Resolving Waiting Time Issue in Healthcare: A Simulation Modelling Approach

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ABSTRACT

Healthcare Services across the globe are going through a very challenging phase under the current economic uncertainty. Among many other public services which are under the financial scrutiny healthcare services is the most affected one. This is primarily attributed to severe funding cuts and reduced headcounts that have resulted in long waiting queues for a variety of medical treatments. The delay in treatments due to the lack of resources have caused huge outcry among the general public. Therefore, healthcare services are under immense pressure to reduce their inefficiencies and improve their operational performance. Inspired by the on-going challenges faced by the healthcare service organisations, this research aims to study the role of discrete-event simulation modelling tool in reducing the waiting time issues. This research investigates waiting time issue faced by the physiotherapy department of an Irish hospital. The data for the simulation study was collected through personal visits to the physiotherapy department. As a first step towards the simulation modelling, a process map of the department was constructed. Thereafter, simulation model was developed and tested for alternative scenarios to tackle the waiting time problem. The result shows that simulation modelling can be a very effective tool in resolving the waiting time issue by providing managerial decision makers vital information on how to use their resources efficiently.

1. INTRODUCTION

The Irish public healthcare service is currently going through a tough phase with severe funding cuts, reducing headcounts, and long waiting lists for a variety of treatments due to constrained resources. Data released by The Department of Health and Children [1] shows that the public health sector employed approximately 109,753 people in 2009 making it the largest employer in the state. In 2007 highest number (111,505) of people were employed in public health sector however, recent figures from 2011 shows that this number has now reduced to 104,287 with strong indication of further job cuts in coming years. Reports also show that capital public health expenditure [1] has reduced from €585m in 2007 to €366m in 2010. These findings clearly indicate the extent of impact of recession on Irish healthcare sector. The findings also suggest that public healthcare services need to strive hard to improve their performance to cope up with the existing challenges.

Process improvement as an approach has been widely used in the manufacturing industry since the 1980's and extended from there to service industries ranging from fast-food to banking. However, it has more recently become readily used in the public sector and in the health sector. As a result of this interest, there is now an incipient literature in the field of healthcare process improvement [2]; [3]; [3]; [5]. Many process improvement methods frequently used in the manufacturing sector such as process mapping, process redesign, lean and six sigma are now being widely applied in healthcare sector. Benedetto [3] reports a case study of the usage of the six sigma approach to process improvement in a radiology records department in a US hospital. A large scale deployment of process improvement programme in a US hospital was reported by [6]. Koning et al. [5] showed the use of a lean six sigma approach in improving quality and controlling costs in a Dutch hospital. A study by Taner et al. [7] on the other hand emphasized the use of flowcharts and cause-effect diagrams to identify improvements in a number of hospital processes and suggested that the use of lean six sigma techniques can improve healthcare quality while simultaneously increasing efficiency and reducing costs.

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Simulations in healthcare has been used for last few decades, however, in recent times there has been a rapid growth in the application of simulation for the purposes of improving patient safety and patient care through a variety of applications [8]. Benneyan [9] states that as healthcare organisations strive to remain competitive, simulation can be a valuable tool in an increasing number of Total Quality Management (TQM) and process redesign efforts. Simulations have been quite effective in studying and resolving waiting time issues in hospitals [8], [9]. Process mapping, another popularly used improvement tool and a first step of the simulation modeling approach has been applied in a wide range of industries [10], including manufacturing [11], construction services [12], and healthcare services [13]. Potter et al. [13] showed that hospitals usually examine their work processes involved in patient care in an effort to streamline the processes, gain productivity, reduce costs, and maintain quality. Soliman's [14] research also indicated that business process mapping is a very common industry practice to illustrate the current state processes within companies in order to identify process gaps and future state goals. According to Siha et al. [15], process mapping offers a 'visual aid' to process improvement and provides a means for analyzing the process. They further state that it is a framework that shows relationships between the activities, people, data, and objective. Studies have indicated that the visualization and understanding of the processes helps organizations to identify the possible source of problems and take actions to address them.

The literature emphasises several factors critical to successful outcome from the process improvement- linking with organisational strategy, training in use of techniques, involvement of stakeholders and communication as in [6], [7], and [13]. These research evidences show that healthcare services around the world can benefit greatly by implementing process improvement plans. Particularly healthcare organisations can greatly benefit in reducing their waiting times using simulation models as in [8], [9]. A review of literature indicates that there is very limited research on Irish hospitals that particularly addresses process improvement issues. Ennis and Harrington [16] conducted a quantitative research study of quality management in the Irish health-care sector. Their findings suggest that quality management is what hospitals require to become more efficient and cost-effective. Their research focus was primarily on strong committed leadership and its role in overcoming tensions in quality implementation. In another study, Ennis and Harrington [17] investigated the factors surrounding quality implementation in the Irish healthcare sector. [1]'s study is one of the few studies that reports on quality improvement in Irish hospitals. His qualitative study investigated the real extent to which TQM (Kanji's model) is adopted within healthcare organizations and the way it is put into practice, particularly in Italian and Irish hospitals. His findings indicated that in both countries quality of services is crucial; however, none of these countries have quality as their main or unique concern. The findings suggested that TQM was not very well adapted in these two countries. Gavazzi, [18] supported this by performing a comparative analysis of issues in cost, quality, and access to improve global health delivery between the US and Irish healthcare systems. Their research reported that very few hospitals in Ireland have actually implemented TQM. Although these studies discuss implementation of TQM in Irish hospitals but they clearly show that Irish hospitals are far behind countries such as UK and US. Moreover, literature reporting on adoption of other process improvement plans is scarce. Therefore, this research attempts to fill this gap by reporting a study of an Irish hospital and their adapted approach for performance improvement.

Motivated by the on-going struggle of Irish healthcare services to cope up with the challenges posed by shrinking resources, this research aimed at working closely with a large Irish public hospital and improve the waiting time of their physiotherapy department following the simulation modeling approach. The physiotherapy department was looking at ways to improve their performance and reduce their waiting times. The physiotherapy department is among thirty outpatient departments in the studied hospital which handles approximately 240,000 outpatient activities each year. This department deals with treatment of individuals to develop, maintain, and restore maximum movement and function throughout life. This includes providing treatment in circumstances where movement and function are threatened by aging, injury, disease or environmental factors. Orthopaedic therapists deal with diagnosis and treatment of disorders and injuries of the musculoskeletal system including rehabilitation after orthopaedic surgery. Cases of bone fractures, acute sport injuries, sprains, strains, back and neck pain, spinal conditions and amputations are dealt with by the therapists. The orthopaedic physiotherapy department studied in this research included five therapists and two administrative support staff. These therapists were of three different grades: one senior physiotherapist, one clinical specialist and three basic grade physiotherapists. The department of the hospital was struggling to cope up with constraint resources and increasing patient numbers. The waiting time was one of the primary issues that this department was struggling with. Another issue that the department was facing was the lack of clear visibility of the processes followed in the department. The research was, hence, aimed at addressing these two prime issues of the physiotherapy department.

To address these two issues a simulation modeling approach was adopted in this study. This approach involved steps of process improvement: (a) defining the current process/situation (i.e., process mapping), (b) identifying the problems/issues that need to be addressed, and (c) proposing a new process that addresses these problems/issues. The

methodology formally maps the activities executed by the physiotherapy department and simulates the activities in real-time environment. Process-mapping identifies the core value-adding activities and the core control activities while a discrete-event simulation model is calibrated against department activities so as to create and examine an alternative scenario for the physiotherapy process. In order to achieve the best outcome from the devised tool, some procedural changes were made by way of process re-design that have improved the efficiency of the department. As an initial step towards devising the methodology, the multi-step integrated approach was followed that comprises of a set of preliminary interviews, examination of documentation, observation of processes, iterative mapping of activities and development of a simulation model. There is also a lack of evidence of the application of process improvement plans and simulation modelling in Irish healthcare sector. Therefore, this research is one of the very few studies of its kind that reports on the application of performance improvement plans and simulation modeling particularly in Irish healthcare sector.

The remainder of this paper is organised as follows. Section 2 discusses the methodology adopted in this research. Results and analysis of the proposed approach are illustrated in Section 3 together with key recommendations. Section 4 concludes the paper with future research directions.

2. METHODOLOGY

The project started with the three-pronged research approach of examining, documentation, carrying out in-depth interviews with physiotherapy staff, and observations of the processes in action. Thus, the research follows a triangulation-based research methodology in order to gather data from interviews, documents, and observations [19]. Research identified that a relatively little documentation of the existing processes in the physiotherapy department existed. The available documentation was carefully examined. In-depth interviews were held with department managers, therapists, and with administration staff. One member of the project team spent several weeks during a two-month period of time in the department observing the activity of therapists and administrative staff. The process analysis procedure itself was carried out in four steps: process mapping, process analysis, process redesign, process testing (through simulation). The next section elaborates the process mapping in detail.

2.1. PROCESS MAPPING AND ANALYSIS

Process mapping is the first step of the simulation modelling approach. The preliminary research of the physiotherapy department also pointed out the lack of visibility of the processes within the department. Realizing the lack of visibility in the physiotherapy department, the first stage of the research involved mapping the processes of the department. Five primary elements are associated with the treatment process carried out by the physiotherapy department as shown in the high level map of the physiotherapy treatment process (Figure 1). The first primary activity in the process is labelled as 'referral' and includes receiving in the patient and recording their details. The second activity is to carry out a 'triage', to prioritise the nature and urgency of the case and treatment of the acute patients through its decision-making process. An appointment for treatment is made according to urgency of the case. Appointments are usually made for some future date but for certain cases, for example fractures, an appointment may be scheduled for immediate treatment. The fourth activity is to carry out the actual physiotherapy treatment itself. The final activity is to end treatment by discharging the patient. In the process map, some of the activities are of value-adding nature for the patients in the context of treatment and some are important control processes for the hospital, although those are not value-adding in nature.

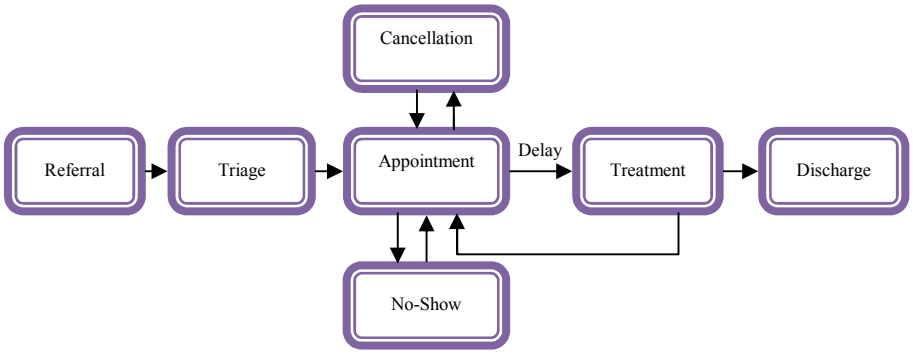

Figure 1. High Level Process Map.

The appointment activity leads to one of three mutually exclusive outcomes: treatment, cancellation or no-show. As noticed from the high level process map (Figure 1), the process includes a primary feedback loop where patients iterate between treatment and appointment until the treatment process ends. There is usually a delay between appointment and treatment. Auxiliary activities like cancellation, no-show are initiated by the patient who contacts the physiotherapy unit, typically by telephone, to say that they will be unable to make the scheduled appointment. A considerable number of appointments result in cancellation and the cancellation rate (termed as CNA for cannot-attend) is a key metric for the physiotherapy unit. The no show activity on the other hand is initiated by the physiotherapy unit itself. This activity examines the appointment schedule to identify those patients who have not turned up for treatment and to decide whether or not another appointment should be made for these patients. At the time of this research data showed that approximately 10–15% of patients do not show up for appointments. The no-show rate (termed as DNA for did-not-attend) is also a key metric of performance for the physiotherapy unit.

2.2. PROCESS REDESIGN

As stated earlier, this research adopted a process-mapping and a discrete-event simulation model approach to create and examine an alternative scenario for the physiotherapy process. After the process mapping of the physiotherapy department was completed, the research aimed at improving the efficiency of the department. A novel integrated approach for the healthcare decision-making problem suggested to the concerned department is illustrated in Figure 2.

In the proposed approach the key actors of the physiotherapy department, particularly those associated with orthopaedic stand of treatment, and a small number of patients were interviewed. A comprehensive research was carried out to identify key metrics and the major current issues in the functioning of the department. The existing documentation relevant to the physiotherapy treatment process, including referral letters, appointment cards and the appointment information system, were also examined. The entire physiotherapy process, beginning from the entry point to the department till the end of it, was observed and documented. The approach suggests the development of the process map in an iterative manner using a commonly available specialist process mapping software tool. The draft map was reviewed by a member of the physiotherapy staff at the end of each iteration. A model was developed that simulates the current physiotherapy treatment process for orthopaedic patients. This simulation model was created using a standard discrete-event simulation software package SIMUL8.

The physiotherapy department of the hospital intended to identify the elements of the service process so as to interpret the whole process. The department further planned to identify different types of services required by the customers and simultaneously observe the contact time of the customer with the service personnel. Further, the activities executed within the department are to be visualised in order to decide the best possible mode of the activities performed under constraints. Therefore, physiotherapy department of the hospital also intended to investigate the impact of a change in the scheduled activities avoiding the possible inherent and adverse risks and subsequent disruptions of the schedules. The likely impact of an increase in physiotherapy resources on patient waiting time was also examined. Based on the data collected from the physiotherapy department of the hospital the simulation model was constructed and results were analysed. The next section reports the findings from the simulation model.

2.3. PROCESS REDESIGN AND TESTING USING SIMULATION MODEL

The data for the simulation study was collected by one of the researchers through personal visits to the physiotherapy department of the hospital. Data was collected during a week-long visit to the hospital during the hours between 9.00 am and 4.00 pm. Some secondary data in form of the historical data was also provided by the department. The process mapping elaborated in section 2.1 is then converted into a discrete-event simulation model based on this data and on the results of the process analysis. The model was then used to examine a different work arrangement scenario in order to remodel one of the major issues faced by the physiotherapy department i.e. excessive waiting time. The components of simulation model are explained below.

The designed simulation model consisted of three work entry points, one each for the new patients, fracture patients, and calls/letters. All three entry points are modelled as arrival processes with average inter-arrival time of 38 minutes for new patients, 32 minutes for fracture patients and 15 minutes for CallsnLetters. The time allotted is based on the data provided by the department. After the entry all arriving patients wait at the ‘Rehabilitation Desk’ for their referral card verification. And the details are collected at the point referred as ‘Queue for Admin Staff’ which also consists of patients who have already been treated and are awaiting further treatment, known as return patient. The model also consists of two work centres as there are two administrative staff in the department. After this point the entries are separated into streams once the processing at the ‘Rehabilitation Desk’ is complete. The patients are then collected from the separate bins using three work centres in the simulation model. The purpose of these work centres patients is

to circulate patients to the various therapist queues. The percentage of patients circulated to each therapist is specified in the 'routing-out' parameter in the model. These routing out parameters are decided according to the collected data. The model also consists of therapist component in the model representing the treatment process of the patients at the therapists and the triage process in the process mapping stage deciding the treatment of the patients either by the therapist, clinical specialist or basic grade staff. Afterwards the simulation model collects different types of patients separately once the treatment at the therapist stage is over. The separation of the return and discharge in this simulation process is achieved by sending return patients to the return patients bin and discharged patients to the discharge box. The patients are collected in three bins according to their labels. The information on the waiting time for patients between submitting referral cards and receiving treatment is then finally stored in a new bin. The distribution of the patients is modelled according to the collected data. The final component represents the end part of the simulation model and indicates discharged patients, i.e., patients whose cards have been placed in the discharge box.

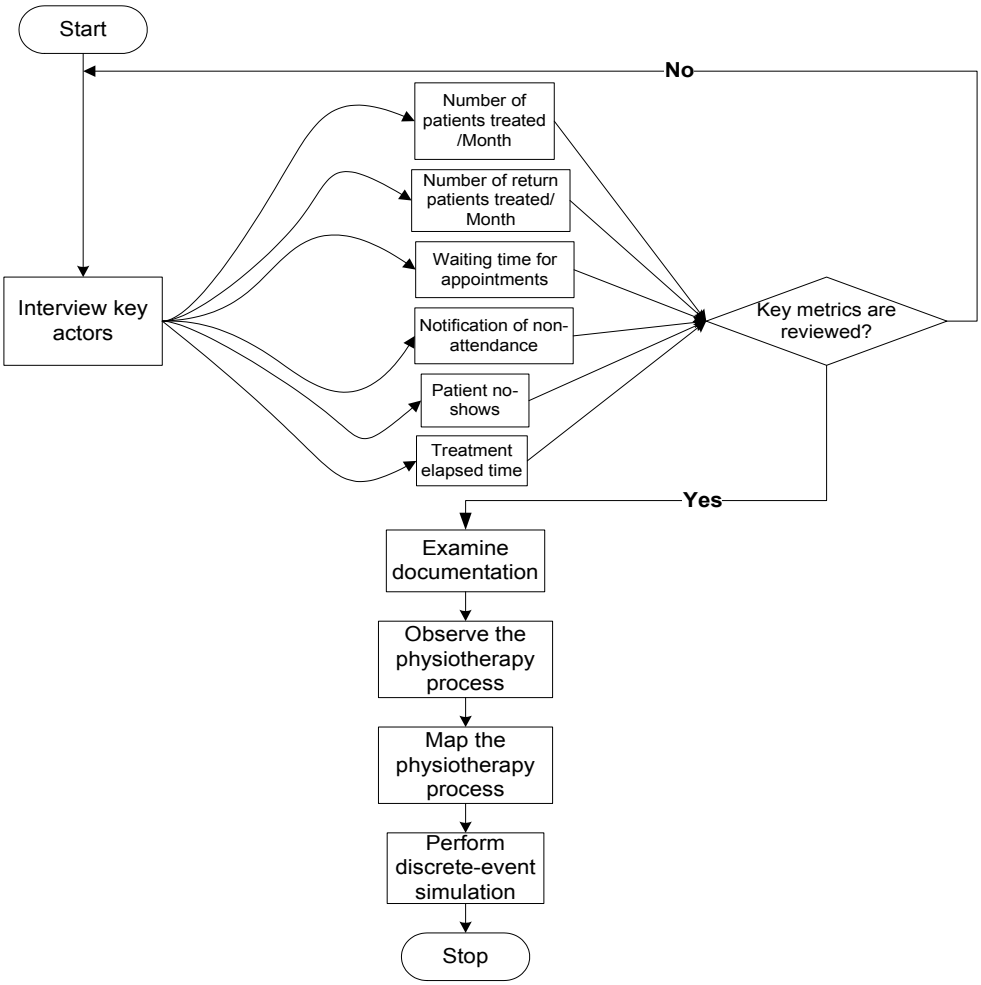

Figure 2. The proposed steps for the process redesign decision.

3. RESULTS

The simulation part of the integrated process-analysis tool was run based on the data collected from the hospital. The simulation was modelled using SIMUL8 software (Figure 3). Simulation was run a number of times and results of different runs are given in Table 1.

The simulation results presented in the table closely matches the real system data of the hospital. The management team was quite keen to know what would be the effect of hiring a new full time therapist. This was resolved with the

help of the devised integrated process-analysis tool having an additional therapist in the system. This is modelled by keeping the therapist's efficiency to be constant and varying the input parameters like patients arrival. The results of throughput are indicated in Table 2. From the results, it is evident that the addition of a new therapist increases the throughput of this department by 23.1 % which is a significant increase.

Table 1. Simulation results using the integrated process-analysis approach.

Runs	NP immediate waiting time(days)	NP routine waiting time(days)	Return patient waiting time(days)	Fracture patient waiting time(hrs)	Throughput of new patients (per year)	Throughput of fracture patients (per year)	Throughput of return patients (per year)
1	4.61	21.75	8.59	6.04	1603	2910	2919
2	4.70	23.95	8.81	6.13	1593	2931	2929
3	5.09	21.76	8.81	6.41	1520	2892	2981
4	4.44	21.78	8.55	6.26	1540	2939	2947
5	4.77	22.42	8.58	6.32	1511	2883	2910
Average	4.77	22.33	8.67	6.23	1553	2911	2937

* NP: New Patient

Table 2. Throughput found from the simulation model.

Patient type	Throughput average	Increase with respect to initial model
New patients	1918	23.1 %
Fracture patients	3222	10.68%
Return patients	3319	13.1%

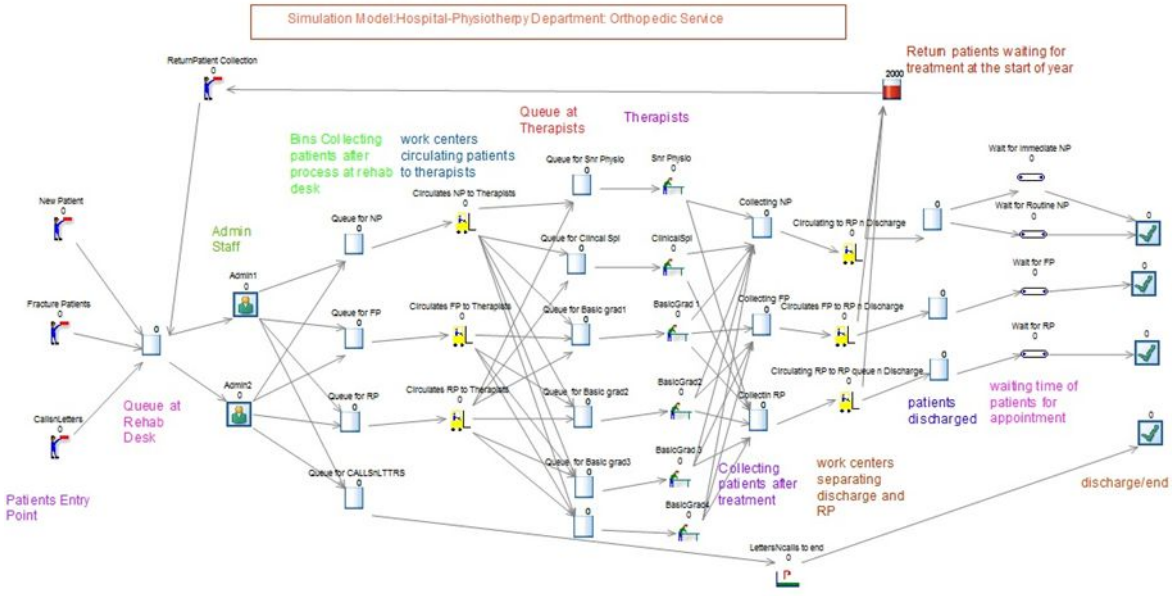

Figure 3. Snapshot of the Simulation Model.

3.1. KEY RECOMMENDATIONS

This research attempted to identify some key issues faced by the physiotherapy department and suggested some recommendations to the management team based on the findings from the process mapping, simulation modelling, and personal observations. Some of the key problems faced by management team at the physiotherapy department and the recommendations to resolve those problems are outlined below:

(i) Did Not Attend (DNA) rate was very high in the physiotherapy department. DNA in this department was around 10-15% every month. This causes problems for other patients and leads to unnecessary increase in patients waiting time. In order to resolve this issue, the management team was suggested to adapt a Text-alert system, to remind patients by sending a message 2-3 days before the scheduled appointment. This suggestion was based on the fact that a Text-alert system has been implemented successfully in a nearby local hospital which reduced the average DNA rate to 6% per month, significantly below that of the hospital under study.

(ii) Administrative staff, while giving appointment to patients through phone, faced bottleneck with calls connecting to country side. It was found that no access to the direct lines was taking considerable time in getting through to the patient thereby causing queue formation at the rehabilitation desk. This study recommended a direct line and a direct telephone line has been provided, based upon the outcome of the proposed model, so as to facilitate the accessibility from the rehabilitation desk.

(iii) The study also suggested using process map at various locations within the department such as at the appointment desk, waiting area, and near the working desk of the therapists and support staff members to increase the visibility and understanding of the processes. The management team has admitted the benefit of the process mapping exercise post this study.

(iv) The use of simulation modelling was also recommended to tackle the waiting time issue by predicting in advance which option would be best to handle the increasing demand in certain periods over the year and in other situations. The simulation assisted the senior management team in making key decisions regarding hiring or shifting the workforce to the required area of the department whenever required. The department is currently considering developing fully fledged software following the simulation model constructed during this study.

4. CONCLUSIONS

The first part of the integrated approach provides a number of benefits to organisations as it identifies the elements of the service process and allows a clearer understanding of the whole process. The approach provides additional benefits such as, identification of different types of services needed by customer, the type of service needed according to type of customer, and contact time of the customer with the service personnel. A good process mapping exercise identifies the core value-adding activities and the core control activities. Identification of these activities provides management with the opportunity to focus on these key activities which are essential for delivering a quality service and to place less emphasis on or remove peripheral or non-value adding activities.

The second part of the integrated approach, i.e., simulation modelling allows the management team to investigate the impact of a change in the activity in the organisation without the possible risk and disruption of testing such a change in real-life. This reduces the inherent and adverse risks while allowing estimation of benefits. The success of such a simulation study depends on a thorough understanding of the process, gained in this case through detailed process mapping and extensive field observations. The integrated approach provides a great deal of information to the management that can be used in determining the future strategies of an organisation or department. An auxiliary benefit is that the first part of the approach can be used in induction programs for new trainees in order to assist them to have a full understanding of the service organisation before formally taking up their roles.

The application of process mapping and simulation modelling is not a new phenomenon in healthcare sector but the study reporting their application in Irish healthcare context is limited. Future research will aim at studying the process improvement initiatives of other Irish hospitals and conduct a benchmarking study. The level of awareness of the staffs is also crucial for the success of the process improvement plans hence, research can further investigate the level of awareness at all the levels within a hospital. Future research can also look at the integration of the process mapping and simulation modelling tool with other planning tools like quality function deployment to enhance the performance of the department and reduce the waiting time.

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