmacy outlets reported the higher level of inventory turnover rate and lower inventory holding days by the warehouse r= - 0.61. These is in line with the study done by Moon *et al*. the performance of the distribution activities at high accessibility to the stored products, improvement of working conditions, reduction in preparation time and errors, etc. and the performance of the internal flow of pharmaceuticals products to care units by measuring the delivery performance, order fulfillment, lead time, supply chain response time, and inventory days of supply which optimized pharmaceutical supply chain will result in decreased stock wastage, stock-out rates, reduced picking time, reduced storage costs and traceability of pharmaceuticals [2].

Conclusion

The current study found that, HCMIS resulted up to 14.06% in order fill rate, 4.48% in line fill rate, 42.85 % in inventory turnover rate, 50% in wastage rate, 1.25% in wastage amount, and 26.1% in order turnaround time percentage improvement majorly through data visibility in TASH.

Generally HCMIS doesn't function up on their level and bring the required achievement due to lack of system wise link to different hospital units and commitment of professionals working with the software and managers. Moreover with all the limitations including interrupted supply resulted from inflexible procurement policy in TASH, HCMIS brought efficient utilization of the available pharmaceuticals.

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