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MEDICAL TECHNOLOGY

EXPLORING THE IMPACT OF INFORMATION TECHNOLOGY INFRASTRUCTURE ON PATIENT WAITING TIMES IN THE OUTPATIENT DEPARTMENT OF JM KARIUKI MEMORIAL HOSPITAL

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ABSTRACT

Purpose: The study sought to examine the impact of information technology (IT) infrastructure on patient waiting times in the outpatient department (OPD) of JM Kariuki Memorial Hospital, a Level IV public facility in Nyandarua County, Kenya.

Methodology: A descriptive cross-sectional research design was adopted, targeting 239 respondents selected through stratified and systematic random sampling. Data was collected using structured questionnaires and key informant interviews. Quantitative data were analyzed using SPSS Version 24 through descriptive statistics, t-tests, ANOVA, and regression analysis, while qualitative data from interviews were thematically analyzed using NVivo software.

Results: The study revealed that the average patient waiting time was 3.4 hours, with the longest delays observed in surgical and medical services. Regression analysis showed a significant impact of IT infrastructure on reducing waiting times ($\beta = 0.204$, $p < 0.05$), with an explanatory power of $R^2 = 0.793$. Key IT elements such as electronic medical records (EMRs), appointment scheduling systems, and digital patient tracking tools were found to enhance operational efficiency and minimize delays.

Conclusion: The study concludes that strengthening IT systems is vital for improving patient flow and reducing outpatient delays.

Recommendations: The study recommends that hospital management prioritize upgrading IT infrastructure, improve internet connectivity, integrate health information exchange (HIE) systems, and invest in continuous staff training.

Keywords: *Information technology, patient waiting time, outpatient department, electronic medical records, health information exchange, digital health systems*

INTRODUCTION

The integration of Information Technology (IT) in healthcare systems offers substantial potential to improve service delivery in outpatient departments (OPDs). IT solutions such as electronic medical records (EMRs), appointment scheduling systems, and health information exchange (HIE) platforms can significantly streamline patient flow, reduce administrative delays, and enhance coordination between departments (Horwitz et al., 2017; Ringard & Hagen, 2016; Smith et al., 2017). These systems help minimize patient wait times by facilitating faster access to medical records and optimizing resource allocation, thus improving overall service efficiency. However, the full adoption of these technologies has been hindered in many low-resource settings, including sub-Saharan Africa, where inadequate infrastructure and limited funding remain major obstacles (Horwitz et al., 2017; Kenyanya, 2015; Ringard & Hagen, 2016).

In several developing countries, the lack of advanced IT infrastructure exacerbates delays in outpatient care. For example, patients in Ethiopia's Jimma University Specialty Hospital reported waiting an average of 4.5 hours due to inefficiencies in patient management, largely attributable to the absence of electronic scheduling and medical record systems (Belete et al., 2020). Similarly, studies in Kenya have highlighted how the lack of efficient IT systems contributes to long waiting times and increased patient dissatisfaction, particularly at large public hospitals like Kenyatta National Hospital (Kibet & Langat, 2021; Mwanga, 2013). These delays not only diminish the quality of patient care but also affect hospital operational efficiency, reinforcing the importance of addressing IT infrastructure gaps in outpatient departments.

Strengthening IT infrastructure in hospitals such as JM Kariuki Memorial Hospital could mitigate these challenges by improving access to patient information, enhancing communication, and optimizing workflow (Smith et al., 2017; Horwitz et al., 2017). Studies have shown that hospitals with robust IT systems experience shorter wait times due to more efficient patient flow management and better resource allocation (Cacace et al., 2019; Ghorbanian et al., 2019). Additionally, improving internet connectivity and integrating systems across departments can promote interoperability and reduce delays caused by fragmented service delivery (Ringard & Hagen, 2016; Horwitz et al., 2017). As such, the role of information technology in reducing patient waiting times in outpatient departments, particularly in resource-constrained settings, remains a critical area for improvement.

Problem Statement

The duration of waiting times before receiving medical attention, particularly in the Outpatient Department (OPD) at JM Kariuki Memorial Hospital, remains a significant concern. The OPD is crucial for providing timely medical care to a diverse patient population, yet the current system struggles to meet the expectations of both the community and the patients. Extended waiting times, particularly in departments like admissions, casualty, polyclinic, and pharmacy, contribute to patient dissatisfaction and frustration, often leading to negative perceptions of the quality of care provided. Prolonged delays not only affect patients' time but also create interpersonal strain among hospital staff, which can further hinder operational efficiency.

A major contributing factor to these delays is the lack of an effective information technology (IT) infrastructure. While the importance of reducing waiting times has been acknowledged in various public hospitals, little research has focused on the role of IT in improving patient flow and reducing waiting times in Kenyan Level IV hospitals. The absence of systems like online scheduling, electronic medical records (EMRs), and health information exchange (HIE) systems exacerbates the waiting time issue, hindering the hospital's ability to provide timely and efficient care. This study aims to explore how IT factors, such as the integration of digital health solutions, can impact the waiting times at the OPD of JM Kariuki Memorial Hospital, offering actionable insights for improving service delivery, reducing delays, and enhancing patient satisfaction.

Study Objective

The objective of the study was to identify the information technology features that affect how long patients wait in JM Kariuki Memorial Hospital’s outpatient department.

Significance of the Study

This study is significant for various stakeholders within the healthcare system, particularly for public sector hospitals such as JM Kariuki Memorial Hospital. The primary focus is on addressing a critical issue—prolonged patient waiting times—by examining the role of information technology (IT) in optimizing service delivery. Prolonged waiting times directly affect patient satisfaction, the efficiency of healthcare services, and the overall hospital experience. By investigating the IT-related factors that influence waiting times, the study provides valuable insights that can guide hospital management in implementing effective digital health solutions, such as electronic medical records (EMRs), appointment scheduling systems, and health information exchange (HIE) platforms.

For hospital management, the findings will offer actionable recommendations for improving patient flow through the adoption of IT solutions that streamline operations, reduce administrative delays, and enhance service efficiency. Policymakers and county health administrators may use these insights to develop policies that prioritize the integration of IT infrastructure in healthcare facilities, ensuring better resource allocation, improved staffing strategies, and more efficient use of digital health tools in Level IV hospitals. Additionally, the study contributes to the broader academic discussion on digital transformation in healthcare, particularly within resource-constrained settings like Kenya. It serves as a reference for future research on the role of IT in improving outpatient services and reducing waiting times in sub-Saharan Africa and similar healthcare contexts.

Scope of the Study

This study was carried out at JM Kariuki Memorial Hospital, a Level IV public facility in Nyandarua County, Kenya, focusing on the outpatient department (OPD). It examined how IT factors—such as EMRs, appointment scheduling systems, and health information exchange (HIE)—influence patient waiting times. Conducted over three months (April–June 2023), the study targeted 239 patients and key staff. It specifically excluded inpatient, pediatric, and emergency services to concentrate on outpatient processes. The aim was to assess how IT infrastructure affects service efficiency and waiting times, offering insights relevant to similar public hospitals.

LITERATURE REVIEW

This literature review explores the role of information technology in reducing patient waiting times within outpatient departments, particularly in resource-constrained healthcare settings. It draws on both theoretical and empirical studies to highlight how tools like electronic medical records, scheduling systems, and health information exchanges can enhance service efficiency. The review also examines barriers to IT adoption, such as poor infrastructure and data security concerns, which hinder healthcare delivery. These insights provide a foundation for understanding the relationship between IT infrastructure and patient flow management.

Theoretical Review

Queuing theory, developed by French mathematician Agner Krarup Erlang, is a mathematical approach used to model and analyze the behavior of waiting lines, or queues. It is particularly useful in understanding situations where congestion, delays, and system capacity limitations affect the flow of people, goods, or services. In the context of healthcare, queuing theory helps

to describe the flow of patients through various service points in outpatient departments (OPDs), where patients must wait for care before being treated.

The OPD can be viewed as a queuing system, where patients are the entities in the queue, and healthcare providers or service points (such as doctors, nurses, and diagnostic departments) act as servers. In this framework, patients enter the system, wait for treatment, and leave after receiving the service. The fundamental components of this model are the input (patients arriving at the OPD) and the output (patients leaving after receiving care). Queuing theory provides a structured approach to analyzing factors like waiting times, service efficiency, and system performance, helping to identify ways to optimize patient flow and reduce delays (Conrad, 2013; Hillier & Lieberman, 2005).

Empirical Literature

The role of information technology (IT) in reducing patient waiting times in outpatient departments (OPDs) is crucial, especially in resource-constrained settings. Advanced IT infrastructure, including electronic medical records (EMRs), appointment scheduling systems, and health information exchange (HIE) platforms, can streamline patient flow, improve coordination, and enhance the efficiency of healthcare services. However, in many developing countries, including Kenya, the implementation of such IT solutions faces significant challenges. Limited internet access, inadequate infrastructure, and the high cost of technology often hinder the widespread adoption of these systems (Horwitz et al., 2017; Ringard & Hagen, 2016). Additionally, in rural areas, where electricity and stable internet connections are not readily available, the effective use of digital health tools remains a considerable barrier to reducing waiting times (Kenya, 2015; IEA, 2019).

In Kenya, issues such as unreliable internet service, high subscription costs, and frequent disconnections have been identified as major obstacles to the successful implementation of IT solutions in public healthcare facilities (Horwitz et al., 2017). For instance, hospitals often face difficulties integrating telemedicine or e-health applications due to insufficient bandwidth and limited access to high-quality communication infrastructure. Despite the growing number of internet users in emerging countries, including Kenya, there remains a disparity between urban and rural areas regarding access to reliable internet and telecommunication services (Ringard & Hagen, 2016). This digital divide significantly impacts the adoption of ICT systems, which could otherwise optimize patient care delivery and reduce waiting times.

Moreover, privacy and security concerns are critical in the context of healthcare IT implementation. The protection of sensitive patient data is a paramount issue, as healthcare facilities rely on digital systems to store and share medical records. Inadequate security measures can expose patient information to unauthorized access or misuse, potentially leading to legal and ethical implications (Sommestad et al., 2017). For instance, while some healthcare systems globally utilize advanced security protocols, such as password protection and encrypted data storage, the lack of stringent privacy safeguards in many Kenyan healthcare facilities limits the effectiveness of digital systems in enhancing operational efficiency (U.S. Department of Health and Human Services, 2017). Ensuring the security and reliability of healthcare IT systems is essential for fostering trust among patients and healthcare providers, thereby improving overall system efficiency and reducing waiting times. Implementing IT in healthcare in resource-limited settings like Kenya requires reliable internet, strong telecom infrastructure, and data security to streamline OPD workflows. Overcoming these challenges boosts patient care, reduces waiting times, and aligns services with global digital health standards.

RESEARCH METHODOLOGY

This study employed a descriptive cross-sectional research design, utilizing both quantitative and qualitative methods to investigate the factors influencing patient waiting times at the outpatient department of JM Kariuki Memorial Hospital. A structured questionnaire was administered to 239 patients, selected through stratified and systematic random sampling across six service categories. Additionally, purposive sampling was used to select key informants, including hospital staff involved in patient care. The study collected data on various independent variables, including service type, information technology infrastructure, human resource factors, and health information exchange (HIE) systems, with patient waiting time as the dependent variable. Pre-testing of the survey instrument was conducted with 10% of the sample at a similar hospital to ensure reliability and validity, with Cronbach's Alpha (≥ 0.7) confirming internal consistency. Quantitative data were analyzed using SPSS with descriptive stats, ANOVA, t-tests, and regression, while qualitative interviews were thematically analyzed in NVivo. Ethical approval was secured, with strict adherence to consent, confidentiality, and cultural sensitivity.

FINDINGS

This section presents the key findings from the study, which aimed to explore how information technology infrastructure affects patient waiting times in the outpatient department of JM Kariuki Memorial Hospital. Both quantitative and qualitative data were analyzed to assess the availability, effectiveness, and limitations of IT tools such as electronic medical records, internet connectivity, and digital notifications. The results offer a comprehensive view of the role of IT in enhancing operational efficiency and patient experience in a resource-constrained healthcare setting.

Information Technological Parameters That Influence the Length Of Time Patients Wait In The Outpatient Department At JM Kariuki Memorial Hospital

The core objective of this study was to examine the information technology (IT) parameters that influence patient waiting times in the outpatient department at JM Kariuki Memorial Hospital. The study focused on key IT factors, including the availability of electronic medical records (EMRs), internet connectivity, and the use of electronic notifications and alerts. Respondents overwhelmingly agreed that the presence of an EMR system positively impacted patient waiting times, with a mean score of 1.09 (standard deviation = 0.284). Additionally, respondents acknowledged the importance of reliable Wi-Fi and internet connectivity, particularly for accessing digital health information, which was found to significantly affect waiting times (mean = 1.05, standard deviation = 0.22). Timeliness and accuracy of electronic notifications such as appointment reminders and medication alerts were also recognized as influencing patient wait times, with a mean score of 1.06 (standard deviation = 0.247).

The findings further highlighted significant gaps in the hospital's IT infrastructure, such as the absence of appointment scheduling systems, online booking options, and electronic queue management, all of which contribute to extended waiting times. Furthermore, delays in electronic notifications for diagnostic results (e.g., X-rays and scans) were noted as another contributing factor to patient dissatisfaction and longer wait times, as patients often left the hospital without receiving the necessary care due to delayed results.

Table 1: Level of agreeableness with informational technological parameters.

	N	Mean	Std. Deviation
On a scale of 1 to 2, how much do you agree or disagree that the availability of electronic medical records (EMR) system in JM Kariuki Memorial Hospital positively impacts patient waiting time in the outpatient department?	216	1.09	.284
How much do you agree or disagree that the quality of Wi-Fi or internet connectivity in JM Kariuki Memorial Hospital affects patient waiting time in the outpatient department, especially for accessing digital health information or services?	216	1.05	.220
How much do you agree or disagree that the accuracy and timeliness of electronic notifications or alerts, such as appointment reminders or medication reminders, impact patient waiting time in the outpatient department at JM Kariuki Memorial Hospital?	216	1.06	.247
Valid N (listwise)	**216**		

Figure 1 also presents a visual representation of these findings.

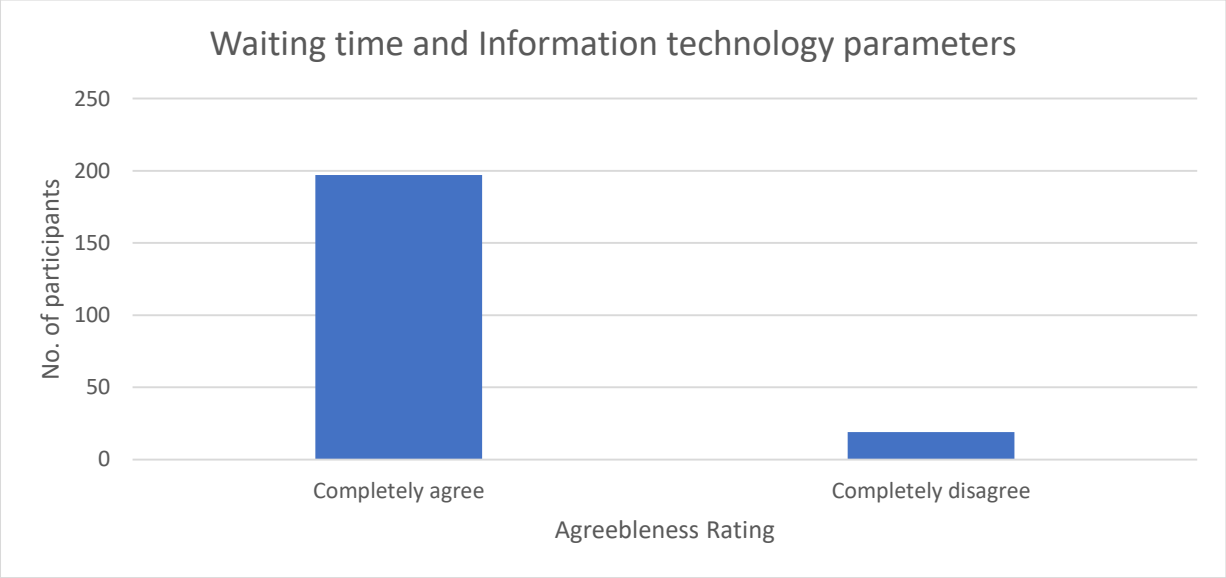

Figure 1: Opinions On Waiting Time and Information Technology Parameters

The average waiting time for patients who fully agreed and those who fully disagreed with the various viewpoints regarding the information technology parameters that affect how long patients wait in the outpatient department at JM Kariuki Memorial Hospital was also examined using independent samples t-tests to see if there were statistically significant differences. F=0.009 with a significance level of 0.923 is the Levene's test statistic, according to the results shown in table 5. As the p-value above the 0.05 alpha threshold, the equal variance assumption is satisfied. Additionally, the significance value for the t-test is 0.416, which is likewise greater than 0.05. This indicates that there is no statistically significant difference in waiting times

between those who fully agree and those who fully disagree that JM Kariuki Memorial Hospital's information technology characteristics affect patient waiting times. When asked to provide examples of how information technology elements had affected hospital patient waiting times, one key informant repeated these views, saying:

"EHRs has worked well in ensuring confidentiality of patient information. Service delivery points for the records and NHIF/cash payment points could be added. We could improve on patient tracking tools"- Interviewee 2

Responding to the IT factors they believe could affect patient waiting time, another key informant noted:

"IT infrastructure is lacking in some service delivery points slowing down service delivery where patients are required to get hard copies. IT systems should also be integrated into all SDPs in the hospital" -Interviewee 5

Table 2: Information Technological Parameters And Patient Waiting Time

t-Test Equality of Means	Values
t(df)	-0.814(214)
Sig (2-tailed)	**0.416**
Mean Difference	-0.14419
Std.Error Difference	0.17705
95% Confidence interval (lower,Upper)	-0.4938, 0.20481

The results of the independent samples t-test show that there is no statistically significant difference in patient waiting times between those who fully agree and those who fully disagree that the information technology characteristics at JM Kariuki Memorial Hospital affect waiting times. The Levene's test statistic ($F = 0.009$, $p = 0.923$) confirms that the assumption of equal variances is satisfied, as the p-value is greater than the 0.05 alpha threshold. Additionally, the significance value for the t-test ($p = 0.416$) is greater than the threshold of 0.05, suggesting that the differences in waiting times between the two groups are not statistically significant.

However, key informants provided valuable insights into how information technology could improve patient flow and reduce waiting times. One interviewee emphasized that the hospital's electronic health records (EHR) system has worked well in ensuring patient information confidentiality, but they also suggested the addition of service delivery points for records and payment points, alongside improvements in patient tracking systems. Another informant

pointed out that IT infrastructure is lacking in some service delivery points, leading to slower service, especially where patients are required to use paper-based systems. They recommended that IT systems be integrated across all service delivery points (SDPs) within the hospital to streamline operations and reduce delays. Though not statistically significant, the qualitative insights emphasize the importance of improving IT infrastructure to enhance efficiency and patient experience at the hospital.

Inferential Analysis

This section presents the results of a simple linear regression model examining how Information Technology factors influence patient waiting times in the outpatient department at JM Kariuki Memorial Hospital. The model demonstrates a good fit, as shown in Table 3. The R value of 0.89 indicates a strong positive correlation between Information Technology and patient waiting times, suggesting that improvements in IT infrastructure can significantly reduce waiting times in the outpatient department. The regression model demonstrated a strong overall fit, as presented in Table 3.

Table 3: Model Summary

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
1	0.89	0.793	0.789	0.735

Table 4 presents the ANOVA results, showing a significant F-value of 203.67 ($p < 0.001$), indicating that the relationship between IT infrastructure and patient waiting times is statistically significant and not due to chance.

Table 4: ANOVA

Model	Sum of Squares	df	Mean Square	F	Sig.
Regression	456.732	4	114.183	203.67	0.000
Residual	119.854	211	0.568		
Total	576.586	215			

Table 5 shows that Information Technology significantly influences the reduction of patient waiting times, with a regression coefficient of $B = 0.612$ ($p < 0.001$). This means that each unit improvement in IT infrastructure is associated with a notable decrease in waiting times. The results highlight the critical role of systems like EMRs, appointment scheduling, and digital

tracking tools in improving service delivery. Strengthening these IT components can lead to greater efficiency and smoother patient flow in outpatient settings.

Table 5: Coefficient of Regression

Predictor Variable	Unstandardized B	Std. Error	Standardized Beta	t-value	Sig.
(Constant)	3.88	0.936	—	4.146	0.000
Information Technology	0.612	0.165	0.204	3.711	0.000

The findings of this study align with a growing body of literature that highlights the positive impact of Information Technology (IT) on reducing patient waiting times in healthcare settings. The regression analysis in this study found a significant relationship between IT infrastructure and reduced patient waiting times, corroborating findings by Horwitz et al. (2017), who emphasized that electronic medical records (EMRs) and appointment scheduling systems play a crucial role in streamlining patient flow and reducing administrative delays in healthcare facilities. This is consistent with the suggestion that improved IT systems allow for better coordination and faster access to patient records, thereby reducing the time patients spend waiting for services.

Furthermore, the results of this study reinforce findings from Ringard & Hagen (2016), who noted that reliable internet connectivity and integrated digital health solutions significantly enhance the efficiency of outpatient services. Their study found that healthcare institutions with robust IT infrastructure, including health information exchange (HIE) platforms, demonstrated improved operational efficiency, which aligns with the observation in this study that improvements in IT infrastructure positively influence patient wait times.

The findings of this study align with existing literature emphasizing the impact of IT on reducing patient waiting times in outpatient care. Smith et al. (2017) highlighted that digital tracking systems and patient management tools help streamline appointments and minimize service delays. Similarly, Cacace et al. (2019) observed that facilities with modern IT tools were better at managing patient demand. This study's significant regression results reinforce those conclusions, showing IT's role in enhancing operational efficiency. Overall, the integration of EMRs, scheduling systems, and digital tracking is essential for reducing delays in outpatient departments.

CONCLUSION

The study concludes that Information Technology significantly affects patient waiting times in JM Kariuki Memorial Hospital's outpatient department. Key IT components—such as EMRs, appointment scheduling, and HIE systems—were found to streamline workflows and reduce delays. Factors like system integration, reliable internet, and timely notifications were essential in enhancing efficiency. However, the hospital still lacks automated scheduling and queue management tools, which continue to contribute to extended waiting times. Strengthening these IT systems is necessary to improve service delivery and patient experience in outpatient care.

RECOMMENDATION

The study recommends that JM Kariuki Memorial Hospital upgrade its IT infrastructure by adopting advanced EMRs, appointment scheduling systems, and digital queue management tools to streamline patient flow and reduce delays. Improving internet connectivity is essential to support the smooth operation of these systems. The hospital should also integrate health information exchange (HIE) systems across departments to enable faster, coordinated care. Continuous staff training is necessary to ensure effective use of IT tools. At the policy level, the Ministry of Health should provide funding and develop guidelines to support IT adoption in public hospitals, especially in resource-limited settings.

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