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Enhancing Efficiency in Public Healthcare's Specialized Departments with Triage Protocol

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Abstract

Public healthcare in low-resource settings continues to face challenges as demand for services grows faster than available resources, resulting in longer waiting times, a significant challenge. This study evaluated patient flow using a discrete-event simulation model, incorporating the triage protocol to assess its impact on waiting times, Length of Stay (LOS), and resource utilization. Arrivals, service times, and resource availability data were collected, a model was developed, verified, and validated against real-world operations, and triage-based improvement scenarios were simulated. Results revealed major bottlenecks in antenatal and gynecology consultations, triage, and delivery units, where patients faced the most extended delays and resources were overstretched. Implementation of the triage protocol showed limited effect under current staffing, but when combined with optimized resourcing, waiting times in high-pressure areas were nearly eliminated, and overall LOS was reduced by 5.6% in the Labour and Delivery (L/D) clinic and 12.1% in the Mother Child Health (MCH) clinic. The study concludes that triage protocols are effective in improving patient flow when integrated with resource optimization and workflow redesign. This research provides new evidence on resource-sensitive strategies that can enhance maternity care performance and inform policy for scaling maternal health interventions under Universal Health Coverage (UHC) in low-resource contexts.

Keywords: Discrete event simulation, Triage tool, Maternity, Labour and delivery, Low resource.

1 | Introduction

Public healthcare globally has faced challenges because the growth rate of resources, specialists, and facilities still lags compared to the increasing demand for primary healthcare [1]–[3]. The resource constraints faced by hospitals are due to insufficient funds to purchase, acquire, and maintain resources, as well as to the management systems and practices employed by the hospital. Thus, hospitals continue to face numerous challenges worldwide due to the growing population and the increasing need for specialized, professional healthcare.

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Waiting time is an indicator of the quality of a healthcare service; long waiting times are a real healthcare problem worldwide, and even more so in third-world countries with a very high population density and poverty [4]. Waiting time, timely treatment, and Length of Stay (LOS) are some of the key performance indicators of a hospital's performance [5]. Donabedian [6] indicated based on his Donabedian model framework, the following KPIs to gauge the performance of obstetric triage in a hospital: waiting time for initial assessment, LOS, priority care, and resource utilization rates.

Despite the WHO's efforts through Universal Health Coverage (UHC) to ensure efficient healthcare, the performance of healthcare systems still faces difficulties, which are key causes of delays in achieving key Sustainable Development Goals (SDGs), especially SDG 3 on good health and well-being. As part of its efforts to ensure the highest attainable level of health, the government of Kenya adopted UHC under its Big Four agenda, aiming to provide all Kenyans with quality care without incurring financial burdens [7], [8]. This led to the introduction of a free maternity services program in Kenya in June 2013, dubbed Linda Mama, under the National Health Insurance Fund (NHIF) [9], [10] which led to an increase in patients visiting health facilities for skilled services. The effects of this have strained the healthcare system, led to delayed or poor diagnoses, compromised the quality of healthcare services, resulted in delays in offering services, overextended resources, complications for both mother and child, dissatisfaction on the patient's side, and jeopardized patient safety.

In the past, hospitals in developing countries relied heavily on audits, standards from accredited bodies, and regulations to improve the quality of healthcare [11]. The National Health Service (NHS) director [12] emphasized the need to address long waiting times in emergency care and evidenced the need for urgent improvement strategies to be implemented. Rohleder et al. [13] suggested that future research should focus on the need to identify ways of improving hospital performance without adding staff, but by utilizing the current staff levels. There's a lack of evidence from African contexts, including Kenya, where hospital workflows and resource constraints differ significantly. There's minimal exploration of how triage protocols affect specialized departments, such as maternity, inpatient wards, and diagnostics [14]. This reveals an existing gap in which optimal improvement strategies, such as triage tools, have not been effectively utilized to enhance hospital performance at current resource levels.

Not knowing the patient's condition upon arrival to allocate priority and offer initial treatment, as well as to allocate appropriate resources, has led to detrimental health conditions for the patient and cost implications for the hospital. The lack of proper diagnosis for patients, characterized by ad-hoc challenges to treatment and early diagnosis, poses a critical challenge in assigning priority based on the patient's condition [15], [16]. The American College of Obstetricians and Gynecologists committee [17] recommends that pregnant women be triaged based on acuity rather than time of arrival. The study, therefore, focuses on evaluating patient processes in the Maternity Department (MD) using a triage protocol in an Arena simulation to improve hospital performance and inform resource utilization. This research employs a case study approach based on a specialized department in a public hospital in Kenya, providing real-world insights into the impact of triage-based process improvements on patient flow and resource use within the MD.

2 | Relevant Literature Review

2.1 | Triage Protocol

The triage protocol is a lean diagnostic tool used to improve performance and ensure the proper utilization of available resources. Not knowing the patient's condition upon arrival to allocate priority and offer initial treatment, as well as to allocate appropriate resources, has led to detrimental health conditions for the patient and cost implications for the hospital. Triaging of patients to identify and prioritize them based on the urgency of care is very relevant where demand for care exceeds resource availability [5], [6]. Triaging of patients during admission helps to classify patients based on their criticality by assigning colour codes, red, orange, yellow, and green, to determine urgency [16]. The application of triage as an admission procedure for classifying of patients based on criticality enables a reduction of patient waiting time as well as informs on the resource distribution decisions as it enables one to accurately direct patients to the right resource in the shortest time possible.

There is evident advanced and successful adoption of triage tools in improving the quality of care and patient outcomes in developed countries. These high-income countries have successfully adapted the five-level triage tool; in contrast, the same tools are not suitable for developing low-income countries due to their different epidemiology, high service demand, and limited resource arrangements [18]. Moreover, triage scale tools designed for developed, high-income countries, such as the five-level triage tools, exhibit variations in outcome as well as the degree of validation and reliability. This, therefore, makes it exceptionally difficult to predict an ideal triage tool for a particular context when implemented in low-income countries [19].

Reliable, simple, and efficient triage tools are emphasized by clinicians for developing counties' hospital settings [20], [21]. Some triage tools developed for low-resource settings in developing countries include the Emergency Triage Assessment and Triage system. This three-level triage tool has seen extensive successful applications across the African region [22]. Other recommended tools for low and middle-income countries include Emergency Triage Assessment and Treatment (ETAT), South African Triage Scale (SATS), and Interagency Integrated Triage Tool (IITT) [23], [24]. These tools are used at the point of entry (admission) of patients into the hospital and utilize signs and symptoms rather than physiologic parameters when defining urgency. They have demonstrated acceptable reliability and validity in a variety of Accident and Emergency facilities.

2.2 | Literature on Related Work

Several studies have researched the implementation of triage tools in obstetric and emergency care, highlighting both their benefits and limitations. A consistent theme across the literature is that triage protocols enhance accuracy in prioritization and patient safety. Still, their impact on waiting time, LOS, and resource utilization remains underexplored.

For instance, [25] demonstrated that triage improved the accuracy of patient categorization upon arrival, while Best and Sesay [26] and Easterbrook [27] emphasized that standardized tools, such as SOTS and AOTAS, enhanced patient safety, satisfaction, and healthcare provider performance. Similarly, Hesham et al. [28] found that obstetric triage protocols improved both nurses' knowledge and the timeliness of initial assessments. Collectively, these findings suggest that triage tools facilitate more informed decision-making and clinical judgment among staff, ultimately enhancing the quality of maternity care.

Most studies employing triage have focused on emergency departments in high-resource, urban hospitals, with few addressing rural, low-resource, or non-emergency settings such as maternity units, outpatient clinics, or surgical wards [29]. This limited contextual diversity constrains the applicability of existing findings to healthcare systems where staffing shortages, infrastructural limitations, and patient surges are common.

However, there is less agreement on the effect of triage tools on waiting times and LOS [4]. For example, adapting the Cape Triage Score system in primary healthcare settings found no reduction in waiting time or LOS, partly due to differences in survey tools and a lack of consideration for resource utilization. In contrast, Quaile [29] reported an improvement in timeliness of care from 19 minutes to 10 minutes, although their study did not extend this to overall waiting time or service flow. Likewise, both Hesham [30] and Best et al. [26] did not assess how triage protocols influenced waiting time, LOS, or resource distribution, highlighting a common gap across studies.

Research in broader emergency care contexts further illustrates these limitations. Mitchell et al. [18], [31] examined the Interagency Integrated Triage Tool in low-resource emergency departments, confirming its validity and acceptability, yet again neglecting the dimensions of waiting time, LOS, and resource utilization.

A notable lack of evidence remains from African contexts, including Kenya, where hospital workflows and resource constraints differ significantly. There's minimal exploration of how triage protocols affect specialized departments, such as maternity, inpatient wards, and diagnostics [14]. This gap limits the generalizability of existing findings to resource-limited health systems, where operational realities often diverge from those in high-income settings.

Overall, while the literature supports the use of triage tools to improve patient safety, clinical accuracy, and healthcare staff performance, a clear gap remains in understanding their operational impact, specifically on waiting times, patient flow, and resource allocation. To the best of the researcher's knowledge, no study has combined triage tools with Arena simulation modeling in MDs to address these issues. This study, therefore, seeks to bridge that gap by evaluating patient processes through simulation to optimize waiting time and resource utilization.

3 | Methodology

The methodology followed the stages as illustrated in *Fig. 1*. Data collection included both primary as seen in *Table A 2* and secondary sources shown in *Table A 1*. Key areas include patient pathway flow, patient waste, bottlenecks that limit optimal performance, and the root causes of wasteful steps. The collected data informed the simulation parameters used to build the Arena Discrete Event Simulation (DES) model.

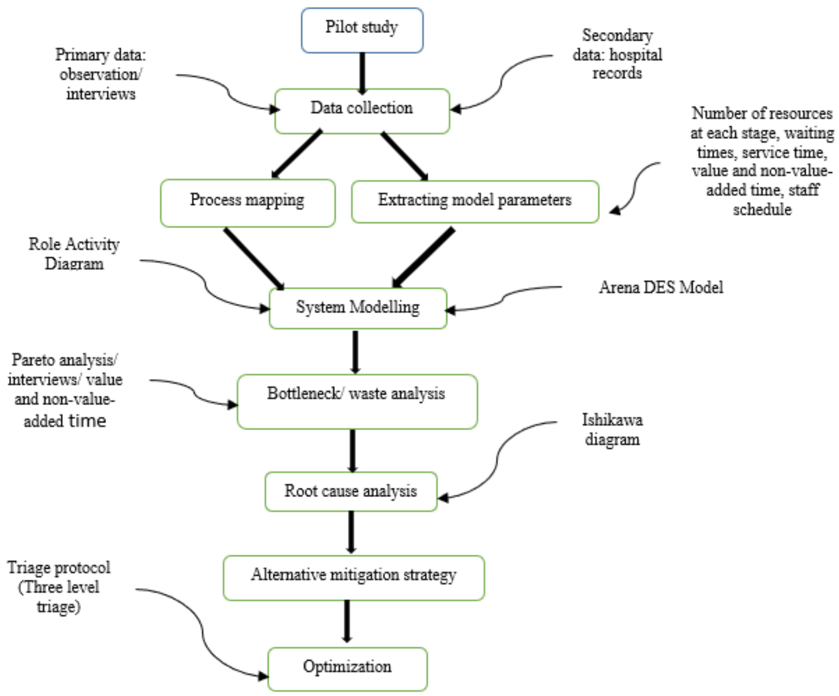

Fig. 1. Conceptual framework of methodology.

The case study was conducted at a level-four public referral hospital, one of the most extensive healthcare facilities in the county. The MD is a specialized unit that provides both outpatient and inpatient services to walk-in patients and those referred by other healthcare providers. It comprises the L/D clinic and the Mother Child Health (MCH) clinic. A pilot study was conducted at the case study facility to refine data collection tools and ensure contextual accuracy. It involved reviewing hospital records, including daily patient volumes and service delivery charters, and conducting brief observations and interviews to capture workflow dynamics and staff-patient interactions. Insights from the pilot study informed the main data collection and improved the robustness of the model inputs.

3.1 | Patient Care Pathway

Data collection involved directly tracking patients from the moment they arrived in the MD until their discharge, as shown in *Fig. 2*. At each stage of care, information was gathered on the number of patients present, the staff available, the time patients spent waiting, and the actual service time. In addition, the hourly arrival of patients was recorded, and this arrival pattern was later used to define the patient arrival schedule within the simulation model.

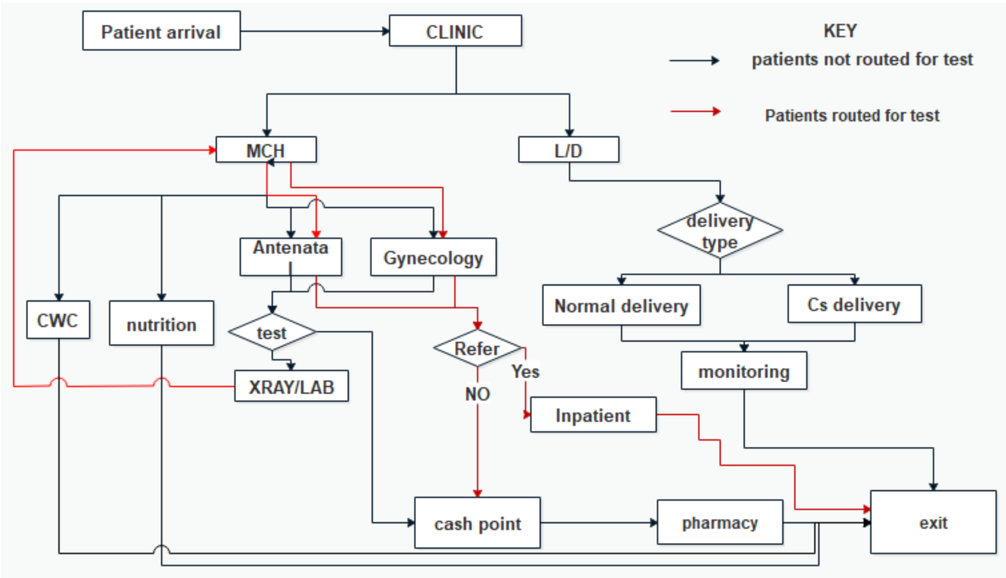

Fig. 2. Care pathway followed by maternity department patients.

3.2 | System Modelling (Discrete Event Simulation)

The methodology proposed by Rossetti [32] was adopted to develop the Arena simulation. First, data on waiting and service times were collected, along with resources at each process stage. The data were then converted into model parameters used to build the DES model. The Arena simulation package was used for this study. The model was then verified through animation visualization and validated to ensure it accurately mimicked real-world systems. Finally, the improvement scenario, the Triage protocol, was implemented.

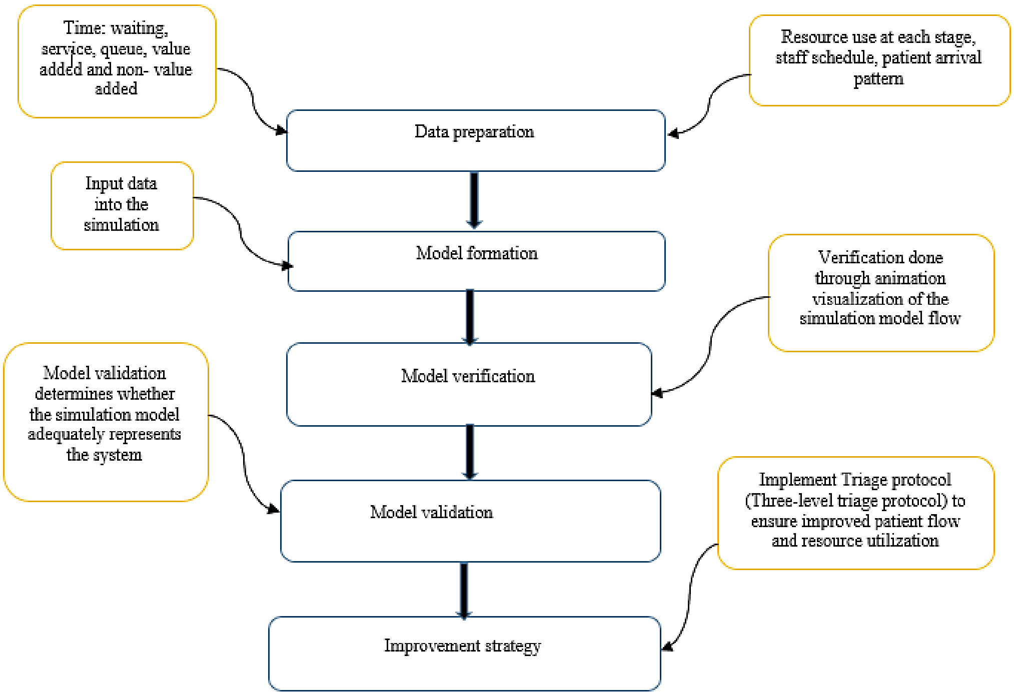

Fig. 3. Graphical representation of the steps followed to build the discrete event simulation model.

3.3 | Triage Modelling

A simplified triage protocol was modeled in Arena using a percentage-based criticality approach. Each patient was assigned a criticality level using discrete probability distributions that reflected the expected case mix. The assigned value was stored as an attribute and used in Decide modules to route patients into priority queues, where higher acuity categories were always served first. Prioritization was achieved through queue ranking, and the model tracked waiting times from arrival to discharge to assess the impact of percentage-based triage on system performance.

3.4 | Model Verification and Validations

Verification was conducted through animation visualization of the simulation model's flow and debugging, resolving errors such as entities not leaving the system and resources not being released. Increasing the patient's arrival pattern implied that waiting times increased. A comparison was made between the simulation model outputs and the actual (empirical) process flow data to enhance the model's validity and ensure it accurately represents the current situation, as shown in *Fig. 4*.

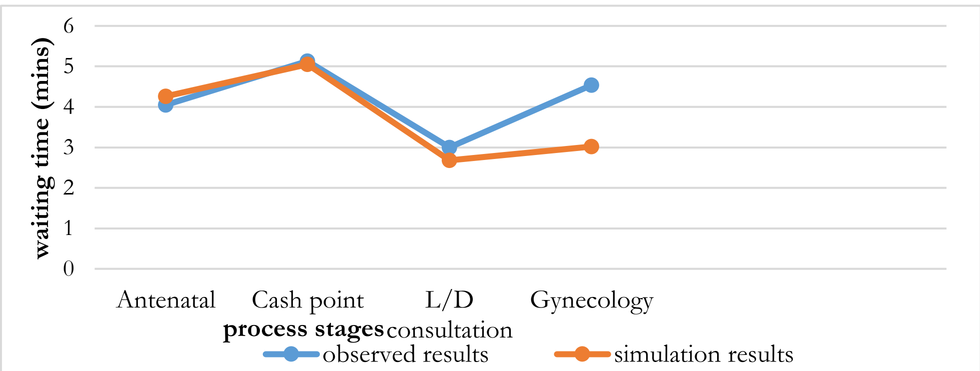

Fig. 1. Observed the queue waiting time and the simulation queue waiting time.

Table 1 illustrates that the deviations for antenatal, cashpoint, and labour/delivery consultations remained under 10%, demonstrating that the simulation provided a strong representation of actual system performance. This aligns with [33], who notes that models with deviations below 10% can be considered reliable reflections of reality. In contrast, the units with deviations above this threshold were influenced by factors outside the model's scope, such as staff temporarily leaving to handle emergencies, taking breaks, or arriving late.

Table 1. Comparison between observed waiting time and simulation waiting time.

Unit	Observed Results (Minutes)	Simulation Results (Minutes)	% Deviation
Antenatal	4.05	4.26	-5.19
Cash point	5.13	5.05	1.56
L/D consultation	2.98	2.68	10.07
Gynecology	4.54	3.02	33.48

4 | Results and Analysis

4.1 | Study Results

The model identified critical pressure points within the maternity pathway, where patients experienced extended waiting times and resources were under considerable strain, as shown in *Table 2*. The most affected areas were the antenatal and gynecology units of the MCH clinic, as well as the triage room and both the standard and cesarean delivery rooms in the Labour and Delivery (L/D) clinic. Compared to other stages in the patient flow, these units consistently recorded the longest delays, underscoring their significant role as operational bottlenecks. These findings highlight the need for targeted interventions.

The uneven distribution of workload and the mismatch between patient arrival rates and available staff capacity further justified the need for targeted interventions, ranging from optimized triage protocols and staffing adjustments to workflow redesign and resource reallocation, as well as streamlining service delivery, since the imbalance between patient inflow and available resource capacity created systemic inefficiencies that prolonged waiting times and reduced overall service performance

Table 2. Simulation results on waiting time and resource utilization.

Unit/Clinic	Queue Waiting Time (Minutes)	Scheduled Utilization
Antenatal services	4.2599	0.71
gynecology consultation	3.0235	0.69
Normal delivery	9.4990	0.23
L/D triaging	7.9078	0.39
normal delivery monitoring room	8.6485	0.29
Cs monitoring room	0.0000	0.08
LAB	0.5925	0.15
XRAY	0.0000	0.13
Caesarean delivery	4.1137	0.23
cash point	5.0487	0.14
pharmacy	0.2139	0.41
L/D consultation	2.6757	0.52

4.2 | Improvement Strategy (Triage Protocol)

In this study, a Design of Experiments (DOE) framework was employed to systematically evaluate the performance of different triage configurations within the MD simulation. Four key control scenarios were modelled: a baseline case without a triage protocol, the introduction of a triage protocol, a triage protocol combined with additional staffing resources, and a stress-test scenario simulating peak patient arrivals. These experimental setups enabled assessment of how triage implementation and resource adjustments influence system behavior under varying operational conditions.

Patients attending the antenatal and gynecology consultation units experienced considerable waiting times of 4.26 minutes and 3.02 minutes, respectively, in addition to an average of 5.05 minutes at the cash point. The antenatal and gynecology units demonstrated the highest levels of resource utilization, at 71% and 69%, respectively, as seen in *Table 3*, indicating that staff in these areas were operating near or beyond their optimal capacity. Such intensive use often results in service congestion and extended patient delays. In contrast, process stages with lower utilization rates indicate untapped capacity and uneven workload distribution, highlighting the need to redistribute resources and adjust staffing patterns to achieve balanced utilization, as well as enhance patient flow and overall service performance.

In the L/D clinic, patients faced even longer delays. The triage room recorded an average waiting time of 7.91 minutes before service, followed by an additional 2.68 minutes at the consultation stage. Similarly, patients in the standard delivery unit waited 9.50 minutes, while those in the cesarean delivery unit waited 4.11 minutes before receiving care.

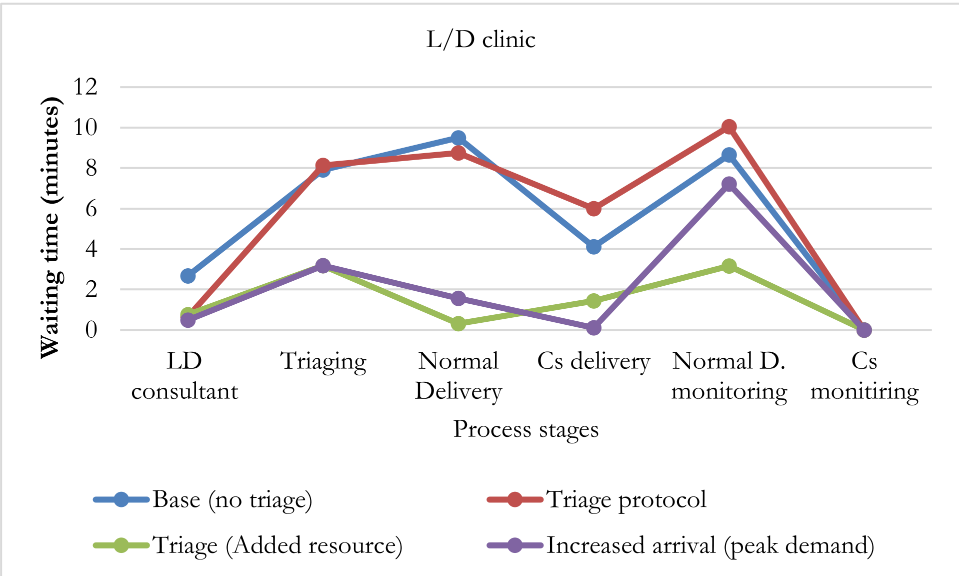

Fig. 2. Waiting times at the mother child health clinic.

The initial implementation of the triage protocol did not substantially reduce waiting times under the current resource levels. However, as shown in *Figs. 5* and *6*, simulations indicate that increasing resources in the most congested areas yields significant improvements. Waiting times in the antenatal and gynecology units dropped from 4.26 and 3.02 minutes to 0 minutes, respectively, while consultation delays in the L/D clinic reduced from 2.68 minutes to 0 minutes, signifying a 100% reduction.

Table 3. Scheduled utilization under triage protocol.

Scenario	**Control**						**Response**												
	Resource Personnel						**Scheduled Utilization**												
	No. of Triage Staff	**No. of LD Consultants**	**No. of Gynaecologist**	**No. of Cashiers**	**No. of Antenatal Nurses**	**No. of Gynaecologist**	**Casher 1**	**Casher 1**	**Pharmacist**	**Antenatal nurse**	**Antenatal nurse**	**Gynaecologist**	**Gynaecologist**	**Triage Staff 1**	**Triage Staff 2**	**LD Consultant 1**	**LD Consultant 2**	**Gynaecologist**	**Gynaecologist**
Base (no triage)	1	1	1	1	1	1	0.14	-	0.41	0.71	-	0.69	-	0.39	-	0.52	-	0.69	-
Triage protocol	1	1	1	1	1	1	0.15	-	0.45	0.56	-	0.83	-	0.4	-	0.52	-	0.83	-
Triage (Added resource work as a set)	2	2	2	2	2	2	0.21	0.2	0.42	0.32	0.31	0.82	0.73	0.19	0.22	0.28	0.25	0.82	0.73
Increased arrival (peak demand)	2	2	2	2	2	2	0.21	0.21	0.71	0.7	0.72	0.77	0.71	0.21	0.19	0.26	0.26	0.77	0.71

The cash point also improved, with waiting times reduced by more than half, from 5.05 minutes to 1.7 minutes. These improvements were accompanied by a better balance in resource utilization across units, where previously underutilized resources, such as the cashier, showed increased utilization rates, as seen in *Table 3*.

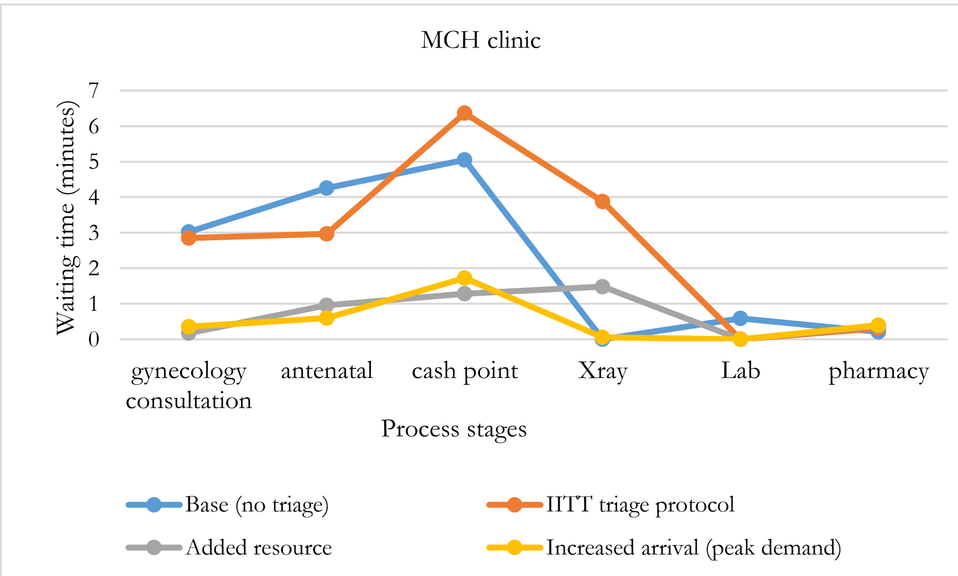

Fig. 6. Waiting times at the labour and delivery clinic.

At optimal resource levels, the triage protocol proved instrumental in reducing waiting times across all stages of the patient process. This, in turn, led to a shorter overall LOS, decreasing from 1,118.1 minutes to 1,055.7 minutes in the L/D clinic, equivalent to a 5.6% reduction, and from 39.29 minutes to 34.52 minutes in the MCH clinic, representing a 12.1% reduction. The relatively small decrease in LOS at the MD aligns with findings by Swart et al. [4], who reported that the introduction of triage protocols alone did not significantly reduce patient LOS.

5 | Managerial Implications

The findings of this study carry significant implications for hospital administrators and health system managers. First, the identification of antenatal, gynecology, and delivery units as critical bottlenecks highlights the need for targeted managerial interventions, such as dynamic staff allocation, workload balancing, and process redesign, to minimize delays. The results demonstrate that while triage protocols can enhance patient flow, their effectiveness depends on adequate resourcing and operational support, meaning managers must plan for both protocol adoption and resource optimization in parallel. At the institutional level, this requires the routine use of simulation modelling to inform evidence-based decisions on staffing, scheduling, and service point capacity expansion.

At the policy level, the study highlights the potential for integrating structured triage tools into national maternal health strategies and UHC programs. By standardizing triage protocols within maternal care pathways and linking them to resource planning frameworks, healthcare facilities can ensure more equitable distribution of care, reduce inefficiencies, and improve patient outcomes across facilities. Furthermore, the evidence that triage protocols alone are insufficient without supporting resources signals the need for policymakers to align human resource investments and infrastructure development with service delivery reforms. Integrating such evidence-driven interventions into broader maternal health policies can therefore contribute to achieving SDG targets for reducing maternal mortality, while also improving the overall efficiency of healthcare resource utilization.

Beyond maternal health, this framework has broader applicability. The methodology used to combine process mapping, simulation modelling, and performance measurement can be adapted for use in other hospital departments or health programs to identify inefficiencies, optimize resource utilization, and evaluate policy interventions. In doing so, it provides a scalable approach for enhancing service delivery within constrained health systems.

6 | Conclusion

This study aimed to investigate performance gaps within the MD by modelling patient flow, waiting times, and resource utilization across key service points. The findings revealed that operational bottlenecks were concentrated in the antenatal and gynecology consultation units of the MCH clinic, as well as in the triage, standard delivery, and cesarean delivery rooms of the L/D clinic. These stages consistently recorded the most extended delays and highest levels of resource strain, directly aligning with the research objective of identifying critical pressure points in the patient care pathway to optimize performance. Notably, while the initial implementation of the triage protocol demonstrated limited impact under current resource conditions, its integration with optimized staffing levels and workflow redesign yielded substantial improvements. Waiting times in several high-congestion areas were reduced to near elimination, overall resource utilization was balanced more effectively, and total LOS decreased by 5.6% in the L/D clinic and 12.1% in the MCH clinic.

The study contributes to knowledge by demonstrating that triage protocols, when used in isolation, cannot resolve systemic inefficiencies but are highly effective when combined with strategic resource optimization. In practice, this evidence highlights the importance of hospital managers and policymakers complementing protocol adoption with deliberate resource planning and workforce adjustments to achieve significant reductions in delays and improvements in patient experience. Finally, the findings open avenues for future research to explore the scalability of such interventions across diverse healthcare settings, assess the long-term sustainability of improvements, and investigate patient-centered outcomes, such as satisfaction and safety, in relation to the implementation of resource-sensitive triage.

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Author Contribution

Conceptualization, P.K. and J.W.; formal analysis, N.K.; investigation, N.K. and J.W.; Methodology, N.K., J.W., and P.M.; data maintenance, N.K.; supervision, J.W. and P.M.; visualization, N.K., J.W. and P.M.; writing-original draft, N.K., J.W., P.M and S.M.; writing-reviewing and editing, N.K., J.W., P.M and S.M. All authors have read and agreed to the published version of the manuscript.

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Data Availability

The analysis data used to support the study findings are included in this research article and the appendix and will be available upon request.

Conflicts of Interest

The authors declare that they have no conflict of interest.

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Appendix

Table A 1. Hospital records on the number of staff and patients served.

CLINIC	MCH						L/D
No. of Staff	1		1		1		15
	CWC		ANTENATL		GYNECOLOGY		L/D
	New Visits	Revisits	New Visits	Revisits	New Visits	Revisits	All Visits
Jul-22	105	543	48	166	0	0	187
Aug-22	127	419	87	211	0	0	186
Sep-22	132	485	84	224	0	0	181
Oct-22	120	454	87	200	0	0	160
Nov-22	110	523	68	130	0	0	170
Dec-22	115	381	105	212	0	0	195
Jan-23	158	502	121	196	0	0	203
Feb-23	149	454	115	204	76	0	162
Mar-23	138	535	88	160	105	29	165
Apr-23	115	478	97	229	45	34	174
May-23	296	57	296	57	56	39	204
Jun-23	104	380	104	380	62	41	175
TOTAL	1669	5211	1300	2369	344	143	2162

Table A 2. Observed waiting time.

MCH CLINIC-Unit	Time in Minutes				
	Morning	Afternoon	Average	Value Added Activity	Non-Value-Added Activity
Time to locate Gynecology unit	07.21.04	06.17.10	06.49.07		✓
Waiting time at Gynecology unit	03.41.00	05.27.10	4.54.01		✓
service time at Gynecology unit	05.53.07	05.24.14	05.38.61	✓	
Time to locate Antenatal unit	05.14.21	05.08.18	05.11.20		✓
waiting time at antenatal unit	03.34.13	04.36.00	04.05.12		✓
service time at antenatal unit	04.05.44	07.06.13	05.05.79	✓	
time to locate cash point	05.22.44	04.52.89	05.07.67		✓
waiting time at cash point	05.05.11	05.21. 01	05.13.00		✓
service time at cash point	11.14.39	14.41.90	12.58.15	✓	
Time to locate CWC unit	08.32.17	06.52.01	07.42.09		✓
waiting time at CWC unit	125.41.32	11.18.54	68.29.48		✓
service time at CWC unit	09.04.80	10.01.34	09.08.48	✓	
time to Nutrition unit	00.30.41	00.42.21	00.36.31		✓
waiting time at Nutrition unit	35.41.03	15.21.18	25.31.11		✓
service time at Nutrition unit	03.19.38	06.27.42	04.53.40	✓	
time to locate lab	01.48.68	02.01.05	01.54.77		✓
waiting time at the lab	01.15.48	01.45.32	01.30.40		✓
service time at the lab	67.42.14	41.32.05	54.37.16	✓	