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Information Systems Infrastructure Used For Health Commodities Management And Service Delivery: A Case Of Level 4 Public Hospitals In Western Kenya

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Abstract: ***Frequent service delivery interruptions at the public hospitals due to inadequate resources has led to spread of communicable diseases, disabilities and death among patients seeking medical attention. The objective of the study was to determine the relationship between information systems infrastructure available at the hospital warehouse and unit stores for capturing health commodities consumption data and service delivery at level 4 public hospitals in western Kenya. The study was anchored on two theories; Contingency theory and Theory of Constraints. The study adopted cross sectional research design with a target population of 99 level public hospitals and 426 respondents from service delivery units plus management. Quantitative data was collected using questionnaires and observation checklists while qualitative data was collected using interview schedules. Both reliability and validity of the study tools were tested to ensure internal consistency of the tools. Stratified sampling technique was used for selecting the hospitals where sample size was calculated using Yamane formula giving 79 hospitals. Purposive sampling techniques was used to give a sample size of 316 respondents. Data was analyzed using descriptive statistics and inferential analysis. Correlation test was used to test the association between the study variables. The results established significant positive relationships between information systems infrastructure and service delivery where the correlation coefficient indicated that 86.7% variation in service delivery was determined by information systems infrastructure at p=0.000. Also regression coefficient (β) was at 1.134 indicating that a unit change in information system infrastructure led to an increased improvement of service delivery by 1.134 units at the level 4 public hospitals. The study demonstrated that appropriate use of the available information system infrastructure to collect health commodities consumption data promotes health commodities availability and accessibility at the service delivery units thus efficient service delivery to patients. The study recommended need to train health commodities users on operations and appropriate use of the available information systems infrastructure to capture accurate consumption data at the hospitals and also interlinkage of available automated systems to various service delivery units for efficient operations.***

Keywords: Information systems Infrastructure, Health Commodities, service delivery

I. INTRODUCTION

Globally, healthcare expenditure is growing higher where health commodities are recorded as huge consumers of the expenditure in hospitals. In USA, though the health systems are still generally inefficient as stated by Frogner, Frech and Parante (2015), the healthcare expenditure accounts for 17.4% of its GDP. In Sub Saharan African countries including Kenya, the health commodities account for approximately 40% of the total hospitals expenditure, yet the population is still not accessing these commodities especially in public hospitals leading to patients' dissatisfaction (Kenyanya, 2015). Effective and functional health commodities management systems are required at the hospitals to promote efficient

service delivery (Koumanakos, 2008, Harland and Caldwell, 2007). The study assessed appropriate use and operations of the available information systems infrastructure used for capturing health commodities consumption data at the service delivery units of the level 4 public hospitals in western Kenya. As this promotes availability and accessibility of required health commodities.

A. INFORMATION SYSTEMS INFRASTRUCTURE

Information system is any organized combination of people, hardware, software, communications networks, data resources, policies and procedures that transforms data, stores, retrieves and disseminates information in an organization (O'Brien, and Marakas, 2007). Technically it is a set of interrelated components that collect, process, store and distribute or retrieve information to support decision making, coordination and control in an organization (Patterson, 2005). Business firms rely on information systems to run inter organizational supply chains, carry out and manage operations therefore every business organization needs an information system infrastructure to keep track of all business activities from planning to delivery (Nowduri and Al-Dossary, 2012). Available information systems infrastructure support organization to analyze data and create solutions to identified problems (Laudon, and Laudon, 2006 and Kontio, 2005). Healthcare industry have either manual or automated information systems for tracking health commodities consumption data at all the service delivery units. (Kulp, 2002 and Kumar, Gotz, Nutley and Smith, 2017)

B. HEALTH COMMODITIES MANAGEMENT SYSTEMS

Commodity management is a set of policies, procedures and controls that monitors and determines levels of inventories to be maintained in an organization (Chase, Jacob and Aquilano, 2007). In healthcare systems, health commodities management systems is a support function which is very vital in influencing both clinical and financial outcomes. The health commodities are classified in major groups as pharmaceuticals, non pharmaceuticals, diagnostics, nutritional, medical equipment and infection prevention and control products (USAID, 2011 and Kim, 2005). Clear strategies for health commodities management systems are therefore required to promote health commodities availability and accessibility to meet patients demand thus reduce service delivery interruptions (Carlson, 2002). The study was conducted at level 4 public hospitals in western Kenya. Hospitals approved as level 4 by the Ministry of Health are capable of responding to any emergency cases including maternal complications, offering outpatient, inpatient, diagnostic services and specialized care (KHSSP, 2014-2018 and Kenya Health System Assessment, 2012).

C. STATEMENT OF THE PROBLEM

Effective and functional health commodities management systems requires that processes and operations within hospital warehouse and unit stores must be monitored regularly and documented as management and control performance indicators (Ayad, 2008 and Aronovich and Kinzett, 2001). The prime objective of health commodities management systems is to avoid excessive or inadequacy but to ensure availability and accessibility of the commodities to reduce service delivery interruptions to patients. Despite huge expenditure in purchase of health commodities in public hospitals and availability of Health Commodities Management Systems Guidelines for users, several surveys conducted still record that public hospitals are faced with several challenges like inability to access adequate health commodities and weak health commodities management systems. This has led to delayed response to emergencies and other health conditions resulting to spread of communicable diseases during outbreaks, disabilities and death amongst the population seeking medical attention at level 4 public hospitals.

D. GENERAL OBJECTIVE

To establish the relationship between information systems infrastructure used for health commodities management and service delivery at level 4 public hospitals in western Kenya.

a. SPECIFIC OBJECTIVES

- ✓ To assess the availability and appropriate use of manual information systems infrastructure in capturing health commodities consumption data at the hospital warehouse and unit stores (casualty, laboratory and pharmacy)
- ✓ To assess the availability and appropriate use of automated information systems infrastructure in capturing health commodities consumption data at the hospital warehouse and unit stores (casualty, laboratory and pharmacy)
- ✓ To evaluate interlinkage of automated information systems to various service delivery units at level 4 public hospitals
- ✓ To determine knowledge and skills of the health commodities users on operations and appropriate use of the available information systems infrastructure at the service delivery units.

II. LITERATURE REVIEW

A. THEORETICAL REVIEW

a. CONTINGENCY THEORY

Contingency theory is an organization theory developed by Fred Fiedler in 1958 that rejects classical management theory of having only one best way of structuring and managing an organization but dependent on a number of factors and contingent variables (Holmes, 2013 and Donaldson, 2001). The organization will not undergo structural adjustments in the event of any mismatch between the contingent variables and the organization structure, but instead the contingencies will dictate the explicit structure, activities and management style of an organization (Hicks, McGovern and Earl, 2001).

Fiedler (1964), developed and evaluated a contingency model using the Least Preferred Coworker Scale (LPC). The findings established that knowledge management and technology are key contingents leading to better organization performance (Birkinshaw, Nobel and Ridderstrale, 2002). This implied that the managers should always assess the changes in the environment and determine the appropriate decisions that will promote efficient organization performance (Northouse, 2007 and Morgan, 2007). This study assessed available information systems infrastructure plus user knowledge and skills for operations and appropriate use at the hospital warehouse and selected unit stores at the level 4 public hospitals.

b. THEORY OF CONSTRAINTS

Theory of constraints which was developed by Dr. Goldratt, states that no matter how well every system performs, it must have at least one constraint that limits its performance (Goldratt, 2004). It is based on the principle that a chain is only as strong as the weakest link or constraint thus there is need to focus on effectively fixing the identified constraint in order to improve the performance of the organization (Kazim, 2008). The strong links in hospitals are health workforce with wealth of technical expertise guided by laid down policies guidelines and procedures on patients management for better health outcomes. However there are still weakest links causing high rates of deaths, disabilities and spread of communicable diseases among patients seeking medical attention in public hospitals as reported by different surveys. This study was conducted to identify any constrain(s) limiting efficient service delivery to patients at the hospital warehouses and unit stores of casualty, laboratory and pharmacy in managing health commodities in relation to information systems infrastructure.

B. CONCEPTUAL REVIEW

a. INFORMATION SYSTEMS INFRASTRUCTURE

The prime objective of health commodities management systems is to avoid excessive or inadequacy but to ensure availability and accessibility of the commodities to reduce service delivery interruptions to patients ((Sangeeta and Nadeem, 2014 and Raffaele, Alfredo, Salvatore, Stefano and Debora, 2013). Good understanding of the processes and activities involved in health commodities management systems is required to promote efficient service delivery in hospitals. Health commodities revolves around the flow of information, time, physical goods, management of damaged goods, safety procedures and customer returns (Gupta and Kant, 2000). In level 4 public hospitals, accurate health commodities consumption data are generated at specified time using the available information systems infrastructure which can either be manual or automated (USAID, 2011).

Manual information system is whereby no mechanical or electronic devices are used to perform any task instead, humans are required to perform all the tasks. According to Kulp, (2002), manual system, in accounts is a book keeping system where records are maintained by hand without using a computer system. Manual systems are most commonly found in small enterprises that have few transaction however the systems suffer from a high error rate and are much slower than computerized systems. This is different from healthcare industry where manual information systems is found at both high and low care levels as means used for gathering health commodities consumption data using designated paper-based MOH registers or forms like MOH 642 and MOH 643, Laboratory Top Up forms amongst others (USAID, 2014).

Automated information system in health commodities management involves collection of data electronically using various technologies in order to increase efficiency, reduces cost of operations, errors and turnaround time, improves planning, control operations and decision making processes (Kumar et.al., 2017and Lambert, 2001). In level 4 public hospitals where the study was conducted, decision making broadly includes managerial aspects such as planning, organizing and control of health systems to promote efficient service delivery to patients. Organizations have used automated information systems efficiently to link the stakeholders by providing accurate and timely information for decision making (Akram, 2011). Since health sector supply chain is concerned with the flow of information between the stakeholders, available automated information systems should be interlinked to various service delivery units to enhance reporting and promote efficient service delivery (Anand, Baridalyne, Kapil, Satyavir, and Vivex, 2010).

Accurate and timely information is critical resource to supply chain management activities that should not be distorted between functional areas. Inefficiencies caused by distorted information include misguided capacity plans, excessive inventory investment, lost revenues, ineffective transportation and poor customer service amongst others (Gerald, Karl and David, 2017). Therefore, there is need to train healthcare providers handling health commodities at various service delivery units on operations and appropriate use of tools on the available information systems infrastructure at the hospitals.

b. SERVICE DELIVERY AT LEVEL 4 PUBLIC HOSPITALS

The primary goal of any hospital is to offer quality services to patients seeking medical attention. Patients with different illness visit hospitals to receive medical attention to revert the conditions which may cause disabilities, spread of communicable diseases or death in case of delayed response (Ali, 2013 and WHO, 2000). Service delivery is an output of health workforce, health commodities and health finance. These inputs should be well coordinated, accessible and timely to meet the patients demand (Barouch, 2011 and American Health Association, 2000). Efficient service delivery according to WHO (2010), is one of the six health system strengthening pillars promoting quality health outcomes, therefore, for any hospital to record it, skilled personnel, appropriate infrastructure, adequate health commodities, effective communication strategy and standard operating procedures to guide the processes are very vital (Owino and Kinoti, 2015, Hodge and Brown, 2011 and Shaw, 2003). The indicators measured by the study under service delivery were

accessibility, reliability, responsiveness, quality assurance and safety at level 4 public hospitals.

c. GOVERNMENT POLICIES AND GUIDELINES

Healthcare system worldwide has various policies and guidelines defining and describing different health inputs, outputs and outcomes for each care level. For instance, types of services to be offered, number of health workforce required, types and quantities of health commodities required at each care level. In Kenya, the Ministry of Health developed health commodities management systems policy guidelines highlighting various procedures and processes leading to effective and functional health commodities management systems. The guidelines highlights the types of information system infrastructure for capturing accurate health commodities consumption data, procedures for appropriate operations and use. The document also highlights ways of analyzing data and transmission for decision making. The study assessed the availability and full implementation of the guidelines at level 4 public hospitals as a way of promoting effective and functional health commodities management systems leading to efficient service delivery.

C. EMPIRICAL REVIEW

The baseline of the available information systems infrastructure is appropriate use by the healthcare providers to capture accurate health commodities consumption data. Several studies that had been conducted on information systems were mainly comparing the efficiency of manual versus automated with the majority preferring automated over manual. However depending on the organization set up, with proper trainings and adherence to guidelines and standard operating procedures, manual information system also delivers quality results.

Mitta, Hsann and Yang (2017) conducted a study on technology in healthcare at a general hospital in Singapore. The main objective was to simulate and compare a manual hospital supply chain management model versus a process that is technologically integrated using RFID technology. The results established that adoption of RFID for medical supplies improved efficiency by tracking usage and ensuring availability, significant cost savings and decreased manpower dependency as compared with manual processes. Dongsoo (2005) analyzed different supply chain management applications like Vendor-Managed Inventory adopted by healthcare sector in Korea to improve health commodities handling efficiency. The findings indicated that real time information sharing functionalities led to timely consumption data and exact commodities status at the hospitals resulting to accurate demand forecasting, reduce lead time and significant decrease in pharmaceutical products cost.

Costa, Sameiro and Nobre (2005) conducted a study in Hospital de Brags in Portugal to assess whether the logistics supply process was supported by information technology to allow proactive replenishment of health commodities based on hospital services consumption records. The results established that adoption of adequate information technology was critical for the success of health commodities management at the hospital. A study was conducted by Adzimah, Aikins, Duah and Gyawu, (2014) in Ghana at selected hospitals in Ashanti to assess the health commodities management practices and how the findings will help in improving health service delivery. The results established that effective health commodities management systems make efficient, reliable and enhanced health service delivery in hospitals. Improved information technology was one of the key factors leading to effective health commodities management. Okello (2017) analyzed different supply chain management practices in private healthcare institutions in Nairobi, Kenya to establish how information technology affects the operational performance of the private hospitals. The findings indicated that the information technology had positive impact on performance of private hospitals in Nairobi. The research suggested replication of similar study in public hospitals in Kenya to find out the impact of information technology on the hospital performance.

III. METHODOLOGY

The study adopted cross sectional research design and positivism philosophy to handle and address data from different sources. The target population was 99 level 4 public hospitals in western Kenya and 426 respondents comprising of nursing officers, medical laboratory technologists, pharmaceutical officers, store personnel and county health management teams consisting of health accountants, health administrators and supply chain management officers. Stratified sampling technique was used to sample the hospitals where each county formed a stratum from which samples were selected randomly using simple random technique. Yamane formula (1967) was used to calculate the sample size of 79 hospitals. Purposive sampling technique was used for the respondents both at the hospitals and county health management levels. Data was collected using questionnaires, observation checklists and interview schedules and analyzed by descriptive statistics and inferential analysis. Both bivariate and multivariate linear regression model were used and study hypotheses were tested and would be rejected if $p > 0.05$.

IV. STUDY FINDINGS

Descriptive statistics and inferential analysis were conducted and results summarized as shown in the tables below

	Interviews	**Questionnaires**	**Observation Checklists**
Target	30	316	79
Completed	28	301	77
Proportion	93.3%	95.3%	97.5%

Source: Survey Data, (2021)

Table 4.1: Survey Response Rate from Interviews, Questionnaires and Checklists

Table 4.1 indicates that the overall response rate of the study was at 95.4% where the interview schedules data contributed to 93.3% while the questionnaires and observation checklists contributed to 95.3% and 97.5% respectively. Seven

healthcare providers at the hospitals and two county health managers declined to participate in the study. Observation checklist was not administered to two level 4 public hospitals by the researcher and research assistants.

Observation Checklist	Yes		No	
	Freq.	%	Freq.	%
Inforamtion systems infrastructure avaialable at different units of the level 4 public hospitals assessed is manual	73	94.8	4	5.2
Inforamtion systems infrastructure avaialable at different units of the level 4 public hospitals assessed is automated	4	5.2	73	94.8
Availability of manual data tools for capturing health commmodities consumption data at the units	64	83.1	13	16.9
Appropriate use of the available consumption data tools at the assessed units of level 4 public hospitals	53	68.8	24	31.2
Automated information systems interlinked to diffeent service delivery units within the hospitals	1	25	3	75
Availability of staff training records on operations and appropriate use of the available information systems infrastructure	18	23.4	59	76.6

Source: Survey Data, (2021)

Table 4.2: Frequency of Information Systems Infrastructure

Results from observation established that 94.8% of the level 4 public hospitals were using manual information systems to capture health commodities consumption data. Only 5.2% of the hospitals especially at the pharmacy units had installed and were using automated systems to capture health commodities data. However only one of the 5.2% hospitals had its automated systems interlinked to different service delivery units within the hospital. Manual data collection tools were adequately available in 83.1% of the hospitals but it was observed that 31.2% of the hospitals were still not using the data tools appropriately. Low proportion of the hospitals 23.4% had training records indicating that commodities users had been trained on operations and appropriate use of the available information systems infrastructure as shown in table 4.2 above.

Similar findings were recorded among the key informants who stated that both manual and automated information infrastructure were available at level 4 public hospitals within the county however over 90% of the hospitals were using manual system

"Majority of the hospitals submit health commodities reports through manual information system. Even the health administrators table the requisition in hard copies to executive members. However, all level 4 hospitals and above should have automated information systems for collecting and submitting health commodities consumption data, this will enable all stakeholders to view and analyze the data in advance thus create efficiency."

Items	N	Descriptive Statistics				
		Frequency		Min.	Max.	Mean (M)	Standard Deviation (SD)
		Agree	Disagree				
The hospital has an information systems infrastructure used for capturing health commodities consumption data	301	300 (100)	01 (0)	2.00	5.00	4.661	0.495
The type of information systems infrastructure available at the hospital warehouse (central store) is manual	301	301 (100)	00 (00)	4.00	5.00	4.787	0.410
The type of information systems infrastructure available at the service delivery unit stores (casualty, laboratory and pharmacy) is manual.	301	256 (84)	45 (16)	1.00	5.00	4.229	1.094
There are adequate manual health commodities consumption data tools used at the service delivery units as defined in the health commodities management systems guidelines	301	270 (90)	31 (10)	2.00	5.00	4.532	0.750
The type of information infrastructure used at the hospital warehouse is either partially of fully automated	301	194 (64)	107 (36)	1.00	5.00	3.701	1.404
The type of information infrastructure used at the service delivery unit stores (casualty, laboratory and pharmacy) is either partially or fully automated	301	196 (65)	105 (35)	1.00	5.00	3.804	1.151
The available automated information system is not interlinked between the user units like hospital warehouse, unit stores and administration offices	301	193 (64)	108 (36)	1.00	5.00	3.498	1.578
Commodities users at the hospital warehouse and unit stores have not been trained on operations of the available information systems infrastructure (manual/automated)	301	260 (86)	39 (14)	2.00	5.00	4.233	0.730

Source: Research Data, June 2021

Table 4.3: Descriptive statistics on Information System and Service Delivery

Table 4.3 illustrates that in a pool of 301 respondents, 100% agreed that hospital had information systems infrastructure used for capturing health commodities consumption data at (M=4.661 and an SD =.495). 100% of the respondents also agreed that the type of information systems infrastructure at the hospital warehouses were manual at (M=4.787 and SD=.410) while at the service delivery unit stores, 84% respondents agreed that the type of information systems infrastructure available is manual at (M=4.229 and SD=1.094). 90% of the respondents agreed that tools for collecting consumption data were adequate at (M=4.532 and SD=.750). Availability of partially or fully automated information systems at the hospital warehouse and unit stores were at (M=3.701; SD=1.404 and M=3.804; SD=1.151) respectively. It was observed that only 14% of the respondents disagreed that health commodities users had not been trained on operations and appropriate use of the available information systems infrastructure at (M=4.233 and SD=.730) at level 4 public hospitals in western Kenya.

Model Summary

R	R Squared	Adjusted R Squared	Standard Error of the Estimate	Change Statistics: R Squared Change	F Change	df1	df2	Sig. F Change
0..932[a]	0.868	0.867	0.359	0.868	1964.361	1	299	0.000

ANOVA

	Sum of Squares	Df	Mean Squared	F	Sig.
Regression	253.757	1	253.757	1964.361	0.000[b]
Residual	38.625	299	0.129		
Total	292.382	300			

a. Dependent Variable: Service Delivery
b. Predictors: (Constant): Information System

Regression Coefficients

Model	Unstandardized Coefficients: B	Unstandardized Coefficients: Standard Error	Standardized Coefficients: Beta	T	Sig.
(Constant)	0.726	0.109		6.663	0.000
1 Information System	1.134	0.026	0.932	44.321	0.000

Source: Research Data, June 2021

Table 4.4: Regression Analysis of Information Systems Infrastructure and Service Delivery

From the simple linear regression shown in table 4.4 above, a unit of information systems infrastructure score would increase service delivery improvement by 1.134 units. This results was statistically significant at 5% significance level (F=1964.361 and p=0.000). The coefficient determination (R^2=0.867) which implied that 86.7% of variation in service delivery was determined by information systems infrastructure at the level 4 public hospitals in western Kenya. The results showed that there was a statistically significant correlation coefficient of 0.932 at p=0.000. This therefore indicated that the model was reliable in predicting the relationship between information systems infrastructure used for health commodities management and service delivery.

Model Summary

Model	R	R Squared	Adjusted R Squared	Standard Error of the Estimate	Change Statistics: R Squared Change	F Change	df1	df2	Sig. F Change
1	0.946[a]	0.895	0.893	0.323	0.895	628.412	4	296	0.000
2	0.948[a]	0.899	0.897	0.317	0.004	522.322	1	295	0.001

ANOVA[a]

Model		Sum of Squares	Df	Mean Squared	F	Sig.
1	Regression	261.579	3	65.395	628.412	0.000[b]
	Residual	30.803	272	0.104		
	Total	292.382	275			
2	Regression	262.707	5	52.541	522.322	0.000[c]
	Residual	29.675	295	0.101		
	Total	292.382	300			

Regression Coefficients

Models		Unstandardized Coefficients: B	Unstandardized Coefficients: Standard Error	Standardized Coefficients: Beta	t	Sig.
1	(Constant)	1.243	0.177		7.035	0.000
	Information System	0.398	0.089	0.327	4.493	0.000
2	(Constant)	1.336	0.176		7.594	0.000
	Information System	0.334	0.089	0.274	3.742	0.000
	Interaction Term (POL * HCM)	0.235	0.070	0.142	3.349	0.001

a) Dependent Variable: Service Delivery;
b) Predictors: (Constant), Information Systems Infrastructure, Interaction (Gov. Policies *Health Commodity Management); and
c) Significance level, p<0.05

Source: Research Data, June 2021

Table 4.5: Multiple regression analysis of independent, dependent and moderating variables

The findings in table 4.5 shows that the correlation coefficient R^2 value of 0.895 was obtained indicating relationship between independent information system infrastructure used for health commodities management and dependent variable; service delivery. Considering moderating effects of the Government policies and guidelines on information systems infrastructure, the correlation coefficient R^2 value changed from 0.895 to 0.899. This indicated a net positive improvement which was significant. Generation of moderating effects of Government policies and guidelines gave an interaction term of regression coefficient (β) of 0.235 however the independent variables information system infrastructure recorded a reduction in the regression coefficient (β) from 0.398 to 0.334 and p=0.001 but was still significant. From the multiple linear regression results above, there was sufficient evidence that information systems infrastructure used for health commodities management had a significant relationship on service delivery at the hospital warehouses and unit stores of casualty, laboratory plus pharmacy at level 4 public hospitals.

The findings converged with other findings of a study conducted in Portugal at a high care level hospital by Costa et.al., (2005) which established that information technology adoption was critical for the success of health commodities management at the hospital. The findings were also similar to the findings by Okello (2017), which established that information technology had positive impact on performance in private healthcare institutions in Nairobi, Kenya.

V. CONCLUSION

The study focused on establishing the relationship between information systems infrastructure used for health commodities management and service delivery at level 4 public hospitals in western Kenya. The results indicated significant relationship leading to a conclusion that appropriate use or operations of available type of information system infrastructure will capture accurate consumption data generated at service delivery units. This will sort out inaccurate health commodities consumption data leading to service interruptions either through inadequate or excess quantities causing stock out or expiries at the assessed units thus efficient service delivery to patients at level 4 public hospitals.

VI. RECOMMENDATION

For efficient service delivery at level 4 public hospitals, identified gaps like low proportion of health commodities users trained on appropriate use or operations of available systems, low automation at the service delivery units to capture accurate health commodities consumption data, low proportion of interlinkage between the units with automated systems should be addressed.

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