Improving Patient Experience in Healthcare Processes: Discrete Event Simulation-based Approach

Yusta Wilson Simwita[*]

Abstract

In an effort to improve patient experience, hospitals face pressure to streamline care processes. This study used discrete event simulation to investigate strategies to improve patient experience in the treatment process characterized by long waiting times. The study proposes a new model of care whereby trained non-surgeons, such as physiotherapists and registered nurses, are involved in treating patients with minor orthopaedic cases. This proposition is expected to have a positive effect by reducing patient waiting time by approximately 73%. Given that developing countries are facing a critical shortage of healthcare personnel, the realized capacity can save the lives of patients that are not supposed to be seen by surgeons due to inadequate capacity. This study informs healthcare managers and policy makers that patient experience in the treatment process can be improved by adopting less-costly strategies, such as using a mid-level workforce to increase workforce capacity and minimize waiting time. This study focused on a single care process with a limited number of variables. It is proposed that subsequent studies could include more than one care process and more variables.

Keywords: *patient experience, waiting time, discrete event simulation, queueing theory*

1. Introduction

To improve patient experience, hospitals face pressure to streamline care processes to reduce inefficiencies such as waiting time (Agostinelli et al., 2020; HBR, 2019). Long waiting times, unpredictable demand increases, and inadequate resources are vital challenges affecting patient experience (Abo-Hamad & Arisha, 2013; Crisafulli et al., 2019). Waiting for a service is frustrating and can negatively affect patient perception of the quality of care, and for decades this has been a common cause of patient complaints (Shah et al., 2015; Thompson et al., 1996). From a patient's perspective, waiting to receive care, to find out what their diagnosis is, is one of the most frustrating part of patient experience. Waiting for diagnosis results affects a patient's perception about medical care, especially when it goes beyond the expected patient time-limit (HBR, 2019; Suki & Lian, 2011).

Eradicating waiting time inefficiencies could help improve patient experiences in healthcare processes (Abo-Hamad & Arisha, 2013; Crisafulli et al., 2019). A complicating factor is that patient treatment processes are highly complex and variable. In addition, a patient treatment process involves several departments, and requires active collaboration between professionals and practitioners with

[*] University of Dar es Salaam Business School, Dar es Salaam, Tanzania: simwita2009@gmail.com

varied skills (Agostinelli et al., 2020; Russo & Mecella, 2013). In this view, improving patient experience becomes very complicated, given that healthcare has limited resources and unpredicted demands that lead to inefficiencies such as waiting time (Ocloo et al., 2020). As a result, there is growing interest in adopting industrial process strategies, such as simulation, as they have proven to improve the quality and efficiency of manufacturing and other services (Young et al., 2004). Simulation has proved to be an effective tool to improve healthcare processes by identifying and resolving several problems inherent in these processes (Barjis, 2011; Duguay & Chetouane, 2007; Karnon et al., 2012; Santibáñez et al., 2009; Wang et al., 2009). Thus, this study used simulation to explore how to reduce patient waiting time to improve patient experience.

Literature highlights several studies examining patient experience in healthcare processes (Friedel et al., 2023). However, focus has been on the correlation between clinical quality and patient experience (Congiusta et al., 2019) and developing frameworks which suggest a relationship between experience, quality, satisfaction and loyalty behaviours in healthcare. Ponsignon et al. (2015) developed an interactive simulation-based decision support framework for improving planning and efficiency of healthcare processes. There is a shortage of studies that focus on minimizing patient waiting time to improve patient experience in healthcare processes.

More recently, Halabi et al. (2022) used simulation to improve patient experience in a tertiary academic hospital. Their main focus was to improve quality and patient satisfaction. Also, Friedel et al. (2023) conducted a comprehensive review to describe and summarize the process of measuring, publishing, and utilizing patient experience in countries with developed healthcare systems, such as Europe and the USA; and identify possible approaches for improvement. They found out that the comparability of the results for these countries is difficult due to their contextual differences (ibid.).

Drawing from the preceding discussion, the reviewed literature does not clearly indicate how to reduce patient waiting time, and hence improve patient experience in treatment processes. Based on this gap, this study used discrete event simulation to determine how to reduce patient waiting time and improve patient experience in healthcare processes by addressing the research question: How can waiting time be reduced to improve patient experience in healthcare processes? In this study, patient experience comprised the totality of experiences a patient had at multiple touch points along the patient treatment journey: from symptoms to diagnosis, and then to treatment and post-treatment outcomes (HBR, 2019).

2. Theoretical Framework

2.1 Queuing Theory and Patient Experience

The queueing theory (QT) is a mathematical theory widely used with simulation to improve patient experience in healthcare processes (Peter & Sivasamy, 2019;

Yakimov et al., 2017). The QT focuses mainly on the queueing of patients in determining how to minimize waiting time and improve patient flow. On the other hand, simulation mimics the queue to represent the reality in the model. In this context, Aziati and Hamdan (2018) used simulation and QT to model and simulate the queuing system of the patient's current situation using the ARENA software. Their study improved patient experience by minimizing waiting time and improving resource utilization. A recent research by Qandeel et al. (2023) used QT to determine the statistical waiting time and queuing lines at the emergency department to allow decision makers at the King Hussein Cancer Center (KHCC) to increase staff, tools and space.

Other studies that used simulation and QT to explore and improve healthcare processes include Hu et al. (2018), who examined the capability of QT when combined with simulation. They suggested that combining queueing and simulation is a powerful approach to improving healthcare processes. Furthermore, Vass and Szabo (2015) used QT to evaluate frequent patient complaints of waiting time (which is too long), small waiting rooms, and insufficient workforce. They managed to identify the magnitude of the more general problem, the relationship between resources and waiting time, and to provide a way to understand and monitor the performance of the emergency department.

As already pointed out, patient experience comprises the totality of experiences a patient has at multiple touch points along the patient treatment journey, which starts from symptoms to diagnosis, and ultimately to treatment and post-treatment outcomes (Beattie et al., 2015; HBR, 2019). Waiting time has been found to have greater effects on patient experience (Shah et al., 2015; Thompson et al., 1996). This is witnessed in developing countries whereby patients spend two to four hours in outpatient departments before meeting a doctor (Biya et al., 2022).

The QT provides managers with an understanding of the causes of excessive waiting times and the relationship between waiting times and capacity (Patrick & Puterman, 2008). Variation between demand and capacity is the critical cause of waiting time. Derivatives from the fundamentals of QT suggest that to minimize waiting time, capacity must be set higher than demand (Patrick & Puterman, 2008; Qandeel et al., 2023). Several alternatives can be used to manage capacity and demand to minimize waiting time. This includes scheduling resources, e.g., doctors, appointment systems, increasing resource capacity using shift systems, etc. (Elalouf & Wachtel, 2022; Johnston et al., 2022). It is hypothesized that increasing resource capacity in the queues increases the ability to handle patients, thus reducing waiting time.

Literature indicates that QT is massively applied in queueing problems to investigate how to minimize patient waiting time and improve patient flow (Qandeel et al., 2023; Vass & Szabo, 2015). Since this study examined queue problems, QT was deemed more appropriate. However, literature states that QT alone cannot bring comprehensive and complete results. So, to complement this deficiency, QT was combined with simulation to investigate how waiting time could be reduced to improve patient experience in healthcare processes.

Given the context of this study, increasing resource capacity is recommended as a reliable approach to minimize patient waiting time and hence improve patient experience. Resource capacity can be created at the triaging stage by routing patients according to the urgency and criticality of their treatment. Triaging and fast-tracking is a model that gives low-acuity patients their stream so they can spend less time in a queue waiting for treatment. This is because most treatment for low acuity patients uses less time than for high acuity patients. For example, in the case of the orthopaedic care process, 80% of cases are non-surgical, and can be easily managed by other workforce models than surgeons (Comans et al. 2014; Rymaszewski et al. 2005). Thus, this study used simulation to investigate how triaging and fast-tracking strategies could reduce waiting time.

Using simulation, this study proposed an alternative treatment scenario to meet its objective. The scenario involved changing the care model by involving well-trained physiotherapists or registered nurses to handle minor orthopaedic cases. Literature estimates that 34–43% of referrals to orthopaedic outpatient departments do not require management from an orthopaedic surgeon (O'Farrell et al., 2013).

3. Methodology

3.1 System Description and Study Setting

This study was conducted at the Bugando Referral Hospital, located along the shores of Lake Victoria in Mwanza City. The hospital is at the tertiary level serving primarily the lake and western zone area of the United Republic of Tanzania. The lake and western zone constitutes six regions: Mwanza, Tabora, Kigoma, Kagera, Mara and Shinyanga. In general, this hospital serves approximately 13m people. Its capacity is around 900 beds, with approximately 1000 employees.

This hospital is faced with the challenge of improving patient experience. The ever-increasing and unpredictable patient demand makes this problem more complex. Based on the opinion of the management, they are concerned with finding an efficient way of improving patient experience in care processes. The main interest of the management is to find out how to minimize patient waiting time, to improve patient experience. Thus, this study used simulation to determine how to reduce patient waiting time, to improve patient experience.

3.2 Describing Clinical Operations
Immediately after arriving at a hospital, a patient's journey starts with registration at the registration department. Due to the big number of patients arriving at this clinic, some patients arrive around six in the morning although the registration window opens at eight in the morning. After registration, the patient enters the orthopaedic clinic, where s/he must wait for the surgeon. Here, a nurse guides and directs the patient to the surgeon's room when the surgeon arrives. When the surgeon is ready, the patient starts the examination process immediately. After examination, a patient can either be sent for ancillary service, or sent back home if no test is necessary. Those with ordered ancillary service proceed to their respective test as ordered, which can be either an X-ray or a lab test. After completing the test process, a patient brings the test results back to a nurse, who takes them to the surgeon for further diagnosis or decisions on surgery if needed by that patient. It should be noted that after presenting the results to a nurse, a patient has to wait again for his/her turn to meet with a surgeon so that the test results can be translated. A diagrammatic presentation of this process is given as Figure 1. This conceptual model of the studied orthopaedic care process is used for animating this clinic when running the simulation.

3.3 Orthopaedic Department Resources
During this study, four (4) specialized surgeons were working at this clinic. Bugando Hospital also has five rooms set aside for elective and emergency patients. In the operating room, orthopaedic surgeons are allocated two rooms, and are scheduled to work, in pairs, on Mondays, Wednesdays and Fridays. For clinic sessions, orthopaedic surgeons attend to patients on Mondays and Wednesdays, with surgeons working in pairs. Other resources at the clinic include three nurses who escort patients to surgeons for examination when their records arrive from the registration department. The Bugando Hospital also has one central laboratory and an X-ray department (See Figure 1).

3.4 Data Collection and Simulation Model Development
This study was observational; thus, the data collection process, which took three months, covered mainly observational data from the studied orthopaedic care process. To have a holistic view of this care process, patients were traced from their arrival to their departure in the treatment process. The data included arrival time, waiting time at each stage of assessment, assessment or examination time at each point (including time for registration), x-ray, examination at the clinic by surgeons and lab test. The main tools used for data collection were a stopwatch and pre-defined data sheets. In total, data for 233 patients was collected at each stage of treatment. Based on literature, 80% of orthopaedic patients end their journey at the clinic. Therefore, the clinic care process was explored to get essential details regarding the factors affecting patient experience in the orthopaedic care process.

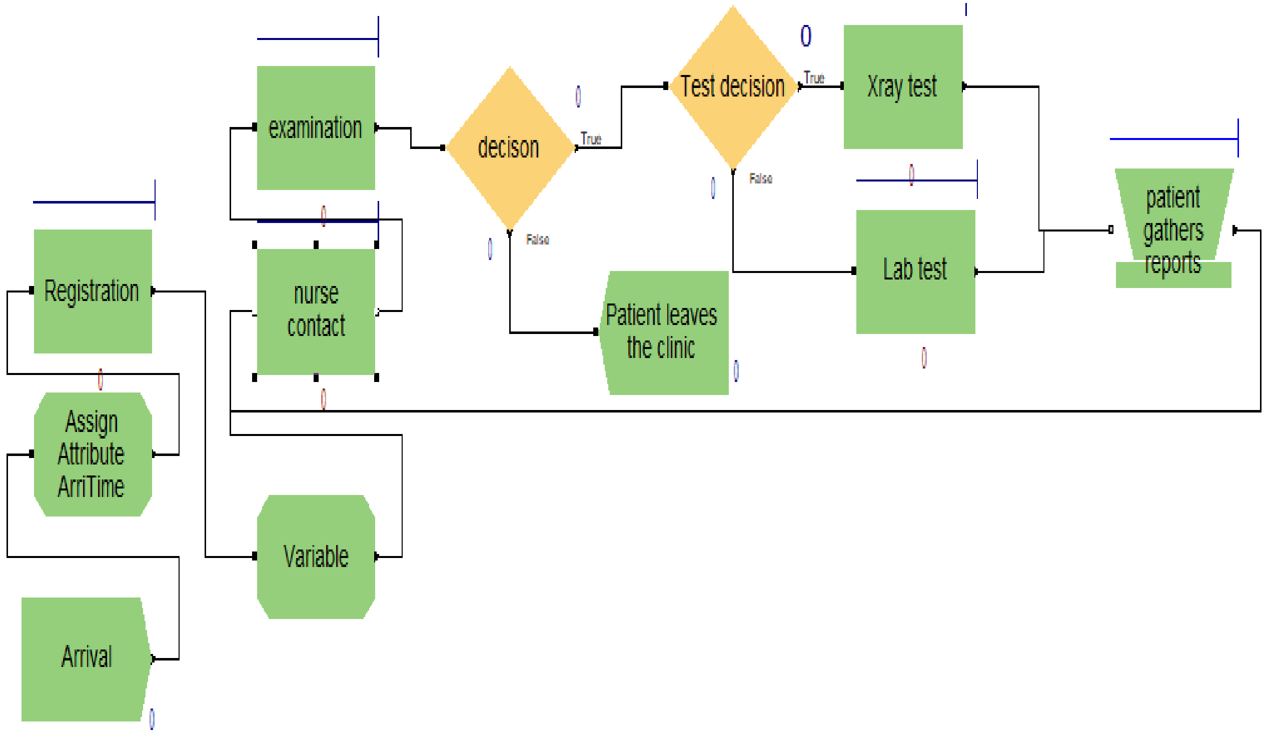

Figure 1: Conceptual Model of Bugando Orthopaedic Clinic Care Process before Alteration
Source: Layout of the Orthopaedic Department (by Author)

The variables were operationalized systematically. Waiting time for this study was defined and measured as the time a patient had to wait for a particular service. Service time was defined and measured as the time a patient used for treatment, operation, registration and any other service such as laboratory and x-ray tests. Patient experience of care was considered the totality of experiences a patient had at multiple touch points along the patient treatment journey: from arrival to diagnosis, and then to treatment in different services.

All key procedures for simulation modelling were followed. First, a detailed analysis of the collected data was conducted for distribution fitting. Statistical analysis—including Scatter plots and linear correlation techniques—were used to assess data independence. SPSS, box plot techniques, summary statistics, and histograms were used to hypothesize families of distribution. Chi-square was used to determine the representativeness of the fitted distribution. Thus, the chi-square for the goodness of fit tests guided the selection of respective distribution. The Arena input analyser was used to generate the parameters of the selected distribution. The generated parameters were used to develop the simulation model, as presented in Table 1.

Table 1: Input Parameters for Simulation Model Development

Process	Distribution	P-value	Chi-square
Arrival	0.5 + EXPO(6.88)	0.0892	17.8
Registration	6.5 + LOGN(10.6, 7.36)	0.0922	17.7
Nurse Triaging	TRIA(0.5,2,6.5)	0.36	13.15
Examination	2.5 + WEIB(15.8, 1.75)	0.413	15.7
X-ray	13.5 + WEIB(4.25, 2.21)	0.476	3.55
Laboratory	19.5 + 17 * BETA(2.76, 3.97)	0.0359	16.9

Source: Analysis of collected data

3.5 Model Design, Verification and Validation

Replicating the actual treatment processes that comprise human behaviour and several decisions into a simulation model was impossible; thus, several assumptions were made to define model limits based on the available data. First, the study considered the operational system only between 8.00 am and 4.00 pm. Secondly, it was assumed that the resources were available for orthopaedic patients all day. Thirdly, this study considered all patients who arrived at the clinic; therefore, they had the same priority in all queues. However, the model used had some limitations. All transfer times (transport times) in the orthopaedic care process were ignored. Also, this study focused only on the orthopaedic department, particularly on the interaction between specialist surgeons and patients; thus, the admission and discharge processes were not included in the model.

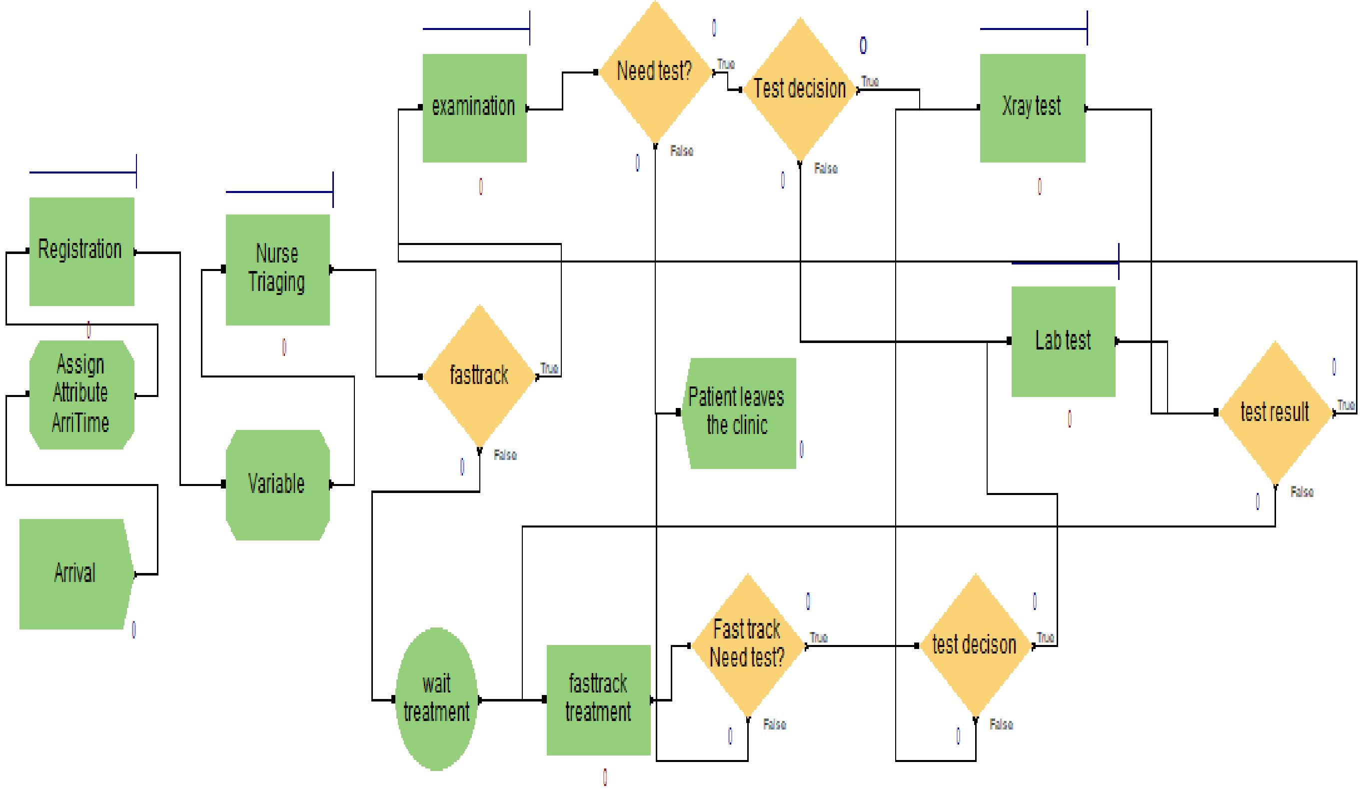

Figure 2: Proposed Conceptual Model after Embedding the Proposition

Source: Redesigned orthopaedic department layout drawn by the author

The verification process of the study was done by using Arena debugging facilities and animation to check whether the model was running as intended and with no errors. During the model validation process, the first step was to ensure that the face validity of the model was relatively high. This was done by involving key orthopaedic specialist surgeons and heads of operating theatre at each stage of the model development. This involved discussing the assumptions and model results with those key personnel of the care process. Patient waiting time for examination at the clinic (see Table 2) was used to validate the model further. As part of the validation process, simulation was run using the actual recorded arrivals at the registration department instead of sampling from exponential distribution, and the same results were obtained.

Table 2: Waiting Time as a Performance Measure for Validation

	95% CI interval for the mean
	Patient waiting time at the clinic
System value	2.1
Simulation value	2.29

Source: Analysis of collected data

3.6 New Model for the Proposed Treatment Scenario

The preceding proposition implies that patients with minor cases will be handled by a registered nurse or physiotherapist. Based on the literature, it was assumed that 34% of patients at the clinic used the fast-tracking stream (O'Farrell et al., 2013). This alternative workforce model means that surgeons will deal with complex and all surgical cases. This proposition will reduce waiting time because more capacity will be available to all kinds of patients, and they will not stay long in the que system. Using simulation, this study investigated how triaging and fast-tracking could help to reduce patient waiting time, and hence improve patient experience in the orthopaedic care process (see Figure 2).

4. Results and Discussion

This study used simulation and QT to explore how waiting time could be reduced to improve patient experience in the orthopaedic treatment process. Using simulation, it was found that triaging and fast-tracking strategies can help minimize patient waiting time in patient treatment processes, leading to improved patient experience. Simulation has proven that after redesigning the care process, the patient waiting time has been reduced by 73% (see Table 3).

This finding is similar to existing literature that used simulation and QT to minimize patient waiting time and improve patient experience (Aziati & Hamdan, 2018). Within the same theme, studies by Abo-Hamad and Arisha (2013), and Halabi et al. (2022): all established a direct association between minimizing patient waiting time and improving a patient's experience of care.

Table 3: Comparison of Waiting Time before and After Reallocating Resources

Waiting time hours	95 % Confidence interval for mean		
	Mean	*Lower bound*	*Upper bound*
Before	2.29	0.52	4.3
After	0.13	0	0.506

Source: Analysis of collected data

As observed by HBR (2019) and Shah et al. (2015), patients prefer not to wait long for service, especially when they have minor cases; otherwise, they get frustrated and rate the experience of care negatively. Thus, to improve patient experience, healthcare practitioners have no option other than to minimize the waiting time in the treatment process.

Using simulation, this study further observed that the critical bottleneck was at the clinic, whereby patients could wait for longer than two hours. As noted by Kreitz et al. (2016) and Rane et al. (2019), most orthopaedic clinics had long waiting times because most of the orthopaedic cases ended at the clinic. The positive result of using simulation, triaging and fast-tracking strategies in patient treatment processes is also reported by Maulla et al. (2009) who suggested that a fast-track strategy significantly improves care delivery to patients with minor conditions. The reduced waiting time indicates that if Bugando orthopaedic clinic implements this strategy, patients with minor treatment will no longer experience long waiting times. This finding will significantly impact the treatment processes of developing countries, like Tanzania, due to limited resources and high crowding in outpatients clinics (Beard et al., 2014).

The reduced patient waiting time does not have the sole benefit of improving patient experience; rather, it has multiple effects on patients' treatment process. As supported by Maulla et al. (2009), the reduced patient waiting time improves patient access to care, leading to reduced mortality and morbidity, which could result due to patients not receiving care at the right time. It further enhances patient flow in the patient treatment process. These effects have significant implications for areas with resource constraints in the healthcare sector. Alternative workforce models like fast-tracking can help countries with limited resources accommodate more patients and reduce crowding in outpatient departments such as in the orthopaedic department.

From the methodological point of view, this study found that the combination of QT and simulation positively impacts the patient treatment process. As noted by Aziati and Hamdan (2018), the use of simulation and QT enhances the exploration of various strategies that can be used to minimize patient waiting time in patient treatment processes. Given the complexity of healthcare treatment processes and scarcity of resources, using these approaches will be useful in finding alternative treatment strategies to accommodate the unpredictable and growing patient demand. Because the cadre of specialized surgeons has few resources, particularly in developing countries, using simulation and QT to find new strategies to meet the ever-growing demand is critical.

The simulation results from this study provide significant insights to healthcare providers aiming to improve patient experience. The reduced patient waiting time suggests that improving patient experience in surgical care processes can be done using other alternative workforce models not necessarily involving surgeons. Thus, healthcare managers should find better ways to utilize existing capacity to reduce waiting time. Using industrial tools such as simulation and QT can enhance this improved process without interfering with the operations of the existing system. Since simulation only mimics the current system, it enables management to see the expected performance of the new system before implementation. This implies that healthcare managers observe the anticipated benefits of improved systems operation without incurring any implementation costs. The cost will only be incurred if management implements the proposed approach.

This study further contributes to existing literature in several ways. First, the presented redesigned model indicates that improving patient experience in healthcare can be enhanced by reallocating the use of different resources in the system. Big crowds in healthcare centres are typical concerns that call for the need to improve patient experience. The effect of reducing waiting time by triaging and fast-tracking is in line with existing literature, which seem to suggest that the use of physiotherapists in the fast-tracking stream reduces patient waiting time, leading to improved patient care (O'Farrell et al., 2013; Oredsson et al., 2011). This study contributes to existing literature on computer simulation in healthcare processes by considering not only the patient waiting time that affects the improvement of patient experience in healthcare processes, but also proposing some workforce models to improve patient waiting time and their effects on patient experience.

The study provides several insights to policy makers in the healthcare sector. The lack of extra capacity in healthcare will always lead to long patient waiting time in the treatment process. Thus, policy makers should focus on finding strategies that can be used to create additional capacity, especially in highly congested areas like in developing countries. Operational research techniques like simulation and QT can help create extra capacity at a minimal cost. The additional capacity required will depend on the policy makers' target of waiting time and the system's demand. If the demand is too high, more capacity will be needed to avoid long waiting times. Due to the cost of healthcare resources, policy makers can focus on utilizing cheap middle-level resources as recommended (WHO, 2013).

5. Conclusion

Through process analysis, simulation has managed to show areas in the process with long patient waiting times in Bugando orthopaedic care process. The critical bottleneck in the treatment process was at the clinic, where patients spent an average of two hours waiting. This bottleneck caused inefficiencies in the process, which affected patient experience. Using simulation, the proposed strategies of triaging and fast-tracking reduced patient waiting time by 73% in the treatment process. Reduced patient waiting time improves patient care experience in healthcare processes. This study has shown the power of simulation and QT in identifying and resolving problems affecting patient experience in healthcare processes.

Two limitations have been observed in this article. First, simulation does not consider transfer times, varying capacities and locations involved in the orthopaedic care process. Secondly, simulation considered only patients whose journey ended at the clinic. Subsequent studies could explore the entire process.

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