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Technical Factors Influencing Integration of Health Management Information Systems in the Health System in Kenya

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Abstract- The Ministry of Health in Kenya rolled out on HMIS policy in the year 2010. The policy directed that healthcare organizations in Kenya should shift from paper-based health information system to electronic integrated health information systems. However research indicates that HMIS in Kenya are to a large extent still paper based 8 years later. This paper addresses the impact of technical factor on the integration of HMIS. Moreover it also tests whether human infrastructure, IT infrastructure and systems interoperability have an impact on integration of HMIS. Data from a sample of 243 HMIS users were collected and analyzed. Results indicate that technical factor is positively related to integration of HMIS. Whereas a significant relationship was found between human infrastructure, IT infrastructure and systems interoperability. The critical link to integration of HMIS was found to be in systems interoperability, meaning that the more the Health Management Information Systems become interoperable the more likely integration of HMIS is likely to be attained.

Index Terms- Integrated health management information system (IHMIS); Health System Strengthening; Human Infrastructure; Systems interoperability; Information Technology infrastructure

ABBREVIATIONS- Integrated Health Management Information System **(IHMIS);** Community Unit **(CU);** Community Health Workers **(CHWs),** Community Health Volunteers **(CHVs);** Government of Kenya **(GoK),** Health Management Information System **(HMIS),** Ministry of Health **(MoH),** Healthcare Organization **(HCO),** Statistical Package for Social Sciences **(SPSS),** World Health Organization **(WHO),** District Health Information System 2 **(DHIS2);** Low and Middle income Countries **(LMIC); (IT)** information technology

I. Introduction

Embracing modern technology is reasonably key today, when aiming at improving efficiency and reducing operational costs within a health system. While the integration of information systems and health services, potential benefits cannot be disputed, there are many challenges which affect its adoption. In fact, majority of organizations have abandoned their newly acquired information systems only to go back to their old manual system. This study examined the extent the three identified technical factors influence Integration of HMIS. They include **i)** IT infrastructure which can be divided into two related but distinct components as technical and human infrastructure. Technical infrastructure is a set of shared, tangible IT resources forming a foundation for business applications (hardware, software and data), **ii)** Human infrastructure includes human and organizational skills, expertise, knowledge, commitments, values and norms. Availability and adequacy of both technical and human infrastructure must be ascertained up-front. It addresses the basic question of whether the information system will work in a technical sense (Odhiambo-Otieno, 2005b). **iii)** System interoperability is the ability of different information systems to communicate, exchange data and use the information that has been exchanged.

Human infrastructure determines human users, such as network administrators (NA), developers, designers. Generic end users with access to any IT appliance or service are also part of human infrastructure, specifically with the advent of user-centric IT service development. Their information needs should be determined upfront. In a study done in Malawi a good information system needs to establish a comprehensive system capable of feeding information to the users at community, health facility, district and national levels (Chaulagai et al., 2005a). All health workers should be oriented on information management and use through trainings. Data requirements should be chosen taking into account the technical skills of the health workers collecting the data, or the available diagnostic equipment in peripheral health facilities. During the designing and implementing of health information, health workers should be involved in the process (Chaulagai et al., 2005a; Odhiambo-Otieno, 2005b). There is a general lack of right capacity in developing countries especially for statistical analysis. Lack of computer literacy and brain drain is also a problem because most of the healthworkers have never used a computer. (Wave, 2009). Therefore, developing IHMISs continues to be a challenge as reported by (Aladdin *et al.*, 2014). Implementations of health information systems has frequently cause unintended

consequences including communication issues, creation of new or more work, and even adverse events such as medical errors. Unintended consequences occur for several reasons including poor fit with clinical workflow, differences in needs between different user groups (that is clinicians and administrators) or the co-existence of paper based and automated processes. The gap between HISs can be taken care of by integration. Constructing effective integrated systems necessitates an understanding of operative work flow and technical considerations as well as achieving interoperability with existing information system (Wanderer & Ehrenfeld, 2013)

The solution is to ensure that the health sector partners involved in the collaboration will be able to work altogether in order to constitute a coherent and homogeneous set of HMIS. The growing chain of healthcare providers results in the need to share and exchange such data according to (Otjacques, Hitzelberger and Feltz, 2007). The collection and sharing of data, however, is affected by privacy concerns, organizational and technical issues have to be solved and taken into account.

2.3.1 Information Technology Infrastructure

IT infrastructure refers to the composite hardware, software, network resources and services required for the existence, operation and management of an organization IT environment. It allows an organization to deliver IT solutions and services to its employees, partners and/or customers and is usually internal to an organization and deployed within owned facilities. IT infrastructure consists of the following components: i) Hardware: Servers, computers, data centers, switches, hubs and routers, etc. ii) Software: Enterprise resource planning (ERP), customer relationship management (CRM), productivity applications and more iii) Network: Network enablement, internet connectivity, firewall and security.

Most LMIC use paper-based data collection processes at primary healthcare level and paper and computer-based health information systems at country level (Haux *et al*., 2007). However, paper-based information systems are often found to generate data with poor quality and are underutilized within the health information management (Lium, Tjora, & Faxvaag, 2008). This affects the integration of data, hence the design of a system matters a lot.

The technical factors are critical to organizations in their adoption decision of internet-based, inter-organizational information systems (IBIS) include establishing costs, network reliability, data security, scalability and complexity (Bouchbout & Alimazighi, 2008; Soliman and Janz, 2004).

The data flowing through the system are extremely valuable, hence data quality, security among other factors are important technical factors for successful implementation (Fenz, Heurix, Neubauer, & Pechstein, 2014). Hardware and software reliability is another factor to be considered for the success of the system, reliability consists of the accuracy of the data, adequate maintenance of the system and the capability of the hardware (Chaulagai et al., 2005b; Lippeveld, Sauerborn, Bodart, & World Health Organization, 2000). The study by Craighead, Patterson, Roth, & Segars, 2006, related reliability of the Electronic Data Interchange (EDI) system with the frequency of downtime that may lead to a lack of faith in the system. Therefore for success, the system should be free from unplanned down-time.

2.3.2 Information Systems Interoperability

Complexity of the software has been studied extensively by various researchers and they have concluded that there exists a negative relationship between complexity of the software and successful implementation of these systems. According to Petter, DeLone and McLean, 2008, the information systems for Health System should be accessible, compatible, user-friendly, stable and reliable, requiring minimal training and offering strong after-sales service. The system quality features included in the studies were ease of use, ease of learning, system accuracy, flexibility, sophistication, integration capability and customization. They further included information quality features, such as, usability, understandability, relevance and conciseness.

Eze, Awa, Okoye, Emecheta and Anazodo (2013), stressed that data processing, technical, and electronic standards are essential if an equipment is to be able to interconnect, and that data definitions (standards) and terminologies will be essential if health professionals across different organizations are to communicate. It involves systems configuration, interface development, data standardization and conversion, testing and performance management.

Systems interoperability is also a crucial organizational capability that enables firms to manage information systems (IS) from heterogeneous trading partners in a value net-work (Zhao & Xia, 2014). Inter-organizational systems (IOS) standards are a key information technology infrastructure facilitating formation of interoperability. As an organizational ability to work with external trading partners, interoperability's development depends not only on capability building within firm boundaries but also on community readiness across firm boundaries. (Zhao and Xia, 2014) emphasizes in their finding that interoperability acts as a mediator by enabling firms to achieve performance gains from IOS standards adoption. Consequently, it is crucial for firms to become interoperable in order to coordinate and co-create value with their partners. Interoperability is possible only when a common language is used by various IS, despite heterogeneity in software, hardware, and system architecture. IOS standards contribute to interoperability by providing "shared business terms, functions, processes, and protocols. (Zhao and Xia, 2014) argue that IOS standards adoption enables firms to develop interoperability. Specifically, interoperability is developed via two different paths. The first path is internal capability building. The organizational capability literature suggests viewing capabilities as a hierarchy, noting that simpler capabilities are needed to build more complex ones. Thus, identify standardized data infrastructure (SDI) as a simpler ability built from IOS standards adoption, which can be used as a basis for developing interoperability. The second path considers community readiness across firm boundaries. If the same standards have been accepted by more trading partners, achieving interoperability in dynamic value networks becomes easier. The proposed IHMIS would be in charge of managing (i) information, (ii) functions and (iii) processes among the information systems (IS) of partner organizations involved in the network (Benaben, Boissel-Dallier, Pingaud, & Lorre, 2013). Healthcare Organizations are strongly dependent from their ability to successfully manage collaborations and to assume the involved interoperability functions: exchange of information, coordination of business functions and driving of processes. Therefore (Benaben et al.,

2013; Lu, Panetto, Ni and Gu, 2012) recommend considering that crucial position of IHMIS and computed systems, the interoperability functions must be supported by these System.

II. MATERIALS AND METHODS

A mixed method research design was adopted to determine the factors that influence Integration of HMIS in Mombasa (urban), Kiambu (peri-urban) and Kitui (rural) Counties. A list of all registered community units and health facilities within Kitui, Kiambu and Mombasa Counties was obtained from MoH website as at 15th August 2016. The study targeted health organization in-charges and persons responsible for health information management at Tier 2 and 3, and community unit chairs and a CHV at tier 1. Tier 2 refers to the primary care services which comprise dispensaries, health centres and maternity homes and Tier 3 refers to the County referral services, which comprise the former sub-district and district hospitals (MOH, 2012). The total target population was (144*2) 288 respondents. The sample frame of the study included a representative sample of the health facilities in the different counties. At least 30% of the total population is representative (Borg & Gall, 2003). Thus, 30% of the accessible population was enough for the sample size. Purposive sampling was used to choose the most appropriate respondents constituting a sample size of 104 Government of Kenya (GoK) owned health care organizations selected from a population of 144 GoK HO in Mombasa, Kiambu and Kitui Counties. In facilities where health information and records officers were not available, the in-charge guided the researcher in identifying the most appropriate respondent.

Two instruments (a semi-structured questionnaire and a Key informant interview guide) was designed to measure constructs and factors affecting the integration of HMIS, based on information from past studies and the literature. The questionnaire contained 143 items developed by the researcher, the KII had 10 questions. The face and content validity of the instrument were established by experts from various universities across Kenya chosen based on their knowledge in health informatics and management, public health and business information technology as recommended by McDermott and Sarvela (1999). They reviewed the instruments for ease of use, understandability, relevance, wording, grammar, spelling, readability, and flow. Based on their recommendations, changes were made with wording and items were added or deleted. After revisions were made on the instrument, approval was obtained from the university's institutional review board, the data tools were pretested (n= 31) to check internal consistency. Reliability was established using Cronbach's alpha, attaining a standardized alpha of 0.703.

For the main study, 243 consenting participants were visited in their different working stations and requested to complete the questionnaire. 6 key informants participated in the interviews. Data was analyzed using SPSS and content analysis.

III. RESULTS

A total of 243 respondents representing 104 health organizations across the three tiers of the health system in three counties participated in the study. Table 1.2 below tabulates the total respondents per tier per county and Table 1.3 describes the demographic characteristics of the respondents.

Table 1: 1: Tier/Level of operation * County of operation Cross tabulation

		County of operation			Total
		Kiambu	Mombasa	Kitui	
Tier/Level of operation	Tier 1	20	12	23	55
	Tier 2	43	29	37	109
	Tier 3	13	27	39	79
Total		76	68	99	243

Table 1: 2: Demographic characteristics of the respondents

Characteristics		N=243 n	%
		Frequency (n)	Percent (%)
Age	18-24	6	2.5
	25-35	97	39.9
	36-45	85	35
	46-55	33	13.6
	Above 55 years	22	9.1
	Total	243	100
Highest certificate of education attained			
	Primary School Certificate	30	12.3
	Secondary School Certificate	32	13.2
	Diploma Certificate	144	59.3
	University Degree Certificate	37	15.2
Professional training			
	Nurse	91	37.4
	Hospital Administration	19	7.8
	CHV	54	22.2
	Clinical officer	29	11.9
	HRIO	27	11.1
	Lab Technologist	10	4.1
	Medical officer	4	1.6
	Nutritionist	4	1.6
	Pharmaceutical technologist	5	2.1
Working Experience			
	1-10 years	162	66.7
	11-20years	49	20.2

21-30 years	21	8.6
31-40 years	9	3.7
Over 40 years	2	0.8

The study aimed to identify technical factors influencing integration of HMIS. Three indicators were addressed; Human Infrastructure, Information Technology infrastructure and systems interoperability. Table 1.4 indicates the means and standard deviations as well as median and mode for all technical factor items.

Table 1.4 implies that all the 243 respondents participated in giving their opinions on this variable. Respondent's average agreement score that they had adequate and qualified human resource was 23.9, average agreement score that their organizations had a good Information Technology infrastructure was 6.9 and average agreement score that the health information systems were interoperable was 19.5. These findings imply that information technology infrastructure was the weakest so was the systems interoperability. The human infrastructure however had a moderate score. This finding implies that information technology infrastructure was the weakest hence systems interoperability became automatically a challenge. The human infrastructure however had a moderate score. The overall analysis on technical factor shows an average agreement score of 50.3 influence meaning there is an attempt to employ technical factor in public facilities however more efforts needs to be made.

Table 1. 4: Mean and Standard Deviation of the Technical factors

		Human Infrastructure	Information Technology Infrastructure	Systems interoperability	Technical factor
N	Valid	243	243	243	243
	Missing	0	0	0	0
Mean		23.8519	6.9465	19.4856	50.28
Median		24.0000	6.0000	20.0000	49.00
Mode		22.00	6.00	20.00	48.00
Std. Deviation		3.79466	2.47492	2.71109	7.047

4.3.1 Test of Hypothesis

Hoı: Technical factor was likely not to have an effect on integration of HMIS. This hypothesis intended to test whether there was any significant influence of technical factor on integration of Health Management Information System. The hypothesis H01: β1 = 0 Versus H1=β1‡ 0 was tested. Results in Table 1.5 shows a significant, strong and positive relationship between technical factor and integration of HMIS (r =.770**, P=.000). This led to rejection of the null hypothesis (Hoı) and the acceptance of alternative hypothesis (Hı). This study, therefore, concludes that technical factor has a significant positive relationship with the integration of HMIS.

Study findings on the specific factors identified in this study also indicated that: Human Infrastructure (r= .557**, P=.000), IT infrastructure (r= .635**, P=.000), System Interoperability (r= .644**, P=.000) were all were positively and significantly influencing integration of HMIS. The findings indicated that the strongest correlation under the technical factor was between Systems interoperability and integration of HMIS.

Table 1.5: The relationship between technical factor and integration of HMIS

	n=243	
	Integration of HMIS	P-Value
Human Infrastructure	.557**	0.000
IT Infrastructure	.635**	0.000
System Interoperability	.644**	0.000
Technical factor composite	.770**	0.000

**. Correlation is significant at the 0.01 level (2-tailed).

Results in Table 1.6 show the F-ration is 351.9 which is significant P<.001. This result implies that we reject the null hypothesis and accept the alternative hypothesis. Therefore, the study concludes that the technical factor is a good predictor of integration.

Table 1.6: Technical Factor and Integration of HMIS: Model Validity

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	73712.28	1	73712.2	351.9	.000[b]
	Residual	50471.59	241	209.426		
	Total	124183.8	242			

a. Dependent Variable: Integration of HMIS

b. Predictors: (Constant), Technical Factor

The study further revealed that Technical factor explains 60.9% of the total variations in the integration of HMIS (R^2 =.609), as indicated in Table 1.7. The coefficients in the regression model as shown in Table 1.7 indicate that technical factor will always exist at a certain minimum (β0=50.034, P=.000). However a change in the technical factor also remained positive and significant, in this case β1 as indicated in table 1.7 show that the change will also increase integration by 2.476. This implies that when the technical factor improves, the integration of HMIS will also improve.

Table 1.7: Technical Factor and Integration of HMIS: Regression Weights

Model		Unstandardized Coefficients		Standardized Coefficients	R^2	t	Sig.
		B	Std. Error	Beta			
1	(Constant)	50.034	6.702			7.465	.000
	Technical Factor	2.476	.132	.770	.609	18.761	.000

a. Dependent Variable: Integration of HMIS

The study further broke down the specific technical factor parameters and subjected them to multiple linear regression analysis and all the parameters were predictive of integration of HMIS as shown in Table 1.8. Results indicate that Human Infrastructure, IT infrastructure and System Interoperability in a combined relationship still remained as good predictors to improved integration of HMIS if they were improved. Therefore the increase in any unit of the specific variables would also lead to an increase in the integration of HMIS. Results indicate that a higher increase in the integration of HMIS would occur if IT infrastructure improved. This is an indication that IT infrastructure is quite fundamental in the success of integration of HMIS.

Table 1.8: Specific Technical factors predictors with integration of HMIS

Model		Unstandardized Coefficients		Standardized Coefficients	t	Sig.
		B	Std. Error	Beta		
1	(Constant)	55.262	7.603		7.269	.000
	Human Infrastructure	1.808	.268	.303	6.750	.000
	IT infrastructure	3.317	.441	.362	7.516	.000
	System interoperability	2.726	.418	.326	6.519	.000

a. Dependent Variable: Integration

The Key Informant Interview with the Sub County and county management team member's results confirmed what most of the respondents had pointed out. There was shortage of human resources in most of the facilities, health workers were mostly overloaded with work. There was general lack of capacity in analysis and interpretation of data. The county was making attempts to conduct on-job trainings however they were not intensive due to lack of resources. A skilled work force is an essential ingredient for effective integration of HMIS in healthcare. Systems professions, service providers and team leaders in HMIS activities with high skills levels and experience in an organization are important components. However as reported by one of county HRIO most of the healthcare facilities lacked team leaders for HMIS activities. The in-charges are left to handle HMIS activities yet they have other responsibilities which are more core to them.

The KII respondents agreed that the management teams were aware they needed to put up a budget to improve on Information Technology Infrastructure in their counties and plans were underway. There was also an agreement that there was need to automate and standardize the manual HMIS, there is need to involve the healthcare personnel in the identification of HMIS activities, ensure internet connectivity is enabled in the healthcare facilities, however the challenge was resources. The need to increase the number of computers and ICT systems was identified. More so the respondents felt there was need for the health system to build more capacity in Health Information Managers who can keep truck on the current and future technology needs.

IV. DISCUSSION

Technical factors include both technology and human infrastructure. These are resources that any management uses to achieve its goals. Management of the health system is largely affected by how well a health institution has matched its health workers knowledge and understanding about the job and also the ability to use the tools availed to them to make their work easier so that the production levels increases. HO can perform better with quality and resourceful people. Developing IHMIS continues to be a challenge as found in this study. This findings agree with the findings of (Aladdin *et al.,* 2014; Wanderer & Ehrenfeld, 2013; Zhao&Xia, 2014). The major challenge with IHMIS is inadequate use of ICT in healthcare and unskilled health workforce. Investment in capacity development and training in technological, communication and content development of skills will ensure more successful integration of HMIS.

Unreliable power supply and internet connectivity is a problem in all the three counties. The counties need to deal with enabling fiber network, access to reliable power supply, backups, and insufficient infrastructure. The better these things are functioning the greater the chance for successful HMIS integration.

The findings on the influence of Human infrastructure, Systems Interoperability and IT infrastructure regression analysis show that the three technical factors are significant. This study, therefore rejects the null hypotheses and concludes that human infrastructure, systems interoperability and IT infrastructure have significant effect on the Integration of HMIS. The study findings revealed that most of the data collection and reporting tools were paper based, this therefore greatly hinders interoperability, this findings agree with Aladdin et al., 2014 who reported that due to the co-existence of both the manual and automated processes unintended consequences arise due including communication breakdown, creation of more work and even adverse events such as medical errors. This therefore makes it difficult to achieving interoperability with existing information systems. This implies that systems interoperability is a crucial organizational capability that enables firms to manage information systems. This study therefore proposes adaptation of the two critical paths identified

by (Zhao and Xia, 2014) that are important in enabling interoperability. They include, standardizing data infrastructure and creating community readiness to adopt change. Therefore this study findings recommends that healthcare organizations in Kenya need to build collaborations in exchanging information, coordination of their business function and process. If this is acceptable among the healthcare providers then achieving interoperability and value networks becomes easy.

Results from regression analysis in Table 1.7 and 1.8 a multiple regression reveals that the technical factor has an influence on the Integration of HMIS. This implies that the HO need to examine and re-adjust their technical factor to be in line with the changing healthcare environment and realign with the new technical factor requirements for integration of HMIS to be achieved. Technical factor is a dynamic capability and the HO that are able to adjust their technical factor to the new changes will be able to achieve better results in their facilities. This findings are in line with conclusions made by (Petter, DeLone and McLean, 2008) who reported that the information systems for Health System should be accessible, compatible, user-friendly, stable and reliable, requiring minimal training and offering strong after-sales service. This study observes the need to have systems that are easy to use, easy to learning, system accuracy, flexibility, sophistication, integration capability and customization.

The findings in this study are in line with the findings of earlier scholars who did studies aimed at linking technology to HMIS. This study confirms the work done by Eze, Awa, Okoye, Emecheta and Anazodo (2013) who emphasized that technological factor is a key factor in IHMIS and it is unavoidable for HO that want to develop and maintain effective management in line with the current market. The researcher maintained that technology adoption is crucial for improved management of the health system.

Health professionals across different organizations need to understand data processing process, equipment in use, be knowledgeable and skilled for integration of HMIS to be achieved. As (Aladdin *et al*., 2014) found out that unintended consequences arise when adapting to IHMIS if employees are not well informed about this systems such issues include communication, creation of new or more work, and even adverse events such as medical errors when they do not understand the systems.

Systems interoperability is a crucial organizational capability that enables firms to manage information systems (IS) from heterogeneous trading partners in a value net-work (Zhao & Xia, 2014). Developing IHMISs continues to be a challenge as reported by (Aladdin *et al*., 2014), this is confirmed by the findings of this study because internet connection, power issues and availability of computers was a big challenge in the HO studied. He also reported that most LMIC use paper-based data collection processes at primary healthcare level and paper and computer-based health information systems at county level, this is a great hindrance to integration of HMIS. This report is in agreement with the study findings.

The study found statistical evidence that technical factor positively and significantly influences the integration of the HMIS. Technical factor accounted for (60.9%) of the total variation in integration of HMIS, it had the highest influence on integration of HMIS. Study findings also showed that an increase in one unit of the technical factor would increase integration by 24.76%. Under the technical factor, Systems interoperability was found to have the strongest association with integration of HMIS. Therefore the study concludes that it is okay for a health care organization to adopt a health information systems that meets their needs however it is important for the system to be flexible and interoperable with other systems. Petter, Delone and Mclean, (2008) emphasizes that information systems should be accessible, compatible, user friendly, stable and reliable. Unreliable system with frequency of downtime leads to lack of faith in the system. Therefore the systems adopted should be reliable.

V. CONCLUSION

It can be concluded that technical factor of a healthcare organization is an important variable that explains, to a great extent, the variation in integrating HMIS in Kenya. Therefore Integration of HMIS in Kenya can be achievable if all the identified study variables were taken into account and improved. The main reason as to why integration of HMIS in Kenya Healthcare organization has not been achieved is because paper based information systems are still greatly in use, therefore hindering systems interoperability. Internet connectivity, power, skilled staff, computer hardware and software are still inadequate in the facilities in Kenya, yet technical factor is the foundation of getting health management information systems integrated. This means that those HCO that are able to adapt to technology in line with the changes in the environment are able to achieve efficiency in their operations by getting there systems integrated. Therefore the HCO should always endeavor to properly develop the IT infrastructure and adopt electronic health management information system.

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