

**Maximizing patient flow in the provision of cardiac surgery care**

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A dissertation submitted to Trinity College Dublin  
in partial fulfilment of the requirements for the degree of  
Master of Science in Health Informatics

**2012**

## **Declaration**

I declare that the work described in this dissertation is, except where otherwise stated, entirely my own work, and has not been submitted as an exercise for a degree at this or any other university. I further declare that this research has been carried out in full compliance with the ethical research requirements of the School of Computer Science and Statistics.

Signed:\_\_\_\_\_

Sajeesh Kesavan.

4<sup>th</sup> September 2012

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#### Abstract:

Patient flow is the process of providing timely and efficient care. Hospital operational efficiency can be achieved by optimizing patient flow. Modelling patient flow in health care system is vital in understanding the real functioning of the system. This research explores the factors responsible for maximizing patient flow in the cardiac surgery care process specifically. In exploring these factors due importance is also given to the ICT implications on patient flow. Using the research methodology of interviewing and queuing theory applications, it has been identified the factors responsible for optimized patient flow. This research process points out the operational efficiency of the operating theatre and intensive care unit in particular. It is identified that operational limits of the specified units are stretched to its maximum limits. Downsizing the existing system can have negative consequences for patients. However, scope for efficiency is substantial. Change in work flow practices and interoperable information system dedicated for data mining of the patient flow process are the recommended solutions.

## **Acknowledgements**

I would like to take this opportunity to dedicate my entire coursework to my mom who passed away recently. I thank her sincerely for her support and encouragement for my studies during her last days.

On this occasion, I would like to thank my supervisor Mary Sharp for guiding me in building this thesis layer by layer. Her constructive criticism and timely reply is very much appreciated. Lucy Hederman, my course coordinator, for the last two years helped me immensely and contributed significantly in building my research knowledge.

I would like to thank all my colleagues at work and in college for their unduly support. I thank all the participants of the interview who found their valuable time in sharing their knowledge. I would like to thank my friends in helping me in understanding the basics of mathematical modelling.

My wife Maya, daughter Meera and my two month old son Mithun, missed you all for the last year. Thank you very much for being very patient and kind enough in understanding the situations.

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**Abbreviations:**

ICT – Information communication and technologies

OT - Operating Theatre

ICU – Intensive Care Unit

TPOT – The Productive Operating Theatre

CUH – Cork University Hospital

JCAHO- Joint Commission on Accreditation of Healthcare Organizations

IHI – Institute of Healthcare Improvement





## **Chapter 1 Introduction:**

This section provides a brief introduction to the concept of patient flow, background of the Research site. This section outlines the objectives the author wishes to accomplish by this research process. The author will describe the concepts of patient flow and its impact on the Irish healthcare system.

### **1.1 Introduction:**

“ the challenge is to make change rather than to observe change”.

(Dept. of Health & Children, 2010).

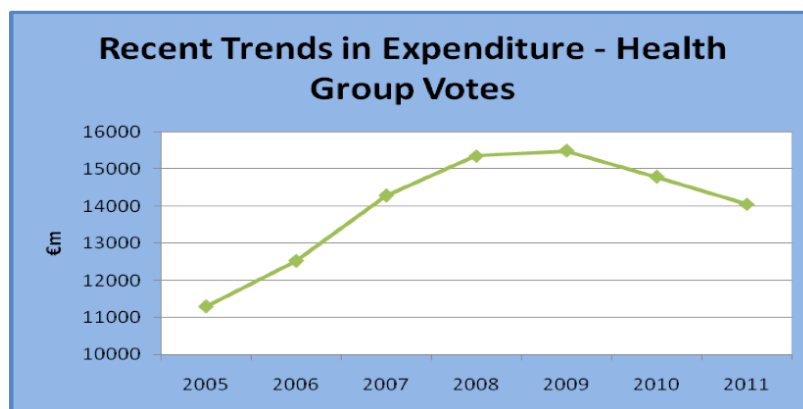
The global chanting in healthcare sector is “Hospitals to do more with less”. From the operational research point of view, its being efficient with less resources. One of the major element in improving efficiency in healthcare is by improving patient flow. Patient flow in healthcare industry is the efficient and timely process of providing health care. Health care industry unlike other service sectors is a very complex area with highly volatile field. Different types of patient samples, high level clinical decision making requirements are few of the complexities involved in patient flow. Hospital areas are always exposed to undesired effects leading to various levels of uncertainties. Katrava et al., (2009) describes, the global view of the patient flow focuses on the concept of patient process and on its efficiency. Disruptions to patient flow are commonly seen in the form of inefficient transfers between units, or high utilization of the patient units. Hence, efficient flow of patients is very important because it can reduce costs and increase bed turnaround (Rojas (2010) cites Jenson ( 2005). Cote. M.J., (2000) describes, patient flow concepts share four common characteristics namely,

- a. an entrance,
- b. an exit,
- c. a path connecting the entrance to the exit and
- d. the random nature of the health care elements.

Ireland like any other developed nation faces a herculean challenge in maintaining a sustainable health care delivery system with scarce resources. The challenges here includes increased consumer expectation, demographic pressures and coping up with the advanced technological changes.

Dr. James Reilly T.D. Minister for Health, Ireland (2011) cautions, “The extent of the financial crisis facing Ireland, and the challenges which this poses for health in particular at a time of growing demand, means that the Government must press ahead with major health sector reform. Only in this way can we deal with the lack of equity in the health system, and the very significant waiting lists”.

The below figure mentions how the budgeting for healthcare has plateaued and in a downward trend recently.



**Figure 1: Recent trends in Health Expenditure ( Dept. of Health Comprehensive Review of Expenditure ,Sep.( 2011).**

Clearly the onus is on the health care managers in delivering services with higher quality in the most cost effective and efficient manner. Hence, the effective management of hospital resources is vital in meeting the growing demand for the hospital beds (Health Strategy Implementation Project, 2003). The HSE Corporate Plan 2008 – 2011 aims to focus on reducing the patient length of stay in acute hospitals by converting inpatient work to day case work. It also plans to reduce inpatient bed numbers and associated costs. This is in view of the fact that, operating room (OR) department is a key hospital resource in any acute hospital. 60 – 70% of all hospital admissions are caused by surgical interventions and it has been estimated that it accounts for more than 40% of the total expenses of a hospital (Guerriero &



Guido, 2010). Appropriate scheduling of operations and matching patient requirement are pivotal in maximizing the patient flow.

Under the National Recovery Plan 2011 – 2014, total current expenditure for the public health service is being reduced by nearly €1.1 billion. However, in order to meet the worsening economic situation, an excess of € 2 billion will have to be taken out of the health budget over the same period. Adding to this cuts, the Plan also aims to reduce the public sector workforce by 23,500 by 2015 of which the health sector will be a major contributor. To withstand these adverse conditions health management gurus are busy in developing strategies in being flexible, creating new ways of working, how to eliminate waste and streamlining the health system.

The Department of Health Statement of Strategy 2011-14 has identified the key factors in improving patient flow which are :

- “Money follows the patient” financing mechanism throughout the public hospital system. This involves treating a person on a ‘per patient’ basis. Hospitals will be paid according to the service rendered and will be eligible for incentives based on their service value.
- Establishing how consultants and other health professionals work, modernizing rostering and organizational arrangements.
- Gradual phase out of acute hospitals into independent hospital trusts. These hospitals will be not-for –profit trusts with managers accountable to their boards. The board members plans to be comprised of local communities and staff.
- Formation of a patient level costing project which traces resources actually used by individual patients during their flow process.

All these above mentioned plans can have a deeper impact on the patient flow in the future Irish hospitals. However, it should only maximize the patient flow. The ultimate aim of these reforms are to achieve a single –tier health service which will deliver equal access to care based on individual needs. The Department of Health and Children concedes that the only way

to achieve savings in the running of hospitals is by reducing the funding and improve efficiency.

Total cash reductions required 2012-2014 is explained in the table below.

Parameters	2012 €m	2013 €m	2014 €m	Total €m
Annual savings Target as per Dept.	-317	-194	-151	-662
Full Year cost of 2011 savings	-7	-8	0	-15
Employment control framework target	-52	-52	-52	-156
Total cash reduction required	-376	-254	-203	-833

**Table 1: Table 1.0: Recent Trends in Expenditure for the Health Group of Votes** (Department of Health Comprehensive Review of Expenditure, Sep. 2011)

This table outlines the savings targeted from the healthcare budget in the coming years.

## 1.2 Background

The overall healthcare scenario in an Irish perspective is undergoing a sea change and it has too. This sea change in the health sectors has motivated us to revisit the concept of patient flow. Cote. M.J., (2000) states patient flow as an aggregate is equivalent to the demand in the health care services. This research aims to focus on the patient flow activities of Department of Cardiothoracic Surgery, Cork University Hospital (CUH). CUH is the largest hospital in Ireland with more than 1000 beds (CUH –HSE, 2011). Cork University Hospital is the only hospital providing cardiac surgical services to the population of southern parts of Ireland. In 2010, the division of Cardiac

surgery performed 445 cardiac cases (Cardiac theatre log book, CUH 2011). After shifting its services into a newly build 85 million euro , state of art Cardiac renal centre, the pressure on the department to provide its services to the public optimally is immense. This newly build centre includes a modern two operating rooms, 10 bedded cardiac intensive care unit, 10 bedded High Dependency Units and 34 bedded cardiothoracic ward. 90% of the persons being operated are elective. The author in this research focuses on achieving optimal patient flow within these departments in the delivery of patient care.

Ideal patient flow rate can be achieved by faster response times but with scarce resources, these delivery requirements are seldom met. Public hospitals are very vulnerable to these conditions. For example, increased waiting time for cardiac surgery has a definite negative impact of the quality of life of patient suffering from atherosclerotic heart disease ( Rexius, et al ., 2005). It is not a surprise that inpatients are absolutely dissatisfied with the current patient flow rate .A study by Landry & Phillippe ( 2004) cited in Hanne, et al.,(2007) revealed that logistics related activities account for about 46% of hospitals total budget. Despite its importance, the role placed by logistics is often overlooked by health care organizations. Due to the stagnated patient flow, patients in the inpatient units are not able to vacate a bed and leave the unit because service delivered to them are untimely. Decrease in revenues has forced the health care system to institute intensive cost reduction programs. Despite implementing these initiatives, some health care systems are still having difficulty in decreasing costs.

### **1.3 Motivation for the proposed research**

The author works in an environment where the challenges for optimal patient flow are enormous. Some of the problems facing the optimal patient flow rate here are inadequate information systems, others from resistance to change by staff or authorities and also the whole complexity of the health care delivery processes. One of the major challenges for a day-for surgery operating room is accurate coordination and timely situation awareness. Smooth, efficient patient flow relies on accurate, real-time situation awareness owing to

frequent and often unpredictable changes in workflow (Hu, P.F et al., 2006). To provide real-time information on events and changes, most solutions require a labour intensive process to input and update clinical information systems. Care givers seldom understand the change in demand patterns, the inter-relatedness of resources and demands in their daily workflow. Also existing information systems do not capture data related to the detailed sequence of patient flows in the hospital because of the integration, interoperability and infrastructure issues within these information technologies (Konrad, R.A., 2009).

Hospitals these days are decentralized that each unit functions individually where the authors Unit is no exception. Hence, patient flow rate is often slowed down because only coordinated care between the various departments can improve patient flow rate. Hospital staff are focusing more on individual unit operations and its productivity, without considering the impact on the rest of the hospital. Working amidst these challenges motivates the author in proposing to carry out this research.

#### **1.4 Research Question and Study Aims**

The Research question for this study is :

- How efficient is the current patient flow in a cardiac surgery department in a public hospital?
- How to maximize patient flow in the provision of cardiac surgery?
- How can ICT solutions pave way for maximizing patient flow?

The objectives of this study are to:

- Identify the current patient flow process in the cardiac surgery patients.
- Calculate the efficiency and the utilization rates of the services provided by cardiac surgery department.
- Evaluate if ICT solutions can impact the current patient flow process.
- Evaluate the challenges in implementing ICT solutions.

## 1.5 Overview of the Research

This proposed research was carried out by using Queuing Theory Model and a semi-structured interviews of the staff involved in management levels which includes consultants, nurse managers, IT head of the hospital. The Queuing Theory Model was used to calculate the efficiency and the service rate of the cardiac surgery department. The Interviews led to the analysis of current patient flow, work culture, challenges in implementing patient flow solutions in the department. The research action was preceded with a review of literature. The literature review was carried out to identify the patient flow concepts, its advantages, barriers, facilitators, how technology can improve patient flow. The Literature review also led to the identification of patient flow parameters mathematically and formed a basis for the interviews of the operational heads of the department.

## 1.6 Overview of the Dissertation

Chapter 1 This chapter has presented the introduction to patient flow, background, motivation for the research, the research question, its objectives and an overview of the dissertation.

Chapter 2 provides the literature review. The literature review addresses the issues of patient flow in terms of its effect on an Irish perspective, its barriers, facilitators, technical solutions.

Chapter 3 presents the design of the research methodology. This chapter also outlines the fine details of the semi-structured interview being carried out. It explains the queuing theory model in detail. What datasets were used and how the data's were implemented in finding the solution.

Chapter 4 presents the detailed results of the queuing theory model in terms of the efficiency and service rates of the department. It also analyses the qualitative data of the semi-structured interviews in depth. Chapter 5 discusses the results, how they address the research question, the results and its significance and finally the limitation of the study.

Chapter 6 finally concludes the dissertation, with recommendations for maximizing patient flow and technological solutions in improving patient flow .

## Chapter 2 Literature Review

### 2.1 Introduction

The ever complex healthcare system worldwide manifests with multiple entry points and numerous service providers. This large ecosystem is making life very difficult for patients, their care givers and health care practitioners. The flow of patients in this large scale ecosystem for their well-being has led to the formulation of a term called “ Patient Flow “. Patient flow is the buzz word in the operational research of the health care industry. Patient flow is defined as “the way in which a patient moves through a hospital throughout a stay or visit....(where) the overall aim of improving flow is to increase throughput and minimize delays while assuring that high performance in flow is not at the expense of poor quality” (Institute for healthcare improvement, 2005). In healthcare, flow is the movement of patients, information or equipment between departments, staff groups or organizations as part of a patient's care pathway.

From the clinicians perspective, the patient flow focuses on the progression of the patients health status, and the whole disease process. The main objectives of patient flow initiatives are to reduce wait times; improve quality, appropriateness and continuity of care and create a system that meets divergent needs and demands of the client. Mahaffey (2004) explains, patient flow can have an impact on emergency department overcrowding and diversion, cancelled surgeries, admissions delays, refused transfers and capacity/demand mismatches. Additionally, the Joint Commission on Accreditation of Healthcare Organizations (JCAHO ) initial “Emergency Department Overcrowding Standards” has slowly been implemented as standards for better patient flow in every department that interfaces with patients. Modelling patient flow in health care systems is considered to be vital in understanding the operation of the system and therefore prove to be useful in improving the functionality of the health care system. Improving

patient flow is one way of improving health services. Evidence suggests that enhancing patient flow also increases patient safety and is essential to ensure that patients receive the right care, in the right place, at the right time, all of the time (reliability). However, it is important that patient flow does not improve at the expense of safety or system reliability (IHI, 2005).

Describing patient flow to its core, Marshal et al., (2005) explains, patient flow has operational and clinical perspectives. The former represents the movement of patients through a set of detailed and complex locations in a health care facility. While the latter represents the progression of a patients health status. The JCAHOs standards is taking a serious looking at the patient flow and is expecting the hospitals to carry out a thorough assessment of flow and determine any issues that may impact their ability to provide quality and timely care. They survey the data on the following four specific areas, available supply of patient bed space, the efficiency of patient care treatment in service areas, the safety of patient care treatment in service areas, and support services that impacts flow.

This literature review aim to focus exclusively on the patient flow in the provision of cardiac surgery patients. Delivery of surgical services involves multiple concurrent activities and coordination of their outcomes (Sobolev, et al., 2008) . These activities takes place in sequence of events or in flow process. These events are interrelated and can affect each others performance significantly.

A literature review was carried using key words like patient flow, cardiac surgery, heart operation, patient flow technologies. The databases accessed were CINAHL, PUBMED, IEEE, SCIENCE DIRECT, GOOGLE SCHLOAR, PUBMED.

## **2.2 Ground Zero: Patient Flow in Cardiac Surgery Process**

One of the dimensions of healthcare quality is to speed up the process of healthcare treatment, as higher quality is associated with shorter patient waiting times. Hence, due to the significant expense of many healthcare resources (e.g. surgical operating theatres), healthcare managers desire keeping these resources highly utilized. Rohleder.,et al., (2005 ) illustrates the



concept of patient flow by the theory of Swift Even Flow described by Schmenner and Swink (1998) who states that “high utilization levels and relatively low throughput times can be maintained only when input flows and processing times are consistent”. This theory helps explain the natural tension of quickly moving patients through healthcare operations while simultaneously achieving high utilization. Flow in healthcare environments tends to be very uneven due to random patient arrivals, particularly emergencies and highly variable medical procedure times.

Getting into the reality picture of the hospital and patients these days, 5% of hospitalized patients accounted for 40% of acute care hospital days in which two-thirds of patients were 75 years or older. This longer than average length of stay experienced by hospitalized senior has created system access and flow problems and has resulted in the unfortunate practice of labelling older persons as bed blockers( Holtby, 2007),

Meyers ( 2004 ) cited in Peltokorpi et al., (2008) cautions that operating rooms(OR) utilise only 68% of their capacity. Using OR time efficiently is especially challenging when long cardiac surgeries are scheduled to fixed OR block time. This situation is typical in open heart surgeries where a high variability in the length of required OR time combined with four and a half hour average OR time duration makes scheduling two operations during a normal eight-hour workday difficult. Peltokorpi et al., (2008) highlights the importance of evaluating the effect of various process improvements to OR cost, results have to be calculated with case-specific, relative cost for operating time, underused time, and overused time. This quite complicated network of patient flows is often not controlled, with serious negative effects on the hospital's performance. This can lead to the risk of death while waiting for cardiac surgeries which is 0.28% per month of waiting.(Seddon et al.,1999).

Poor patient flow management can plague modern hospitals by ending up with short supplies, long queues , delays, bottlenecks, increased length of stays, lower productivity, workload variability. Walley & Steyn (2006) on the basis of an analysis of 33 different sites, found that “typically 60 to 70% of the patients occupying hospital beds are receiving active treatment and the rest are either waiting for initial visits by doctors, who themselves are stuck in the

system because of delays, or are not ill but have not left the hospital for some reason". Aiken et al., (2002) showed a direct link between poor management of patient flows and patient outcomes. In a population study of 232,342 of surgical patients discharged from 168 hospitals Aiken et al.,(2002) found that each additional patient per nurse meant a 7% increase in patients likelihood of dying within 30 days of admission . Today, more than 10% of acute inpatient beds are devoted to critical care and the number of patients requiring intensive care is predicted to double by year 2020 mainly due to the elderly population growth. Nevertheless to say that the acuity of patients that are being treated in ICUs have created severe pressures on hospitals ( Kumar et al., 2010). Excessive specialization of staff, professional demarcations, cancellation of clinical procedure, poor communications among departments and disciplines, prevalence of autonomy or accountability, are the reality when it comes to the hospital floors (Villa., et al., 2009). These attitudes are leading to access block which is the most serious issue confronting the acute care setups in hospitals. Fatovich et al, (2009) warns, there is a 20 – 30% excess mortality rate every year attributable to access block and emergency department overcrowding. This equates to at least 80 deaths/million population a figure that is similar to the road toll deaths.

In an observational study, Al-Hakimet et al., (2009), demonstrated that preventable variation in terms of disruption and delay within the OR resulted in poor information quality resulting in increasing in surgical time and forced surgeons and patients to endure an unnecessary delay of 26% on the surgery time in average. This disruptions are related to medical surgical errors in OR. These disruptions also prolong surgery session time, increase costs. . Disruptions also lead to stress and fatigue for both the staff and patient. Lederman et al., (2002) cautions the intangible emotional barrier that a non-acute patient waiting at community undergoes while waiting for a bed in a busy public hospital system. Wilson et al., (1995) adds, 16.6% of admissions to public hospitals lead to an "adverse event" resulting in disability or a longer hospital stay for patients. In this, delays contributed to 20% of adverse events. Of these delays, diagnosis because of missing treatment and imaging

records accounts for 56.8% and treatment delays 46.6%. Increased length of stay means high risks for infection associated extended stay as well. Catherine et al., (2009) critiques the health care systems which are erroneously designed to process maximal efficiency for locality instead of directing all resources to maximal patient flow. These problems are caused by individual departments maximizing their own efficiencies, which comes at the expense of patient satisfaction and ultimately increased costs to the organization. Cahill et al., (1999) recommends that all healthcare system must balance the need for access and availability of ICU versus excess capacity that wastes increases limited healthcare resources. This is in reference to the ICUs consuming nearly 30% of all inpatient expenditures while representing only 8% of the patient population.

### **2.3 Irish perspective of Patient Flow**

PA Consulting Group on behalf of the HSE, reviewed the acute hospital bed capacity amongst the Irish hospitals in 2008. The review assessed the expected demand for acute health care up to 2020. The primary goal of this review was moving towards integrated care being following in established health care systems in the developed world. It was found that Ireland will need to plan for a 60% increase in demand for public health care by 2020. The average length of time patients stay in hospitals in Ireland is relatively long when compared with some of Ireland's best performing hospitals and hospitals in other countries. Irish hospitals have delivered the second lowest reduction in Average Length of Stay (ALOS) of any OECD country over the last ten years. In Ireland, 37% of total inpatient beds are occupied by patients who in Australia would no longer be expected to be in hospital; the number of day cases carried out is only half that of Canada and 12% below the OECD average; 39% of medical and surgical inpatients, on the day of care, could have received their care in an alternative setting or at home. There are currently 11,660 public beds in public hospitals. In addition there are nearly 4,400 private beds (2,461 in public hospitals and 1,926 in private hospitals). The review concludes that patients could be better served with less public patient beds than currently exist. Countries such as Australia, UK, Finland, Denmark and Canada could treat the same number of patients as Ireland

treats today with between 2,000 and 5,000 less public patient beds., Delivering 100% of the Integrated Health System by 2020 would mean, for example, that the Irish health system would be performing at the same level as Denmark is today. This review even though aimed towards integrated health care, leads us primarily to the issues concerning with patient flow being discussed in this literature review.

## **2.4 Physiological impacts of Patient Flow**

From a patients point of view cardiac surgery is a process consisting of multiple phases, which includes a several months wait for coronary arteriography after other heart examinations and finally waiting for cardiac surgery. In theory the urgency of surgery is determined based on symptom status, anatomy and clinical acuity, however in practice access to surgery is influenced by length of the waiting list which can vary from 3 weeks to 7 months. Also, to remember the public/private patients issue, where the latter gets into the flow in lesser time. Length of hospitalization period is about 10 days. An increasing body of research evidence shows that the waiting period is difficult for patients. It has been found that during the waiting period to cardiac surgery patients suffer from impaired functional status, chest pain and shortness of breath, anxiety, depression and fear of death, and when the waiting period is long, nearly half of the patients are forced to seek hospital care because of cardiac symptoms (Koivula et al., 2002) , Reducing the waiting time is the only way to minimize complications explains Blackadar et al., (2009) as complications occur relatively early during the time of the waiting list even though there is no prediction tools to predict complications. Once the patient finally gets operated the patient flow concerned with logistics in the transportation of patients within various departments are enormous. Patient flow is not about only getting access into the hospital, once the patient gets into the flow, logistical issues are numerous. Immediate post cardiac surgery, the patient transfer to the intensive care unit may not be smooth as well. Bambi (2010) on the analysis of Australian Incident Monitoring Study in Intensive Care found a mortality rate of 2% among 176 anonymous incident reports related to patients transportation. Also, transporting critically ill

patients between hospitals has been recognized as a potentially hazardous manoeuvre, where a change in management of 40 to 50% patients occurred ( Day.,2010.)

## **2.5 Economic Impacts of patients flow**

Literature indicates that delays and disruptions have substantial financial implications for hospitals, affects the quality of patient care, prolong waiting lists, are recognised as a growing problem throughout the developed world . Patient who wait in line may take their frustration out on satisfaction scores, and poor patient flow may be a symptom of quality of care problems, explains Dickinson (2006) and he concludes by stating over time it may also affect hospital revenue and hospital closure itself.

Cancellations of the day of surgery is quite common in a busy hospital, this hurts hospital revenue, as well as physician and patient satisfaction. However, Cancellations can often be avoided by ensuring that all laboratory testing, EKGs and x-rays are completed and results are available to caregivers by the day of the surgery(Anonymous, 2007), These cancellations adds Lederman et al., (2002), may lead to ineffective treatment plans and inefficient bed use resulting in decreased hospital funding. This decreased funding also has an inevitable flow-on impact on patient care and staff workloads. The concept of *efficiency* refers to the maximization of health outcome for a given cost, or the minimization of costs for a given health outcome. Resources are allocated efficiently only if the relative cost of two inputs is equal to their relative worth (Williams, 1998).

## **2.6 Facilitators of patient flow**

Institute for healthcare improvement (IHI) (2005) recommends the engagement of the clinicians in incorporating their clinical view in mapping session of patient flow . Mapping here may involve patient pathways and associated processes. By the facilitation of matching work rate to new work that comes in, demands can be met. Systems that keep the flow and keep things moving will have quicker referral to treatment times. Any patient waiting for clinical decision making should also be considered. The IHI,( 2005)

recommends a vision for enterprise improvement and foundation of quality information followed by the sustained measurement and aligned incentives. This point is shared by Mahaffey (2004), who highlights the various capacity issues arising in the hospitals, especially from its unique resources like Ot, ICU or emergency department. Their uniqueness in unpredictability and fluctuation is core to the patient flow. However, single department solutions may create or worsen bottlenecks in other areas. Thus validating the point that patient flow touches every department. Also, only an enterprise initiative can deliver sustained improvements. Providers can predict a day in advance and with accuracy when a patient will be discharged. By beginning discharge planning early in the patients care plan, inefficient discharges can be reduced.

## **2.7 Barriers in patient flow**

In an observational study ,Al-Hakim et al., (2009), lack of understanding the principles of productivity management techniques within the OR and lack of technical information to perform the activities in OR were the primary barriers in patient flow within an OR. Variation normally affects the quality of patient care, prolong waiting lists, and results in medial errors, however, in most cases these variations are controllable. The failure in adapting health care informatics by the health care professionals in full swing is widely prevalent. Issues such as data management, data modelling, and knowledge management have a long way to go before reaching their maturity level with other technologies. These issues can further lead to the ever going integration problems of the information systems in the health care industry. The failure in information systems in not focusing on service oriented solutions is attributed to this cause. (Berler et al., 2005).

Mahaffey (2004) explains, the sheer size and depth of the healthcare setting has been very challenging where patient flow initiative is no exception. The patient flow process reaches across various departments that may have conflicting goals and incentives. In response to this health authorities worldwide are dedicated in the implementation of variety of patient flow strategies. However, Dyke et al., (2011), questions the lack of evidence or guidance required for the implementation of patient flow improvement

strategies and particularly the factors that facilitate and hinder these implementation guidelines.

The crucial challenges in planning of the surgery admission schedule are dealing with uncertainties. Jittamai et al., (2011) recommends, the duration of activities related to the intake process, recovery processes, surgeries, availability of medical staffs, and emergency patient arrivals are needed to be considered stochastically in order to make the research problem more realistic and practical. The difficulties and obstacles between surgeons and patients in the aspects of expression, transmission, understanding and communication of information are widely prevalent. The negligence of this information quality on an effective OT management during the day for operational and real-time control of processes and workflows impacts patient flow strategies as well. In spite of the awareness of information quality can affect the performance of the patient flow process, lack of quantitative research hardly lays the foundation for patient flow strategies (Al-Hakim.et al., 2009).

In a qualitative study by Dyke et al., (2011), to identify the facilitators and barriers to the implementation of patient flow improvement strategies, staff resistance, entrenched organizational culture, lack of staffing resources, lack of data to monitor progress were illustrated as the main barriers in implementation patient flow strategies. Rohleder et al.,( 2005) also shares the same view of this with a report that states that the effect of artificial variation caused by personal preferences and beliefs of clinicians can make the surgical scheduling less efficient. Proudlove et al., (2005) compares the health care industry with manufacturing industry where the absence of dedicated production manager in the former is being considered as a significant barrier in the flow process. This dedicated personnel is to be responsible for managing the flow process from start to end . However, the operational staff in hospitals (such as bed managers) rarely attempt to use this activity data to analyse patterns and monitor performance. This highlights the significant fact that very few hospitals record the operational information they would need if they were to try to manage the system effectively. The common misconception that we are different from other business and industries in the healthcare sector is allowing healthcare demand/supply matching to escape

scrutiny. The measurement of healthcare system performance by revenue, cost, satisfaction or clinical outcome are quite superficial. It is common in the OTs to see the challenging nature of clinicians in cost reduction for the effective use of resources (Murray, 2009). The current practice of allocating resources to specialties within a hospital often results in a loss of bed capacity, operating theatre time, and other resources. The underlying reason for this capacity loss is that allocations of beds and operating theatre hours to specialties often tend to be based on historical rights rather than based on resource requirements that is calculated from the flow of patients (Villa et al., 2009).

## **2.8 Technological solutions for patient flow**

Information is the foundation of any patient flow initiative. Patient flow is built upon the capture, integration, and sharing of information, both within and across departments. In reality these numerous information systems and departments just operate as silos. Caution should be taken that introduction of a patient flow-specific solution should only enhance, rather than attempt to replace, current system. It alleviates administrative grunt work and continuous polling for information. With real-time access and dissemination of information, most or all of the unnecessary phone calls can be eliminated. The key objective of the patient flow from the technical point is, the system should provide clinicians a single view of the patient, facilitate clinical information sharing across settings, accelerate clinical decision making, and finally manage patient flow. (Poulos et al., 2007). However, Poulos et al (2007) adds, in the United Kingdom, the National Programme for Information Technology of the National Health Service has specified a number of features designed to support patient flow, but reports of the successful implementation of systems to improve bed management remain scant.

Integrated care is a key strategy in reforming health systems around the world. Kodner (2009) highlights the importance of having integrative initiatives like information management with technology component. He further recommends, creation of information system that monitors indicators to measure outcomes at different level, arrangements such as shared patient



records, regional collaboration and a clear, transparent incentive structure. Quality information systems also enhance communication capacity and info flow across integrated pathways. It is increasingly hard to imagine integrative initiatives without a strong info management and technology component. All these healthcare systems should be based on information sharing systems within different care providers.

Poulos et al., (2007) describes a bed management dashboard system which displays real time process improvement and decision support system. This product is used by hospital administrators, clinicians and managers to streamline the process of admitting, transferring and discharging patients. However, Mahaffey (2004) argues real-time information facilitates decision-making, but actionable information facilitates workflow. This system primarily used in the emergency departments reduces overcrowding and improves patient flow and is associated with increased physician and staff satisfaction. One more example of such technological solution is the Care Card implemented along with electronic kiosks which helps the patients in speeding up their admission process and move more efficiently to maintain a constant patient flow. This Care Card envisages to streamline the administrative processes, thus eliminating redundant tasks and wait times.(Swaskoski., 2009) .

Another example is Walczak et al.(2003)'s use of the artificial intelligence method of neural networks to facilitate the modelling and prediction of resource utilization associated with patient length of stay. As information technology continues to revolutionize the health care delivery process, a wealth of electronic data from operational systems is becoming more available and readily accessible to support analysis. Using such detailed operational data effectively requires a number of complementary techniques and technologies.(Isken, et al., 2002), Chan et al., (2008) share their experiences in the development of a computer-based real-time analysis tool which has the potential to allow accurate, objective and impartial assessment of causal factors and promote better understanding of the rationale behind strategies to improve patient flow.

In contrast to these advantages of the medical technologies most experts believe that medical technology advances account for half to two-thirds of annual spending increases( Goyen et al., 2009) . However, by all measures it is apparent that new medical technology is the dominant driver of increases in healthcare costs.

## **2.9 Conclusion**

An accurate and reliable model of patient flow should enable hospital managers to predict future activity on the wards. Such predictions can be extremely useful in assessing future bed usage and forthcoming demands on various hospital resources such as the number of beds required, the length of time for which the beds are required, the case-mix of each ward—the type of beds required and the various associated staffing levels needed. A better way of assessing the system activity in hospitals will ideally be to consider the measurement of flow of patients through hospitals and other health care facilities. Patient flow is an important aspect in the systemic approach of health care services. This literature review highlights the impact of patient flow effect in the daily activities of hospitals. This review takes into the account, the numerous barriers to come across in the successful implementation of patient flow strategies. This literature review clearly demonstrates the implementation of information systems and extraction of information from these systems are the way to look forward to. This review will form a sound knowledge base for the researcher involved while analysing the data towards the maximizing process of patient flow in cardiac surgery.

## **Chapter 3 Research Methodology: Qualitative Research Methods**

### **3.1 Introduction**

This chapter aims to investigate and extract the ideas, values, beliefs of the professionals involved in the patient flow of the Unit. The research methodology employed here is qualitative research methodologies. The author in this chapter describes the research design and the research tools applied in this dissertation. The researcher explores the efficiency of the current patient flow, how to optimize the patient flow from the experts who run the department.

### **3.2 Qualitative Research Methodology**

Qualitative research deals with various intricacies about phenomena (Strauss et al., 1998). This phenomenon involves feelings, thought processes and emotions, which may be difficult to extract or understand through conventional, research methodologies (Silverman, 2006). Bryman (2009) adds the term qualitative research means any types of research which yields findings that is not arrived by statistical or any other quantification approach. Researchers believe that qualitative studies provides a deeper understanding of persons lives, life experiences, culture, interactions between various states and details about organization functioning (Silverman, 2006). Qualitative research relies less on counting and correlating, at the same time giving importance to interpretation, integration and summary (Weiss et al., 1995). Flick (2009), highlights how pluralized the world of life is. He cautions this has led to individualization of living, new biographical patterns, new subculture, and new ways of living. This has led the social researchers to confront with new contexts and perspectives within qualitative research tools. These tools analyse, concrete cases based on their locus focusing on expressions and activities in their own local contexts.

The author based on the recommendations by Strauss et al.,(1998), highlights the key factors which inspired in carrying out this research studies using qualitative research:

1. Developing detailed descriptions. Qualitative research enables us to learn the information in a well detailed and described way.
2. Integrating multiple perspectives: Qualitative studies describes about the organization in totality by gathering different observation from each respondents.
3. Describing process: Human enterprise process and its outcomes are detailed as well.
4. Developing holistic description: Qualitative studies describes how a system works or fails to work. The comprehensive information obtained from various sectors describes how the entities within the sectors go together.
5. Learning how events are interpreted: Qualitative research enables to learn about perceptions and reactions based on individual experiences.
6. Bridging inter-subjectivities: This enables the reader to introspect a report and relate with the research participants views.
7. Identifying variables and framing hypotheses for quantitative research: Qualitative studies can provide the basic preparation for quantitative research by leading quantitative investigators with description of process and system.

### **3.3 Semi-Structured Interviews**

Semi-structured interview is one of the popular qualitative research method employed in various qualitative studies. The researcher believes semi-structured interview yields high quality of data apart being flexible in seeking in this data. Semi-structured interviews fetch data in between the reality and representation. Gubrium et al., (1997) cited in Silverman (2006 ) describes emotionalism is one of the analytical preference in qualitative research which favours the understanding of the biography of the

researchers and participants. Interviewing is an example of the model emotionalism.

Semi-Structured interviews can help us achieve the full development of information as each respondent is expected to provide a great deal of information irrespective of the sample size. Mathers (1998) explains, semi-structured interview facilitates a flexibility to interview all participants to be asked the same questions within a framework. . Mathers(1998) adds face-to-face or personal interviews are labour intensive but can be the best way of collecting high quality data, especially when the subject matter is very sensitive. Thus, semi-structured interviews in general can be treated as detailed reports on external realities.

Participants are usually encouraged to talk about their experiences through open ended questions followed by further questions determined by the responses gathered (Dearnley, 2005). In semi-structured interview process the researchers has a interview guide which includes a list of questions or specific topics to be covered. Questions here may not follow on exactly as scheduled in the guide. However, all questions will be covered as they discuss on things said by the interviewers. Here there is greater interest in the interviewee's point of view. Emphasis is also given on generality rather than on specific ideas. Dearnley (2005) adds, the open ended questions are usually aimed to facilitate greater depth and vitality for new concepts to emerge. If the researcher is beginning the investigation with a clear focus, interviews will be clearly semi-structured ones where specific issues can be addressed.

### **3.4 Sample size and design**

Sampling:

Inspired by the features of semi-structured interviews, and the rich data it always yields, the author initiated the designing stage. The interviewees were chosen according to the criteria derived from the research objectives.

Interview guide was compiled. The interview guide was extracted based on the literature review. Samples were selected using purposive sampling method. Total of 36 open and closed end questions was complied with

majority of the questions being open-ended which encouraged the respondents to give long elaborated answers. Participants were also asked to furnish their background/experience, qualifications etc in a form. (Appendix: C). Only seven of the eleven participants filled in the form. Other participants was unable to furnish these details because of time constraints. The researcher limited the number of respondents to 11 as its believed that in-depth information can be collected with limited respondents. Dearnley (2005) shares this same belief and points out large number of respondents can hinder the researches ability to get in depth data and may also miss the opportunity of getting each respondents understandings. Purpose sampling, which strategizes group participants based on the relevant research question, was used to select the samples (Black,1999). In purpose sampling the researcher handpicks the subjects on the basis of specific characteristics. The respondents here included hospital consultants, managers and ICT head of the hospital.

Ethical Approval: Qualitative research studies focuses on exploring, examining and describing people in their respective environments. Any research involving the participation of people requires an awareness of ethical issues that can derive from the interactions (Orb et al., 2001). Ethics here pertains to doing good and avoiding harm. Its imperative that the respondents are protected in any research study. Ethical approval was sought from three different institutions in the country for this research study. Ethical approval was granted from the Clinical Research Ethics Committee of the Cork Teaching Hospitals, Ethics Committee, Trinity College Dublin, and Quality Coordinator, Cork University Hospital (Appendix D, E, F). Samples interviewed are summarised below:

Samples	AREA OF WORK	Background	YEARS OF EXPERIENCE
Sample No.1	Anaesthesia & ICU	Consultant	15
Sample No. 2	ICT	ICT Head	34
Sample No. 3	Cardiothoracic Surgery	Consultant	> 15
Sample No. 4	Anaesthesia & ICU	Consultant	20
Sample No. 5	Cardiothoracic Ward	Clinical Nurse Manager II	10
Sample No. 6	Cardiothoracic ICU	Clinical Nurse Manager II	18
Sample No. 7	Cardiothoracic OT	Clinical Nurse Manager II	36
Sample No. 8	Cardiothoracic ICU	Clinical Nurse Manager III	-
Sample No. 9	Cardiothoracic Surgery	Consultant	-
Sample No. 10	Cardiothoracic Surgery	Consultant	-
Sample No. 11	Nursing	Asst. Director of Nursing,	-

**Table 2 Sample Summary**

### **3.5 The interview process**

On the ethical approval to carry out the interviews from the respective authorities, the interview process was started by meeting the interviewees in person and contacting by emails. All the participants were emailed a copy of information document detailing about the interview process. All the participants were receptive for the interviews and considered it in a positive way. Time was one of the pitfalls for few participants as they were tied up with their own clinical and administrative responsibilities. 11 participants were

interviewed in a months time. All the participants before the interviews signed informed consents. The interviews were held face to face in the various office suites of the hospital. Participants must feel comfortable and relaxed during the interview process. The venue should offer privacy, proper seating arrangements and uncluttered (Dearnley, 2005). The interviews were recorded in two smartphones for backup purposes. Interview duration ranged from 10 mins to 39 mins. The recorded interviews were transcribed verbatim. Normally, one-hour interview may take five hours to type verbatim based on the typing skills and also 20-25 single-spaced pages. The researcher spent 1-3 hours typing verbatim (Dearnley, 2005). This also helped the researcher to get totally immersed in the data. The problem of confidentiality and ethical issues are also negated in this case. Polit (2006) stresses the importance of maintaining confidentiality by not linking the information provided by the participants in any public forum. The researcher ensured high confidentiality was always ensured throughout the research process.

### **3.6 Data Analysis based on the Themes**

Qualitative researchers in general are aware of the lack of tools to analyse qualitative data and the need for better tools and techniques has been the core need of qualitative analysis. In this era of social networking, sharing and improving of existing techniques, disclosing analysis methodology are key features in improving qualitative analysis techniques. The author in this research interviewing the respondents ended up collecting 70 pages (single-lined) of rich quality data. The author researched analysing these data with few qualitative analysis software like NVIVO which was very time consuming. At last these laid the foundation for the author to use thematic analysis to analyse the data.

Thematic analysis is the process of searching for themes that will lead to a description of a phenomenon (Fereday et al., 2006). Here, qualitative data is read and re-read leading to a form or pattern formation in the data which are analysed in the end. This research encompasses Thematic Network Analysis formulated by Attride-Stirling (2001) in Thematic networks: an analytic tool for



qualitative research. Attride-Stirling (2001) proposes web-like illustrations called thematic networks that summarize the main themes from the data analysed. This technique explores the understanding of a core issue or an idea. The main advantage of this thematic network analysis is it systemizes the text data methodologically, the steps involved in the analysis is well laid out, and clearly underlays the patterns in the data. The web-like network offers an illustration of the textual data in a representational means which would have been difficult to analyse in its raw form. The author was fully aware of the fact that thematic network analysis does not aim to discover arguments or rationalizations, rather its only a technique to break-up text.

Attride-Stirling (2001)'s Thematic network analysis systemises the data into:

- a. Basic themes: These are the most basic and lower order themes in the textual data. On its own, they brief very little about the texts.
- b. Organizing Theme: These are clusters of group of Basic Themes. They reveal what is the underlying meaning of the texts.
- c. Global Theme: A group of Organizing theme constitute a Global Theme. Global themes explains the texts as a whole within its context. They form the core of a thematic network.

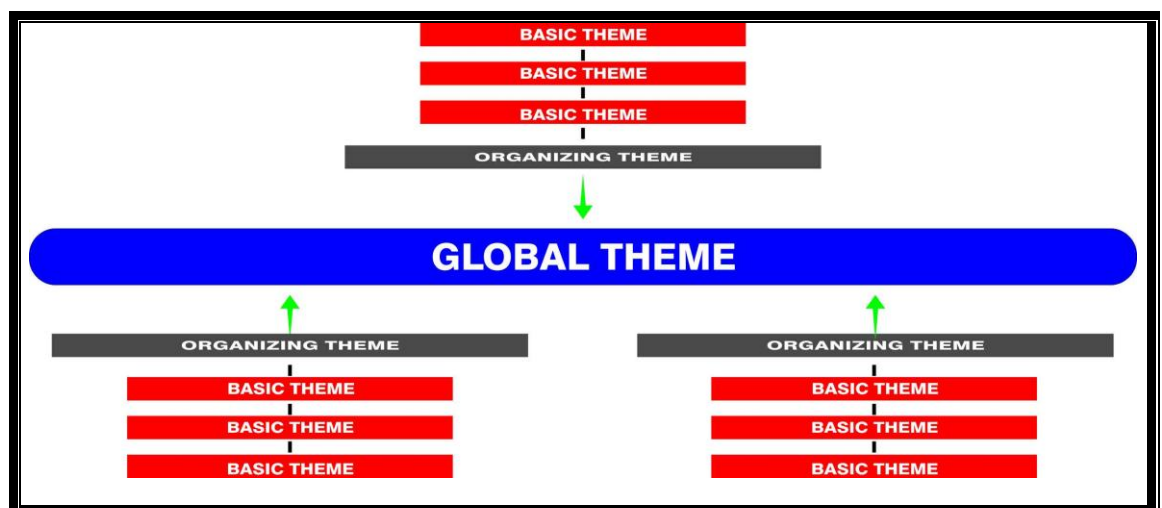


Figure 2 Thematic Networks

Thus a thematic network comprises of Basic themes which are classified and held as a cluster by Organising themes. These

organising themes are reinterpreted along with Basic themes and illustrated in a single conclusion which becomes the Global Theme. These networks are schematically represented as web-like networks, with no hierarchy and emphasizing more on interconnectivity. These thematic networks illustrate the underlying principle in the text as a tool and discloses the concepts in the data.

### 3.7 Validity

Validity involves the creditability and reliability of research performed in qualitative research is often debatable (Silverman, 2004). The author has put all the effort in ensuring the validity of this research. The data obtained from the interview process has a complete audit trail. The author believes the data obtained is credible, reliable and can be defended when challenged.

### 3.8 Applicability

Applicability allows the studies to be applied to another group of sample in similar settings. The author believes that this research is specifically applicable for this particular setting only and the data studied may not be replicated or generalized to another setting.

### 3.9 Reflexivity

Reflection enables people to recollect their experiences evaluate it. Fulfilling no formal training in the interviewing process, the author was fully committed to maintain transparency to the research process. Being a researcher who was examining his own organization, the researcher has to reflect seriously on the ethical implication of carrying out the interviews (Dearnley, 2005).

The researcher is aware of the potential problem of reporting the research findings to the appropriate authorities at work. However, being an inside-researcher, the author had the advantage knowledge of culture, organization of the people involved while carrying out the interviews.

### 3.2 Research Methodology: Queuing Theory

The services generally provided in healthcare arena are queue based. The research setting on this occasion is no exception. Here, the patients wait in a queue to be seen by the consultants, followed by waiting in the queue to get operated, they queue to stay in the ICU and final queuing to get discharged to the ward. The presence of queue is imminent in the whole process. The author in this research has applied the principles of queuing theory in measuring the patient flow mathematically. The quantitative approach incorporating queuing theory is the research methodology discussed further.

Queuing theory works was pioneered by Jackson (1957) (Boucherie et al., 2011). Queue formation is a social phenomenon where the beneficiaries are the entities who serves and the entities who waits (Mcmanus et al., 2004). The products created and services delivered commonly are routed through network of queues (Bhat, 2008). Queuing theory measures the parameters like time in the system and the total time spent in the system. Marshall et al., (2005) adds, this can help managers to test scenarios, minimize and avoid bottlenecks and maximize patient flow. Also, Mcmanus et al., (2004) explains, it enables managers to plan the optimal supply of the fixed resources required to variable demand required.

Cochran et al., (2007) highlights, queuing theory predicts the throughput of any entity from any station. Moreover, queuing theory can be modelled to understand the functionality of any system activity (Marshall et al., 2005). Thus, using existing mathematical techniques or developing new techniques to analyse the underlying processes, queuing theory has over the years been developed. This has enabled the queuing theory to mature into a model by incorporating various system characteristics in representing the real world phenomenon.

Bhat (2008) describes queuing theory models around the process by approximation of a random phenomenon. This probabilistic model brings the process to a closer reality because of the various uncertainties involved in the real-world phenomenon. Queue Formation is not linear, Cochran et al., (2007)

cautions, each additional 5% of resource utilization is much harder to achieve than the previous 5% .

The unit demanding service can be a human or any entity. The unit providing service is known as the server. In real world, a queue cannot be avoided because there is always a mismatch between the entities who arrive for service and the service provided for the entities. Cochran et al., (2007) warns waiting behaviour can get bad when queuing limits are approached resulting in turning away entities even before reaching the capacity. The facilities to provide service in healthcare in this case are scarce continuously. Hence Boucherie et al., 2011 recommends focusing on service processes, which are predefined.

### 3.2.1 Queuing Theory Fundamentals

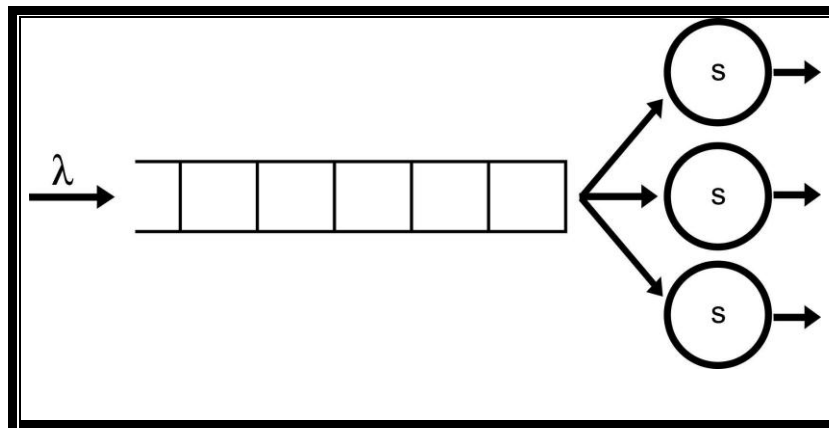
#### M/M/1 Model:

David.G.Kendall in 1953 provided the notation for describing the characteristics of a queuing model. Kendall introduced an A/B/C queuing notation found in all modern works of queuing theory (Biju et al., 2011). Kendall's notation is represented as M/M/1 model. The arrivals of the entities are assumed to occur in a Poisson process represented as ( $\lambda$ ). Poisson processes here is the stochastic process where the number of events and the time interval between these events are counted. Real time arrival and demand processes are empirically shown to be approximated by Poisson Process. (Bhat, 2008). Hence Poisson process is the most commonly used arrival process in modelling any service industries. Thus the number of entities  $N(t)$  arriving during a time interval  $(0,t)$  has a Poisson distribution. Assumption is also made that the service times has an exponential distribution with probability density (Bhat,2008). Thus, M/M/1 or M/M/n represents

- M (M=Markovian, memoryless)for Poisson or exponential.
- Exponential service time distribution
- Single server or Multiple server (n).

The M/M/1 model is used extensively in capacity planning in the service industries because of its robustness of assumptions and its ease of use

(Green, 2002). The most important and powerful formula by John Little is  $L = \lambda W$ , where  $L$  is the number of entities in any system,  $\lambda$  is the arrival rate, and  $W$  is the time spent waiting (Green, 2002).



**Figure 3 Multiple servers**

**Utilization rate ( $\rho$ ):** The ratio of arrival rate to service rate is known as service utilization (Bhat, 2008). This service utilization is considered as a measure of system efficiency and refers to the hospital occupancy level in this context. Green (2002) describes systems are efficient if their service utilization operate at 85% capacity. In any acute hospital bed crisis can be expected if average bed occupancy is greater than 90% or more. (Bain, 2010).

**Arrival Rate ( $\lambda$ ):** The average number of customers who enter the system is arrival rate, usually represented in units of time. Arrivals are a product of external factors which are always random process with variability's in the form of being late, early or unannounced or not showing up (Boucherie et al., 2011). Bhat (2008) adds, arrival process are represented by the number of customers arriving during a time interval or the time interval between each successive arrivals.

**Service Rate ( $\mu$ ):** The average number of customers served in a given time. This is dependent on the system capacity and determines the number of customers who can wait in the queuing system.

**Servers ( $N$ ):** The service mechanisms are provided by the servers which can be arranged in series or parallel. Servers can be one or more. Servers in this context is hospital beds.

System capacity: The number of customers that the system can serve is system capacity. The more the capacity, the service rate improves. If the system has the option to rush customers the service capacity increases as a result, however rushing these customers increases the risk of customers being reworked at a later point of time. This potentially has a negative impact on the service capacity where works are going to be outstanding (Singh et al., 2012).

Queue discipline: Queues can be served on the basis of 'first come, first served, last come, first served and based on random selection.

The above mentioned elements are modelled based on several assumptions. However, Green(2002) claims when an arriving patient finds beds are full, the patient has to wait until a bed is ready, which seldom happens. These elements namely, servers, system capacity and queue discipline are normally deterministic except the arrival rate which is uncertain. Thus the resulting process being stochastic (Boucherie et al., 2011).

### 3.2.2 Why Queuing Theory?

Queuing theory models the execution of a thorough analysis of a system without having any impact on the system during its experiments. Queuing theory in comparison with any lean healthcare management or any other theory of constraints has the ability to allow for a quantified comparison of any system performance by comparing the current and expected performance of an alternate design( Zonderland, 2009). Bhat (2008) adds, queuing theory is a simpler model, which is easier to be analysed and to extract information.

Computer simulation is an alternate operations research technique to queuing theory for evaluating a system's performance (Boucherie et al., 2011). Though simulation provides a method for evaluating proposed changes in healthcare delivery, Green(2002) highlights the lack of research available on the appropriateness of this modelling techniques. Queuing theory model

requires fewer data in comparison to the simulation model. Despite its powerfulness, simulation models are time-consuming to build using simulation software program. The information required to build these simulation models are well detailed as well. Zonderlang (2009) explains, queuing theory enables the managers in carefully analysing the formulation of equations, which paves way for a robust insight into the relationships within the system. The main disadvantage of computer simulation model is the long execution time involved and the amount of output data generated (Marshall et al., 2005). Simulation modelling features the possibility of considering any system characteristic however this at the same time is one of the drawback of this model as the researcher may get lost in details and lose vision of the real problem (Zonderlang, 2009). Thus for the development of a robust model to be built on the patient flow, success of current models like queuing theory, simulation modelling, artificial intelligence using neural networks should be considered and evolved as an hybrid approach.

### 3.2.3 Research Design

After understanding the queuing theory model in detail, the author initiated in the collection of data. For this elements and properties of data were identified. The major source of data came from the cardiac database in the hospital maintained by a dedicated data manager. The author collected the data retrospectively. Relevant data of one year's was collected from May 2011 to April 2012. The reason for selecting this time frame was because the cardiac surgery services were transferred to a new building on May 2012. The author believes that data for one year is sound for any research and will reflect true findings.

The data collected were entered in a Excel 2011<sup>®</sup> (Microsoft Corporation, Redmond, WA) where all the relevant calculations were made. After the submission of the ethical approval forms, the author was given access to the following data.

- a. Arrival data for OT (cardiac surgery patients): Arrival data in this case was the number of patients referred for surgery by the cardiologists. The referrals came from other hospitals, emergency, and general practitioners. Referrals for each month were taken and average arrival

rate per day was calculated from the database. Arrival rate in this case is stochastic and followed Poisson processes.

- b. Service rate for OT (cardiac surgery patients): Service rate was calculated from the data collected. Average rate of surgeries performed in the given working days was calculated. Service rates are deterministic, using the domain knowledge, the service rate was manipulated to see the system efficiency.
- c. Arrival rate of OT (thoracic/other surgery): The department catered for thoracic surgery and other minor procedures like pacemaker insertion, bronchoscopy etc., In order to identify the real efficiency of the OT, the data related to thoracic and other procedures were considered. Data here were collected from the admission/discharge log books of OTs and Cardiac ICU. Access to these log books were given by the managers in the respective units. Average arrival rate of thoracic/other procedures were calculated based on the given working days.
- d. Total service rate for OT: Domain knowledge of the author who works in the department was used to calculate the total service rate.
- e. Arrival data for ICU: Arrival data for all the patients ( cardiac, thoracic, general admissions)in the ICU was accessed from the ICU admission log books.
- f. Servers for ICU: The total number of existing servers in the ICU is six.
- g. Service Time per patient in ICU: The data related to this was accessed from the cardiac surgery database. The average amount of time spent in ICU was calculated.

After collecting the relevant data tests for stationarity in time were calculated using Queuing theory formulas. For OT, M/M/1 model was used. The OT functions with two operating rooms, but it's the same surgeon who performs all the cases. Hence OT was considered to be functioning with one server. For ICU, M/M/n model was used. The ICU here has six beds, which was considered as six servers(n). Actual utilization and efficiency of the system was determined by these tests. These tests were followed by tests of independency. Here the author using the domain knowledge determines what happens if the service rate, service time, servers are manipulated. These



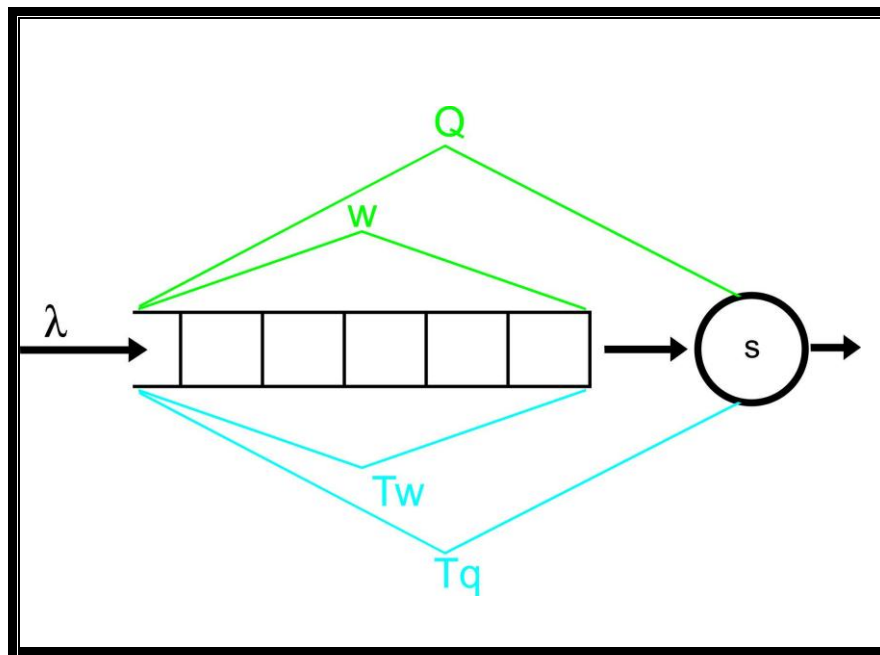
independence tests were carried out using several assumptions of the elements. The following Queuing Theory equations were used:

FORMULAS	EXPLANATION
<u>M/M/1 MODEL:</u>  $\rho = \lambda/\mu$  $L = \rho / (1 - \rho)$  $W = 1 / (\mu - \lambda)$  $L_q = \rho^2 / (1 - \rho)$  $E(W_q) = \lambda / \mu * (\mu - \lambda).$	$\lambda$ = Arrival Rate for OT  $\mu$ = Service rate for OT  $W$ = Average amount of time that a customer spends in the system.  $L$ = Average number of customers in the system.  $L_q$ = Average number of customers waiting in the queue  $E(W_q)$ = Time spent by a customer waiting in the queue.

**Table 3: Establishing M/M/1 Model**

FORMULAS	EXPLANATION
<p><u>M/M/n MODEL:</u></p> <p>a. <math>\rho = \lambda s / N</math></p> <p>b. <math>K = \frac{\sum_{i=0}^{N-1} \frac{(\lambda s)^i}{i!}}{\sum_{i=0}^N \frac{(\lambda s)^i}{i!}}</math></p> <p>c. <math>C = 1 - K / \left(1 - \frac{\lambda s K}{N}\right)</math></p> <p>d. <math>Tq = \frac{Cs}{N(1-\rho)} + s</math></p> <p>e. <math>Q = c * \frac{\rho}{1-\rho} + \lambda s</math></p> <p>f. <math>Tw = \frac{Cs}{N(1-\rho)}</math></p> <p>g. <math>W = c \frac{\rho}{1-\rho}</math></p>	<p><math>\lambda</math> = Arrival Rate for ICU</p> <p>N = Number of servers.</p> <p>S = Service time per patient in days.</p> <p><math>\rho</math> = Traffic intensity or utilization for</p> <p>N =number of servers.</p> <p>K = Intermediate value to simplify Calculations. It has no Intrinsic meaning</p> <p>Tq= Total time in Queue</p> <p>Q= Total patients in Queue</p> <p>Tw=Time waiting in the Queue</p> <p>W= Patients</p>

**Table 4: Establishing M/M/n Model**



**Figure 4: Representation of Queuing Theory parameters**

The findings from the above formulas are discussed in the next chapter.

### 3.2.4 Triangulation

Triangulation usually refers to the combining multiple research methodologies to produce a comprehensive representation of the research objective. This combination of methodologies compensate for the weaknesses and blink spots of each single methodology (Flick, 2009). Thus the author in this research methodology has triangulated the semi-structured and queuing theory model to come to a common conclusion. The process of triangulation strengthens the findings obtained from a qualitative process by cross checking it with other relevant research information (Polit et al., 2006). Both results by focusing on different issues are complementary to each other and thus leading to a fuller picture.

### 3.3 Conclusion

The chapter outlined the research design on the qualitative and quantitative research perspectives. The focus here was on semi-structured interviews and queuing theory and the process involved in accomplishing it. The next chapter will deal with results of this interview process and queuing theory results.

## Chapter 4 Implementation and Research

### 4.0 Introduction

This chapter discusses the results achieved from the semi-structured interviews. The results are discussed using a six step process of Attride-Stirling (2001) Thematic analysis networks.

#### 4.1 Attride-Stirling (2001) using a six step process of thematic networks

Step 1:

- a. Text segments were dissected using coding framework.

Step2:

- a. Themes abstracted from coded text segments

Step 3:

- a. Arrange themes
- b. Select Basic Themes
- c. Rearrange into Organizing themes
- d. Deduce Global Themes
- e. Schematic representation of thematic network

Step 4:

- a. Describe the network
- b. Explore the network

Step 5:

Summarize Thematic network

Step 6:

Interpret Patterns.

Steps 1 , 2 , 3 yielded the author with the following themes:

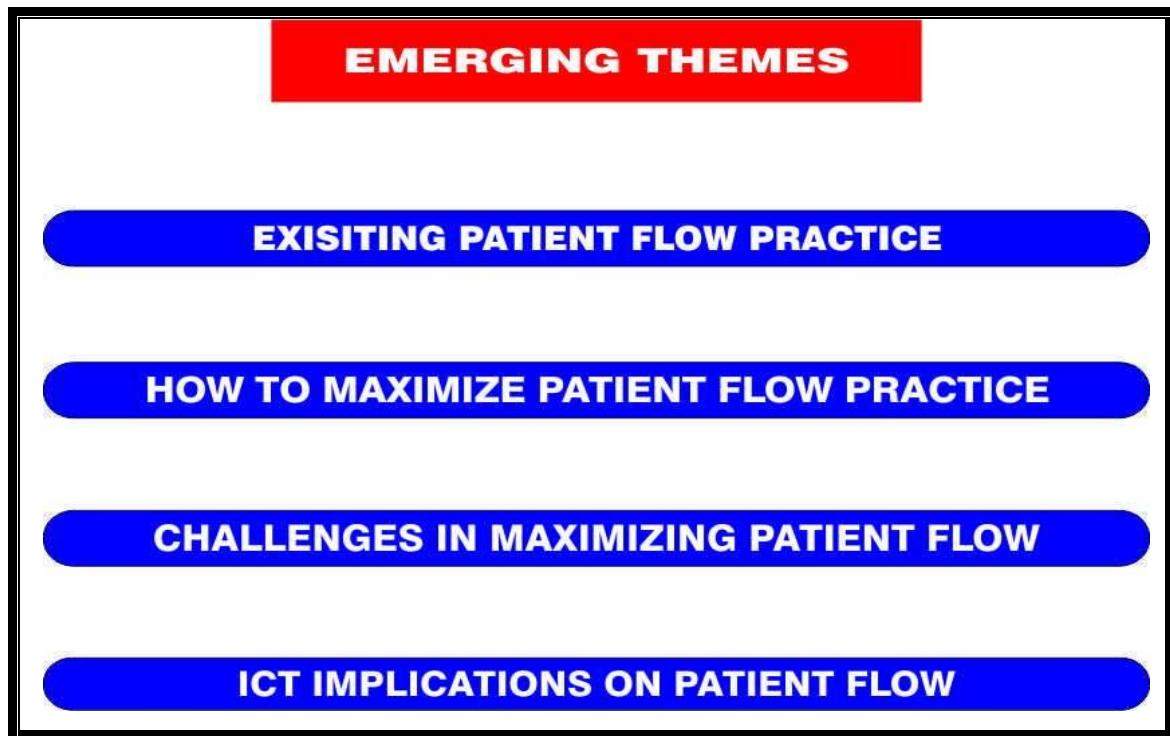


Figure 5 Emerging Themes

#### 4.2 Theme 1: EXISTING PATIENT FLOW PRACTICE

The global theme 'Existing Patient Flow Practice' was deduced from seven organizing themes. These organizing themes emerged from fifty one basic themes. This global theme describes the global view of the existing patient flow practices in the Hospital.

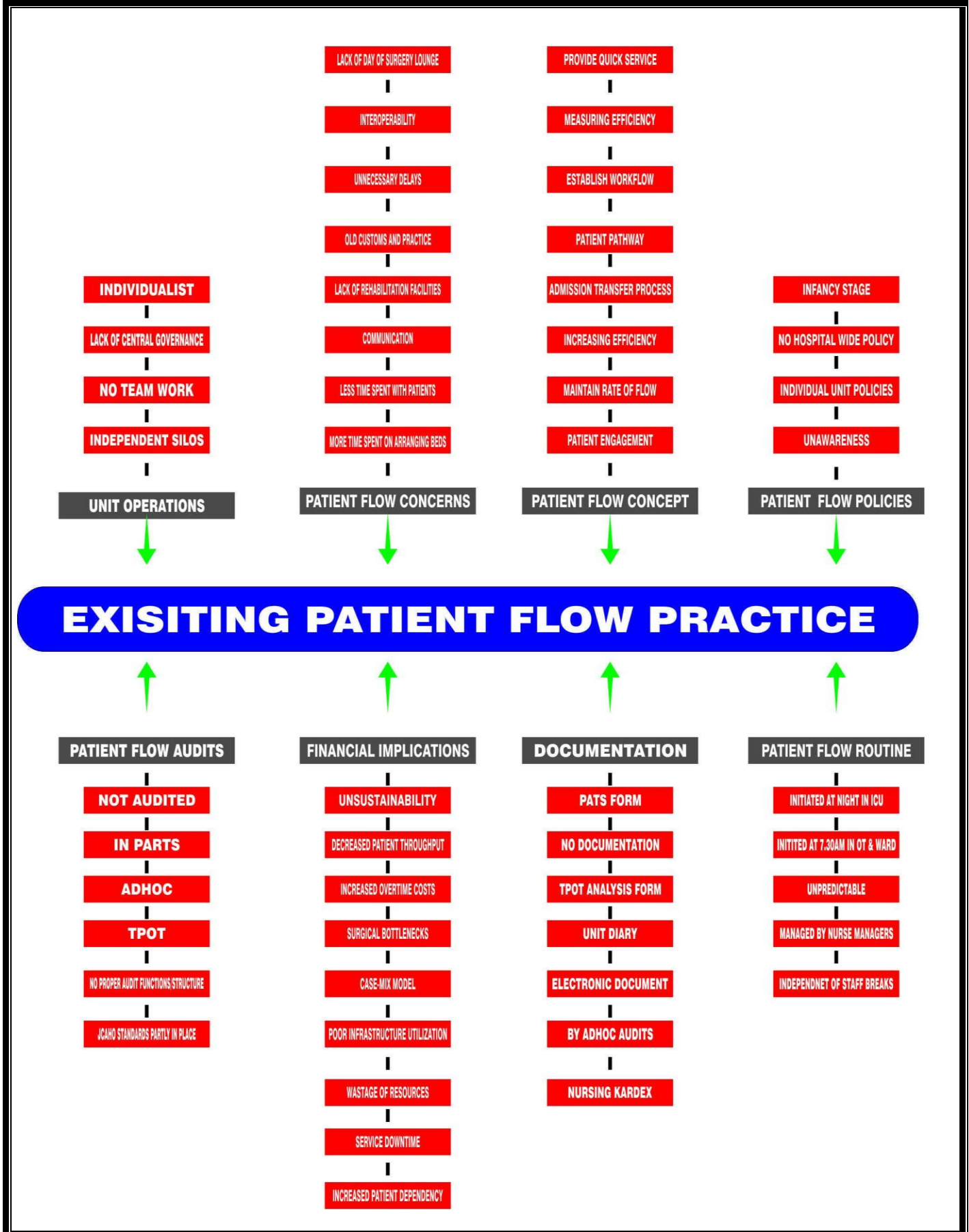


Figure 6: Thematic Network 1: Existing Patient Flow Practice

Patient Flow Concept:

The participants with their vast experience in their own area were fully aware of the patient flow concept from the clinical and operations research point of view. The participants were fully knowledgeable of the patient flow determinants like service, efficiency, workflow, patient pathway, engagement. These are described from the participant's own words:

- Getting the patient from date of admission to discharge through the service as quickly as possible and with the best outcomes as possible.
- My understanding is that you follow the patient from admission to discharge and you see how efficient the system is from admission to discharge.
- I guess it's establishing what it is, the limits, patients getting in and out theatre environment, everything from sending for the patient and back out from the theatre and back to the ward or the ICU.
- For me the patient flow is the whole patient pathway from the time the patient receives or goes to the doctor right through or to the consultant through their private or all patient appointment, and the time they get their to come in date through their pre assessment, day of surgery right through the process of patient flow.
- Patient flow means the patient starting from the admitting ward and back to the discharge area, the ward from where the patient comes in.
- My understanding is increasing the efficiency towards, providing equal and better care and maximising more patients through the system.
- We are responsible for a flow and the rate of progression of that flow, to the various intervals and to the various kind of the procedures that the patient will have to go through.
- It's the process by which patients engage with our service and the means of timing which they pass through the service which we need to give them.

### Patient flow concerns:

Overall, the participants were satisfied with the whole patient flow, however concerns do exist big time. The main concern was the lack of day of surgery lounge in the hospital, which will improve the bed availability for the hospital as a whole. Participants were concerned about communication processes within the units, old customs and practice, unnecessary delays, the amount of time spent on arranging beds, lack of hospital policies in practice and lack of rehabilitation facilities for patient referrals. Interoperability within the existing information systems within the units was the ICT concern. Excerpts from the interview:

- I suppose we were initially very concerned some years ago but, now we sort of have regular meetings for every two weeks with the consultants, the ward, theatre and ourselves anaesthetics and we look at how we can improve the flow, how we can get the patients to the unit and ward faster.
- We have paper and the computer system which are not connected which causes lot of hassle sometimes, with labs or blood results with theatres.
- There are unnecessary delays, the delays where they impact most are, delay in getting patient out of a theatre in time, either getting the patient to leave theatre going back to the ward or leave theatre, going back to the ICU.
- I think if we can get day of surgery admission lounge opened here as well, it will also help from patient perspective as well bringing the patient in the morning which is better for the patient as well.
- We are having problem with the ward, the patients are not discharged at the time they should be.
- What happens in a hospital settings, happens by custom and practice rather than by way of best evidence or by way of lean analysis of process.



- There is an admission and discharge policy, but it hasn't been passed yet, it is in its infancy stage and has to be passed by all stakeholders.
- The difficulties we have in more complicated patients to move them from our area to other hospitals, particularly in rehabilitation.
- 80 % of work time spent in arranging beds for patient flow.

#### Financial Implications:

Financial implications of patient flow can have disastrous implications for hospitals. The participants warned, unsustainability in service, compromised quality of care, inefficient hospital system, decreased patient throughput, overtime costs, poor utilization of the existing infrastructure, surgical bottlenecks, wastage of existing resources, service downtime are the financial implications of patient flow. The HSE operating on a case-mix model is affected. Further, compromised patient flow can increase the morbidity and mortality of patients as well. These implications are illustrated below:

- I understand if the patients are delayed, discharge from theatre after 5pm, there is going to be an overtime cost. I understand that if the patient in ICU is not discharged, in a timely manner that it is costly.
- Its inefficient for the hospital and staff and for the patients.
- If they are here for an extra day it costs us more and the waiting lists get longer.
- If patient flow is very badly managed, then the number of cases you can do is reduced.
- Any delays in the patient flow is time which is money, it is also going to affect you patient throughput, because if you have delay in your theatre time, its going to have knock on effect on the next patient.
- If you improve the patient flow, we can do more number of cases, we can be more efficient, we can save a huge amount of money and the OT wont be running late.

- The financial implications would be that, with the same amount, you could do more cases, definitely its increasing the efficiency, so economically that is a positive thing.
- Within the Irish healthcare system, the funding comes through the case-mix model, within the case-mix the outcomes is measure of financial efficiency is by cost per case. So if you can reduce your cost per case, you will be far more efficient, you will get better throughput, you will get better budgeting utilization.
- If the patient pathway is complex and if the length of stay is longer than two days than the norm, then you are going to be penalised.
- Financial implications are obviously are that wastage, which includes, if you are set up for a day to do three cases, and two of those cases cancelled, consequences for the theatre during that situation is that there is considerable downtime for lot of people .
- First of all its for the patient, if the patient doesn't get the appropriate treatment, in appropriate fashion, the cost of hospitalization, morbidity cost, mortality cost, any efficiencies within the hospital system has a cost.

#### Documentation:

Patient flow practice is documented invariably in the units. Documentation sources include Cardiac surgery database form, TPOT analysis form , local unit diary, Anaesthetic Information systems, nursing kardex. Adhoc audits studies are also documented. Excerpts regarding this from the participants are:

- It isnt documented, timing isnt documented, from one place to another and the reasons for delay is not documented.
- We document everything in our diary.
- There is some documentation in nursing level in theatre, somebody arrives, what time they went to sleep, what time they went into theatre and what time they left but what it doesn't take

into account is that what time things happened, but that's not the same time as when they were ready to happen.

- There is no formal documentation of it on an ongoing basis, its been on an adhoc basis, people have been trying to monitor it has an audit.
- When we were doing TPOT, we were doing process maps, we were looking at new patient throughput.
- Documentation point of view, anaesthetic is excellent, we have all the computerized system, we feed all details, time, we can retrieve back, or print out, there is nothing we can mask or hide.
- The most important thing is we should document when the patient is called for, document when the patient really arrived, when the patient is moved to anaesthetic room, when the patient is moved from the anaesthetic room to the theatre, when the patient incision is started, and when you finish.
- But we have formally not documented, time to OT, time to ITU, even if it has been documented, there is no one to note that its documented on the aspect of the flow.

#### Unit operations:

The three units OT, ICU and ward represented by the participants reflect units can be individualistic, more focused about their own workflow. However, few participants feel the relationships between the units have improved in the past few years. These units have no central governance hence poor team work exists and how the units act as independent silos is also highlighted by the participants:

- There is no one overseeing the flow from OT to the unit to the ward.
- To a degree, I mean they are all inter dependent , but each on a problem, seek to blame one further down, its sort a circle, so everybody else thinks that the problems is somebody else's problem.

- But the trouble is well is there isn't over arching governance of the management of the whole bed turnover resource for the three of them.
- They are three discrete areas, each have their own system and so there is nobody in charge of the three.

#### Patient flow routine:

The units are primarily run by nurse managers. The participants share the high unpredictability that exist in their units which affects patient flow. The participants were of the opinion staff breaks may or may not impede patient flow. Participants representing ICU described how they initiated patient flow during the night shift itself whereas the ward and OT had to wait until the morning to make decision on patient flow.

- In fact it is done from the night before in certain patients, because the staff on the floor are very experienced, they will know without even being told which patient are ready to go, so we start the process by the night shift.
- I start my checks at 7.30. First patient will be send for at 8am, that when the porter down stairs would arrive, 2<sup>nd</sup> patient will be send for 8.15, we double up all the time, we get our meals on duty so that we don't stop our works for meals.
- To admit a patient from ITU , staff breaks can slow things by 30 mins.
- I don't think the patient should wait in OT just because somebody needs to go on a break or something like that.
- I am sure staff breaks do have an impact on patient flow, but if managed properly they should not have.

#### Patient flow audits:

The participants were of the opinion that there is no proper audit system in place. Even if it did exist it was an adhoc based. The hospital comes under the accreditation of the Joint Commission on Accreditation of Healthcare Organizations (JCAHO). However, JCAHO recommendations are only partly in place.

The participants explain:

- I think patient flow from OT under TPOT is audited, but other than that I am not sure.
- It's been audited from time to time, our charts have been looked at in the quality office.
- You need to enhance systems to provide data, but then you have to process to audit as well.
- We don't have proper audit function/structure.
- There should be a systematic approach to an audit as supposed to an adhoc individualistic approach.
- We audit lots of areas of work, particularly, morbidity, mortality, but say, we don't have flow chart looking at patients,. For e.g. how long should bypass patient's be in the hospital for.
- We are working on it but it's hard to get it going with the resources available, it's improving but I don't know if it will be reached on the JCAHO standards.

#### **4.3 Theme 2: CHALLENGES IN MAXIMISING PATIENT FLOW**

This global theme incorporates three organizing themes held by 23 basic themes. This theme outlines the challenges faced in patient flow in the form of logistics and staffing issues point of view. Patient centered care aspects of patient flow is also discussed. The illustrations include:

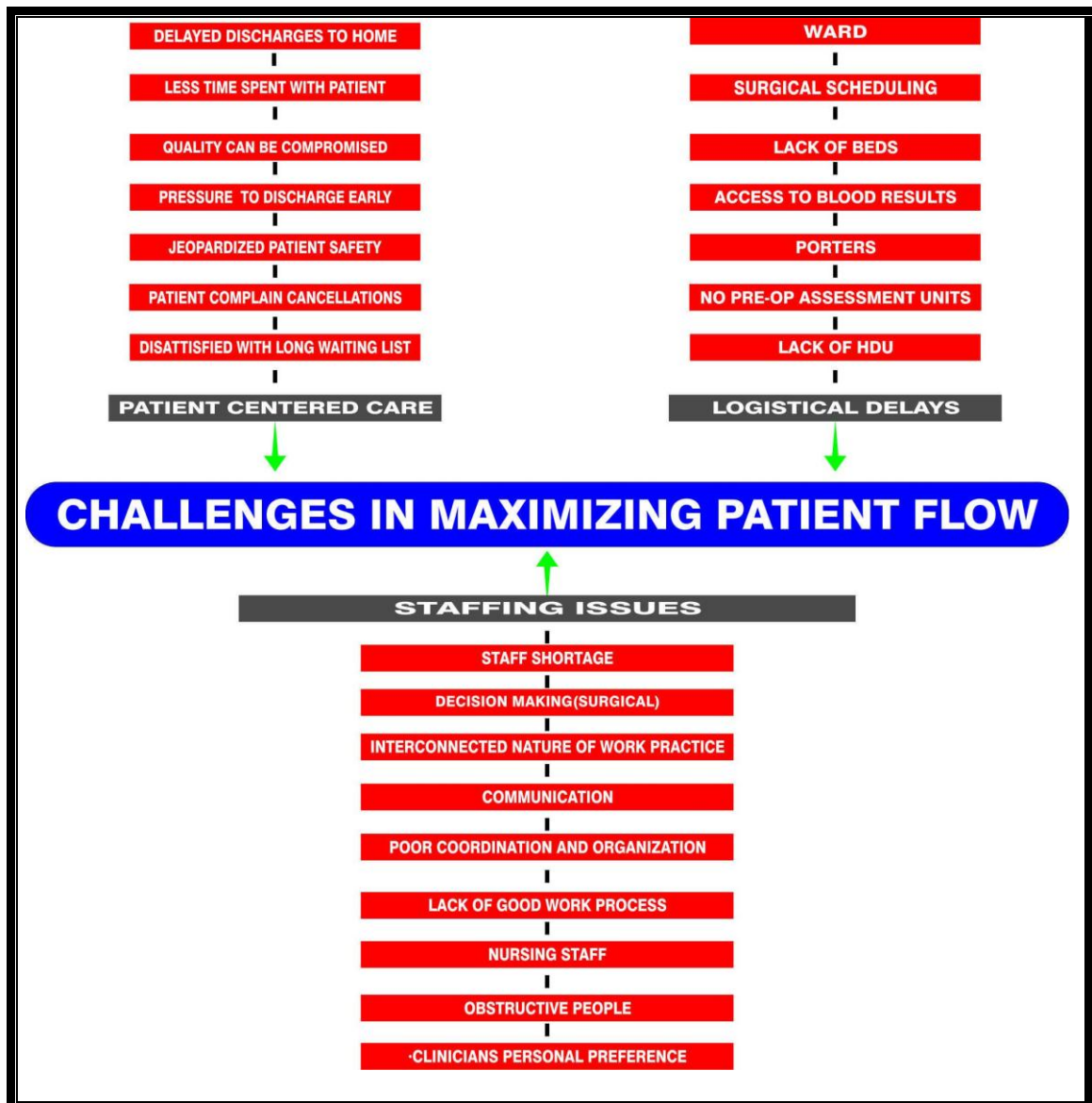


Figure 7: Thematic Network 2: Challenges in Maximising Patient Flow

#### Logistical Delays:

Participants list out the logistical delays from patient flow perspective. Lack of beds, porters, lack of pre –op assessment units, HDU, surgical scheduling, ward infrastructure are the logistical causes of delays in patient flow. The participants explain:

- Usually the problem is the ward, they cant get their patients out fast enough in order to facilitate us to send our patients down, that then delays the theatre and everything is backlogged.

- If the OT starts at 8am, patients transfers are going to be delayed.
- Blood results not back, porters not ready to take the patients, patient not ready for OT.
- Sometimes they send the patient back if the bloods are not written on the patient notes.
- Looking at delays, you will see that we don't have, or our patients are not pre assessed before coming into theatre.
- I think the surgical team has to make a early decision, and send them early.
- I suppose the biggest in this hospital is I suppose, is the absence of HDU, so that means we have a very limited observation area at ward level which is really only suitable for very straight forward cases.

#### Staffing Issues:

Participants coming from various backgrounds and disciplines explain how reliable they have to be to each other when working as team. Participants who work as a multidisciplinary team often come across, issues like staff shortage, personal preferences, lack of good work process, poor decision making, lack of coordination and organization, communication issues in the day to day patient flow practice. These issues are illustrated below:

- Everybody is working with the moratorium.
- Sometimes, we are not staffed for 6 people, we are staffed for 5 people, obviously, we have to cancel a case then.
- If you need a OT to run , they need 3 nurses, you have two nurse that is waste of two nurses , because you have two nurses, you are not doing a case, but you have two nurses they are idle there . So if you have one extra person means you can have the OT running.
- If you look at the ICT investment in the Irish health care system, compared to the ICT investment in the other healthcare systems, we are well below, what will be considered as below the industrial average.

- Some people are obstructive.
- I don't know why at each step people might not be able to take patient, but the communication might be the explanation, but it doesn't change the fact.
- If you are waiting for a consultant to make a decision on a patients discharge, that will delay patient flow.
- If the decisions are not made early , patients tend to stay, and if they don't move patient flow is impacted, some decisions has to be made.
- I suppose every clinicians would have their own ideas, and there exists a disparity between them in treating their own patients.

#### Patient Centered Care:

Participants while discussing seriously about improving efficiency with regards to patient flow they are still inclined to their fundamentals, patient centered care. Participants feel improving patient flow efficiency can hinder quality care, jeopardize patient safety and patients get less time to spend in hospitals. Participants feel the goal is to maintain a balance and optimized flow. The factors discussed here include:

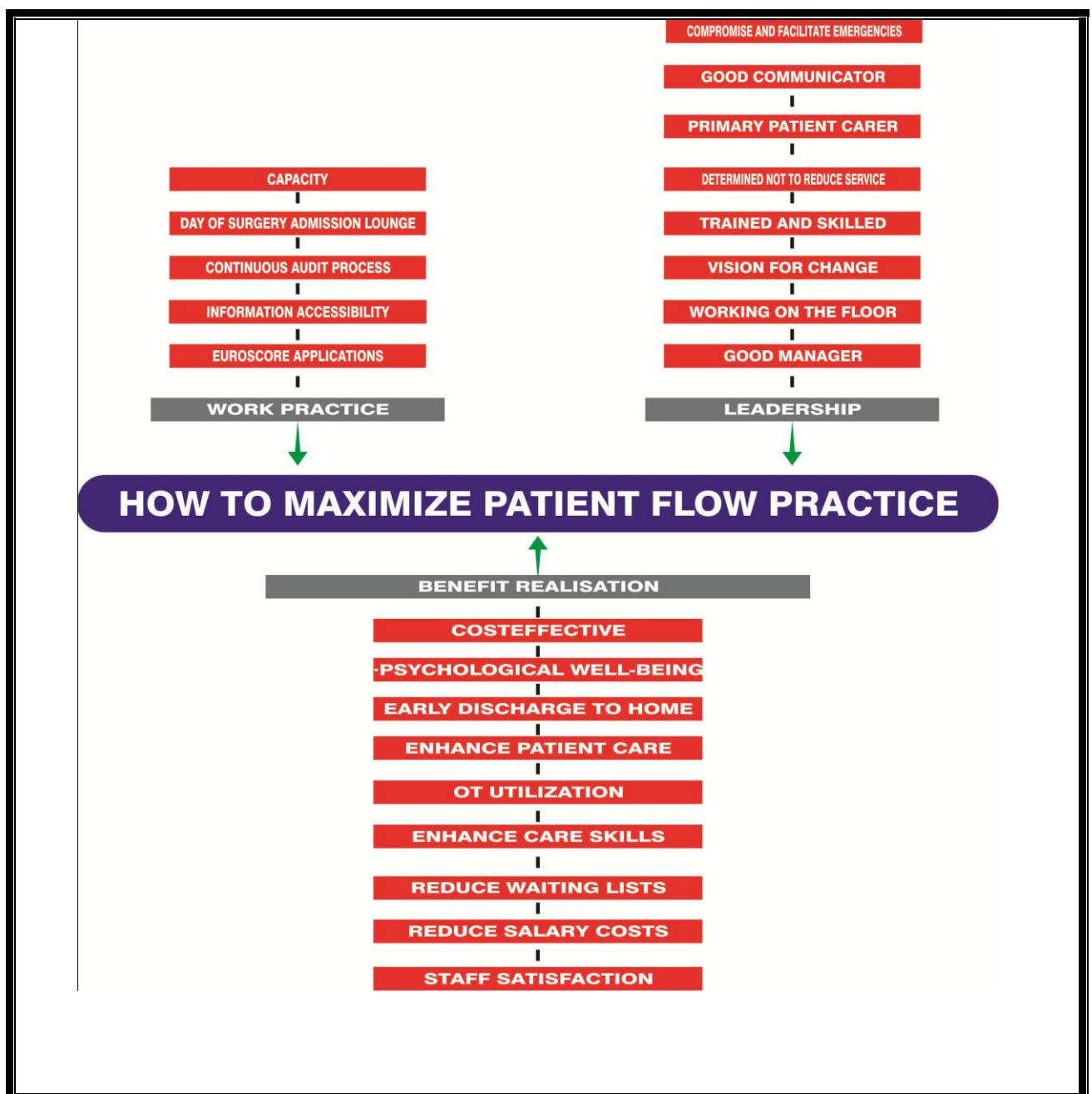
- You cant spend much times with the patient as you would like to, because you are so busy.
- The dissatisfaction comes trying to get the patients in, waiting,
- I don't receive specific complaint related to the fact that why I didn't get to transferred to OT , the only times essentially regarding the flow is when we cancellations, and our cancellations rate can vary from 25 – 75% depending on the situations.
- Speed is not everything, quality is the important.
- You would wonder if they are going home early, its kind a normal now, having the extra day is gone, there is a big pressure to get them out.
- I dont totally agree with that just because more patients are going through the system, doesn't mean that their care is compromised, partly in fairness people have more experience ,



you do more cases, people become experienced, more flow should make them better, in dealing with patients.

#### 4.4 Theme 3: How to maximize patient Flow

The third global theme derived from the interviews is how to maximize patient flow. Participants with their vast experience have recommendations for maximizing patient flow. This global theme encompasses three organizing themes. The number of basic themes within this organizing themes are 22. Participants envisage benefits realization is an important factor in maximizing patient flow.



### Figure 8: Thematic Network 3: How to Maximise Patient Flow

#### Work Practice:

The participants feel that the existing work practices needs to be revamped. Increasing the capacity to render services is also felt. Easy access to information, which will also enhance audit process, is pointed out. Applications of Euro score tools to calculate the morbidity and mortality or cardiac surgery patients are required as well.

#### Excerpts from the Interview:

- There isn't enough capacity at the critical care level. Critical care is a bottleneck for all patients (cardiac , general ) in the system here, because the capacity that exists in this hospital is tiny compared to the size of the hospital.
- I think if patient's are pre-admitted, or pre-assessed before they coming in, there will be lots of issues that are flagged.
- So from an ICT perspective it's the ability to easily access the information, when and as required.
- You can take up the particular classification of disease of illness, what the average LOS versus someone else's average LOS versus the national average LOS and if the LOS is way out , you can ascertain patient flow is not efficient. That's a very crude audit, but that is the most obvious one at this moment.
- Euro score anticipates the problem, that one might expect, so it prepares you.

#### LEADERSHIP:

The participants being leaders in their own units stress upon the importance of leadership in maximizing patient flow. The ideal characteristics of a quality leader the participants feel are:

- You can be a very good manager but not necessarily a good leader.
- They can advice me from outside, but people on the ground knows the best.
- A good leader who has a vision, will go and see the patient pathway and look at the patient flow and wont be running the show from the office.
- Some areas have poor leadership and that is a problem.
- Managers as leaders, consultants and as nurses, they need to be able to step back from cold faces of times and have to plan and look at how can we improve and its not just about people adopting that leadership role.
- We cant expect someone to take the management and leadership role if they haven't been trained or haven't been skilled in that discipline.
- Leadership is just not about the people, its about the organization and how it empowers the people to be leaders.
- It is my determination not to reduce the service, because in the past I feel, the service were often cut rather than looking at efficiencies.
- I think, the first and most important job is to do appropriate to the patient and beyond that in terms of improving the flow of the system, communication is the primary attribute that is necessary.
- We flag it straight away, first thing in the morning if there is any problem we flag it straight away, that is very important.
- If we don't get the leadership, we cant make it happen. They have to make it happen. They have to take the ownership of the project and drive it forward.

### BENEFIT REALISATION:

The participant's caution, the awareness of the benefits of patient flow amongst the whole staff is paramount. This is a primary step in achieving optimized patient flow. Awareness should be realized on:

- Patients come in they don't need to be in the ICU for any length of time, psychologically its not good place to be.
- For the hospital its cost wise, for the patient there will be discharged earlier and patient flow is good ,its cost effective all round.
- You are doing more number of cases, more satisfaction at the end of the day.
- It will have an impact on the waiting list to come down.
- If the patients are not done in time, they come in a poorer state, so they tend to stay longer, so it has a negative impact as well.
- It makes them more efficient, it's a leaner process and reduce waste and increase performance.
- We can get more patients done, majority of the funding is provided for salaries probably in excessive 70%-80% may be
- You do more cases, people become experienced, more flow should make them better, in dealing with patients.

### **4.5 THEME4: ICT IMPLICATIONS ON PATIENT FLOW**

The last theme to be formulated from the qualitative data is the ICT implication on patient flow. These themes evolved from three organizing themes. There are 28 basic themes as clusters to the organizing themes. Participants review the existing information systems in the department. Participants also share their knowledge about challenges and solutions for ICT implementation to improve patient flow.

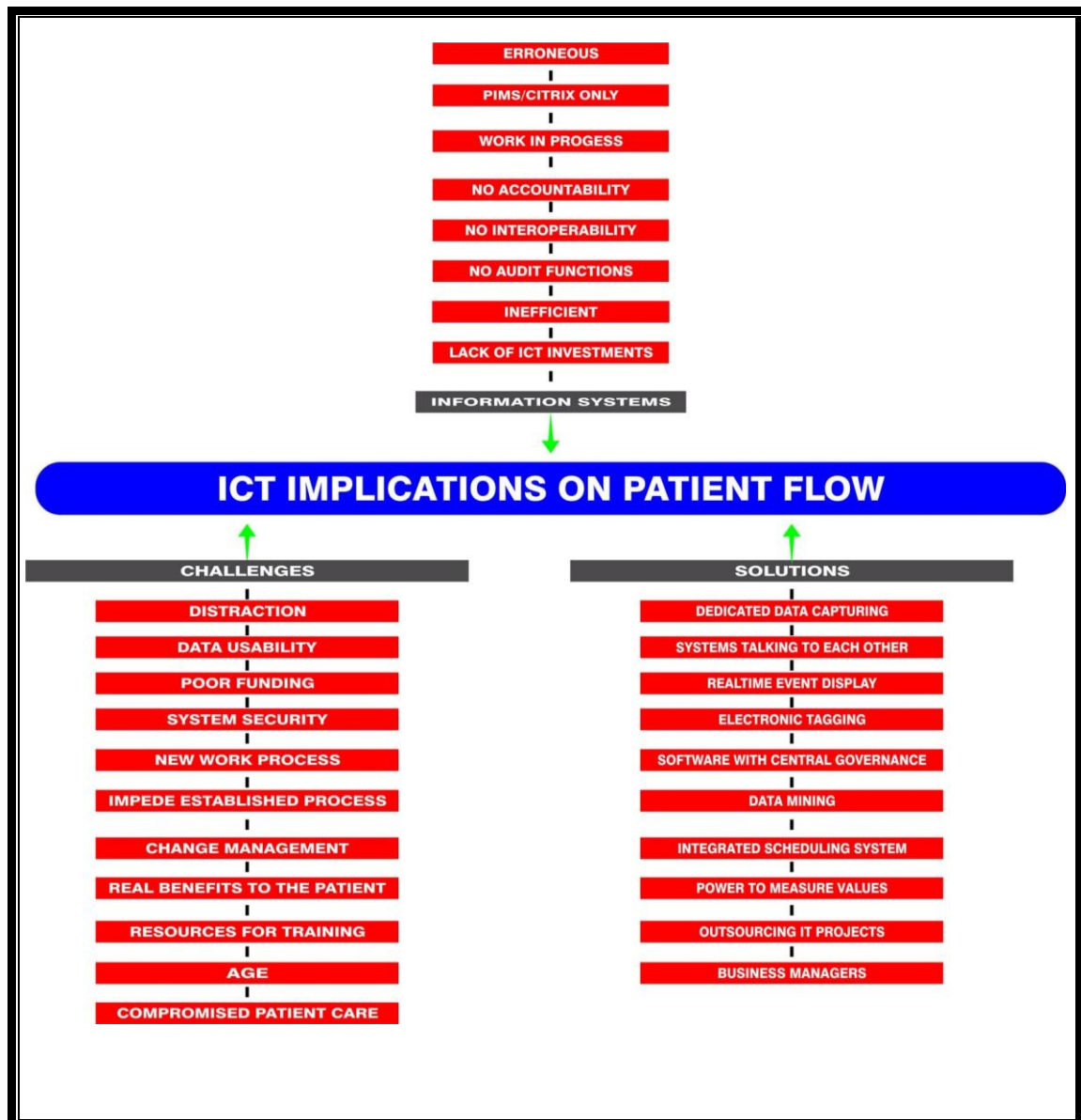


Figure 9: Thematic Network 4: ICT Implications on Patient Flow

#### EXISTING INFORMATION SYSTEM:

Participants are gravely concerned about the existing information systems in the department. Their concerns are:

- The PIMS was used to be for the year, the result showed up wasn't accurate, for cardiac patients yes and for thoracic patients no.
- At the moment we have business project meeting, they will be capturing and it is not up and running in each theatre yet, it will be and that will be linked to the whole process. So that will be able to get our data of that.

- There is not a system in place that automatically catches all the lapses.
- Having lots of data is in own its inefficient, we need to do something with it, and having resources needs to be something with it.
- They are writing bits and pieces, but that system is not accountable to anybody, until otherwise if the consultant makes a huge fuzz or writes a letter to somebody, making enemies, and ruining the whole atmosphere.
- But there isn't a system, set out from the start stating this is the care plan , this is the organizational service need, that does all in advance, that doesn't exist.
- When we are collecting the data at this moment we are collecting manually for the TPOT programme and that is one area we have identified.
- It's the big comprehensive view, you get the individual pieces, but it's the comprehensive integrated view and the comprehensive integrated scheduling of the activities, that is where it falls down.
- Projects needs to be business led, if its going to be business led, the people need to be given the time and space to do it. If you need to configure a system and if need to evaluate or test a system, we need to be given the people, time and space to work on it.

### CHALLENGES:

Here participants outline the challenges facing the implementation of ICT solutions in the department. Poor funding, change management, real time benefits, slowdown in existing workflow process are few of the challenges. Data utilization and system security aspects are also addressed. The excerpts include:

- It's a new concept for new staff, lot of staff wouldn't be IT literate to a certain point, so it will be challenging in the whole concept, fear of IT system.
- Resources to have the changes, teaching, the people.

- At the end of the day, people are still busy and occupied with all the other stuff they do, looking after the patients and so it is an distraction or another piece of work for people to have to be doing.
- I think as long as you don't distract them from the patient going back to PC , logging in, feeding in, this is going to fail the system to a degree.
- Lot of anesthetists, surgeons they tend to stick to their own methodology, and they are not going to change.
- It is because the older the person having the consultants are , the less likely they are going to change their way of practice.
- There are people who turn up ideas, who we cant support because of the resources we have, which is very disappointing.
- The management challenge is that the management in the hospital fully don't appreciate the role that ICT can play in the organization and in their own service area, and they tend to focus on very specific narrow things, rather than saying how can we get value overall.
- Any project that is national or local project, they will give the money to do it, but they don't give you the people, they don't give us the money to employ people. So the money we get is directly for hardware and software component, not for the people.
- There is not any huge appreciation or willingness to interact with ICT amongst the nursing staff.
- One of the biggest things which are across the board is a lack of ICT training, lack of understanding of ICT programs and the one that specifically impacts the HSE area is surprisingly is the data security one.
- I think it has to be an evolution, that its not just about the IT system, its about the organizations and the people ability to absorb systems.

- There should be a systematic approach to an audit as supposed to an individual adhoc approach. We don't have that audit resource to do that.
- First and foremost we must show that its is beneficial to the patient.
- If you are going to engage in a new process, that process for the most part must not interfere with the flow pattern that has already been established.
- If you are going to do something with the data, you need the resources, to implement the changes that you are required to do with the data.

### ICT SOLUTIONS:

The participants recommended ICT solutions in the form or real-time event display system, electronic tagging to map the flow of patients, dedicated data mining tool, integrated scheduling system. The main essence of ICT solution mentioned by the participants is the power to measure values using robust technologies.

- People related to IT should come with IT systems, should have systems which are related, talking to each other.
- It has been identified by showing by TPOT, the power of measurement, the power of having your data, is what you need.
- Its very scientific in the sense that you can capture the data, so therefore can be better assessed as data as supposed to assumptions.
- If all went computerized, electronic documentation would improve need to transfer everything what happened, lack of real time event display information, we don't know what is happening in OT, we don't know what is happening in ICU.
- There was going to be an electronic tag, what time was the patient send for. This was the project that was never got off.
- You want one dedicated piece of software, may be it can gather information from other sources if it is set it up accordingly, but



only if it automatic, whether you could display the patient status where they are and when they are leaving.

- If I was the head of the ICT, I would like to contract out the bulk of ICT services to a service provider and say, come in and fix the problem for me.
- What we need is managers, they don't need to be ICT managers, they need to have professional business managers who knows what the business requirements.

#### 4.6. QUEUEING THEORY RESULTS

Elements identified in the queuing theory model were entered into the Excel sheet. They were categorized as follows to find out the real and assumed patient flow in the cardiac surgery process:

- a. Real Patient flow in OT (Cardiac Surgery)
- b. Real Total Patient flow in OT (Cardiac & other procedures)
- c. Assumed patient flow in OT (Cardiac Surgery)
- d. Assumed Total Patient flow in OT(Cardiac & other procedures)
- e. Assumed Patient Flow in OT using two servers.
- f. Real Patient Flow in ICU.
- g. Assumed Patient Flow in ICU.

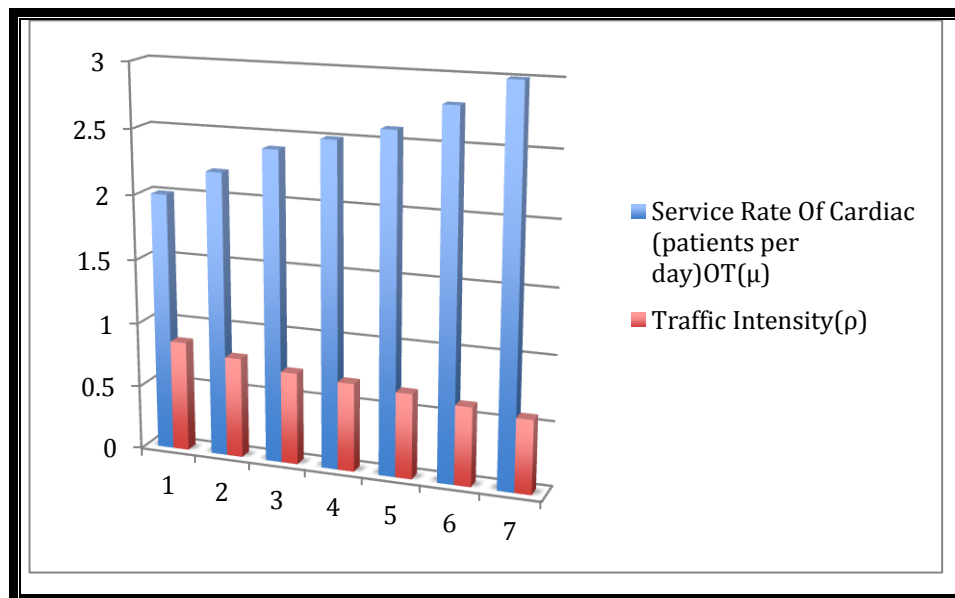
##### 4.6.1 Real Patient flow in OT (Cardiac Surgery) using M/M/1 Model

- ❖ The total number of cardiac surgeries performed on the study period was 430 cases.
- ❖ The total number of working days was 251 days for the study period.
- ❖ Arrival rate of Cardiac patients per day ( $\lambda$ ) is 1.7131474 patients per day.
- ❖ Service Rate of Cardiac patients per day ( $\mu$ ) is 0.172423835125594 patients per day. This value was assumed to 2 as its not possible to operate on the calculated number practically.
- ❖ Traffic Intensity or utilization of the system is 0.856573705 or 85% of the times the OT is utilized for surgery.
- ❖ Average number of customers in the system (L) is 5.972222222 patients

- ❖ Average amount of time that a customer spends in the system( $W$ ) is 3.486111111 per day.
- ❖ Average number of customers waiting in the queue( $L_q$ ) is 5.115648517
- ❖  $E(W_q)$  is the waiting time in the queue, or the time spent by a patient waiting in queue which is 2.986111111.
- ❖ In the above findings,  $L$ ,  $W$ ,  $L_q$  &  $E(W_q)$  are biased values. This is because conflict of waiting times between the elective patients and emergency patients. Of the 430 cases operated 191 patients were elective, the rest were emergency, hence the real waiting time for patient cannot be calculated.
- ❖ Hence, the M/M/1 model used here was used to calculate the actual utilization rate of the OT only

#### 4.6.2 Assumed patient flow in OT( Cardiac surgery) using M/M/1 Model

Using the queuing theory principles and the actual arrival and service rate from above, the author assumed what happens if the service rate is increased. That is the effect on OT if the number of cases performed each day is increased. This is graphically represented as:



**Figure 10: Service Rate Vs Traffic Intensity in OT (Cardiac Surgery)**

This graph shows that utilization rate increases as the service rate increases.

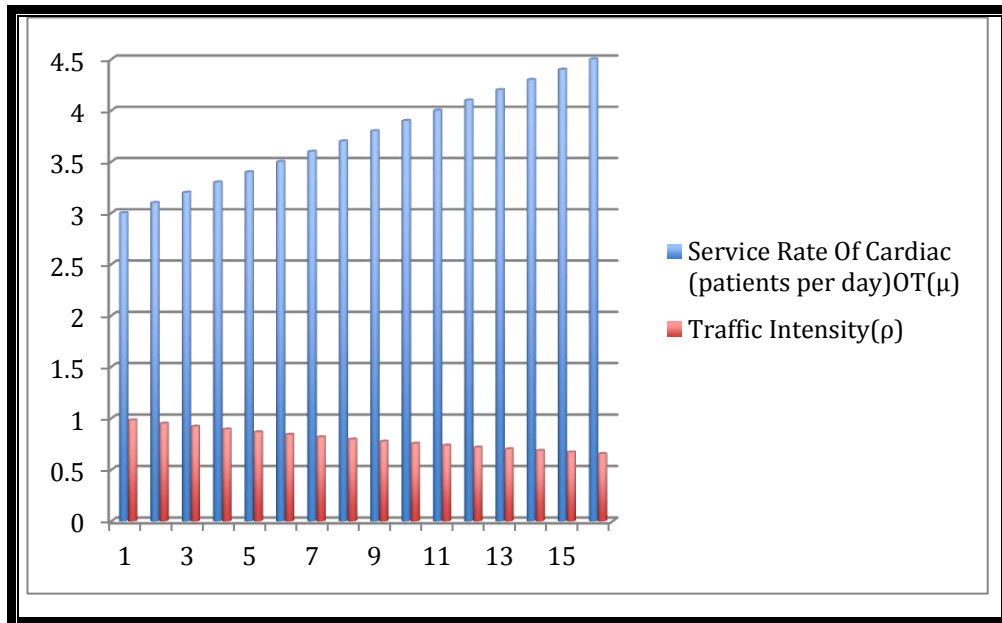
Service Rate Of Cardiac (patients per day)OT( $\mu$ )	2	2.2	2.4	2.5	2.6	2.8	3
Traffic Intensity( $\rho$ )	0.856574	0.778703	0.713811	0.685259	0.658903	0.611838	0.571049

**Table 5: Service rate and Traffic intensity values- OT (Cardiac Surgery)**

#### 4.6.3 Real Total Patient flow in OT (Cardiac & other procedures) using M/M/1 Model

- The total number of surgeries performed on the study period was 430 cardiac surgeries and 308 thoracic and other procedures.
- The total number of working days was 251 days for the study period.
- Arrival rate for total number of patients to the OT is 2.943099397 patients per day.
- Service rate of total patients operated were applied using domain knowledge of the author. In this case it 4 cases per day on the average.
- Traffic intensity or utilization of the overall system is 0.735774849 or 73% of the times the OT is utilized for surgery.
- Average Number of Customers in the System(L) is 2.784651073
- Average amount of time that a customer spends in the system(W) is 0.946162768
- Average number of customers waiting in the queue (Lq) is 2.048876224
- E(Wq) is the waiting time in the queue. i.e, the time spent by a patient waiting in queue is 0.696162768
- In the above findings L, W, Lq, E(Wq) are biased values. This is because conflict of waiting times between the elective patients and emergency patients.
- Hence, the M/M/1 model used here was used to calculate the actual utilization rate of the OT only.

#### 4.6.4 Assumed Total Patient flow in OT(Cardiac & other procedures) using M/M/1 Model



**Figure 11: Service Rate Vs Traffic Intensity in OT (All surgeries)**

The above chart shows utilization improves as service rate improves.

Service Rate Of Cardiac (patients per day)OT( $\mu$ )	3.4	3.8	4	4.2	4.5
Traffic Intensity( $\rho$ )	0.865617	0.7745	0.735775	0.700738	0.654022

**Table 6: Service Rate and Traffic Intensity values for OT (All Surgeries).**

#### 4.6.5 Assumed patient flow in OT with increased servers using M/M/n Model

- This scenario assumes that if the number of servers in OT is increased to 2 from the existing 1 server. This scenario incorporates M/M/n model, n represents the number of servers. The findings are:
  - Arrival Rate Of Patients (patients per day) ( $\lambda$ ) is 2.943099397
  - Number of servers are 2
  - Service Time per patient (s) in days is 0.50. The author assumes that if there are two servers, two surgeons will be operating in each

OT. Assuming if each surgeon performed 2 cases then service time per patient is 0.50 per day.

- Multiple (2) server traffic intensity or utilization ( $\rho$ ) is 0.735774849.
- The Probability that all the servers are busy ( $C$ ) is 0.623772869
- Total Time in Queue ( $T_q$ ) is 1.680381329 days
- Total patients in Queue( $Q$ ) is 3.208539488
- Time waiting in the Queue ( $T_w$ ) is 1.180381329 days
- Patients waiting in the Queue ( $w$ ) is 1.736989789

Again, because of the conflict between the elective and emergency patients,  $T_q$ ,  $Q$ ,  $T_w$ , and  $w$  values are biased and insignificant in this context.

#### 4.6.6 Real Patient Flow Analysis in ICU using M/M/n Model

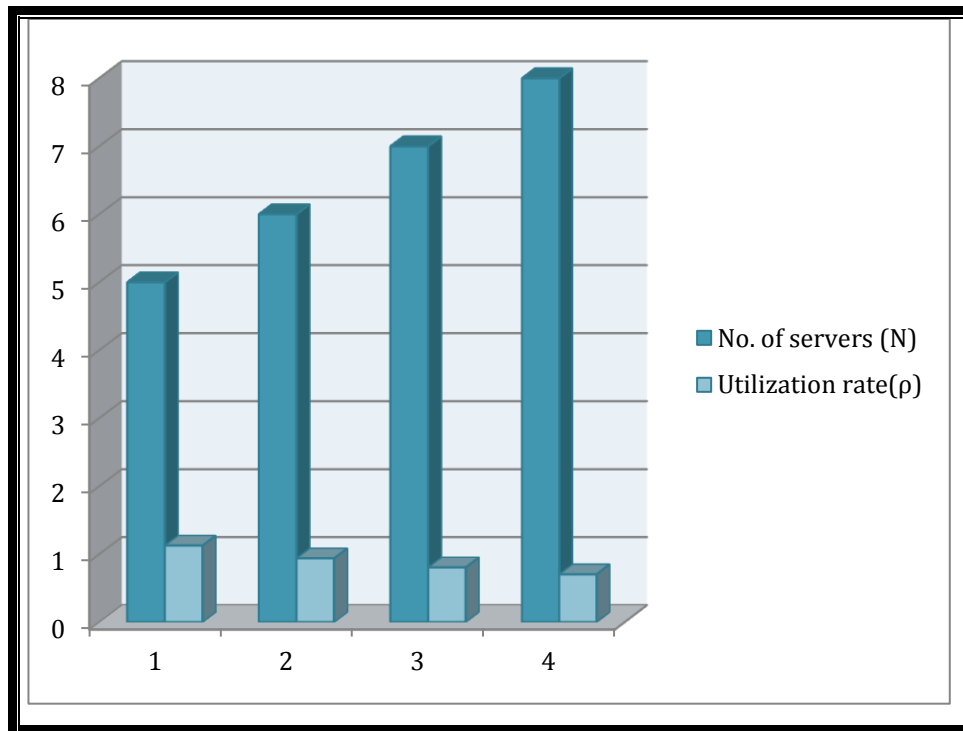
- This scenario incorporates M/M/n model,  $n$  represents the number of servers.
- Arrival Rate of patients per day to ICU ( $\lambda$ ) is 1.994520548. This is calculated by the average number of patients admitted to the ICU in 365 days.
- Number of servers or beds in ICU is 6
- Service time per patient or average time spent per patient in ICU is 2.824527476 days.
- Multiple (6) server traffic intensity or Utilisation ( $\rho$ ) is 0.938929681.
- The Probability that all the servers are busy ( $C$ ) is 0.83702347, or out of 100 days 83 days ICU beds are busy.
- Total Time in Queue ( $T_q$ ) is 5.108843573 days.
- Total patients in Queue ( $Q$ ) is 18.5024512
- Time waiting in the Queue ( $T_w$ ) is 2.284316097
- Total patients waiting in the queue ( $W$ ) is 12.86887311

#### 4.6.7 Assumed Patient Flow Analysis in ICU using M/M/n Model

Assumption here involves manipulating the number of servers from 5 to 8.

Graphical representations of the assumption are shown below.

By increasing the servers, the change in utilization rate is noted.

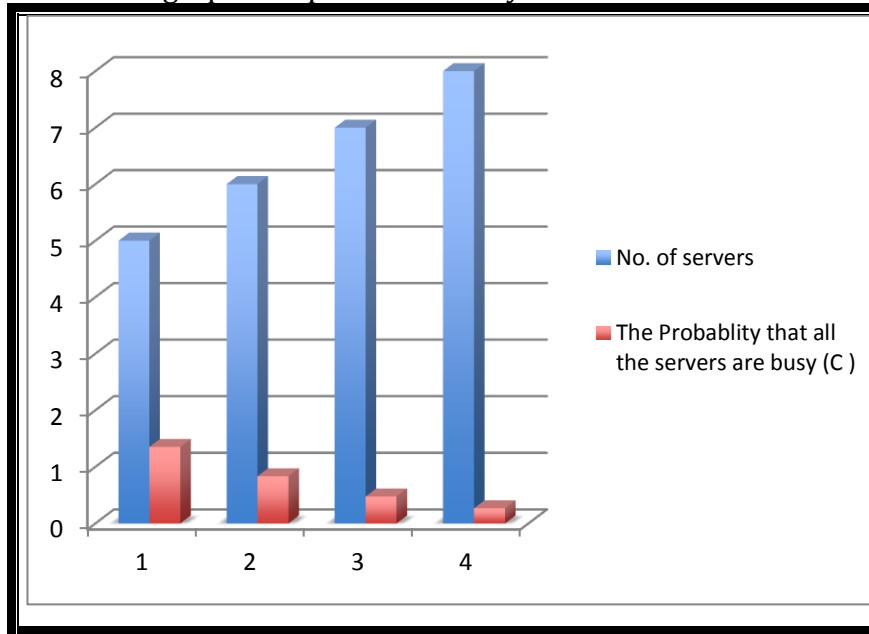


**Figure 12: No. of Servers and the utilization rate in ICU**

No. of Servers (N)	5	6	7	8
Utilization rate (ρ)	1.126716	0.93893	0.804797	0.704197

**Table 7: No. of servers and utilization rate values**

The below graph compares how busy the units can be in relation to the servers.

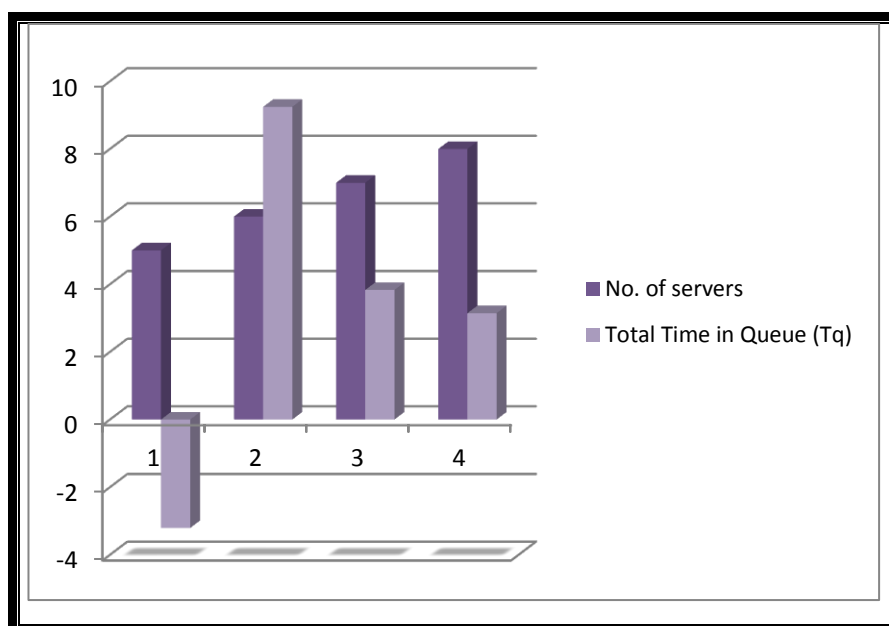


**Figure 13: No. of servers and the probability of servers being busy in ICU**

No. of Servers (N)	5	6	7	8
The Probability that all the servers are busy C	1.352837	0.832915	0.4763	0.26837

**Table 8: Server and probability values in ICU**

The total time spent in Queue changes by the increase in the servers.



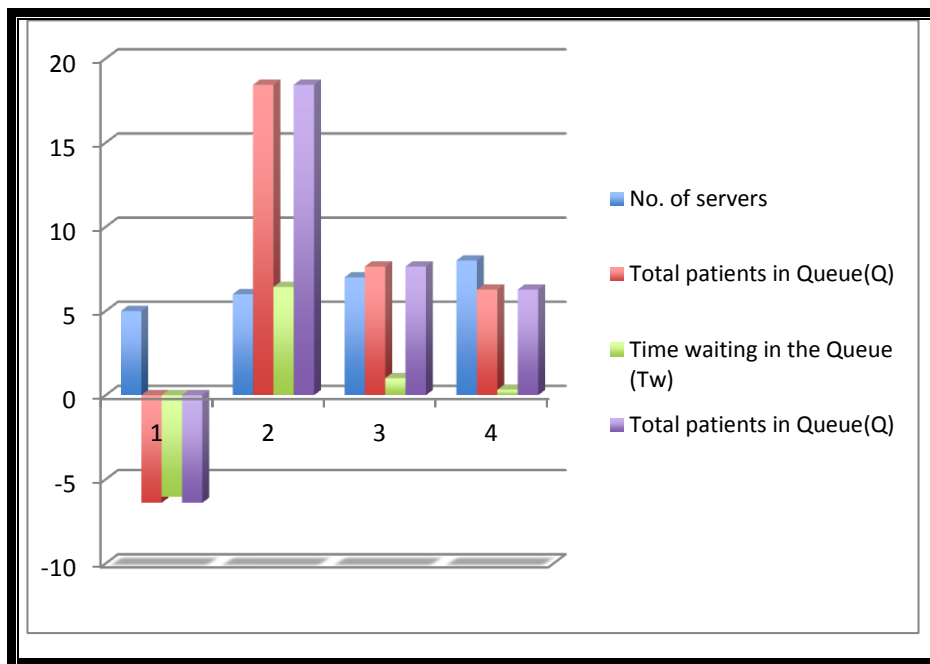
**Figure 14: No. of servers and total time in Queue (Tq).**

With the increase in servers, the total time in Queue ( $T_q$ ) is decreased.

No. of Servers (N)	5	6	7	8
Total Time in Queue ( $T_q$ ) in days	-3.2065	9.244968	3.832506	3.14485

**Table 9: Values of no. of servers and total time in queue in days.**

The number of servers here determine the total patients in the queue, time waiting in the queue, and total patients in Queue.



**Figure 15: Comparison of Queuing Theory Parameters**

No. of Servers (N)	5	6	7	8
Total patients in Queue (Q)	-6.39542	18.43928	7.644012	6.272469
Time waiting in the Queue ( $T_w$ ) days	-6.03102	6.420441	1.007979	0.320323
Patients waiting in the Queue (w)	-12.029	12.8057	2.010434	0.638891

**Table 10: Values of M/M/n calculations**



#### 4.6.8 Limitations of Queuing Theory applications

- Calculations of the arrival rate for elective patients and emergency patients separately was not feasible.
- Hence, the vital parameters like total time spent in the queue, total number of patients in the system, total number of patients waiting in the queue could not be calculated.
- While calculating the arrival rate for OT, emergency patients operated on the non-working days were exempted which was negligible value however.
- Long-term patients who stayed in the ICU for more than 3 days reflected on the average time spent in the ICU of all patients.
- These patients were excluded from the service time in the ICU.

#### 4.7 Conclusion

This chapter has laid out the results of the qualitative data extracted using Thematic Network analysis. This was followed by the results of Queuing theory calculations. The next chapter will evaluate and analyse the above mentioned findings.

## **Chapter 5 Evaluation and Analysis**

### **5.1 Introduction**

This chapter deals with the evaluation and analysis of the results gathered from the research methodology. Analysis of semi-structured interview using the thematic networks and Queuing theory results are inferred in detail.

### **5.2 Semi-Structured Interview analysis**

This qualitative data is discussed based on the four themes derived by Altride-Stirling thematic networks:

#### **5.2.1 Existing Patient Flow Practice**

Basic understanding of the concepts in any operations is the key in the field of operations research. The participants holding key portfolio in the department are well aware of the patient flow concepts. The participants highlight their primary responsibility in optimized patient flow in day to day activities.

Participants are fully aware of the values of patient flow in improving the efficiency, workflow process and getting the patient engagement as a result.

However, concerns do exist in the existing patient flow practice. The participants feel lack of day of surgery lounge, old customs and practices, communications gaps impede patient flow. Participants are concerned about the interoperability of the existing information systems. As care givers, participants feel they spent more time arranging beds and less time with patients.

Patient flow process in the Units may be individualistic, where the participants feel each unit is concerned about their own well-being with no teamwork.

Thus, they end up acting as independent silos. The primary reason for this practice is the lack of central governance of all the Units. Existing patient flow practices lacks policies to run the Units. Lack of hospital wide policy is highlighted by the participants. Auditing patient flow practice is a key factor in

enhancing patient flow, however audit tools in the Units are in its infancy stage or merely existent. Lack of proper audit functions/structure is to be noted. The lack of audit functions can be related to the fact that documentation on patient flow exists only in the individual Unit level. There is no common documentation for the three Units. The TPOT analysis form incorporates only OT based patient flow, the ward and ICU are thus left behind. Electronic documentation on patient flow do exist in the OT which are scrutinized for adhoc audits. The participants warn about the financial implications of patient flow which can be consequential if the existing patient flow practice continues. Considering the financial climate the country is in, the participants feel patient flow slowdown can be unsustainable for the unit. The case-mix model on which the budgeting is allocated for the Units can be derailed if decreased patient throughput, surgical bottlenecks, poor infrastructure utilization, wastage of resources, overtime costs co-exists.

Despite the various flaws in the existing practice of patient flow participants feel they are meeting the operational needs of the hospital as a whole. However, they are seriously concerned about the improving the efficiency of the current practice under the current economic climate. The participants feel the Units have to prove themselves that they productive enough with the existing facilities and thus the urge for improving efficiency is seen. This initiative has led the participants in arranging fortnightly meetings to discuss patient flow issues.

### **5.2.2 Theme 2: How to maximize Patient flow practice**

Aware of the urge in improving the operational targets of the Units, the participants have identified the key areas to improve patient flow. Participants feel primarily it's the work practice factors needs to be addressed. Participants point out the lack of capacity especially the ICU beds as a key deterrence in improving patient flow. From the Ward point of view opening of day of surgery admission lounge will relieve the pressure on ward beds. Apart from this participants feel continuous audit process is paramount in any

operational research. Easy access to the patient flow information for sharing and communicating is also mentioned. Participants share the experiences of caregivers and as managers. They mention the benefits of maximising patient flow needs to be realised. Benefit Realisation of patient flow include proper OT utilization, reduced waiting lists, reduced salary costs. From the patient's perspective, it gives them a psychological well-being, they can be discharged to home early. For the staff, patient flow optimization can enhance their care skills, and feel satisfied at the end of the day.

Challenges need to be lead by a good manger with a vision for change. The participants being managers and administrators stress on the leadership qualities are inevitable in maximising patient flow practice. The participants mention the leader should basically be trained and skilled with good communications skills in delivering and achieving patient flow targets.

### **5.2.3 Theme 3: Challenges in maximising patient flow**

Challenges are part of any operational goals. Patient flow practice is no exception. Logistical delays are part of any hospitals environments. In this case, the participant's feel, Wards are primarily responsible for delaying patient flow. The reasons cited for this are lack of beds, lack of access to blood results, delays in decision making by the surgeons. However, few participants feel wards are forced to take care of highly dependent patients with less resources. Hence, lack of High Dependency Unit is going to have an effect on patient flow process overall. OT surgical scheduling process are also questioned by the participants.

Some participants feel patient flow stress on improving operational efficiency only. Patient centred care, the key goal of the hospital philosophy can be compromised. Improving operational efficiency can compromise patient care quality. It can jeopardise patient safety and these participants get less time to spent with patient. However, other participants counteract against this point, they feel from the patient point of view, reduced patient flow can lead to cancellations of surgeries and thus patient themselves are dissatisfied with long waiting lists. Participants point out the staffing issues can impede patient flow big time. The commonly addressed staffing issues are staff shortage, lack of communication. Some participants feel, nursing staff and clinicians

personal preference can impair patient flow. Participants highlight the importance of the high interconnected nature of work practice that exists and the lack of awareness of this amongst the staff. Thus, participants feel, identifying and addressing challenges in patient flow process is vital in meetings the targets.

#### **5.2.4 Theme 4: ICT Implications on patient flow**

Auditing and analysing patient flow process with the use of information systems is the latest trend in hospital operational research. Participants feel the Units are not ready for this because the existing information system are erroneous with no audit functions. These systems lack accountability and interoperability thus being inefficient. Lack of ICT investments are the reasons cited for this situation. The poor absorption of the ICT elements into the hospital system can be noted by the number of challenges mentioned by the participants in implementing any ICT solution in the hospital. The participants, feel staff consider ICT solution has a distraction to their existing work process. Change management issues are highlighted here as well. Any new ICT implementation can impede the existing workflow process, thus compromising patient care warn the participants.

From the ICT perspective, poor funding, system security, resources for training are pointed out. Participants are deeply concerned about the data usability of the data collected from the information systems and the real benefit for the patients. Participants as primary end users for these information systems recommend dedicated data capturing systems which can talk to each other. Participants require information systems with power to measure values for data mining. Participants feel lack of communications amongst the units can be improved by real-time event display system. Patient flow can be tracked by electronic tagging and integrated scheduling system. However, all these systems require central governance, highlights one of the participants .

From the ICT perspective, one participant feel IT projects should be outsourced for the timely delivery of the end products. Also, ICT projects needs business managers and not administrative managers. The participants feel, making the existing systems interoperable within the Units is the primary

step to be taken in ICT interventions. Also, the participants feel its high time the true values of existing information systems are utilised using the current information systems. Participants are gloomy about any ICT investments to be made in the near future.

### **5.3 Queuing Theory Analysis**

Analysis of the Queuing theory applications on the OT and ICU are addressed below:

#### **5.3.1: Efficiency of OT**

Traffic intensity or utilization of OT for cardiac surgeries using M/M/1 model is 85% which is normal for any system. However, traffic intensity or utilization of OT for all the surgeries is 73% when 4 patient's are operated per day on a average. This highlights the point that if service rates are rushed up which can have an effect on the capacity and its resource planning. Based on the assumption model it is recommended that the ideal service rate of 3.5 to 3.8 patients per day operated can sustain the system. Another model of assumption using M/M/n model in the OT shows that increasing the server in OT from the existing 1 maintains a utilization rate of 73%. However, the capacity is increased here, with two surgeons operating. Hence the probability of the servers being busy is 62% or out of 100 days only 62 days are occupied. This probability facilitates emergency admissions who normally exceed the elective patients. This also facilitates the patients who are elective for surgeries, thus reducing their waiting list time. Thus queuing theory results in the OT shows that the existing system is working to its optimum. Increasing the servers to two that is two surgeons operating independently each day will reduce the waiting list time for elective patients.

#### **5.3.2: Efficiency of ICU**

Traffic intensity or utilization rate for ICU is 93% which is abnormal. This utilization rate significantly can affect the OT in performing surgeries because of lack of ICU beds for patients post -surgery. This can affect the ICU in accepting emergency admissions causing bottlenecks for the hospital ICU beds. The probability that all the servers are busy is 83% that is out of 100 days, beds are available for 27 days only all other days the ICU is occupied.

On the average each patient has to wait for 6 days to get into the ICU which is practically not possible, but its significance is to be noted. Total number of patients waiting in the queue is 12. That is for every 6 patients discharged to the ward, there are 12 patients ready to get in of which only 6 can get in. Again, this scenario in practice is not possible.

Based on the assumption model of  $M/M/n$ , the significance of reducing a bed in the ICU can be disastrous for the ICU which is already running to its maximum capacity. For example, if because of budgetary requirements one bed is reduced, the total number of patients waiting in the queue and time spent becomes negative or infinite in this case which impairs the efficiency of patient flow as a whole. Another example is if there is an increase of a bed by 1 in the ICU, there is a drastic change in the efficiency of ICU, which the operations managers may not wish, hence the ideal bed requirement for the ICU at this stage is 6.5. This 6.5 number of server will accommodate all the emergency admissions and elective surgeries. Catering general ICU admissions is also feasible. Thus to summarise, the capacity of ICU is slightly over-utilized impeding the patient flow process in cardiac surgery.

#### **5.4 : Conclusion**

This penultimate chapter analysed the details of patient flow aspects based on the qualitative data and quantitative data obtained from semi-structured interviews and queuing theory models respectively. The issues of capacity in the ICUs is evident from the qualitative and quantitative data. The next chapter finishes of this research process by conclusion, limitations and recommendations of this research.

## **Chapter 6 .0 Conclusion, Limitations and Future Work**

### **6.1 Introduction**

This chapter concludes this research process by outlining the findings of this research process , its implications and recommendations for the cardiac surgery patient flow process. This chapter also discusses the limitations and future directions based on this research process.

### **6.2 Conclusion and recommendations**

Discoveries can sometimes facilitate in achieving the organization's goals. This research process envisaged maximising patient flow in the provision of cardiac surgery and the author believes, the maximising factors have been identified to the best of authors knowledge. This research process helped in formulation of a road map to efficiency. Lewis et al., 2011 describes every healthcare delivery system in this world has a unique range of services, however has a finite or limited service capacity. Boucherie et al., (2011) hence cautions that hospitals operate with strict business restrictions. The scarce availability of resources has lead the hospitals to operate under high capacity utilization conditions. This research process assessed the efficiency by knowing the capacity of the healthcare organization and how well the capacity is utilized. The measured efficiency of capacity is working to its optimum except the ICU , where the capacity is slightly over utilized. Mcmanus et al., (2004) supports this point by explaining how ICUs can present as bottlenecks within a busy hospitals, their expansion however is costly and difficult to gauge. Caution should be taken in not stretching the service rendered to the patients. Fine balance between demand and need should be maintained. Patient throughput can be increased by paying careful attention to staff perception, data collection. and by prioritising work (Cochran, et al., 2007). Metrics is the key in patient flow, without metrics there is no urge for action. Metrics if measured will result in action which can lead to rewards or penalties.

The author believes this research study will enable healthcare managers in predicting the future activity of their organizations. Occupancy rates in the hospital measures the real time hospital performance. The length of stay parameters determines the costs and the number of patients being treated in



the hospital. The research study implemented in a Unit who works on the case-mix model is crucial to identify the real costs of running the units for the systems own survival. Its puzzling to note that the arrival process is invariable to the ICU despite scheduling surgical procedures.

Thus, effective scheduling of surgeries is recommended in making the demand process smoother. Mcmanus, et al., (2004) argues the traditional and historic methods of calculating the requirements of hospitals need to cease. Healthcare operations should be market-driven with austere environment. The lack of consideration for the total care chain process from admission to discharge is evident, rather the practice followed is more focus on individual units. This practice has resulted in poor patient access to services with increased costs. Capacity decisions taken by healthcare managers should take into consideration the quantitative models of analysis. An under provision of hospital beds can result in patients refused admission in to the system. Whereas overprovision can result in underutilisation of the resources which is already scare.

Significant problems in healthcare such as access block and long waiting lists for elective surgery, have led to calls for keeping hospital occupancy at no more than 85%.(Bain et al., 2010). Where as the ICU in this context has an occupancy of 93%. Rushing up ICU patients to the ward to save a bed and accepting them in few days time for further management doesn't improve throughput .Singh et al., (2012) recommends an ideal ICU should be able to adapt to new demand of patient flow by aggressively discharging patients and be able to respond to emergencies thus less likely to behave as a bottleneck unit.

It's a concern that existing information systems lack the facility to calculate the amount of time spent in the unit and how it affects their health. Even though, these information may exist, access to this information is lacking. Its evident from the studies that it's the re-engineering of the system is what is required and not money to solve waiting lists in hospitals.

### 6.3 Conclusion based on the research questions

The author would like to elaborate on the research findings based on the research question addressed in the Introduction Chapter.

1. How efficient is the current patient flow in a cardiac surgery department in a public hospital?

Queuing theory models applied in OT and ICU reveal that OT is running to its optimum capacity and its utilization rate is appropriate. The issue with OT is the capacity to cater for emergency surgeries whose arrival rates are randomly based. With the facilities for two operating rooms and three cardiothoracic consultants available, it is advised the OT operate with two servers, where two surgeons operate one each day, rather than the existing practice of one surgeon operating a day. Staffing resources and work practice needs to be established for this process. Its evident from the research that the ICU with its 6 beds is slightly over utilized. This has led to the delayed scheduling of patient's for surgeries because of lack of beds in ICU. Lack of high dependency beds in ICU , long term patients in ICU and the hospital practice of accommodating general ICU patients can be attributed to the increased utilization of the ICU resources.

These queuing theory findings can be validated by triangulating the qualitative data obtained from the interview process in the research design. Analysis of interview data shows that capacity in ICU is an key factor in patient flow impedance. Efficiency in OT and ICU has still scope for improvement in maximising the existing patient flow practices. This is shown by sorting out the work practice issues in the fortnightly team meeting in the Unit. Making the OT more productive is also witnessed by TPOT project.

2. How to maximize patient flow in the provision of cardiac surgery?

Queuing theory results show patient flow in OT can be maximised by adding an additional server. This additional server will make the OT more efficient and promote optimised patient flow from its perspective. The trouble lies in ICU where its resources are stretched. The ICUs operating efficiency can be

improved by at least adding 0.5 server. Logistical facilities do exist for this, however staffing issues are hindering this process. Under the current economic climate where cut backs are inevitable, any reduction in the existing service can be dangerous for the patients. Reduction in any of the existing service can make patient waiting time for surgery to be infinite. Qualitative analysis supports the same idea, however it adds more inputs to maximise the service by changing the existing historic work practice and systems.

### 3. How can technological solutions pave way for maximizing patient flow?

The operational research using queuing theory has established the capacity issues in the Units. Research works similar needs to be carried out throughout the year in any operational environments. This is where information system that performs data mining comes into play. The metrics derived from the data can result in any reward or penalty for the Units. Without metrics or data in this case, there is a feeling that nothing is being done. This research reveals that dedicated information systems capturing patient flow data are the need of the hour. Information systems incorporating communication tasks related to the patient flow can be adjunctive to the existing systems. As mentioned earlier in from the interview analysis it is understood that participants are not expecting any investment for dedicated patient flow information system in the near future. However, the key here is how existing information systems within the Units can be utilized for data capturing. From the ICT point of view this is achievable when sound interoperability exists. From ICT investment point of view it is to be noted that it doesn't mean cutback means zero investment in ICT. The Government is still investing in ICT as they did five years ago, the problem lies in lack of manpower to carry out this investment works. Thus the investments lay futile.

To summarize on the findings based on the research questions, the existing operational units do have the capacity to run the units in a optimised way with the services in the ICU slightly overstretched. These units however cannot withstand any reduction on the existing services. Operational efficiency can be achieved by making the existing information systems more interoperable

and commissioning it to capture data related to patient flow as well.

#### 6.4 Limitations

The limitations of this study include:

Operational models of any hospital organization can be very detailed and complex. Mathematical models like queuing theory performance has not been evaluated over periods prospectively. The stochastic nature of arrival process in the ICUs may mislead the healthcare managers in underestimating the resources required in the cardiac surgery patients. Patient flow aspects of the ward were not included in this study. The total picture of patient flow is not complete yet. However, in the ward the arrival and service rates are very complex and they cater not only for cardiac surgery patients but also other surgical patients. Hence it was felt data related to the ward may bias this study. While this study was in process, the OT has been forced to shut down for given number of days due to cut backs and staffing issues, hence future studies may yield different results.

The average rate calculated on all the data may not reflect the true picture. From the ICU point of view, long term patients in ICU masked the real service time in ICU. Measuring efficiency in OT and ICU is a huge topic in itself and the author has tried to cover the whole lot under one roof. Validation of interviewed data was not accomplished because of the busy schedule of the participants. However this has been accomplished by triangulating the interview data with queuing theory results in the above section. The authors lack of experience in interviewing and interviewing work colleagues would have failed to extract further rich data.

#### 6.5 Reflection

The author believes that this research study has paved the author to venture into the field of operation research. Coming from a clinical background, the author has realised the true science of management. This research process enabled the author to understand the ICT issues in the hospital. Practical interview skills were gained as the interview process progressed. There was a significant amount of difference in data gathered from the first interview to the

last. Personally this interview process has enabled the author to maintain a relationship with the participants. On the successful completion of this research, healthcare managers may use this research as a reference in their organizational operations.

## **6.6 Future Work**

Individual units namely OT, ICU, and Wards needs to studied for their patient flow efficiency. From the OT perspective, utilization and efficiency of the theatre within itself is a huge study. Queuing theory model can be applied elsewhere in the hospital to capture the efficiency rate.

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## Appendices

### Appendix A: Consent Form for the Interview

**HIEF INVESTIGATOR: MARY SHARP**

**CO-INVESTIGATOR: SAJEESH KESAVAN**

**RESEARCH TITLE: MAXIMISING PATIENT FLOW IN THE PROVISION OF CARDIAC SURGICAL CARE.**

**BACKGROUND OF RESEARCH:** This research is being conducted as part of a thesis to be submitted in partial completion of an Msc. in Health Informatics at Trinity College Dublin. The research will lead to identifying key factors in maximising patient flow in the provision of cardiac surgery.

**PROCEDURES OF THIS STUDY:** This study involves interviewing ten members of Staff, Cardiathoracic department. This interviews envisage to obtain a deeper understanding of staff experience in dealing with patient flows. The interviews are planned to be conducted between March 2012 – April 2012. The interviews will be recorded and transcribed. There are no anticipated risks to participants. Results from interviews will be analysed and used as a basis for recommendations.

**PUBLICATION:** The research will be published and bound as a thesis in September 2012 and held at TCD Library. It may be used in the in a poster presentation if required. All individual results will be analysed anonymously .

**DECLARATION:** I am 18 year s or older and I am competent to provide consent. I have read this consent form to my best of knowledge. I have had the opportunity to ask questions and all my questions have been answered to my full satisfaction. I understand the description of the research that has been provided to me. I understand that the information I provide will not be sold or rented or use for any commercial purposes. I am also aware that no remuneration is provided to the participants. I agree that my data is used for scientific purposes and I have no objection that my data is published in

scientific publications without revealing my identity. I freely and voluntarily agree to be part of this research study, though without prejudice to my legal and ethical rights. I understand that I may refuse to answer any question and that I may withdraw at any time and have my interview to that time be destroyed. I understand that no cost is involved from participating in this study. I understand that my participation is fully anonymous and that no personal details about me will be recorded and erased post study. I understand that under special circumstance my participation can be terminated by the investigator without regard to the subjects consent. I understand that this study is not expected to involve risks greater than those ordinarily found in daily life.

I, the undersigned, hereby consent to participate as a subject in the above described project conducted at the Cork Teaching Hospitals. I have received a copy of this consent form for my records. I understand that if I have any questions concerning this research, I can contact the above investigators listed above. If I have further queries concerning my rights in connection with the research, I can contact the Clinical Research Ethics Committee of the Cork Teaching Hospitals, Lancaster Hall, 6 Little Hanover Street, Cork.

**PARTICIPANTS NAME:**

**PARTICIPANTS SIGNATURE:**

**DATE:**

**STATEMENT OF INVESTIGATORS RESPONSIBILITY:** I have explained the nature and purpose of this research study, the procedures to be undertaken and any risks that may be involved. I have offered to answer any questions and fully answered such questions. I believe that the participant understands my explanation and has freely given informed consent. Confidentiality of records concerning my involvement in this project will be maintained in an appropriate manner. When required by law, the records of this research may be reviewed by government agencies and sponsors of the research.

**RESEARCHERS CONTACT DETAILS:**

**INVESTIGATORS SIGNATURE:**

## Appendix B: Information Sheet for the participants

### INFORMATION SHEET FOR PARTICIPANTS

I am 2<sup>nd</sup> year student pursuing Msc. Health Informatics in Trinity College Dublin. This research is conducted as a partial completion of this course. As a part of my research I am investigating how to maximise patient flow in the provision of cardiac surgery in the Cork University Hospital, Cork. This study involves measuring the patient flow using mathematical models and analysing it with the data collected from the interviews.

You are invited to take part in an interview. Participation in this research is entirely voluntary. If you are interested in taking part in this study you will be given this information sheet and requested to sign a consent form. You have the right to withdraw at any time and you may omit individual responses without any consequences. Interviews will last for a maximum of 45 minutes involving 36 questions. These questions precede with few general personal questions which includes age, sex, experience, profession, nationality & position held. The only purpose of these personal questions are to analyse data in view of socio-demographics of the participants. These interviews will be recorded and transcribed.

Participating in the interviews will give you the opportunity to share your experiences and make recommendations on how to maximise patient flow in the cardiac surgical process. I am not aware of any risks for participants but can assist you in making contact with the required staff counsellor whenever needed.

Participant and third party anonymity will be preserved at all stages of the research. This includes analysis, publication and presentation of the resulting data and findings. By anonymity in the context of this study I mean no one will have access to our interview transcript except me. The report will be written in a way that will make it impossible to identify any individual. If required, I will contact you to verify direct quotes and their contextual



appropriateness before using them. I will keep all data confidential. All records of interviews will be erased and shredded when the research is complete.

In the extremely unlikely event that illicit activity is reported to me during the interview I will be obliged to report it to appropriate authorities. There are no conflicts of interest to declare.

If you have any questions about any aspect of the study I am always obliged to answer them. I am happy to send a summary of the research findings on request.

My contact details are:

Sajeesh Kesavan,

Co-investigator,

3, Elm Mews,

Classes Lake, Ovens

Cork Co.

Email: [kesavans@tcd.ie](mailto:kesavans@tcd.ie)

Ph: 0872840409

Thank you for taking the time to read this information sheet. If you interested in participating in this interview, please sign the attached consent form.

Yours sincerely,

Sajeesh Kesavan.

Date:

## Appendix C: Questionnaire for the Interview

### Questionnaire for interview:

#### Maximizing patient flow in the provision of cardiac surgery care.

**Research Question:** How to maximize patient flow in the provision of cardiac surgery care? What is the role of health information systems in improving patient flow?

#### General Information:

- a. Area of work
- b. Gender
- c. Age
- d. Profession/Background
- e. Nationality
- f. Qualifications
- g. Years of experience at work
- h. Full-time/part-time
- i. Are you aware why you have been asked to participate in this study?
- j. How did you react to this proposal?
- k. What concerns did you have



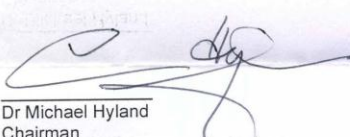
#### **Patient flow Questionnaire:**

1. What is your understanding of the concept of patient flow?
2. Is there any hospital policy/ protocol in practices used to transfer patient in your unit
3. Are you concerned regarding the quality of patient flow?
4. Are you aware of the financial implications of patient flow?
5. Are you concerned about the patient flow affecting your other routine patient management tasks?
6. What is the average time spent in arranging beds for patient flow?

7. What are the commonest cause of time delays in transfers between the units?
8. How do you deal with the various uncertainties that arise during the patient flow?
9. Do scarce resources contribute to poor patient flow?
10. How is patient flow documented in the current practice?
11. Do you think that each of your individual units functions individually focusing more on individual unit operations and its own productivity?
12. What time do you start to initiate the patient flow during shift?
13. What are the commonest causes of delays in patient flow?
14. Do staff breaks have impact on the patient flow?
15. Do you think the communication failures are the commonest cause for patient flow?
16. Do you think change in the work practices can improve patient flow?
17. Do you think medical decision making influences the patient flow?
18. Do you think leadership qualities influence the patient flow?
19. Who do you report to if there is a slowdown or bottleneck in the patient flow?
20. Do you think the quality of care can be compromised if patient flow is increased?
21. Are patient satisfied with their flow during the treatment?
22. Do family members influence patient flow?
23. Do you think porters delay patient flow?
24. Is there an artificial variation caused by the personal preferences and beliefs of clinicians in influencing the patient flow?
25. Can importance to patient flow jeopardize patient safety?
26. Considering the current practice of patient flow being followed do you feel the need for improvement in patient flow?
27. Do you know if the current patient flow is audited?
28. What do you perceive are the benefits in improving the patient flow?
29. Are there educational/resources available on maximizing patient flow?

30. Are you aware of the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) new standards for managing patient flow strategies?
31. Can applications of Euro score in the cardiac surgery improve patient flow?
32. Do the existing information systems capture data related to the detailed sequence of patient flow?
33. Do you think there is a technological gap in the current patient flow model?
34. How can technology gap address the patient flow?
35. What challenges are likely in managing changes associated with IT implementation?
36. That covers the things I wanted to ask, is there anything you would like to add?

## Appendix D: Clinical Research Ethics Committee of the Cork Teaching Hospital Approval Letter

  <p>Tel: + 353-21-490 1901 Fax: + 353-21-490 1919</p>	<p>COISTE EITICE UM THAIGHDE CLINICIÚIL <b>Clinical Research Ethics Committee</b></p> <p>Lancaster Hall, 6 Little Hanover Street, Cork, Ireland.</p>
<p>Coláiste na hOllscoile Corcaigh, Éire <b>University College Cork, Ireland</b></p>	
<p>Our ref: ECM 4 (dd) 06/03/12</p>	
<p>15th February 2012</p>	
<p>Ms Mary Sharp Tutor School of Computer Science and Statistics G34 O'Reilly Institute Trinity College Dublin 2</p>	
<p><b>Re: Maximising patient flow in the provision of cardiac surgery care.</b></p>	
<p>Dear Ms Sharp</p>	
<p>Expedited approval is granted to carry out the above study at</p>	
<p>➤ Cork University Hospital.</p>	
<p>The following documents have been approved:</p>	
<p>➤ Application Form ➤ Detailed Protocol ➤ Interview Questionnaire ➤ Information Sheet ➤ Consent Form.</p>	
<p>We note that the co-investigator involved in this study will be:</p>	
<p>➤ Sajeesh Kesavan.</p>	
<p>Yours sincerely</p>	
	
<p>Dr Michael Hyland Chairman Clinical Research Ethics Committee of the Cork Teaching Hospitals</p>	
<p>➤ Consent Form ➤ Information Sheet ➤ Interview Questionnaire ➤ Detailed Protocol ➤ Information Sheet</p>	
<p><i>The Clinical Research Ethics Committee of the Cork Teaching Hospitals, UCC, is a recognised Ethics Committee under Regulation 7 of the European Communities (Clinical Trials on Medicinal Products for Human Use) Regulations 2004, and is authorised by the Department of Health and Children to carry out the ethical review of clinical trials of investigational medicinal products. The Committee is fully compliant with the Regulations as they relate to Ethics Committees and the conditions and principles of Good Clinical Practice.</i></p>	

## Appendix E: Trinity College Dublin Ethical Approval Letter

From: research-ethics@scss.tcd.ie Research Ethics

To: kesavans@tcd.ie

Date: Thu, 29 Mar 2012 12:25:41 +0100

Subject: RE: Ethical Approval Forms for Cork Teaching Hospitals.

Dear Sajeesh,

Ethical approval has been received from Cork University Hospital for your research. You may now proceed with this study.

We wish you success in your research.

Kind regards

Gillian

**Appendix F: Approval Letter from Quality Unity, Cork University  
Hospital, Cork.**

**From:** Marie Fitzgerald (Quality Co-ordinator) **Sent:** 09 March 2012 14:49:17  
**To:** Saj Kesavan (CUH Nursing - CICU) **Subject:** RE: "Maximising patient  
flow in the provision of Cardiac Surgery"

Saj,

Your research proposal – “Maximising patient flow in the provision of Cardiac  
Surgery” has been approved.

Good luck with your project

Marie

Marie Fitzgerald  
Quality Co-Ordinator  
Cork University Hospital  
Wilton  
Cork  
Tel: 021 4922888  
Email: [marie.fitzgerald2@hse.ie](mailto:marie.fitzgerald2@hse.ie)