Teamwork and Patient Safety in Surgery

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To Maa and Pa, and Anuj

Abstract

There is a growing concern that adverse events occur frequently in operating theatres. Adverse events such as wrong site surgery and surgical site infections have a severe detrimental impact on not only the patient but also the healthcare staff and the services. Institute of Medicine's report, '*To err is human*' highlighted that teamwork failures are a leading cause of death and suffering. Yet, in surgery, measuring teamwork and designing interventions to improve teamwork and patient safety in operating theatres remains an area of research that is largely unexplored. This thesis aims to measure and improve teamwork in operating theatres to ensure safer surgery. In this project, the WHO surgical safety checklist was evaluated for its impact on patient safety. The WHO checklist improved patient safety processes in operating theatres but its impact on teamwork, intra-operative problems and theatre efficiency was not clearly understood. Therefore, a framework was developed to measure teamwork failures, equipment problems and technical failures as surrogate markers of teamwork, patient safety and efficiency in operating theatres. Equipment failures emerged as a sensitive measure of teamwork in operating theatres. Teamwork failures were also associated with technical failures, delay in case progress and patient harm. It emerged that the WHO checklist can improve teamwork and theatre efficiency and reduce equipment problems in operating theatres when it is used in its true spirit rather than a tick-box exercise.

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Declaration

I declare that the research presented in this thesis is my original work and contributions of other researchers and individuals have been appropriately acknowledged.

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Thesis outline

In the introduction, I discuss the complexity of surgical systems, challenges and threats to patient safety. Then I move on to discuss the significance of assessing complex systems like surgery not merely on the basis of morbidity and mortality parameters but other measures of quality of care. I discuss how adverse events are systems failures arising due to lack of teamwork and communication in a complex and high-risk environment. Discussing the importance of teamwork in surgery, in chapter 3, I describe interventions such as checklists and team briefings to improve teamwork in operating theatres. Having discussed the role of teamwork in operating theatres, in chapter 4, I present a review of literature on measurement of teamwork in surgery.

Checklists and briefings have emerged as the key interventions to improve teamwork in operating theatres. Recently, the World Health Organisation introduced a surgical checklist for operating theatres. This checklist is a combination of checks and briefing elements to ensure that certain processes essential to patient's safety in operating theatres are carried out. Imperial Healthcare NHS Trust was chosen as a pilot study site of the checklist, which gave us an opportunity to evaluate the impact of WHO checklist on teamwork and patient safety. Chapter 6 describes and presents the findings of the pilot study designed to evaluate the WHO surgical checklist.

Compliance to the WHO surgical checklist was found to be variable. In chapter 7, I describe a qualitative interview study conducted to understand the benefits, drawbacks and user opinions of the WHO surgical checklist. This study was useful in understanding how to ensure long-term resilience and compliance of the WHO surgical checklist.

Based on the interview study, I modified the surgical checklist to make it more suitable to the needs of NHS.

While the UK evaluation found that patient safety processes improved, the relationship between the WHO checklist and clinical outcomes could not be clearly established. Therefore surrogate markers of intra-operative outcomes and theatre efficiency had to be defined, and a framework for measuring teamwork and other failures in operating theatres was developed. This lead to chapter 8, which is a descriptive observation study of problems and failures occurring in the operating theatres in order to identify markers of teamwork, theatre efficiency and patient safety. This framework was subsequently (in chapter 11) used to assess and evaluate the surgical checklist and its importance in preventing errors in surgery.

With the theatre observation study, equipment failures emerged as major problem in the operating theatres, which were closely associated with teamwork failures. Therefore, it was necessary to further explore equipment failures in operating theatres to understand teamwork and other 'systems factors' associated with them. Chapter 9 and 10 describe two multicentre studies examining the nature of observed and self-reported equipment failures and exploring underlying teamwork and 'systems' factors.

The WHO surgical checklist has been made mandatory for NHS by the National Patient Safety Agency. However, for the checklist to be beneficial and resilient, it needs to be used correctly. Chapter 11 describes a study to assess the usability and variation in the quality of checklist use. Using the teamwork framework developed, the impact of the checklist on theatre teamwork, equipment failures, and patient safety was assessed. In

chapter 12, I summarise the research findings, discuss the limitations and challenges faced and conclude by defining the scope for future research.

Project Hypotheses

Teamwork failures during surgery can lead to equipment problems, surgical delays and patient harm.

A well-designed and implemented checklist intervention can improve teamwork; reduce equipment problems and patient harm during surgery.

Specific research questions

Can teamwork interventions such as checklist improve patient safety and clinical outcomes?

What is the impact of teamwork failures in operating theatres?

Can teamwork failures be measured using observational methods?

Can equipment problems be measured using observational methods?

Are Equipment problems secondary to poor communication and teamwork?

Do Teamwork failures lead to equipment failures, technical failures and compromise patient safety?

Can teamwork in the operating theatre be improved with the use of the checklist?

Does the effectiveness with which the checklist is used have an impact on safety and teamwork in operating theatres?

Project aims

The aims of this research project are:

- To discuss the role of teamwork in surgery and its impact on patient safety.

- To discuss various interventions to improve teamwork in surgery drawing onto the role of checklists and briefing interventions in improving teamwork.

- To evaluate the impact of WHO surgical checklist on clinical processes, clinical outcomes and theatre efficiency.

- To study associations between teamwork failures, technical failures and equipment failures and their impact on patient safety.

- To develop a feasible and reliable framework for measuring teamwork and markers of intra-operative care and efficiency.

- To evaluate the usability of WHO checklist and variation in the quality of checklist use and its impact on failures and teamwork in operating theatres.

Chapter 1

Surgery- a complex system

1.1 Introduction.

Surgery is an integral and indispensable part of healthcare. In UK, one in eight of us will undergo surgery at some stage in life (Weiser, Regenbogen et al. 2008). Surgery today is a viable and preferred choice of treatment for cancer, trauma and other diseases. Surgery is a desirable and well-established profession for young budding doctors and nurses who choose it as a life long career. The fascination of surgery may be due to the 'hands on' approach to deal with disease, or injury, or the sophisticated technology involved but the ultimate objective of every surgeon, nurse or anaesthetist is to treat his or her patient satisfactorily and safely. This chapter provides an overview of the history of surgery from the dark ages to the current era and discuss the challenges faced then and now. It also talks about the complexities of the surgical systems and how teamwork plays a role in effective functioning of this unique system.

1.2 The evolution of Surgery.

Today, millions of surgical procedures are performed each year globally, but there was a time when surgery was performed only as a last resort in moribund patients and was associated with high morbidity and mortality. In this section, I give a brief history of surgery describing how surgery evolved through time and cultures.

The first evidence of a surgical procedure goes back to the Neanderthal ages. Skull remains from Neanderthal era have been discovered which depict "trepanation", the oldest known surgical procedure (Restak 2000) where, a window is made into the skull to treat intracranial diseases. It was used to treat extra-dural hematomas resulting from trauma.

An Indian scholar and physician called Sushrutha in 600 BC wrote the oldest known text of surgery. His knowledge of surgery is contained in his text known as '*Sushrutha Samhita*'. It very elaborately describes diagnosis, treatment and prognosis of various ailments as well as various surgical procedures including cosmetic surgery like rhinoplasty; as in ancient India, avulsion of nose was a common mode of punishment (Rana 2002).

In the medieval world, until the Renaissance, the practice of surgery was mainly restricted to the Middle East. By the 13th century, the need to have a structured training for physicians became more evident in Europe. Montpellier, Padua and Bologna Universities emphasised the academic side of Surgery, and by the fifteenth century, Surgery was a separate university subject. Rogerius Salernitanus composed *Chirurgia*, which laid the foundation for modern surgery. By this time, the role of barbers as surgeons was a well-established tradition in Britain. With Physicians coming out of the universities eager to practice surgery, an area of conflict emerged between the company of barbers and fellowship of surgeons. In 1540, Henry VIII in order to resolve the conflict merged the two to form the Company of Barber-surgeons. But they always maintained an uneasy relationship. The 18th century, however, saw the rise of private anatomy schools and the development of an academic basis for surgical practice through the teaching and publications of the leading European surgeons. Thus, in 1745, the

surgeons broke away to form a separate Company. In 1800, the Company of Surgeons was granted a Royal Charter to become The Royal College of Surgeons of London, later of England (Royal_college_of_surgeons). Hence, we see that surgery slowly evolved from a seldom-practiced unregulated cult to a specialized branch of medicine under the control of a royal college. Now, surgical training is a well structured, eight year programme after medical school which is guided by a curriculum, evaluated through periodic appraisals and royal college examinations, and regulated by various agencies such as the General Medical Council, National Patient Safety Agency and the Royal College of Surgeons to ensure minimum standards of care.

1.3 Early challenges to surgery.

Patient harm due to surgery has always been the most important concern to a surgeon. Until the 19th century, pain was possibly the biggest deterrent to surgery and therefore its use was restricted to life threatening conditions. In late 19th century, ether was first used as an anaesthetic, which marked the beginning of painless surgery (Aldrete, Marron et al. 1984). Infection still remained the biggest killer after surgery. Joseph Lister a surgeon from Glasgow described the use of carbolic acid to disinfect instruments, surgical incisions and dressings (Lister 1867). With discovery and mass production of penicillin during 2nd world war, infection related mortality in surgery started declining. In 1969 Polk, established the role of prophylactic antibiotics in preventing surgical site infection (Polk and Lopez-Mayor 1969). Today there are well-established guidelines for antibiotic prophylaxis.

In the 20th century the advancement in surgical technology has been tremendous. Lesser blood loss, smaller incision and quicker recovery have been the prime driving forces in turn making surgery possible for extremes of ages and co -morbidities. Open surgery is rapidly being replaced by endoscopic surgery. Robotic surgery entered the arena in the last decade, which is promising to take surgery to the next level of technological sophistication (Ahmed, Khan et al. 2009).

1.4 Changing challenges in surgery.

With the two greatest challenges to surgery overcome and development of minimally invasive techniques, the acceptance of surgery among masses has increased manifolds. More than 200 million surgeries are performed globally each year (Weiser, Regenbogen et al. 2008) with more than 8 million surgeries performed in UK alone (Vats, Vincent et al.).

The increasing appeal of surgical procedures has put considerable pressure on surgical services, which are constantly trying to reduce the waiting period before a patient has surgery. At the same time, we are also providing treatment for patients with increasingly complex co-morbidities in the extremes of ages involving sophisticated technology. This technology is complex and vulnerable to failures that can be potentially harmful in unfamiliar hands. Surgery today has become a complex system of care, which depends on individuals with special skills to work together in cohesion to drive it. Such a system demands a greater degree of inter-professional teamwork and communication and can easily lead to error and patient harm. While the techniques and technology have been advancing tremendously through research, the importance of ensuring safety and

teamwork in such a system has been largely overlooked. Thus, arises the present challenge of preventing inadvertent harm to patients as a result of changing needs of a complex system.

1.5 Complex nature of surgery.

Surgery has moved from the barbershops of the past to the high- tech operating theatres of today. Up to two-thirds of the adverse events in hospitalized patients are related to surgery (Leape, Brennan et al. 1991). Evidence suggests that patient harm in surgery is largely due to the factors that interplay within a complex system (Vincent 2004). This section describes the complexities that such a system involves. It is important to describe these complexities as in the present healthcare they pose a great challenge to patient safety. These challenges arise due to demanding teamwork and co-ordination that is required to work effectively.

1.5.1 Surgical care pathway.

One would like to think that the surgical care pathway is a simple process where the patient comes to see the surgeon, they decide upon the surgery and surgery takes place. Figure 1 shows that the pathway is quite complex and it involves interaction, and decision making at various levels. Moreover, parallel to the main pathway, there are further more interactions and pathways that operate to facilitate surgery, these include administrative tasks to organise theatre lists and ensuring that all resources needed before surgery are available and patient work up is complete (Figure 2). For example, in order to undertake surgery, the patient needs to be fit to undergo surgery, for which he/

she is arranged to come to separate pre-operative assessment clinic. On assessment, if required, investigations are sent off and specialty referrals made to manage associated medical problems such as cardiac failure or renal impairment. The case files for the patients are requested through a separate complex channel of communications to make them available in time for clinic appointments and ward admission. The surgical appointments are organised through a separate management tree critical to continuity of care and follow up of the patient. Equipment required for the surgical procedure is organised by the theatre staff and managers. The equipment may be requested from sterilisation services or arranged from other hospitals or companies. The care of the patient before and after the surgery is handed over from one ward nursing team to the other through the recovery team. Therefore, it is clear that the process requires good coordination and clear communication between the surgeons, anaesthetists, nurses and managerial and administrative staff to provide safe, efficient and timely patient care.

Figure 1.1 Surgical care pathway.

```
┌─────────────────────────────────────┐
│ Patient sees the surgeon in the clinic.│
│ Investigations requested.             │
└─────────────────────────────────────┘
                │
┌─────────────────────────────────────┐
│ Investigation results reviewed.       │
│ Decision made to operate. Patient     │
│ booked on waiting list, clinic letter │
│ dictated.                             │
└─────────────────────────────────────┘
                │
┌─────────────────────────────────────┐
│ Patient called in for assessment in Pre-│
│ operative assessment clinic.          │
└─────────────────────────────────────┘
                │
┌─────────────────────────────────────┐
│ Patient admitted to ward for the      │
│ surgery. Assessed by nurse.           │
└─────────────────────────────────────┘
                │
┌─────────────────────────────────────┐
│ Patient reviewed by surgeon, consent  │
│ confirmed and site of surgery marked. │
└─────────────────────────────────────┘
                │
┌─────────────────────────────────────┐
│ Patient assessed by Anaesthetist      │
└─────────────────────────────────────┘
                ↓
┌─────────────────────────────────────┐
│ Patient transferred to the theatre,   │
│ anaesthetized and surgery performed.  │
└─────────────────────────────────────┘
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Figure 1.2 Complexity of surgical pathway.

1.5.2 The patient.

The patient is the prime focus of this complex system. Every patient is unique with his own individual needs. A simple procedure such as an inguinal hernia repair may pose a small threat to a healthy young patient as compared to an elderly patient with a valvular heart disease who is on anticoagulants for a metal heart valve. Both patients require different level of planning and organisation for the same procedure. With the increasing life expectancy, patients with severe medical conditions are undergoing surgery. It requires a high level of inter-specialty communication and co-ordination to manage these medical conditions in preparation for surgery.

When patients are admitted to hospital for elective procedures, there is sufficient time to plan and prepare for surgery but emergency surgical admissions pose a bigger challenge to surgical planning as well as decision-making. These patients are often very sick and need greater collaboration and communication between the surgeons, anaesthetists and theatre staff for safe, appropriate and timely management.

Therefore, patient variables can make even simple surgical procedures complex and require greater teamwork and communication to ensure patient care and safety.

1.5.3 Operating theatres.

Operating theatres are highly specialised units that are labour as well as technology intensive. An operating theatre suite consists of a set of atriums, which are built to specifications to ensure good lighting, good clean airflow and ergonomic movements. An ideal operating theatre should have the following characteristics (Harsoor 2007):

1. Location- it should be located in a low-rise building with adequate natural light and away from the regular traffic of patients and flow of air from the wards.

2. It should be designed ergonomically to minimize criss-cross movement of machines and staff members.

3. It should have dedicated electric lifts.

4. It should have a regular supply of gases and water.

5. It should have adequate illumination.

6. it should be fire safe with fire exits.

An NHS operating theatre comprises of:

a) A room where the operation takes place. This room contains the operating table, operating lights, oxygen, air and vacuum supplies, machines such as the suction apparatus, screens and stacks for laparoscopic procedures, anaesthesia machine and medical waste disposal systems. All these systems require maintenance, which is provided by different departments from within or outside the hospital. To make sure that for every procedure, these resources are available and functioning requires prior planning and coordination.

b) A preparation room where the nurses organise the equipments needed for the procedures. This is an area where the nurses would store the surgical instruments for surgery. Different procedures require different equipments. To ensure that the required equipments are sterilized and available involves communication between the surgeons and nurses who can then arrange equipments from various companies and hospital sterilization units. An induction room where the anaesthetist administers anaesthetic agents under monitoring. It contains the anaesthesia machine, monitoring apparatus, intubation trolley and the drugs cabinet.

c) ensure sterility.

In the operating theatres, various problems can arise that could have an impact on patient care. Operating theatres are resource intensive environments where a variety of surgical instruments, electronic equipments and other resources are required to perform surgical procedures. Often, one or more of these resources may be missing or unavailable leading to chaos and tensions (Christian, Gustafson et al. 2006). Operating theatres depend heavily on the use of complex, technology intensive equipment. It is

imperative that such equipment requires high maintenance and technical knowledge to perform effective and safe surgery. Also different manufacturers and suppliers may provide various resources. Instruments might be sent out to outside agencies for sterilization. These functional arrangements require complex communication and coordination between the surgeons, theatre nurses and the external agencies to ensure that the right equipments and resources are available in time for the surgical procedures. All these variables pose significant challenges to theatre teams; therefore good teamwork is essential to working in the operating theatres.

1.5.4 Surgical teams.

The surgical team is a group of individuals who work together to perform a surgical procedure and share a common goal, which is to ensure correct surgery on the right patient safely. The surgical team comprises of:

a) Surgeon- who is responsible for performing the procedure. He should have seen the patient on a number of occasions prior to performing the procedure, taken an informed consent and marked the surgical site after reviewing the patient and answering patient's queries on the day of the surgery. He should be competent in performing the procedure and is also responsible for overall care of the patient before and after the procedure.

b) Surgical assistant- is usually a surgical trainee who is responsible for peri-operative care of the patient and making sure that all the investigation results needed prior to surgery are available.

c) Anaesthetist- who is responsible for providing anaesthetic support for the procedure, monitoring patient's medical well-being during the procedure, giving prophylactic

antibiotics etc. He also has a role within and outside the operating theatre, which is crucial to the safety of the patient.

d) Operating Department Practitioner- provides assistance to the anaesthetist. He/ she is the first person receiving the patient in the operating theatre and along with the anaesthetist, also responsible for checking the anaesthetic machines and drugs.

f) Scrub nurse- is responsible for assisting the surgeons during the procedures by providing the instruments needed to perform the operation. For a surgeon to be able to perform surgery safely and accurately, it is important that the scrub nurse understands the procedure; the equipment needs and has the situational awareness to anticipate the next step of the procedure and be ready with the equipment needed for the next surgical step.

g) Circulating nurse- along with the scrub nurse, organises the equipment for the surgery. Prior to the procedure the nurses confirm the patient identity and procedure. During the procedure, circulating nurse is the eyes and hands of the scrub nurse to the outside world. The circulating nurse should have the spatial orientation of the theatre and know the location and functioning of the equipment needed. She needs to communicate efficiently with the scrub nurse to facilitate the surgery. Circulating nurse and scrub nurse also conduct the swabs, instruments and needle counts during and after the procedure to prevent retained foreign bodies. Different individuals are responsible for various tasks crucial to a surgical procedure and it requires good communication and teamwork to co-ordinate these tasks effectively. For example, lack of communication between surgeon and scrub nurse can lead to situations where right equipment may not be available for the surgery. Lack of co-ordination between surgeon

and surgical assistant can make the surgery more difficult and even lead to iatrogenic injuries.

In UK, recent changes to the healthcare structure have introduced new challenges to the way surgical teams work. European working time directive is one such challenge. From August 2009, all NHS hospitals have to ensure that doctors are working on an average, 48 hours a week as compared to previous 56 hours a week. This directive has been introduced to ensure that doctors providing care to the patients are not tired and overworked. However, it poses a new challenge of ensuring continuity of care in service provision. It means that the patients will be looked after by a number of different doctors working on a shift system. In such a system, in order to ensure continuity of care, the role of good communication and an effective handover cannot be over emphasized. These challenges further highlight the need for good teamwork between the surgical teams to ensure patient safety.

1.6 Conclusion.

Surgery has been transformed into a complex system that relies heavily not only on the competency of the surgeons and anaesthetists but also the nurses who provide assistance and support in the ward, clinics and theatres; the technology needed to perform the surgery, the staff who ensure that the technology is available and functioning and the administrative staff who communicate between different specialties and the patients to ensure that dates are booked, investigations are arranged and letters are sent. Good teamwork is essential for such a system to function effectively. Often, the

roles and tasks of different team members are not clearly defined and this ambiguity may lead to certain safety checks or tasks being missed due to blurred responsibility (Kwaan, Studdert et al. 2006; Tan, Naik et al. 2006). In event of errors occurring, patient safety may be compromised which could lead to prolonged hospital stay, increased morbidity or even death. In the next chapter I consider the nature of risks to patients undergoing surgery.

Chapter 2

Quality and Safety in Surgical care

2.1 Introduction.

Surgical technology has made it possible to treat complex pathologies with minimal blood loss and shorter length of hospital stay associated with surgery. An increasing number of people are undergoing surgery. A growing percentage of these patients are in the extremes of ages or have significant co-morbidities. For instance, between 1987 and 1990 there has been a 67% increase in the use of coronary artery bypass surgery on patients aged over 80 years (Peterson, Cowper et al. 1995). Similarly an increasing number of cancer patients are undergoing curative and palliative surgery due to improved prognosis following cancer surgeries, better patient selection and staging and improved peri-operative care. Table1 below illustrates the trends of improvement in one and five-year survival rates for patients diagnosed with cancer in 2000-2001 as compared to year 1971-1975. It shows that the one-year and five-year survival rates for gastrointestinal cancers (Oesophageal, stomach, colon and rectal cancer) have almost doubled in 25 years. This is due to early screening and diagnosis, multidisciplinary approach to cancer treatment, effective chemo and radiotherapy, and also the advancement in surgical techniques and introduction of laparoscopic surgery to stage and treat these cancers thereby reducing the surgery associated morbidity and mortality.

Table 2.1 Relative age standardised cancer survival rates for England and Wales (CRUK).

Cancer Type	Sex	One-year survival rate (%)		Five-year survival rate (%)	
		1971- 1975	2000- 2001	1971- 1975	2000- 2001
Oesophagus	M	12	30	3	8
	F	16	27	5	8
Stomach	M	13	37	4	15
	F	15	40	5	18
Colon	M	39	74	22	52
	F	40	73	23	53
Rectum	M	50	76	25	50
	F	51	75	27	52
Breast	F	82	96	52	81
Prostate	M	65	91	31	71

The incidence of infection following surgery has also been gradually declining. Table 2 below shows the incidence of surgical site infection after orthopaedic procedures in UK. Which shows that with the use of prophylactic antibiotics and better surgical planning, the risk of infection following surgery has been reduced significantly.

Table 2.2 Rate of surgical site infection in UK (1996- 2007) (Jen, Holmes et al. 2008).

Year	Surgical site infection (all ages in orthopaedic surgery)	
	Cases	Rate (per 1000 bed days)
1996/7	2219	14.7
1997/8	2242	15.4
1998/9	2601	15.8
1999/0	2687	15.9
2000/1	2698	15.8
2001/2	2752	15.9
2002/3	2993	15.9
2003/4	2873	14.1
2004/5	2796	13.1
2005/6	2554	11.3
2006/7	2398	10.2

Wider varieties of surgeries are being carried out by minimally invasive techniques using laparoscopic and robotic technology. This has resulted in a reduction in blood loss and shortened hospitals stays (Nagpal, Ahmed et al.). Increasing use of advanced analgesics that can be controlled by the patients themselves also contribute to a reduction in post-operative morbidity such as pneumonia and thrombo-embolism.

Further, many procedures that were previously performed by open technique involving a large skin incision, are now increasingly being performed using laparoscopic technique which reduces the post operative pain and enhance recovery.

2.2 Measuring performance and effectiveness in surgery.

With the growing number of surgeries being performed by healthcare providers, it is important to ensure patient safety and effectiveness in surgical service provision.

2.2.1 Outcome measures.

Morbidity and mortality are the outcome measures that have been traditionally used to measure the effectiveness of surgical care and patient safety. They are useful when outcomes themselves are of interest and reflect all facets of surgical care collectively, including differences in technology and patient variables (Faiz, Haji et al.). They can also be used to identify areas of need and resource utilisation at a national or regional level.

They are also less useful for assessing quality of care at a more specific level such as a particular department or a surgeon as they may not detect the various factors applicable locally such as the severity of existing morbidity among patients treated in that department etc. Risk adjustments have been used to take into account such factors however a systematic review conducted by Pitches et. al (Pitches, Mohammed et al. 2007) found that the view that hospitals with high risk adjusted mortality provide poorer care is inconsistent. Therefore, risk adjustment although helpful in reducing the bias due to patient factors, can be misleading. Statistical risk adjustment of outcomes cannot resolve its poor correlation to performance (Pitches, Mohammed et al. 2007). Risk

adjustment may not allow for case mix variables, as they may be unknown and in some cases, it may even introduce a bias.

Clinical outcomes may be influenced by factors other than quality of care therefore, although they could serve as alert systems to trigger an investigation into the system (Jarman, Aylin et al.), they should not be used as a yardstick to reward or punish a hospital or clinician. Moreover this system only compares the performance and does not highlight the areas of improvement (Lilford, Brown et al. 2007).

Outcome measures are of little use when the system is analysed to obtain information on system changes to improve quality of care (Lilford and Pronovost). These measures can identify the area of need but do not give any information about the underlying causes. In addition, the sample size required to show the effectiveness of an intervention against an adverse outcome that has a very low incidence may be large and not feasible at a single centre. Therefore in certain instances, process measures may be more useful in understanding surgical performance and efficiency.

2.2.2 Process measures.

Experts believe that processes may be better measure of quality of patient care provision at root level (Lilford, Brown et al. 2007) as compared to outcome measures such as risk-adjusted mortality. Patient safety processes are established and evidence based practices that should be ensured before any surgical procedure. For example, timely administration of antibiotic prophylaxis has been shown to reduce surgical site infections therefore, adherence to antibiotic prophylaxis guidelines before a surgical procedure can be used as a process measure. The benefit of using process measures is that it reduces the case mix bias as it uses the chances of an error occurring as the

denominator rather than the number of patients treated. It reduces the confounding bias that arises when a surgeon or hospital is caring for more unwell patients (Lilford, Brown et al. 2007).

In surgery, patient safety processes are performed by various individuals as explained in the previous chapter, and in order to ensure that processes are adhered to, inter-professional teamwork is important. Studies show that these processes are poorly performed in the absence of good teamwork among the care providers (Gawande, Zinner et al. 2003; Kwaan, Studdert et al. 2006). For example, use of prophylactic antibiotics is an important process to prevent surgical site infection. However, antibiotic prophylaxis may be missed due to poor communication between surgeons and anaesthetists (Tan, Naik et al. 2006; Haynes, Weiser et al. 2009). Similarly, ensuring arrangement of blood before a major surgery is a process critical to patient safety, yet in the absence of good teamwork among surgeons, nurses and anaesthetists, it may be overlooked. This can put patients' life at risk and lead to crisis during the surgery. Setting up of the suction machine, electric diathermy machine and body warmer at the start of surgery are processes that may be omitted or partly performed if the co-ordination between team members is poor. Therefore, it is obvious that if we want to improve the provision of processes we have to improve teamwork in surgery. Whereas it is easier to measure patient safety processes, the underlying teamwork problems are not apparent to the untrained investigator. The insight into underlying teamwork errors is necessary to understand the cause of poor processes and thereby improve them.

In the absence of good teamwork, processes and tasks crucial to high quality surgical care are forgotten or under performed (Undre, Sevdalis et al. 2006) which may lead to

adverse events (Sutcliffe, Lewton et al. 2004). The next section discusses the causation of adverse events and underlying factors.

While the outcome measures such as morbidity and mortality may be attributable to the unpreventable patient factors, process measures can help in understanding poorer outcomes as a result of factors that can be prevented. These 'adverse events' where the patients come to harm that could be prevented by effective and safe health care systems will be discussed in detail in the next section.

2.3 Adverse events in Healthcare.

Adverse events can be defined as errors in healthcare that lead to unintended injury to the patient which may result in temporary or permanent disability and is not caused by disease process (Vincent 2001). Adverse events in healthcare have been a growing concern for the health authorities, clinicians as well as the general public. Adverse events can not only result in patient harm but also reduce staff morale. They also lead to litigation and law suites, which has greater financial and social implications on healthcare (Leape, Brennan et al. 1991). In this section, I will describe the extent and implications of adverse events, their causes and how the system plays a vital role in causing as well as preventing these errors.

Studies show that nearly 10% of patients admitted to acute care hospitals suffer adverse events (Table 3) (Vincent, Neale et al. 2001). In 2000, United States Institute of Medicine reported that there are up to 98000 deaths each year due to medical errors (Kohn, Corrigan et al. 1999). A retrospective record review of 1014 medical records by Vincent et al. in a UK Hospital showed an adverse event rate of 10.2% of which at least

half were preventable and almost a third led to moderate or greater disability or even death (Vincent, Neale et al. 2001). They also showed that these events prolonged hospital stay by 8.5 days, which not only means extra costs and staff time but potential loss of valuable space and time that could have been used to care for other patients.

Table 2.3 Adverse events in acute hospitals in five countries (Leape, Brennan et al. 1991; Ludbrook, Webb et al. 1993; Wilson, Runciman et al. 1995; Thomas, Studdert et al. 2000; Vincent, Neale et al. 2001; Davis, Lay-Yee et al. 2003)(Adapted from Vincent et al)

Study	Number of acute care hospitals	Date of admissions	Number of hospital admissions	Adverse event rate (% admissions)
Harvard Medical Practice Study (HMPS)	51	1984	30195	3.7
Utah-Colorado Study (UTCOS)	28	1992	14052	2.9
Quality in Australian Health Care Study (QAHCS)	28	1992	14179	16.6
United Kingdom	2	1999	1014	10.8
Denmark	17	1998	1097	9.0
New Zealand	13	1998	6579	11.2
France **	7	2002	778	14.5
Canada	20	2000	3745	7.5

*The California study assessed `potentially compensable events'; ** Figures from France are from the pilot study not the full study

2.4 Adverse events in surgery.

40-60% of all adverse events in healthcare are related to surgery (Brennan, Leape et al. 1991). In fact, they are more likely to occur in surgical care than in non-surgical specialties. Analysis of these adverse events reveal that nearly half of these are

preventable (Gawande, Thomas et al. 1999). The risk of preventable adverse events increases with the age of the patient, so they are more likely in elderly patients (Gawande, Thomas et al. 1999). To understand the patient safety risks involved in high turnover surgery, many studies have been conducted in past years. Considering that over 8 million surgeries are performed each year in the UK alone, it would suggest that a large number of patients come to preventable harm from surgery. According to a recent National Patient Safety Agency (NPSA) alert (National_Patient_Safety_Agency(UK) 2009), major complications are reported to occur in 3–16% of inpatient surgical procedures, with permanent disability or death rates of approximately 0.4–0.8%. In England and Wales, 129,419 incidents relating to surgical specialties were reported to the NPSA's Reporting and Learning System in 2007 of which 1,105 lead to severe harm to the patient and 271 lead to death.

2.5 Operating theatres and adverse events.

Operating theatres are complex environments. This environment is prone to errors, which can lead to adverse events. Two-third of all surgical adverse events occur in the operating theatres (Gawande, Zinner et al. 2003). The factors responsible for errors could be task complexity, communication lapses, blurred inter-professional responsibilities or poor teamwork. Studies have shown that errors in teamwork can lead to adverse events in the operating theatre (Gawande, Zinner et al. 2003).The care of the patient is transferred from ward staff to theatre nurse who may not have seen the patient before. Similarly, after surgery the care is transferred from the theatre staff to the recovery who in turn hand over the patient care to the ward staff. These transitions in

care can be complex and require clear and precise communication. However, during handovers, critical information may often be missed and tasks omitted (Nagpal 2010). Therefore, it is clear that operating theatres are high-risk environments for the patient not only due to the technology involved and due to dependency on cohesive teamwork, but also due to the transfer of care and responsibility from one team to the other. Below I discuss some of the important types of errors associated with patient harm in the operating theatres.

2.5.1 Wrong site procedures.

Wrong site, wrong procedure, and wrong person events can be catastrophic to patients, healthcare professionals, and institutions (Makary, Sexton et al. 2006). Wrong site surgery is considered to be a 'never' event (Michaels, Makary et al. 2007) which should never happen. Wrong-site procedures often occur because of the simple omission of pre-operative safety-checks (Kwaan, Studdert et al. 2006). As it is a rare occurrence, its incidence is difficult to estimate but it is believed that in the US there maybe around 2500 cases per year, of the 75 million surgical procedures performed (Kwaan, Studdert et al. 2006). In 2007, NPSA reported 16 cases of wrong site surgery, which led to one case of severe disability and one death. However, these figures are obviously an under-estimate as they reflect a reporting bias. Near misses are far more common and may not be reported. Kwaan et. al showed that communication errors are the single most common cause of wrong site surgery followed by deviation from protocols and procedures (Figure 2.1).

Figure 2.1 Root causes of wrong site surgery (Kwaan et.al 2006).

Chart showing root causes (horizontal bar chart, x-axis 0 to 80):
- Organisation culture: ~23
- Care planning: ~17
- Continuum of care: ~5
- Leadership: ~47
- Environ. Safety: ~10
- Procedural compliance: ~64
- Competency: ~29
- Availability of info: ~28
- Staffing: ~10
- Patient assessment: ~17
- Orientation/ training: ~20
- Communication: ~70

2.5.2 Retained foreign body.

Ensuring that swabs, instrument and needle counts are correct at the end of a procedure is crucial to safe surgery. It can be a cause of increased patient morbidity or death and also damage the confidence and morale of the healthcare staff. The incidence of retained foreign body in surgery is 1 in 5000 cases (Gawande, Studdert et al. 2003). The risk factors for retained foreign body are emergency surgery, unexpected change in plan of surgery and high body-mass index of the patient (Gawande, Studdert et al. 2003), which clearly indicate that the occurrence of these adverse events are more likely in non-routine circumstances. Swabs are the most commonly retained foreign bodies. Considered to be another 'never' event, that attracts considerable media attention and censure of the surgical community, it is associated with 2% risk of mortality and a re-operation rate of 69% (Gawande, Studdert et al. 2003).

2.5.3 Surgical site infections.

Another preventable adverse event is surgical site infection. Incidence of surgical site infection (SSI) is 3.4% with a case fatality of 5.8% (Astagneau, Rioux et al. 2001). While hospital guidelines make recommendations on the class and dose of prophylactic antibiotics that should be administered, it is often neglected. To be most effective, they have to be administered with in 60 minutes prior to skin incision. There are studies, which show that the compliance with this aspect is as low as 50% (Bratzler, Houck et al. 2005).

2.5.4 Venous thromboembolism.

Deep vein thrombosis and pulmonary embolism constitute 9% of adverse events but 19% of negligent events where the cause of error was non- adherence to protocols due to negligence (Gawande, Thomas et al. 1999). Although guidelines for DVT prophylaxis are established, the adherence to these guidelines can be as low as 30% (Thomas, Studdert et al. 2000). One of the causes for the non-compliance can be explained by the blurred inter-professional communication and blurred roles and responsibilities in the operating theatres (Tan, Naik et al. 2006).

2.5.5 Equipment problems.

Equipment problems are common in operating theatres, which not only cause theatre disruption but also inter-professional confrontation and even patient harm. Missing and malfunctioning equipment required for a surgical procedure are common occurrences in most operating theatres. Christian et al, in their observation of 10 surgical procedures found that there were close to 15 resources added per procedure after the

commencement of an operation (Christian, Gustafson et al. 2006). Equipment problems are more like cause a disruption of workflow, delay case progression and lead to deterioration in the dynamics between team members rather than compromise patient safety. However, in a survey of theatre team members, respondents believed that nearly 10% of errors in the operating theatre were related to equipment problems (Flin, Yule et al. 2006). The American College of Surgeons' Closed Claims study revealed that in 5% of claims, the errors were equipment related (Griffen, Stephens et al. 2007). In addition to case progression, equipment related issues should cause some concern as surgeons often adjust their technique to adapt the procedure in order to 'workaround' equipment problems (Christian, Gustafson et al. 2006). Though this has not been studied in great detail, there is a potential that such an adaptation can result in technical errors. A majority of these equipment problems may be preventable if the surgeons and theatre staff communicate effectively prior to surgery as this will not only help organise equipment well in time but also help in developing a common shared mental model among the team members.

In this section I have discussed various types of adverse events. However, in order to understand these events we need a systematic approach, analyse them and assess their causative factors. The next section will discuss the approach to understand these adverse events.

2.6 Systems approach to the understanding adverse events.

The understanding of patient harm and adverse events has been discussed and researched time and again. With the passage of time, our understanding of adverse

outcomes has evolved. There was a time, when they were thought to be mainly due to patient factors. Patient risk factors such as obesity, smoking, advanced age and coexisting morbidities are associated with poorer outcomes. At the same time technical skills of the surgeons, especially in technically demanding complex surgeries have also been related to postoperative outcomes. While patient factors and surgical skills are critical determinants of adverse surgical outcomes, a wide range of other factors also determine safety and performance. These factors include work environment such as the technology and user interface, working hours, protocols or the lack of them, team structure, leadership and hierarchy or individual factors such as stress and decision-making. Other high-risk industries such as oil industry; defence and aviation have been focusing on these systems related factors of safety and performance for a number of years in order to make their organisations safer. Of late, these factors are increasingly being explored and researched in healthcare (Sexton, Thomas et al. 2000; Lingard, Espin et al. 2004; Sutcliffe, Lewton et al. 2004; Catchpole, Giddings et al. 2006; Makary, Sexton et al. 2006). In other high-risk organisations, working conditions that provoke staff to workaround and improvise have been found to be unsafe and have led to some major incidents (Aviation Safety Network). In order to reduce workarounds, High-risk organisations have implemented Safety Management Systems whereby emphasis is placed on learning from critical incidents and on the implementation of actions to reduce the recurrence of those incidents. In cases where incidents and near misses occur frequently, the processes implemented through a Safety management System can be relied upon to produce continuous improvement and achieve reduction in associated risks (Reason 1997).

In the systems approach to healthcare, the organisation is moving away from a name and blame culture to a more positive and constructive culture of designing a system that teases out errors and ensures processes that are important for safety and quality in healthcare (Studdert and Brennan 2001; Vincent 2004). It involves systematically identifying and reporting adverse events and incidents, analysing these events, introducing changes, and putting in place safety systems or interventions that would prevent these events from occurring again.

2.7 Clinical incident- learning lessons.

A clinical incident can be any unintended or unexpected incident, which could have or did lead to harm or adverse event to one or more patients receiving NHS care. Therefore, it is obvious that Incident reporting lies at the centre of the systems approach to understanding adverse events. In order to identify adverse events, there should be a robust and reliable reporting system that can highlight safety issues. In UK, National Patient Safety Agency (NPSA) has launched a National Reporting and Learning System (NRLS). Similar systems also exist in USA and Australia. Over the past 5 years, over three million clinical incidents have been reported on the NRLS. These incidents are used to identify areas of patient safety risks. Such a system is important as these incidents may not be identifiable as major concerns at a local level, but NRLS can identify patterns and frequencies of these events at a national level and issues alerts. But such a system is largely dependant on the reporting of clinical incidents by health care staff.

2.8 Analysing clinical incidents

Clinical incidents should be seen as a window into the system (Vincent 2004). In the US, the Joint commission has adapted a root cause analysis approach to investigate these incidents. Vincent et. al (Vincent, Neale et al. 2001) at CSRU have developed a systems analysis approach to analyse these events. Based on Reason's model of accident causation and literature on medical errors (Cooper, Newbower et al. 1984; Cook, Woods et al. 1989; Eagle, Davies et al. 1992; Bark, Vincent et al. 1994) Vincent et al (Adams and Bohan 2000; Vincent, Taylor-Adams et al. 2000) identified seven main categories of factors that could affect the safety of the healthcare system (Box 2.1). This framework has been used in the subsequent studies to analyse failures in operating theatres.

NPSA has designed a root cause analysis-teaching programme, which utilises all these approaches to investigate clinical incidents. Incident analysis helps in shaping the system for a safer future and once clearly understood, a tool to predict future potential threats to patient safety. Systems approach to analysis of clinical incidents provides a very effective way of understanding surgical adverse events. It uses a combination of case record reviews, interviews and a checklist of human factors applying Reason's model of organisational accidents to clinical incidents (Figure 2.2).

Figure 2.2 Vincent's framework of clinical incidents (Adapted from Reason's Model of Organisational causes of Accidents)(Vincent, Taylor-Adams et al. 2000).

Box 2.1 Framework of factors associated with adverse events.

1. Institutional context

Economic and regulatory context

2. Organisational and management factors

Financial resources and constraints

Organisational structure

Policy standards and goals

Safety culture and priorities

3. Work environment

Staffing levels and skills mix

Workload and shift patterns

Design, availability, and maintenance of equipment

Administrative and managerial support

4. Team factors

Verbal communication

Written communication

Supervision and seeking help

Team structure

5. Individual (staff) factors

Knowledge and skills

Motivation Physical and mental health

6. Task factors

Task design and clarity of structure

Availability and use of protocols

Availability and accuracy of test results

7. Patient characteristics

Condition (complexity and seriousness)

Language and communication

Personality and social factors

The systems analysis approach is beneficial to healthcare staff as the methods used are designed to promote a culture of openness and prevents finger pointing. It is useful in

preventing them from happening again. But, this system is a retrospective approach to clinical incidents and is used once patient harm has actually occurred. Therefore, increasingly, feasibility of prospective analysis of systems is being researched in healthcare to be able to prevent clinical incidents even before they happen by identifying potential errors in the system (Christian, Gustafson et al. 2006; Catchpole, Giddings et al. 2007). For instance, during an operation, poor communication between nurse and surgeon may lead to certain equipment not being made available which could lead to technical difficulties during the surgery and potential patient harm. However these factors may be difficult to understand with retrospective analysis but will be identifiable on prospective analysis. These methods will be discussed in further detail in the subsequent chapters. Increasingly in surgery, the scope of direct observations and video recordings is being explored to map out surgical errors and problems that could lead to adverse events. But these techniques require a very open culture in the healthcare, where staff is not resistant to being observed for the fear of disciplinary action or litigation. Nevertheless, observation and recording offer us the opportunity to understand the finer nuances of care processes such as team interactions and communication barriers that could lead to adverse events which may not be understood through retrospective case record reviews.

2.9 Conclusion

Patient outcomes after surgery have traditionally been used to assess performance and effectiveness in surgery. However, patient safety processes may be more sensitive measures of assessing quality of healthcare service. In event of poor adherence to

patient safety practices, adverse events can occur. But it is essential to analyse these adverse events systematically to understand the underlying causes. A systems approach to addressing adverse events is necessary to develop a culture where they can be discussed openly and practices and system modifications to prevent them are accepted readily. Many adverse events in surgery are closely related to teamwork in the operating theatres; therefore understanding the role of teamwork in adverse events is necessary.

Chapter 3

Teamwork in surgery

3.1 Introduction

In the previous chapter, I discussed how teamwork plays an important role in the safety of healthcare systems. In this chapter, I discuss the principles of teamwork and its role in ensuring patient safety in surgery. I also present a brief review of literature on interventions used to improve teamwork in surgery.

3.2 Teamwork

Teamwork is important in all organisations ranging from leisure to high-risk industries. In football, teamwork is important in mounting an offensive attack as well as laying out an impenetrable defense. There are situations where the teamwork is far more demanding and challenging with low margins of error as in Formula one racing teams where a few milliseconds saved at the pit stop can be critical. Similarly, in surgery teamwork is important to ensure safety and prevent adverse events.

The term "teamwork" is formed of two widely used terms: Team and Work. In old English, team referred to a," set of draft animals yoked together" and it was not until the 16[th] century that it was applied to a group of humans. In old English "teamwork" meant

work done with a team of beasts". It was only after, nineteenth century, when it took up its present meaning, "people working in concert" (Xyrichis and Ream 2008).

Teamwork in healthcare is defined as *"A dynamic process involving two or more health professionals with complementary backgrounds and skills, sharing common health goals and exercising concerted physical and mental effort in assessing, planning, or evaluating patient care. This is accomplished through interdependent collaboration, open communication and shared decision-making. This in turn generates value-added patient, organizational and staff outcomes." (Xyrichis and Ream 2008)*

This definition indicates some of the key elements of effective teamwork that have been further delineated by other researchers. Effective teamwork comprises of certain behaviors that are reflected in the way effective teams interact. These attributes can be used to assess teamwork skills of an individual or a team. Dickenson and McIntyre described the various components of teamwork (Dickinson 1997). Salas et al conducted a review of literature to define the key components of Teamwork and described leadership, mutual performance monitoring, backup behavior, adaptability, and team orientation as the 'Big five' core components of teamwork and for effective teamwork these core components require supporting coordinating mechanisms such as: shared mental modes, closed-loop communication, and mutual trust (Salas 2005). Table 3.1 describes the various components of teamwork.

Table 3.1 Dickenson and McIntyre's Components of teamwork.

Teamwork Component	Definition
Communication	Active exchange of information between two or more members of the team, as well as an individual team member providing information to others in the appropriate manner. Example: Prior to starting a surgery, surgeon, nurse and anaesthetist discuss the details of procedure, need for antibiotics and any known drug allergies.
Coordination	It reflects the execution of team activities such that members respond as a function of the behaviour of others. Successful co-ordination implies the effective operation of other components of teamwork. In this way, the actions of individual members are merged to produce synchronised team performance. Example: As the anaesthetized patient is wheeled into the operating room, to transfer the patient on the operating table, the anaesthtist secure the airway while stabilizing the head, the ODP and circulating nurse position the 'patslide' under the patient while the surgeon secure the foot end. Then at the command of the anaesthtist the patient is slid onto the operating table with a collective effort of the team.
Situational awareness	It refers to 'awareness' of the 'situation.' "Situation awareness" is the correct term for the field of study that concerns the knowledge and understanding of the environment that is critical to those who need to work in cohesion. Example: During the arthroscopy procedure, the circulating nurse changes the bag of arthroscopy fluid as it empties without being prompted by the surgeon or the scrub nurse, as she knows that the arthroscopy fluid is essential to smooth running of the procedure.
Shared mental model	Organized way for team members to think about how the team will work; helps team members understand and predict the behavior of their teammates. Example: While preparing for the surgery of a patient with latex allergy, the team is briefed about the allergy and team members adapt their

	roles to ensure safety, such as: surgeon and nurses wears latex free gloves, and ensure that the patient does not come in contact with equipment and dressings containing latex.
Leadership	This includes the direction and structure provided by formal leaders as well as by other members. Example: In a busy operating list, the surgeon ensures that the required equipment are available prior to the surgery and adequate staff is available and takes a decision to modify the list or postpone a surgery to ensure safety.
Monitoring team performance	It refers to the observation and awareness of activities and performance of other team members by the team. Example: The theatre sister ensures that surgeon and anaesthetist are available on time to start the operations and briefs the team of any delays and their reasons to ensure that the delays can be avoided.
Back-up behaviour	it involves actually helping other team members to perform their tasks. It also implies a degree of interchangeability among members and willingness to provide and seek assistance. Example: As the surgeon closes the skin wound after surgery, the circulating nurse is busy helping the scrub nurse in tidying up the instruments, the ODP is fetching the transfer trolley, the Anaesthtist adopts the role of ODP and brings the wound dressing for the surgeon so that he does not have to wait for the dressing to be provided.
Team-orientation	This includes the nature of the attitudes that team members have toward one another, the team task, and their team leadership. It also includes self- awareness as team member and group cohesiveness. Example: the surgical team nurses gets together before the start of the surgery, new members are introduced to the team, discuss the order of the list and their roles for the day.

3.3 Teamwork in high-risk organisations.

Teamwork has been studied in some detail in high-risk industries such as aviation, oil industry, military and nuclear industry. In aviation, failures and mistakes can lead to

airline crashes, which could lead to loss of life. In aviation 60-80% of all accidents are due to human error and teamwork failures (Foushee 1984). Similarly, in military, teamwork errors can lead to harm to army personnel as well as civilians. Industries like healthcare have multiple specialised professionals working towards a common goal with a high risk of errors, which can have severe consequences. These organisations function as hazardous, fast paced and highly complex systems, where failures can have disastrous consequences and therefore make risk prevention a priority (Roberts 1990). Aviation and military have been at the forefront in acknowledging the importance of good teamwork in achieving safety and high reliability (Salas 1995).

3.4 Teamwork in healthcare systems.

Health care is also a high-risk environment. In this section I will discuss how healthcare is also a complex high-risk organization and also discuss the role of teamwork in achieving patient safety.

Healthcare is a hierarchical system where physicians lead teams of junior doctors and within a team; the roles are well defined with the consultant (or attending) being ultimately responsible for the care of his patient. Similarly, nurses have a hierarchy too. However, there is also a hierarchy across the two professional groups, which creates ambiguity regarding responsibilities. Furthermore this hierarchy can also inhibit communication. The hierarchies reinforce assertiveness but at the same time create an environment of mutual trust, thereby mitigating the negative impacts of hierarchy, whereby, the team members can monitor each other's performance and provide support when required (Shamir 1990).

In healthcare, team members frequently make decisions crucial to patient care such as, administering antibiotics, requesting investigations, decision to admit, decision to operate. Various team members with varying levels of expertise make these decisions. Therefore, it is essential that these decisions be communicated to the other care providers so that patient care is continuous and evidence based. In the current climate where staffs are working on shift patterns, it is crucial that teams coordinate task management and handover relevant information to the next team.

Apparently minor errors, in healthcare, can lead to patient harm or even death. Therefore, errors are thoroughly investigated and often lead to reprimand and restrictions on the healthcare providers. Although the consultant is responsible for the overall care of his patients, junior doctors and nurses providing care can often make mistakes for which they are accountable.

Healthcare providers may have to perform tasks at short notice within a limited span of time with limited margins of error and delay. Trauma cases coming to emergency department may give the trauma teams only a few minutes to anticipate and prepare for the patient. Once in the emergency room, patient has to be stabilised and examined for definitive management, which will require input from various surgical specialities as well as anaesthetists, and intensivists. Such a stressful environment, demands clear and timely communication between different specialties and good coordination to organise investigations, resuscitate the patient and organise theatres if needed.

In the emergency room various professionals perform separate and simultaneous tasks, which may or may not be mutually interdependent. For instance, during trauma management in the emergency room, the anaesthetist may be securing the airway while

the emergency room nurses, stabilise the neck and the trauma registrar may be inserting a drain to relieve tension pneumothorax. The outcomes of all these tasks are constantly monitored and fed back across the team members. In all, such situations clearly demand good and effective teamwork in terms of communication, coordination, situational awareness and development and maintenance of a shared mental model.

Patient care in surgery involves multiple stages from out patients to preoperative assessment followed by admission to ward and operating theatres. Multiple skilled professionals are involved at each stage. Therefore, communication and coordination between surgeons, nurses and anaesthetists is crucial to ensure that information is passed on reliably.

Although professionals work in their own domains, they heavily depend on other specialist professionals to facilitate their tasks. For instance, although surgeons can independently perform the surgical steps during the procedure; anaesthetists are vital to ensuring that patient is anaesthetised and hemodynamically stable while the procedure is being performed. Also, they depend on the nurses and the administrative staff to book the patient and bed space for the planned day and arrangement of correct equipment for the procedure. It required good communication and coordination between the various members to ensure that correct patient is operated at the right time in the right manner.

3.5 Teamwork failures in operating theatres.

Gawande et al looked into cases of medical malpractice in surgery, and found that, around 70% of adverse events were a result of poor team-communication (Gawande, Thomas et al. 1999). In operating theatres, team structure is ambiguous, where

surgeons, nurses and anaesthetists may not see themselves as part of one team but three different teams. This may affect co-ordination and more importantly prevent them from communicating effectively. This may lead to conflicting assumptions about how work is distributed and coordinated across the team. One example of this ambiguous team structure is conflicting perceptions of surgeons' and anaesthesiologists' about who is responsible for ensuring timely administration of antibiotic prophylaxis (Tan, Naik et al. 2006) and the effect is reflected in the studies which show that timely antibiotic prophylaxis is administered in only 55% of cases (Bratzler, Houck et al. 2005; Haynes, Weiser et al. 2009).

Another deterrent to inter-professional communication is the steep hierarchy, with team members reluctant to communicate across the hierarchies (Thomas, Sexton et al. 2003). Other industries such as aviation have a better understanding of the effectiveness of team communication in preventing errors and adverse events. Aviation's standardisation of cockpit pre-flight communication reflects this understanding. A survey study conducted in surgical operation theatres suggests that two-third of nurses and physicians consider better communication within the teams as the most important element in improving safety and efficiency (Sexton, Thomas et al. 2000).

As is expected, these adverse events are a major concern and cause of mal-practise litigation. Contrary to the premises of malpractice law, studies show that majority of errors do not appear to be solely the result of individual failures (Studdert and Brennan 2001; Gawande, Zinner et al. 2003). Planning and interaction among team members appear to play a critical and under appreciated role (Gawande, Zinner et al. 2003). Teamwork and communication between team members has been largely ignored as a fundamental aspect of surgical safety. Observational studies of communication in the

operating theatre show absence of protocols and variation in effectiveness (Healey, Undre et al. 2004); (Lingard, Espin et al. 2004); (Sutcliffe, Lewton et al. 2004). Failure in pre-operative communication between surgeons and anaesthetists lead to misidentification of patients (Ludbrook, Webb et al. 1993) and wrong site surgery. The Joint Commission on Accreditation of Healthcare organisations (JCAHO) found that 70% of wrong site events could have been prevented by better communication (The_Joint_Commission). While other high reliability organisations such as aviation and the military appreciate the importance of pre-procedural team briefing, in surgery, any form of preoperative communication is only practiced in less than 10% of cases (Sexton, Thomas et al. 2000).

Failures in team communication are only one aspect of systems failure in surgery. As many as a quarter of routine surgical and anaesthetic checks are not carried out, equipment problems are frequent, and adherence to basic procedures varies markedly between different teams (Healey, Sevdalis et al. 2006). In the absence of pre-operative checks, crucial equipment and prosthesis are often missing in most operating theatres (Roth and Gandhi 2004).

Attempts to follow guidelines such as those for antibiotic and DVT prophylaxis are impeded by blurred inter-professional responsibilities, workflow and communication problems (Tan, Naik et al. 2006). Therefore, guidelines or other similar interventions that fail to account for the wider system are unlikely to improve safety significantly.

Understanding the correlation between teamwork and processes is easier but correlating teamwork to outcomes is far more difficult. Mazzocco et. al conducted an observational study and case record review of 300 surgical procedures to understand

the correlation between teamwork and clinical outcomes such as 30 day morbidity and mortality. They found that those patients whose surgical teams showed poor teamwork behaviours had a higher risk of postoperative death and complications (Mazzocco, Petitti et al. 2009).

Therefore it is evident that there is a need to develop and institute measures to improve teamwork in operating theatres. The net section discusses the various interventions designed to improve teamwork in surgery.

3.6 Interventions to improve Teamwork in surgery.

There is growing evidence that teamwork failures are responsible for majority of adverse events related to surgery (Gawande, Zinner et al. 2003). In light of this evidence, a number of interventions have been designed and implemented in operating theatres in an effort to improve teamwork. These interventions have largely been adopted from aviation and defence organisations.

3.6.1 Team training.

Institute of Medicine's 1999 report " To Err is Human" advocated the need to adapt concepts of aviation based team training and Crew Resource Management (CRM) into healthcare in an effort to improve teamwork and patient safety practices (Kohn, Corrigan et al. 1999). In aviation CRM training has been used for more than three decades and has been shown to improve safety attitudes, communication and coordination and also improve error-management (Helmreich 1998). In healthcare, Gaba et al. were first to adopt aviation based CRM training to develop Anesthesia Crisis Resource Management (ACRM) to help anesthesiologists manage crises effectively (Gaba, Howard et al. 1998).

Grogan et al designed a CRM based 8 hour training programme for operating teams. Through role plays in simulated settings, this programme provided training in managing fatigue, managing a team, recognising adverse situations, cross checking and communication, developing a shared mental model and feedback. Team training requires a simulated set up with facilities to reconstructive near- real scenarios and presence of trained assessors to reliably assess performance and provide training. Academic institutions in UK such as Imperial College have simulated operating theatres, specially designed to provide technical and non- technical skills training to surgery and anaesthesia trainees. However, such a set up is expensive and therefore limited in its reach to the healthcare staff working in non-specialist units and district hospitals. Efforts are being made to make simulation technology cheaper and available to wider healthcare staff. Kneebone et al have designed a low cost distributed simulation set which uses inflatable walls and posters to simulate theatre environment (Kneebone, Arora et al.). It enables the setting up of simulation-based training into non-technical skills as well as technical skills, which is portable and available at a fraction of price. But team training has mainly been an academic exercise in surgery and it is only recent that it is making its way into the clinical practice.

In a retrospective health services study conducted with a test and contemporaneous control group involving 182,409 sampled procedures from 108 Veterans Health Administration facilities, Neilly el al showed a 18% reduction in annual mortality one year after implementing a team training programme (Neily, Mills et al.). Catchpole et al studied teamwork in 112 operations before and after instituting aviation style team training for 3 surgical teams (Catchpole, Dale et al.). The team training comprised of a two-day training in the classroom followed by 6 days of coaching in operating theatres.

They found that team- training can improve team performance but the compliance to team-training interventions were strongly influenced by attitudes of key influential individuals, thus highlighting the need for change in organizational culture and attitudes towards such interventions.

3.6.2 Team briefings.

In order to facilitate team communication, develop shared mental models between team members, and improve safety, pre-procedural briefings are considered to be critical in other high reliability organisations. Team briefings have historically been used in the army to exchange relevant information and develop a shared mental model prior to a mission. Similarly, a surgical briefing is typically done before starting a surgical procedure. The theatre team gets together and discusses the patient, the surgical procedure being performed, any critical or unexpected steps, any special instruments required, any anaesthetic concerns, or any nursing issues. Briefings facilitate the transfer of critical information between people and create an atmosphere of openness where team members feel empowered to contribute to the process. Pre-procedural briefings are also considered critical in other high-risk organisations as ways to improve safety by helping team members develop shared mental models of work and act as reminders. The joint commission recommended the use of a 'Time-out' or 'pause for the cause' to confirm the patient, the procedure and the site to be operated prior to the incision (The_Joint_Commission). This is now a mandatory requirement for all operating theatres in the US. This recommendation laid down the foundations for the establishment of pre-operative team briefings where other checks and communication interventions can be dovetailed onto the 'Time-out'. This has resulted in the 'Time-out' serving as a tool for fostering communication between team members. Just as pre-

procedural briefings facilitate teamwork, post-procedural debriefings are considered critical in fostering a culture of open communication within teams. Debriefings are communication interventions that are meant to improve safety through discussion and by reflecting on the causes of errors and critical incidents. Safety checks can be incorporated into the debriefing process which could be the basis for the development of safety centred interventions (Makary, Holzmueller et al. 2006).

3.6.3 The Surgical checklist.

Checklists address human failures associated with omission. Checklists are a list of items that need to be checked to ensure that essential safety tasks are performed. Checklists act as reminders, help in standardisation of processes, add redundancy to the system (Hales and Pronovost 2006), provide quality assurance, improve information flow and provide feedback that can be used for audit purposes (Lingard, Espin et al. 2005). They are particularly beneficial in stressful situations as in a busy theatre list where there is informational overload, multiple steps in a process, departures from routine processes and interruptions or distractions (Reason 2002).

Checklists are routinely used in high reliability organizations such as aviation and the nuclear power industry (Hales and Pronovost 2006). Checklists were first used in aviation in 1940s following the crash of the Boeing B17 bomber on its maiden flight in Oct. 1935. The ensuing investigation revealed that the pilot forgot to release the elevator lock. The pilots called it " too much of a plane to be flown by a man" as the plane required the pilot to perform multiple tasks that were easily forgotten. Therefore, Boeing introduced a flight checklist that reminded the pilots about the tasks that needed to be performed and their sequence. Subsequently, Boeing flew 1.8 million miles without any accidents. Ever since checklists have been used in aviation for all flight sequences. In

aviation, their use is mandatory for every stage of the flight.

The checklists currently in use in health organisations across the world (DeFontes J 2004), (Makary, Mukherjee et al. 2007), (Lingard, Regehr et al. 2008) generally consist of pre-operative checks such as confirmation of site, side and surgery, availability of equipment and the need for special investigations among others. In addition, the teams exchange patient and procedure related critical information and discuss any potential intra-operative events. Chapter 5 further describes the design and development of a surgical checklist in detail.

3.6.4 Effectiveness of checklists and briefings.

A common dilemma among health care staff is whether checklists 'actually work' or only add to the amount of paperwork. The role of checklists in error mitigation is well proven and established in high risk industries such as aviation (Hales and Pronovost 2006) and there is growing evidence of its effectiveness in healthcare. Daily checklists and reminders in care pathways for acute MI and Stroke patients improved adherence to aspirin guidelines and administration of beta- blockers within 24 hr of admission (Wolff, Taylor et al. 2004). In trauma services, patient transfer to regional trauma centres has improved by using a pre-transfer checklist. (Harrahill and Bartkus 1990). In intensive care, checklists have been found useful in predicting successful weaning from the ventilators (Walsh, Dodds et al. 2004). Pronovost et al demonstrated that a checklist of safety related steps resulted in a large and sustained reduction in catheter related bloodstream infections (Pronovost, Needham et al. 2006). In surgery, preliminary results from studies on the benefits of checklists and briefings have demonstrated an improvement in team and safety attitudes (Awad, Fagan et al. 2005) (Lingard, Espin et

al. 2005). There is evidence that they aid in reducing the incidence of events such as wrong site surgery (DeFontes J 2004) and lead to an increase in the use of prophylactic medication in the peri-operative period (Awad, Fagan et al. 2005), (Altpeter, Luckhardt et al. 2007). There is also some evidence that pre-operative briefings contribute to an improvement in the safety culture and team environment within the operating theatre (DeFontes J 2004), (Makary, Mukherjee et al. 2007). Awad et al found that team training in the use of briefings lead to an improvement in the communication between team members (Awad, Fagan et al. 2005). In addition, it has been found that pre-operative briefings result in reduction of equipment problems and an increase in staff morale (DeFontes J 2004).

3.7 Conclusion.

In order to improve teamwork in surgery, various interventions have been proposed and evaluated. Interventions that combine elements of checklist with briefings have been shown to improve teamwork and communication. At the same time it is important that these interventions are tested using standardised measures so that the effectiveness of these interventions can be evaluated.

Chapter 4

Measuring teamwork in surgery- a review of literature

4.1 Introduction

The previous chapter establishes the importance of effective teamwork in surgery. Given its significance in surgical systems, it becomes imperative that teamwork is accurately assessed and interventions are designed to improve healthcare delivery and reduce adverse events resulting from poor teamwork. However, assessment of teamwork is a challenge in surgery and unlike other high-risk industries, continues to be a largely unexplored area of research. Assessing teamwork is necessary to benchmark the performance of teams, which are generally evaluated in terms of clinical outcomes. While poor outcomes may alert us to patient safety concerns, they do not highlight problems that lead to patient harm. Therefore, in order to reduce adverse events and enhance patient safety, we need to identify underperforming teams and develop interventions to improve teamwork. Teamwork assessment has been a benchmark measure in high risk organisations such as aviation and military, to ensure that the teams are working in cohesion and identify personnel who require further training in team working skills. In this chapter, I discuss the need and means to reliably assess teamwork in surgery.

As discussed in the previous chapters, much of the conceptual understanding of teamwork in healthcare has been adapted from research based in industries such as

aviation. However, one may argue that there are some differences between these industries and surgery, which poses different challenges in terms of emergent complexities in the surgical procedures, that no two patients are identical in their problems or surgical interventions. Further, operating theatres are dynamic environments with different specialties requiring different inputs and following separate guidelines and protocols, teams change during and in between procedures, plans change intra-operatively and there is no clear team leader. This necessitates the need for research into development of new tools or modification of the existing measures to reliably evaluate teamwork in operating theatres. There is a growing realisation in the healthcare sector that interventions are needed to improve teamwork in operating theatres. In its 1999, report, Institute of Medicine (IOM) has emphasised the need to introduce aviation style team interventions (Kohn 2000). Defonte et al in a study described the benefits of surgical team briefings on teamwork (DeFontes J 2004). Lingard et al piloted a surgical checklist and team briefing to improve communication in the operating theatres (Lingard, Regehr et al. 2008). But the long-term impact, effectiveness, and sustainability of these interventions can only be analysed if we can accurately assess their impact on teamwork and patient safety. Box 4.1 summarises the advantages of assessing teamwork in operating theatres.

Box 4.1 Key advantages of measuring teamwork.

1. To design a yardstick to classify good teamwork characteristics

2. To compare performance of different teams and identify areas of improvement

3. To assess the effectiveness of teamwork interventions

4. To assess correlation between teamwork and clinical outcomes

To understand the various measures used to assess teamwork in surgery, I conducted a review of literature.

The aims of this literature review is

- to identify teamwork measurement tools used for assessment in surgical care

- to discuss use, validity, and reliability of the same

4.2 Methods

An extensive and structured review of the published literature was conducted using online resources and hand search of references.

The electronic databases MEDLINE (OVID), EMBASE (OVID), PsycINFO (OVID) were searched. Google Scholar and Cochrane Database of Systematic Reviews were also searched. Keywords from key papers and broad literature searches on the electronic databases identified above compiled. Search terms were refined through an iterative

process of reviewing outcomes of preliminary keyword searched in the databases. Key articles' Medical Subject Headings (MeSH) terms were also identified to make the search comprehensive. Using the Boolean term "and", key words and MeSH* terms (Box 4.2) were combined to search for relevant articles. A further hand search was carried out by scanning article references.

Box 4.2 Key words and MeSH* terms.

(1) *Operating Rooms*, Surg$*, Anesthesia*, Operating theatre*, theatre*;*

(2*) Interdisciplinary Communication*, Communication*, Communication Barriers*, Communication failure, Teamwork*

(3) *Measure, intervention, tool, questionnaire, checklist, briefing, survey, team training*

4.2.1 Selection of study.

Electronic citations and abstracts were scanned to select articles for full text review. After going through the text, studies were selected for review if:

They assessed teamwork or any of its components in the field of surgery or anaesthesia.

Or, they demonstrated an improvement in teamwork or any of its components in surgical or anaesthetic fields.

Or, they described the development of a tool to assess or improve teamwork or any of

its components in surgical or anaesthetic care.

Or, they described teamwork failures in surgery or anaesthesia.

Studies that were primarily focusing on adverse events in surgery or anaesthesia but did not study teamwork in detail and merely identified the role of teamwork in their causation were not included in the review.

4.3 Findings of the review- Tools to measure teamwork in surgery.

Various tools have been used to measure teamwork in healthcare organisations. These can be broadly classified into: (1) Observations and (2) Opinion based-Surveys/ questionnaires. Observation based tools can be further classified into (a) field notes based teamwork analysis and (b) behavioral rating scales.

4.3.1 Observational measures of teamwork.

4.3.1.1 Field note based Observation.

Field notes based observation has its origins from ethnographic methodologies used in social sciences. This method involves expert observers being present in the study environment taking notes on the tasks, behaviours and problems. The field notes are later coded and classified into various themes to draw conclusions from the observed data. Field note based observational techniques have been used to explore problems and failures in operating theatres. Lingard et al observed surgical operations and described communication failures in the operating theatre (Lingard, Espin et al. 2004). They classified communication failure events in the operating theatre into occasion, content, audience, and purpose failure and also described the impact of these communication failure events on the outcomes of surgery such as delays, resource

wastage, and adverse events. Christian et al in a study, observed 10 complex general surgery procedures and took minute by minute notes which they later coded and qualitatively analysed into systems factors such as team factors, individual factors, organisational factors, equipment factors, and interpersonal factors and their impact on patient safety (Christian, Gustafson et al. 2006). Catchpole et al observed 24 paediatric surgeries and 18 orthopaedic surgeries combining field notes with NOTECHS and found communication and coordination to be the most common cause of problems in the operating theatres (Catchpole, Giddings et al. 2006). Wiegmann et al in an observation study recorded surgical errors and flow disruptions during 31 cardiac surgery operations. They further classified these errors into teamwork, equipment, interruptions and training related issues and associated them with disruptions in operating theatres(Wiegmann, ElBardissi et al. 2007) and found that disruptions in surgical flow was associated with problems in teamwork in 52% of errors.

4.3.1.2 Teamwork Behavioural rating systems.

Behavioural markers are 'observable, non technical behaviours that contribute to superior or substandard performance within a work environment' (Klampfer 2001). This method uses trained observers who are present in the operating theatre to observe and analyse the team's behaviours and task performance. Behavioural rating tools were primarily designed in the aviation industry to assess team-working skills of pilots and other crewmembers and evaluate effectiveness of CRM training. In aviation, CRM has been used for many decades. By mid- 90s, CRM training was a well established practice in aviation industry. However, standardised assessment of effectiveness of CRM training in imparting non-technical skills remained to be established. This required a systematic

and reliable method of measuring behaviours and team interactions. Therefore, a need was felt to develop a behavioural rating system to assess pilots. As a result, Aviation NOTECHS (Non Technical Skills) rating system was developed to evaluate pilots' non-technical skills such as leadership, coordination, communication, and decision-making (Flin 2003). In the last ten years concepts of CRM training and assessment of non-technical skills have been introduced in healthcare, which has led to the development of a number of teamwork behaviour assessment tools.

4.3.1.2.1 Observational Teamwork Assessment for Surgery OTAS.

OTAS has been designed by Undre et al at Imperial College to measure two facets of theatre teamwork- team tasks and team behaviours (Undre, Healey et al. 2006). It is a tool, which requires two observers to observe and assess teamwork in the operating theatre. One observer uses a checklist to mark the theatre teams on tasks carried out in the operating theatres. The OTAS checklist consisted of tasks that are considered vital to a surgical procedure. The tasks were divided into (1) pre- operative assessment such as preparation of patient notes, anaesthetic equipment checks, communication regarding consent, co morbidities, allergies, and availability of correct instruments; (2) intra-operative assessment such as draping of patient, correct placement and set up of equipment, confirmation of surgical site and side; and (3) post- operative assessment such as reversal of anaesthesia and airway maintenance, appropriate checks for pressure and diathermy site and safe transfer to the trolley. The second observer was also present during the different phases and used a behavioural rating system to mark different team members (surgeons, nurses and anaesthetists) for their teamwork skills such as communication, leadership, coordination, cooperation, and situational

awareness. The behavioural marking system was based on Dickinson and McIntyre's model of Teamwork and used exemplar behaviours to score the team members on a scale from 0-6. The behavioural marking the OTAS has been tested in general surgery, urology and gynaecology surgery and it shows some association with clinical outcomes. Its validity and reliability has been further testing (Undre, Healey et al. 2006; Undre, Sevdalis et al. 2007; Sevdalis, Lyons et al. 2009). Recently, OTAS has been further modified to irefine the behavioural rating system and the task checklist has been taken out. The modified OTAS has been shown to have good construct validity (Hull, Arora et al.).

4.3.1.2.2 Oxford NOTECHS (Non TECHnical Skills) scoring system.

Oxford NOTECHS has been adapted from aviation based NOTECHS scoring system to make it relevant to operating theatre environment (Mishra, Catchpole et al. 2009). In this system, teamwork behaviours have been classified into leadership and management, teamwork and cooperation, problem solving and decision-making, and situational awareness. A trained observer is needed in the operating theatre to mark the theatre teams on these behaviours. Catchpole et al observed 26 laparoscopic cholecystectomies and 22 carotid endarterectomies using Oxford NOTECHS to score the theatre teams. They also observed procedures for any technical errors using a technical error analysis methodology, operating time and other problems as outcome measures, and found that operating times were indirectly related to leadership and management and low incidence of technical errors was associated with higher situational awareness (Catchpole, Mishra et al. 2008) (Mishra, Catchpole et al. 2009). Sevdalis et al modified the NOTECHS by adding communication and interaction

dimensions to make it more relevant to surgery and they found it to be a reliable measure of teamwork (Sevdalis, Davis et al. 2008).

4.3.1.2.3 Anaesthetists Non Technical Skills (ANTS) behavioural marking system.

ANTS behavioural marking system scores the non-technical skills of anaesthetists in operating theatres (Fletcher, Flin et al. 2003). It comprises of four skill groups: task management, team working, situational awareness, and decision-making. It was found to be a valid, reliable, and usable tool to assess non-technical skills of anaesthetists in simulated environment (Fletcher, McGeorge et al. 2002). It has been used in assessing anaesthetists' non-technical skills however its feasibility and reliability in clinical settings such as operating theatres remains to be studied (Flin and Patey ; Reader, Flin et al. 2006).

4.3.1.2.4 Non Technical Skills for Surgeons (NOTSS) rating system.

NOTSS behavioural rating system has been developed by Yule et al at University of Aberdeen for assessing surgical trainees and consultant surgeons on their observable non- technical skills. It divides non- technical skills into situational awareness, decision making, task management, leadership, communication and teamwork (Yule, Flin et al. 2006). The marking system has been tested with 44 consultant surgeons in simulated operating theatre setting, however its feasibility and reliability remained to be tested in the real operating theatres (Yule, Flin et al. 2008). Recently, Crossley et al evaluated the NOTSS in real operating theatre environment. They found that NOTSS assessment was feasible, valid and reliable, however important implementation challenges were

highlighted. Most respondents had reservations about assessing cognition (Crossley, Marriott et al.)

4.3.2 Questionnaire based surveys

Questionnaire based surveys are used to assess the opinions and attitudes of the healthcare staff. They are designed to understand the variation in staff attitudes towards patient safety and teamwork components such as communication, shared mental model, situational awareness, and leadership. Below I discuss some of the surveys used to assess teamwork.

4.3.2.1 University of Texas's Safety Attitudes Questionnaire (SAQ).

Adapting flight management attitudes questionnaire (FMAQ) (Helmreich 1984) used widely in aviation, Sexton et al. (year) developed the SAQ to assess safety attitudes in healthcare (Sexton, Helmreich et al. 2006). The FMAQ was developed after researchers found out that most of the accidents in aviation were due to poor teamwork, leadership, and decision making. As 25% of FMAQ items showed utility in healthcare settings, they were included in the SAQ. The SAQ has 30 items and six domains, namely, teamwork climate, safety climate, job satisfaction, perceptions of management, stress recognition, and working conditions. However, only six out of the 30 survey items measures teamwork. The teamwork climate reflected the perceived quality of collaboration between team members. Teamwork behaviours included assertion (speaking up), conflict resolution when there was a difference of opinion, asking questions related to patient care and coordination.

SAQ has been tested for validity and reliability in the operating theatres. In one study, Makary et al administered the SAQ to 2769 staff including surgeons, nurses and anaesthetists with a response rate of 71% and demonstrated a high face validity and internal consistency (alpha = 0.76) (Makary, Sexton et al. 2006). Content validity of the teamwork domain has also been established by comparison with observational teamwork behaviour ratings. SAQ was further assessed in 203 clinical domains with more than 10000 respondents, to evaluate psychometric properties (Sexton, Helmreich et al. 2006). SAQs have also been demonstrated to be sensitive to quality improvement interventions at Kaiser permanente where it was used to assess the benefits of a briefing intervention in operating theatres (DeFontes J 2004). SAQ has been used widely and there is benchmarking data available that enables organisations to evaluate their climate data (Sexton, Helmreich et al. 2006).

4.3.2.2 Operating Room Management Attitudes Questionnaire (ORMAQ).

ORMAQ survey has been developed by Schaeffer and Helmreich at University of Texas (Schaeffer 1993) and adopted for UK operating theatres by Flin et al (Flin, Fletcher et al. 2003) to measure attitudes to teamwork, leadership, stress, fatigue, and error. ORMAQ is based on aviation's safety attitudes surveys such as FMAQ, CMAQ (Cockpit Management Attitudes Questionnaire) and was developed by the same team that developed the SAQ and both share design characteristics as both were developed from ICUMAQ (Intensive Care Unit Management Attitudes Questionnaire). However, ORMAQ has been designed specifically for the operating theatres. Flin et al's modified ORMAQ contains four sections: (1) Sixty likert scale questions on leadership, confidence,

information sharing, stress and fatigue, teamwork, work values, error and organisational climate; (2) A section to rate teamwork and cooperation; (3) Error management questions; (4) A section inviting suggestions for increasing effectiveness in the operating theatres.

ORMAQ has been used in various studies assessing attitudes among surgeons, nurses and anaesthetists in US and European hospitals and has been shown to be valid and reliable (Sexton, Thomas et al. 2000).

4.3.2.3 Medical Team Training questionnaire (MTT).

MTT was developed from the Team Training Questionnaire developed at Veterans Affairs (VA) Medical centres in US. This questionnaire was used to evaluate the impact of team training based learning exercise for the theatre teams and tested on 384 healthcare staff members. The MTT consists of four factors: 1) Organisational culture, 2) Communication, 3) Teamwork, and 4) Human factors awareness. The MTT study has shown construct validity but other psychometric properties and reliability need to be assessed further.

4.4 Discussion.

Teamwork questionnaire surveys offer a quick and easy way to assess theatre staffs' perceptions. A study conducted at Johns Hopkins Hospital in US demonstrated that improvements in SAQ safety climate is associated with fewer medication errors and reduced length of hospital stay (Thomas, Sexton et al. 2005). Questionnaire surveys are

also less resource intensive, requiring little training in their use. Therefore, organisations can frequently use them as part of their quality improvement programmes. They can help identify specific areas of concern and disparities in the safety attitudes of team members and highlight problems within the work culture.

As a teamwork assessment tool, these questionnaires have some limitations. These surveys are based on self-reports and staff's perceptions, which may not necessarily reflect the actual behaviours in the operating theatres. These surveys may highlight concerns relating to teamwork but do not divulge further information into team interactions and more specific problems within the operating theatres. Surveys are an additional workload for theatre staff and may not be completed sincerely or accurately thereby reducing their reliability. Theatre environment is a dynamic environment with numerous site and specific variability. The surveys are designed to answer specific questions that may not be applicable to all the specialties. Furthermore, a study conducted at 52 sites in US (44 VA medical centres and 8 academic medical centres) showed that the risk adjusted morbidity and mortality in these hospitals did not correlate with the different organisational climate safety factors in the SAQ. However, the reported levels of positive communication correlated with lower risk adjusted morbidity (Davenport, Henderson et al. 2007).

All the behaviour rating systems have been developed based on teamwork concepts from aviation or teamwork models previously used in these industries. These rating systems can be useful in identifying poor behaviours and designing improvement training and feedback to the teams. However, they are limited by the set criteria specified in the tool and are therefore unable to capture behaviours and events outside the scope of the system or different from the exemplar behaviours. Nevertheless, they

capture actual teamwork behaviours rather than perceptions of teamwork and can be used to assess teamwork performance in training setups and provide useful feedback to the participants.

OTAS and NOTECHS have been used in real theatre settings but other systems remain to be studied in such setting. Moreover, NOTSS and ANTS assess teamwork skills of specific team members rather than the entire team.

All the behavioural rating systems are expensive to set up and rely on the observer's understanding of the situation. Therefore they require intense training and reliability testing to reduce observer error and bias. These observers have to be present in the operating theatres, which in itself might create an observation bias and alter the behaviours of the team members..

Behavioural rating systems have been adopted from aviation's NOTECHS but it is essential that changes be made to make them suitable for surgery. For example, OTAS, in addition to behaviour rating, also uses a task checklist that evaluated the level of teamwork in performing tasks within the operating theatres such as setting up equipments for surgery, connecting the diathermy machine to the patient, surgeon checking the availability of blood group and cross match etc. This, up to a certain extent diminishes the dependence on an observer's subjective ratings. One of the limitations of the OTAS has been that it is very lengthy and ideally requires two observers, one to complete the checklist and the other to complete the behavioural ratings. Other limitations of the research in behavioural rating scales conducted so far have been the sample size. Observational studies are exhaustive and observer needs to be vigilant throughout the surgical procedure. Most of the studies that assess behavioural rating

systems have been conducted on shorter and less complex surgical procedures such as cholecystectomies. Major complex procedures are not only lengthy but may pose different set of problems that are yet to be assessed using the behavioural rating systems. Also, there is a paucity of benchmarking data to be able to evaluate quality service provision.

Field note based observation tools are more detailed in their ability to explore systems factors and teamwork failures. They also provide an opportunity to understand the systems factors underlying technical and equipment related failures. Similar to a root cause analysis pathway, experts can use these field notes to reconstruct failure events and explore the underlying factors and teamwork failures. Further, unlike behavioural rating systems where observers score individual members' teamwork skills, field note observations, pay more emphasis on the entire team and also describe the impact of the events on outcomes such as technical errors, theatre efficiency and patient safety. This information can be directly useful in developing interventions to address problems with specific teams. However, one limitation of the observation studies conducted till date has been a lack of a common taxonomy. Different systems of coding field notes have been used which prevents any comparison between different studies. The coding systems are also driven by the objectives and aims of the studies for example, Catchpole et al primarily divided events into minor, moderate and major events, whereas Wiegmann et al classified events into disruptions and subsequently identifying associated teamwork failures that were associated with these disruptions. Most of the studies are one time comparative studies therefore reliability and reproducibility remains to be assessed.

4.5 Conclusion.

Assessment of teamwork in surgery is varied with no established benchmark assessment tool. While surveys are easy to design and administer, they may not represent the true teamwork behaviours of the surgical team. Behavioural ratings and field note based observations provide a more detailed assessment of teamwork but require experts, and are time and resource intensive. Behaviour ratings and questionnaires have been used to evaluate effectiveness of teamwork interventions where as field notes studies have primarily been used to describe problems and failures in operating theatres.

There is a need to design and test measurement tools that could combine the benefits of all the methodologies and provide a more comprehensive and structured view of teamwork in operating theatres.

The findings of this review will be used in the subsequent chapters to design an observational method of teamwork assessment that combines the benefits of field note observations with the systematic coding framework of the behavioural rating systems. This measure will be used to describe teamwork in operating theatres more extensively, evaluate teamwork interventions, and further assess the impact of teamwork on patient safety and theatre functioning.

Chapter 5

An overview of research programme and methodology

5.1 Introduction.

The introductory chapters give a detailed background to research on teamwork in healthcare and surgery. Before I proceed onto the study chapters, I present an overview of the research programme to discuss the background to the studies, the methodology, the relationship of the studies to each other and the evolution of the research programme.

5.2 Mixed methods research.

Teamwork research has been largely conducted by psychologists using qualitative methodology (Helmreich RL 1998; Helmreich 1998; Lingard, Reznick et al. 2002; West 2004; Lingard, Whyte et al. 2006). However some psychologists have used both qualitative and quantitative methods to describe teamwork in surgery (Lingard, Espin et al. 2004). While qualitative methodology has laid the foundations and principles of teamwork research, I wanted to design my research project amalgamating the benefits of quantitative clinical research with the insight of qualitative research. Therefore I chose mixed methodology for my research. According to Creswell et al., "mixed methods research is an approach to inquiry that combines or associates both qualitative and quantitative forms. It involves the use of both the studies in tandem so that the overall

strength of a study is greater than either qualitative or quantitative research" (Creswell 2009). While qualitative research is helpful in an in-depth analysis of a problem, it cannot be used to quantify the differences or strength of association between variables. Quantitative research may have the benefit of demonstrating statistically significant differences but it does not highlight the underlying factors and their impact on a system. Therefore, a mixed methods research was deemed most appropriate for a study of this nature and scale, and enabled me to quantify the impact of teamwork on patient safety in surgery and explore the factors underlying patient harm as well as the interventions to mitigate this harm. Below I present an overview of the methods adopted in my research studies.

5.3 Methodology.

As I commenced my PhD research in 2007, a global WHO project was underway to pilot a surgical safety checklist to improve patient safety in operating theatres. WHO checklist was designed by a panel of expert surgeons, nurses, anaesthetists and patient safety experts under the WHO safe Surgery Saves Lives project. The checklist design has been described in chapter 6. The first study I carried out was a part of the pilot to test the WHO checklist in a London based tertiary care NHS hospital. This study was a pre-post study designed to assess the impact of checklist on clinical outcomes after surgery in a NHS hospital. To assess the impact of WHO checklist intervention it was introduced in two operating theatres. The surgeries performed in these two operating theatres included general surgery, orthopaedic surgery and gynaecology including both elective and emergency procedures. Data was collected on 360 surgical cases in two operating theatres prior to introducing the WHO checklist. Subsequently, data was collected on a

further 360 cases. The data was collected through an intra-operative data form, which contained questions on process measures, such as administration of antibiotics, confirmation of patient identity etc. The data on morbidity and mortality was collected post- operatively. Further a subset of cases was observed to assess teamwork through a modified OTAS teamwork checklist.

This study provided me an opportunity to assess and understand the impact of checklist on teamwork as well as theatre efficiency. Further details of methods and results of this study have been described in Chapter 6.

The results of this study showed that checklist improves teamwork and patient safety related processes however the impact on clinical outcomes could not be directly associated to the checklist. There was a further need to understand the perceived impact of the checklist among its users and human factors associated with checklist intervention and design framework to further assess the impact of WHO checklist. Therefore, next I conducted an interview study to understand surgeons, anaesthetists and nurses perception of WHO checkist. I designed a semi-structured interview study to understand theatre teams' (surgeons, nurses, ODPs and anaesthetists) perception of the WHO checklist and it's perceived impact on teamwork, patient safety and theatre efficiency. I enrolled 15 participants using snowball technique. The recruitment was continued until theme saturation was attained. The interviews were conducted using a topic guide (Appendix 2) and recorded and transcribed for analysis. The analysis was conducted using NVIVO software to identify emerging themes.

I decided to conduct this interview study to understand the perceptions of theatre teams towards teamwork and patient safety and the role of checklist. From the interview study

it emerged that the impact of checklist on clinical outcomes was not evident to NHS staff, therefore there was a need to define surrogate markers of teamwork, patient safety and theatre efficiency that could be used to further evaluate the impact of checklist as a teamwork intervention. Further, it would help me in understanding the barriers to the implementation of checklist and modify it to make it more NHS specific. This interview study and its results have been detailed in chapter 7.

My next study aims to study various teamwork failures, explore their association with technical failures and equipment failures and describes the impact on patient safety and theatre efficiency. In this study, I describe an ethnographic framework designed to quantify and assess teamwork failures, equipment failures and technical failures and their impact on patient safety and efficiency in operating theatres. This study was key to define surrogate markers of teamwork and patient safety that could be studied to understand the impact of WHO checklist in greater detail. Further, from the theatre teams' interviews it emerged that clinical outcomes may not clearly represent the quality of surgical care provided and the benefits of checklist perceived by the surgeons, nurses and anaesthetists. Improvement in clinical processes in operating theatres will contribute to improvement in patient outcomes but the impact would be indirect and therefore not easily measurable. For any teamwork intervention such as a checklist, to be sustainable, staff should be able to perceive a positive impact on intra-operative patient safety and theatre productivity. These surrogate markers can be broadly identified as teamwork failures in the operating theatres, technical failures in the performance of surgical procedures, equipment problems and theatre efficiency.

The study of technical failures in surgery has traditionally been retrospective through case record reviews and has been predominantly clinical outcome related. It has been found that technical failures are often associated with poor teamwork in the operating theatres (Mishra, Catchpole et al. 2009) and may lead to patient harm, increased length of hospital stay and even death. Equipment failures are common in operating theatres, yet being part of the daily routine, largely ignored. Very few studies describe these failures and explore their causation despite their prevalence and impact on surgery and team dynamics (Christian, Gustafson et al. 2006).

This study uses a prospective field note approach to observe and understand surgical systems and study teamwork failures in operating theatres and their association to technical failures and equipment failures in operating theatres.

The methods used in this study were adopted from the ethnographic methodology widely used in social sciences. Catchpole et al and Christian et al have previously used 'field' notes to describe events and problems in operating theatres (Catchpole, Giddings et al. 2006; Christian, Gustafson et al. 2006). Similarly, Lingard et al have used field notes to observe and classify communication failures in operating theatres (Lingard, Regehr et al. 2006). Wiegmann et al (Wiegmann, ElBardissi et al. 2007) observed cardiothoracic surgeries with the main emphasis on surgical errors and flow, however, they did not classify teamwork errors and concentrated on detection times for surgical errors rather than impact on patient safety. Undre et al developed an observational tool called the Observational teamwork Assessment in Surgery (OTAS) where observers use a task list to assess completion of teamwork tasks and simultaneously use behavioral rating to assess teamwork skills of the surgical team members. Many of these studies were focused on a limited aspect of teamwork in the operating theatre such as

communication errors in operating theatres and their interactions. My study aims to schematically capture various teamwork failures, explore their association with technical failures and equipment failures and describes the impact on patient safety and theatre efficiency. Further details and results of this study have been described in chapter 8.

From the interview study and teamwork ethnographic framework study it emerged that equipment problems are common in operating theatres. Equipment problems emerged as an important indicator of teamwork in operating theatres therefore, it was necessary to investigate these problems further to understand teamwork in operating theatres. It is a common perception that equipment problems are frequent in operating theatre environments, yet there is a paucity of studies that investigate these errors in detail.

I designed this study to understand the scale of equipment problems in UK operating theatres, their impact on patient safety and theatre efficiency. For this study I collected data from general surgical, orthopaedic, vascular and gynaecology procedures in operating theatres at three NHS hospitals. The data was collected using structured self-report forms (Appendix 4) that were completed by the surgeon and scrub-nurse collectively at the end of each procedure. The data form was designed to capture the equipment problems faced by the theatre teams, how they were dealt with and their perceived impact on theatre efficiency and patient safety. Further, I observed a subset of operations to (1) collect similar data on equipment problems to assess the underreporting of equipment problems and their perceived impact. (2) I also analysed the teamwork failures underlying those equipment problems and their impact using the ethnographic framework. Further details of the methods and results of this study have been described in Chapter 9.

While the equipment problem data self-report study was being carried out, I also conducted semi-structured interviews with surgeons and theatre nurses to understand the factors underlying these equipment problems, how they emerged as a result of poor teamwork in the complex system. Further, the interview study also aimed to understand the role of checklist as an intervention to reduce equipment problems. Surgeons and theatre nurses were recruited for the interviews till new themes stopped emerging. The interviews were recorded and transcribed and coded with NVIVO software into different themes using the Vincent et al. framework of analysis described in chapter 2. This study and its findings are described in Chapter 10.

From these studies I established a robust understanding of teamwork in operating theatres and its association with theatre problems, delays, and patient safety. Teamwork failures, equipment failures and technical failures emerged as measures of teamwork and patient safety in operating theatres.

The final study described in this thesis is a prospective observation study that adopts the ethnographic surgical team framework to assess the impact of WHO checklist. The WHO surgical checklist has been mandated for use in all operations in England and Wales. The checklist was implemented in all NHS theatres. Therefore a pre-post longitudinal study was not feasible. However, with the implementation of checklist, it was evident that the conduct of checklist by different theatre teams was variable. To assess the impact of WHO checklist, it was essential to assess the quality of checklist use by theatre teams. My hypothesis was the checklist would have a positive impact on patient safety and teamwork during operations where the checklist was performed well. For this study I designed a data form to assess quality of checklist use. For each case under

study, teamwork failures, equipment failures, technical failures and their impact on patient safety and theatre delays were measured. Self-reported surveys were conducted for each case to assess surgeons, nurses and anaesthetists perceived quality of checklist use, benefits of WHO checklist and level of teamwork. Correlation analysis was conducted to understand the association between quality of checklist use, teamwork failures and theatre teams self reported perceptions. Further details of methods and results of this study have been described in chapter 11.

5.4 Conclusion.

I have used mixed methods for this research project. This helped me understanding teamwork and patient safety in surgery both at a macro level that can be quantified and measured, as well as a micro level that provides an understanding of the complex factors underpinning a complex surgical system.

Chapter 6

Impact of WHO surgical checklist on teamwork and patient safety

6.1 Introduction.

Preventable harm caused to patients undergoing surgery has been a growing concern globally. In January 2007, World Health Organisation's (WHO) World Alliance for patient Safety began its work on Second global Patient Safety Challenge. They launched the "Safe Surgery Saves Lives" project, aimed at improving patient safety in surgery on a global scale. This international effort has resulted in the development of a WHO surgical checklist (World_Health_Organisation) that includes items to ensure basic minimum surgical safety checks and has been developed with the intention that it can be applied across the world. In addition to ensuring all necessary checks, the checklist also sets a platform for improving teamwork in the operating theatres. It encourages the theatre team to discuss the procedure and equipment needs, confirm patient identity and exchange information that may be relevant to post-operative patient care. The WHO checklist underwent evaluation at eight international pilot sites across the 8 WHO territories. My hospital was one of the pilot sites for the study. The introduction of WHO surgical checklist in the OT provided an opportunity to study the improvement in patient safety processes, clinical outcomes, and theatre teamwork with an intervention aimed at improving patient safety.

This study describes the results of the UK site for Safe Surgery Saves Lives project to pilot a surgical checklist (Haynes, Weiser et al. 2009).

6.1.1 Intervention- The WHO surgical safety checklist (Figure 6.1).

6.1.1.1 Checklist development.

The Safe surgery saves lives checklist project was initiated under the 2nd Global patient safety challenge in January 2007. The first international consultation was held in Geneva. The consultation was chaired by Prof. Atul Gawande, the lead for Safe surgery saves lives project, and comprised of 50 surgeons, nurses, anaesthetists and patient safety experts from all over the world. The objectives of the first consultation were to address two questions: 1. What are the potential minimum standards of surgical care that can be universally applied across countries and settings and will improve the safety of surgical care? 2. What measurement systems can be implemented to monitor the progress and improvement of surgical safety resulting from these standards? To find answers to these questions, and develop an intervention to improve patient safety and teamwork in operating theatres, four safe surgery team working groups were formed. These team working groups were: 1. Clean surgery, 2. Safe anaesthesia, 3. Safe surgical teams and 4. Measurement. The objectives for the Safe Surgical Teams Working Group were to:

- Determine how to improve the safety of surgery through teamwork and performance improvement.

- Develop a set of guidelines to improve safety of patients undergoing surgery.

- Determine what elements might be incorporated into the checklist to achieve this.

- Evaluate the evidence for including such elements.

In April 2007, the first technical working group meeting was held where the initial draft of a surgical checklist, as an intervention to improve teamwork and patient safety in surgery, was discussed. In the second technical working group meeting, the final version of the surgical safety checklist was reviewed and technical documents supporting the evidence behind the checklist were finalised. Further information on development of WHO checklist is available on the WHO website.

6.1.1.2 Checklist design.

The checklist consisted of 19 item checks (Figure 6.1). The checklist was divided into three parts: the Sign-in, Time-out and Sign-out.

Sign-in.

The sign-in is performed when the patient enters the anaesthesia room or the operating theatre, prior to induction of anaesthesia. The anaesthetist and anaesthesia assistant perform the sign-in with the patient awake. It consists of 7 checks: 1. Confirmation of patient identity, procedure and consent; 2. Surgical site marking confirmation; 3. Anaesthesia safety checks; 4. Functioning Pulse oximeter attached to the patient, 5. Patient allergies; 6. Difficult airway or aspiration risk; and 7. Expected blood loss.

Time-out.

The Time-out is conducted with the anaesthetised patient on the operating table. It is conducted just prior to surgical incision with the surgeon, assistant surgeon, scrub nurse, circulating nurse, anaesthetist and ODP (Anaesthesia assistant) present in the operating theatre. The nurse or the anaesthetist initiates/ leads the Time-out using the

paper checklist and all the team members pause during this period and exchange information as required during the completion of Time-out checks. There are seven checks in this section of the checklist: 1. Confirmation that all team members have been introduced by name and role; 2. Confirmation of the patient's identity, surgical site, and procedure; 3. Surgeon reviews critical and unexpected steps, operative duration, and anticipated blood loss, 4. Anesthesia staff reviews concerns specific to the patient; 5. Nursing staff review confirmation of sterility, equipment availability, and other concerns; 6. Confirmation that prophylactic antibiotics have been administered ≤60 min before incision is made; and 7. Confirmation that all essential imaging results for the correct patient are displayed.

Sign-out.

At the conclusion of the procedure, team performs a Sign-Out before the surgeon leaves the operating theatre. It consists of five item checks performed aloud by the nurse conducting the checks: 1. Name of the procedure as recorded; 2. Confirmation that needle, sponge, and instrument counts are complete; 3. Confirmation of correct specimen labelling including patient's name; 4. Whether there are any issues with equipment to be addressed and finally; 5. The surgeon, nurse, and anesthesia professional review aloud the key concerns for the recovery and care of the patient.

The actual conduct of the checklist has been shown in the video recorded in the CD provided. These videos can also be accessed on the NPSA website (http://www.npsa.nhs.uk/nrls/improvingpatientsafety/anaesthesia-and-surgery/implementingthechecklist/how-to-use-the-who-surgical-safety-checklist/).

Figure 6.1 WHO Surgical checklist.

SURGICAL SAFETY CHECKLIST (FIRST EDITION)
World Health Organization

Before induction of anaesthesia ▶▶▶▶▶▶▶▶ **Before skin incision** ▶▶▶▶▶▶▶▶▶▶▶ **Before patient leaves operating room**

SIGN IN

☐ PATIENT HAS CONFIRMED
  • IDENTITY
  • SITE
  • PROCEDURE
  • CONSENT

☐ SITE MARKED/NOT APPLICABLE

☐ ANAESTHESIA SAFETY CHECK COMPLETED

☐ PULSE OXIMETER ON PATIENT AND FUNCTIONING

DOES PATIENT HAVE A:

KNOWN ALLERGY?
☐ NO
☐ YES

DIFFICULT AIRWAY/ASPIRATION RISK?
☐ NO
☐ YES, AND EQUIPMENT/ASSISTANCE AVAILABLE

RISK OF >500ML BLOOD LOSS
(7ML/KG IN CHILDREN)?
☐ NO
☐ YES, AND ADEQUATE INTRAVENOUS ACCESS AND FLUIDS PLANNED

TIME OUT

☐ CONFIRM ALL TEAM MEMBERS HAVE INTRODUCED THEMSELVES BY NAME AND ROLE

☐ SURGEON, ANAESTHESIA PROFESSIONAL AND NURSE VERBALLY CONFIRM
  • PATIENT
  • SITE
  • PROCEDURE

ANTICIPATED CRITICAL EVENTS

☐ SURGEON REVIEWS: WHAT ARE THE CRITICAL OR UNEXPECTED STEPS, OPERATIVE DURATION, ANTICIPATED BLOOD LOSS?

☐ ANAESTHESIA TEAM REVIEWS: ARE THERE ANY PATIENT-SPECIFIC CONCERNS?

☐ NURSING TEAM REVIEWS: HAS STERILITY (INCLUDING INDICATOR RESULTS) BEEN CONFIRMED? ARE THERE EQUIPMENT ISSUES OR ANY CONCERNS?

HAS ANTIBIOTIC PROPHYLAXIS BEEN GIVEN WITHIN THE LAST 60 MINUTES?
☐ YES
☐ NOT APPLICABLE

IS ESSENTIAL IMAGING DISPLAYED?
☐ YES
☐ NOT APPLICABLE

SIGN OUT

NURSE VERBALLY CONFIRMS WITH THE TEAM:

☐ THE NAME OF THE PROCEDURE RECORDED

☐ THAT INSTRUMENT, SPONGE AND NEEDLE COUNTS ARE CORRECT (OR NOT APPLICABLE)

☐ HOW THE SPECIMEN IS LABELLED (INCLUDING PATIENT NAME)

☐ WHETHER THERE ARE ANY EQUIPMENT PROBLEMS TO BE ADDRESSED

☐ SURGEON, ANAESTHESIA PROFESSIONAL AND NURSE REVIEW THE KEY CONCERNS FOR RECOVERY AND MANAGEMENT OF THIS PATIENT

6.2 Aims.

The aim of this study was:

- To assess the effectiveness of this checklist in improving patient safety processes in operating theatres and in reducing postoperative morbidity and mortality.

- To assess the impact of checklist on Teamwork in the operating theatres and

- To assess the impact of checklist on theatre efficiency.

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6.3 Methods.

6.3.1 Study Design.

Pre and post study to evaluate WHO surgical safety checklist.

6.3.2 Participants and materials.

6.3.2.1 Sample.

The study was conducted in two operating theatres. One theatre was used for orthopaedic procedures and the second theatre was used for general surgery and gynaecology procedures. Data was collected prospectively for 357 surgeries in the pre-intervention phase. Once the checklist was introduced in the theatres, data was collected on further 351 cases. Ethics approval was obtained from the National research ethics committee for this study. Written consent was taken from all the surgeons, nurses, and anaesthetists working in the study operating theatres.

6.3.3 Data collection.

6.3.4.1 Patient safety processes and clinical outcome.

The measures used for assessing effectiveness of the checklist were classified into Processes and outcomes (table 6.1). Process measures are useful in measuring the quality of care and understanding the areas of improvement in a system and are sensitive to assessing the improvements in patient safety practices at the grass root level. The data was collected using a standardised data collection form as shown in appendix 1. I distributed the form to the anaesthetist for each case to gather the

intraoperative data that I collated at the end of each case. For of 30% of cases, I remained in the theatre for the entire case and collected the data simultaneously (along with the anaesthetist) to assess the accuracy of data collection. This technique was employed to capture consecutive case data as there were multiple lists being performed in different theatres simultaneously and I could not have been physically present for all the cases for the entire procedure. Therefore this technique ensured that reliable data was captured for consecutive patient procedures. To collect the outcomes data, I retrospectively followed the patients post-operatively, until discharge, or death, or a hospital stay of 30 days, which ever was the earliest. In cases where the clinical outcomes and complications were not clear, the doctors responsible for the patient's care were directly approached to confirm post-operative outcomes and complications.

The data collection was started in November 2007 for a period of 4 months. In February 2008, the WHO surgical checklist was introduced in the pilot operating theatres over a period of 6 weeks. During this period, the theatre teams were introduced to the checklist intervention through a lecture on patient safety and checklists and also presented the initial results of the pre-checklist data set. During the implementation period, the research team was available in the operating theatre complex to train theatre staff in the use of checklist. After the introduction of the checklist, data was collected until September 2008.

Table 6.1 Measures for effectiveness of checklist.

Process measure	Outcome measure
•**Appropriate antibiotic prophylaxis**- antibiotics administered within 60 min. before skin incision •**Airway assessment-** appropriate airway assessment before start of procedure •**Pulse oximetry-** use of pulse oxymeter for all procedures •**Confirmation of patient identity-** Confirmation of patient identity, site and procedure collectively by all team members before skin incision •**Appropriate i/v access-** two large bore cannulas for all major surgeries or expected blood loss of more than 500ml •**Swab, instrument and needle count-** Conducting counts for all surgeries	•**Surgical site infections** • **Complications-** (Defined as in American College of Surgeons' National Surgical Quality Improvement Program): Acute renal failure, bleeding requiring the transfusion of 4 or more units of red cells within the first 72 hours after surgery, cardiac arrest requiring cardiopulmonary resuscitation, coma of 24 hours' duration or more, deep-vein thrombosis, myocardial infarction, unplanned intubation, ventilator use for 48 hours or more, pneumonia, pulmonary embolism, stroke, major disruption of wound, infection of surgical site, sepsis, septic shock, the systemic inflammatory response syndrome, unplanned return to the operating room •**Post-op mortality-** Death within 30 days of surgery

6.3.4.2 Teamwork measures

For 100 cases, Intra-operative teamwork was assessed using a modified version of OTAS (Observational Teamwork Assessment for Surgery Tool) checklist. As described in chapter 4, OTAS tool has been previously used in operating theatres to reliably assess teamwork task completion. However, the original OTAS consisted of more than 150 task checks. For this study, it was not practically feasible to complete the entire OTAS checklist. Therefore I organized a group of expert surgeon, patient safety

psychologist who designed the OTAS tool, to extract 16 teamwork item checks from the OTAS to represent communication task checks, patient task checks and equipment task checks.

1.Team communication tasks.

- Surgeon briefs team about procedure.
- Anaesthetist briefs team about anaesthetic risks.
- Team confirms patient identity.
- Team confirms procedure.
- Team confirms operation site.
- Team confirms, patient position is appropriate.
- Team communicate about Antibiotic prophylaxis.
- Team communicate about DVT prophylaxis.

2. Team equipment tasks

- Nurse enquires about special instrument.
- Surgeon informs about special instrument.
- Surgeon checks availability of equipment.
- Surgeon informs of special investigation.

3. Team's patient safety tasks.

- Surgeon asks if he can start.
- Scrub nurse informs surgeon of swab count.
- Scrub nurse informs surgeon of instrument count.
- Scrub nurse informs surgeon of needle count.

6.3.4.3 Theatre efficiency.

We were also interested to know if the checklist had an impact on the efficient running of the operating theatres and if the checklist led to any delays due to additional workload for theatre staff. I compared the cancellation of surgeries on the elective lists during the pre-checklist phase with period where checklist was used in the theatres. Only those cancellations were used in the comparison, which were due to problems occurring on the day of surgery, such as unavailability of equipments or notes or beds and lack of time on the list. Cancellations due to change in medical/surgical condition of the patient and non- attendance were excluded. In particular, I was interested to assess any cancellations due to shortage of time as an additional checklist task was introduced.

Theatre delays and inadequate utilisation of theatre time are a major concern for the NHS management and consultants. Therefore, to "get on" with the list without the researcher pestering the surgical team to use the checklist was not an uncommon feeling. Considering that it may take a few minutes to conduct the checklist for each case on the list, I compared percentage delays of more than 15 minutes in theatre list start and finish times.

6.3.5 Data analysis.

The data for this study was collected in a way that ensured anonymity of the participants. The data collection forms had a separate section to identify the case, date and name of the patient and each data form was assigned a unique number. Once process and outcome data was collected, the case identification sections were detached from the data forms and stored separately until the study was over. The data was entered onto excel spreadsheets. Frequencies were calculated for performance of

specified safety measures, major complications, and death before and after implementation of the checklist. Chi-square test was used identify significant differences between pre and post checklist implementation rates for process and outcome measures. Chi-square test was performed to assess significant differences between rate of theatre delays and cancellations.

6.4 Results.

357 patients were recruited in pre-checklist phase and 351 patients were enrolled in post-checklist phase. The study samples consisted of procedures from General Surgery, Gynaecology and Orthopaedic surgery. The procedures ranged from simple arthroscopies and hernia repairs to more complex revision arthroplasties and oesophagectomies. The percentage of emergency surgeries recruited was 18.8% in pre-checklist phase and 14.5% in post-checklist phase. 30% of case (n=210) were parallel observed by anaesthetist and myself with 98% accuracy in inter-observer data measurement.

6.4.1 Patient safety processes and clinical outcomes.

There was a significant improvement in timely antibiotic prophylaxis with the use of checklist (Figure 6.2). There was also some improvement noted in airway assessment with the checklist (Figure 6.3).

The confirmation of patient identity, site and procedure by the whole team together, in the operating theatre increased from 9.5% in pre-checklist period to 97.2% in post-checklist period. In the pre-checklist period, the hospital protocol needed only the Nurse

and/or the ODP to confirm the patient's identity in the theatre, which was performed in all cases.

No significant difference was noticed in the use of appropriate I/V access for the surgeries. Conduct of swab, instrument and needle counts was uniformly high in both the phases of the study.

Use of checklist also indicates a trend towards reduction in post-operative adverse outcomes. The Surgical site infections reduced from 2.0% to 1.7%, and post-operative mortality also declined from 1.1% in pre-checklist period to 0.3% in post-checklist period but the results did not achieve significance (P value- 0.1, chi.sq-2.56, df-1) (Figure 6.4).

Figure 6.2 Adequate Antibiotic Prophylaxis.

(P-value- 0.00, chi.sq-28.11, df-1)

Figure 6.3 Airway assessment.

(P-value-0.01, chi.sq-7.14, df-1)

Figure 6.4 Post surgery complication and death rate.

6.4.2 Teamwork.

In the pre-checklist phase, 33 cases were open surgeries and 17 cases were laparoscopic procedures. In post-checklist phase 24 cases were open procedures and 26 cases were laparoscopic procedures. The average number of Team tasks completed in Pre-checklist phase were 3.88, which increased to 14.96 in post-checklist phase.

In pre-checklist phase, the team discussed equipment needs in only 18-22% of cases. DVT prophylaxis was checked in only 10% of cases. Antibiotic prophylaxis was discussed in only 32% cases. Scrub nurses failed to inform surgeon of swab, instrument and needle count in 84% of cases (Table 6.2).

Table 6.2 Team task completion rate.

	Team tasks	Pre-checklist (%)	Post-checklist (%)
1	Nurse enquires about special instrument	18	80
2	Surgeon informs about special instrument	22	97
3	Surgeon checks availability of equipment	12	100
4	Surgeon informs of special investigation	5	80
5	Surgeon briefs team about procedure	24	100
6	Anaesthetist briefs team about anaesthetic risks	12	100
7	Team confirms patient identity	8	100
8	Team confirms procedure	10	100
9	Team confirms operation site	16	100
10	Team confirms, patient position is appropriate	64	100
11	Team communicate about Antibiotic prophylaxis	32	100
12	Team communicate about DVT prophylaxis	10	63
13	Surgeon asks if he can start	64	97
14	Scrub nurse informs surgeon of swab count	18	90
15	Scrub nurse informs surgeon of instrument count	16	90
16	Scrub nurse informs surgeon of needle count	16	90

6.4.3 Impact of the checklist on theatre efficiency.

The surgical checklist had a significant impact on the patient safety processes and surgical outcomes. However, it was believed that the additional workload introduced by the checklist might lead to theatre delays and cancellations due to shortage of time. On comparing the (on-the day) cancellation of surgeries in the period before and after the implementation of WHO checklist, the results were suggestive of a reduction in cancellations, (Figure 6.5) from 2.05% to 0.85%. In particular, cancellations due to lack of time on the elective sessions also showed a marginal reduction from 0.54% to 0.38% during the checklist phase. Though the reduction is not significant, it suggests a trend, which may be confirmed once the checklist is implemented on a wider scale.

Figure 6.5 Surgery cancellations.

On day cancellations- (Chi.sq- 0.5039, df-1, P>0.1), Cancellation due to shortage of time-(Chi.sq- 0.0279 df-1, P>0.5)

On comparing the number of lists with more than 15 minutes delay between the pre-checklist and post-checklist period, I found no significant difference (Table. 6.3) in list delays with the use of checklist.

Table 6.3 Comparison of theatre delays.

Theatre lists	Pre-checklist (%)	Post-checklist (%)	Significance
Theatre lists with delayed start	44.04	45.70	P- 0.76 (Chi.sq-0.0557,df-1)
Theatre lists with delayed finish	35.70	41.05	P-0.26 (Chi.sq-0.6051,df-1)
Theatre lists that started on time but finished late	20.08	23.90	P-0.55 (Chi.sq-0.4243,df-1)

6.5 Discussion.

There was a significant improvement in patient safety processes with the use of the WHO surgical checklist. The checklist creates a culture in the OT, which encourages the teams to communicate and adhere to patient safety processes. As the checklist not only ensures certain minimum safety standards but also addresses equipment needs for each surgery, a few minutes well spent could over a period, reduce operative duration and thereby list delays.

In the Hospital where the checklist was piloted, the Trust policy mandated that patient identity check be performed by Anaesthesia practitioners in the induction room and surgeons checked the patient identity and procedure in the wards prior to patient coming into theatres. Confirmation of patient identity, site and procedure in the OT was not a

policy. This could account for the low adherence (9.7%) to the identity confirmation processes in the pre-checklist phase. There was only a marginal improvement in airway assessment practices, which could be due to the variability in choice of airway for different procedures such as use of laryngeal mask airway or endotracheal tubes.

The global study results of the WHO checklist evaluation study showed a significant reduction in surgical morbidity and mortality (Haynes, Weiser et al. 2009). However, the UK pilot site post-operative outcomes show a trend towards improvement with the use of surgical checklist but the results are not significant. There was a reduction in post-operative mortality during the checklist phase however, the postoperative mortality rate in the UK hospital is very low and therefore to draw any significant conclusions further studies may be required with larger sample size.

The post-operative outcome data was collected only till the point of patient discharge therefore any complications occurring after discharge were not picked up. To assess the effect of checklist on theatre efficiency, seasonal trends could be a confounding factor. It was also observed that during the post intervention period, once the research team reduced intensity of checklist drive and went away from the operating theatres, the use of checklist dropped and as a result the researchers had to actively drive the use of checklist.

For the checklist to be effective, it should be conducted regularly and systematically. This factor could be responsible for the persistent problems in airway assessment and I/V access processes. Another drawback of the study could be that the quality of checklist use could not be assessed but this limitation will be dealt with in my further studies on checklist use in the theatre.

The checklist clearly shows an improvement in team communication in the operating theatres. It can be attributed to fact that checklists create a platform for opening communication between team members. It encourages team members to ask questions and interject if in doubt thereby removing the element of ambiguity.

DVT prophylaxis was not a check included in the surgical checklist but it is a safety measure relevant to NHS. It is evident that as it was not a part of checklist, the team discussed DVT prophylaxis in fewer cases. But it still shows an improvement from 10% in pre-checklist phase to 63% in post-checklist phase, which may suggest an improvement in safety culture in the operating theatre. As the team started talking about antibiotic prophylaxis, it was observed that they were more open about asking other relevant questions, which they considered important such as DVT prophylaxis. In the post-checklist phase, the teams confirmed swab, needle and instrument in 90% cases as compared to only 10% cases in pre-checklist phase. The 10% cases in post-checklist phase in which the teams did not communicate about the counts were the cases in which the sign out part of the checklist was not performed.

It was also observed that during the post intervention period, once the research team reduced intensity of checklist drive and went away from the operating theatres, the use of checklist dropped and as a result the researchers had to actively drive the use of checklist. While the checklist use has shown a clear improvement in patient safety processes, some theatre staff was reluctant to perform the checklist, as they did not see the relevance of WHO checklist in the NHS. Therefore I conducted the next study in which I interviewed the theatre team members to understand the drawbacks and benefits of the WHO checklist and how to make the checklist more NHS specific.

6.6 Conclusion.

This study shows that adherence to patient safety processes in the operating theatres can be variable and the WHO checklist clearly improves these processes. It also improves the teamwork and communication. The study also indicates a trend towards a reduction in surgical morbidity and mortality, but to establish significant reductions further studies with a larger sample may be required. Moreover, further studies are needed to assess how well checklists are used and how they can be made more NHS and specialty specific.

Chapter 7

Theatre teams' perception of impact of WHO checklist on teamwork and patient safety

7.1 Introduction.

The WHO surgical checklist was implemented and evaluated in two operating theatres in St. Mary's Hospital. As described in chapter 6, WHO checklist led to increased adherence to patient safety processes such as antibiotic prophylaxis increasing to 77% and correct patient identity check increasing to 100%. I presented the study results at the local surgical and nursing meets to describe the purpose of the checklist and generate a positive attitude for its use. However, over the period of the study, I observed that adherence to the checklist ranged from 40-80% (Figure 7.1). I and others have found that the use of pre-operative checklists has to be actively driven by a dedicated research team (Lingard, Espin et al. 2005). Local compliance with the use of the checklist was found to be variable throughout the checklist phase of the study. As I, reduced my constant presence in the operating theatres, the checklist compliance dropped to 42%, and as I again moved in to drive the checklist use, it improved again.

Therefore, I next moved on to understand the surgeons, nurses and anesthetists' perceptions of the WHO checklist and the barriers to the use of WHO checklist. There was a need for further research on drivers and barriers to successful compliance to ensure successful implementation of the checklist across the NHS. Therefore, it was necessary to understand the perceptions of surgeons, nurses, and anaesthetists regarding the surgical checklist and its impact. This chapter describes an interview study

that I conducted to understand the perceived benefits, shortcomings, and barriers to the use of the surgical checklist among the theatre staff and how to ensure a sustained compliance to the use of checklist.

Figure 7.1 Surgical checklist compliance.

7.2 Aims.

- To understand the benefits and shortcomings of WHO surgical checklists.

- To understand barriers to its use and measures necessary to demonstrate its effectiveness.

- To understand how to improve its compliance and resilience.

- To modify the WHO checklist for NHS

7.3 Methods.

7.3.1 Study design.

Semi-structured interview study conducted to understand the theatre staff perception of the WHO surgical checklist.

7.3.2 Participants and materials.

Fifteen healthcare professionals, including 5 surgeons, 5 anaesthetists and 5 nurses participated in the study. Participants were selected using a qualitative sampling frame (Marshall 1996) to ensure a broad spectrum of demographic and professional characteristics. Participants were also identified by snowball sampling techniques (Miles MB and AM 1994). All the participants were experienced healthcare professionals with more than 10 years work experience in operating theatres.

The interviews were guided using a structured topic guide (Appendix 2) with an open framework, which allowed for focus and two-way communication. The topic guide was prepared beforehand which provided a framework for the interview. The topic guide was designed to explore the surgeons, anaesthetists and nurses' views on the following topics:

1) The benefits and disadvantages of using WHO checklist.

2) Barriers to the use of WHO checklist.

3) How to improve the WHO checklist.

4) Checklist implementation- How to ensure the durability of the checklist.

Relevant topics were initially identified and possible issues between the topics or any contributing factors became the basis for more specific questions during the interview in order to explore and identify the causes of barriers to using the WHO checklists. Some questions were created during the interview, which allowed the interviewer as well as the participant the possibility to probe for details and discuss issues.

7.3.3 Data collection.

All the interviews were audio recorded, transcribed verbatim, and submitted to emergent theme analysis. Sampling ceased when categorical and theoretical saturation was achieved.

Ethical code of conduct was carefully followed; participants were given an information Sheet (Appendix 3) and also informed verbally on the day of the interview, of their right to withdraw from the study at any time during the study process. They were also informed that their participation was voluntary and their identity would remain anonymous. Consent form was given and signed by the participant as well as the researcher prior to the interview.

The participants were given the opportunity to see, amend or remove sections of the transcripts that they did not want to be included in the study. Therefore, they could either give their full consent on the day of the interview, which authorised the analysis of the data or see and agree on the transcript before proceeding with the analysis of the interview data collected.

After obtaining the participant's consent, the interview tape and transcript were separated to remove the possibility of establishing any link between them, thus keeping

the participant's identity confidential. The transcripts were analysed only after obtaining a full consent from the participant.

7.3.4 Data analysis.

A data management software (NVIVO 8) was used to manage the interview data. Data from the transcripts were imported into the NVIVO 8 software. The software was used to organise data according to the different categories of Vincent's framework (Vincent, Taylor-Adams et al. 2000), described in chapter 2, to understand the factors responsible for the variability in the checklist compliance. The various factors used in creating the NVIVO coding framework are as follows:

1. Organisational and Management Factors:

   - Financial Resources and constraints.
   - Organisational Structure.
   - Policy standards and goals.
   - Safety Culture and priorities.

2. Work Environment:

   - Administrative and Managerial support.
   - Design, availability and maintenance of equipment.
   - Protocol.
   - Staffing levels and skill mix.
   - Workload and shift patterns.

3. Team Factors:

   - Supervision and seeking help.
   - Team structure.
   - Verbal Communication.

- Written Communication.

4. Individual (staff) Factors:

  - Knowledge and skills.
  - Motivation, physical and mental health.

5. Task Factors:

  - Availability and accuracy of test results.
  - Availability and use of protocol.
  - Availability of clinical information.
  - Task design and clarity of structure.

7.3.5 Quality assurance of data analysis and interpretation.

The consistency (reliability) and confirmability (validity) of data analysis and interpretation was assessed using two techniques. Firstly, external validation of all stages of coding and interpretation of transcripts was performed independently by three experienced qualitative researchers (AV, KN, DV). The results were compared to confirm that there were no significant inconsistencies. Secondly, member checking was carried out to ensure accurate interpretation of the data where the study participants were approached to confirm that the emergent themes were correct and represented the participants' opinions.

7.4 Results.

6.4.1 Benefits of the WHO checklist.

Emergent themes demonstrated that a majority of the respondents believed that the checklist would improve teamwork and communication in the operating theatre. Table 7.1 presents some of the key benefits of the WHO checklists. Another emergent theme was that the checklist would add redundancy to the system, preventing adverse events such as wrong site surgery and surgical site infections. Some nurses were very optimistic about the team introductions and believed that teams introducing themselves in the theatre will help flatten the hierarchy and clarify the roles that different people present in the operating theatres have to play. Many respondents felt that the conduct of WHO checklist I introduced an opportunity for the staff to speak up, discuss patient and equipment related issues prior to the start of the surgery. This would reduce ambiguity, clarify roles, outline the necessary tasks and ensure their completion. An important theme that emerged was that often the surgical team may not see themselves as part of one team but, surgical, anaesthetic and nursing teams coming together to perform a surgical procedure. The WHO checklist allocated a joint sense of ownership to the surgical teams to ensure that important patient safety tasks are completed and relevant information exchanged between team members.

Table 7.1 Role of checklist in the eyes of healthcare professions.

Themes	Healthcare professionals (N)	Comments
Reduces errors	15	*"It prevents disasters in the operating department…..If you cut of the wrong leg, patient is going to live with it for the rest of his life…. Benefit is that you perform the correct surgery on the correct patient"*
Reduces assumptions	4	*"When we have an adverse event and we talk to people, they will say....I assumed that somebody had checked"*
Improves teamwork and communication	15	*"There is a terrible tendency for the team actually not being a team".....comment regarding the Operation theatre and benefits of WHO checklist*
Adds redundancy to patient safety processes	5	*"There is no excuse for getting halfway through the operation and somebody discovering that we don't have the right instruments. It is unthinkable but it still happens "*

(Subjects: 5 Surgeons, 5 Anaesthesia Professionals, 5 Theatre nurses)

7.4.2 Barriers to WHO surgical checklist implementation.

On exploring the causes of variability in compliance and barriers to the universal use of checklist in the operating theatres, various factors emerged. Table 7.2 summarises the key factors that emerged as barriers to checklist use.

7.4.2.1 Organisation and management factors.

The culture within the organisation emerged as a major barrier to implementation of patient safety interventions. The cultural silos that exist within a work environment may influence the attitudes of staff to resist change. As one participant put it:

'It's changing people's ways of doing something. and when you change people's ways of doing something it's always more difficult to do it, whereas if you try and make them do the same thing in a slightly different way, then it's more adaptable.' (Participant 3).

It also emerged that the staff may be reluctant to change if they do not believe that the checklist will bring about an improvement in patient care.

'The barriers are the culture which is at the moment, people's lack of belief that it will actually bring about a useful change, people questioning the evidence base on which this is built, people being resistant to change, people being resistant to introduction of more protocols' (Participant 6).

Lack of responsibility on the part of theatre teams to use the checklist may prevent its use. In addition, there is a lack of clarity about who should be conducting the checklist. If the responsibilities and accountabilities are not well defined, staff may be reluctant to take on the job.

'and that's also a barrier at entry, because people generally won't do something for someone unless they like them' (Participant 3).

'The barriers, I think, are going to be the traditional turf wars almost. Whose job is this? Is this actually the surgeon's job or? And these barriers, they're sort of like, it's almost like trade union things. That's not my job. And there is some, there are some really silly rules, like the anaesthetic assistant moves the lights, not the nurse' (Participant 4).

At the same time the individual team members were reluctant to take on the responsibility of ensuring that the checklist was used correctly.

'And if the nursing team are going to change halfway through the case and if nobody was listening anyway and I would feel it actually really frustrating. And I would be concerned about the purpose of signing it off when actually doesn't that mean that you taking responsibly for it? So who would be signing it off? And what responsibility do you have then?' (Participant 6).

7.4.2.2 Work environment.

In order for staff to perform to the best of their abilities, they should be adequately supported in their workplace. For instance, if a copy of the checklist is not available when needed, then the checks performed may not be consistent or staff may completely miss this task.

'Availability of the checklist itself is another aspect; everybody has to know where it is, so it has to be easily accessible. And then the question of how it's stored' (Participant 3).

The design of the checklist may affect staff's attitudes and willingness to conduct the checks. In a busy theatre schedule where the staff members are pushed for time, the checklist has to be simple and concise so that it acts as an 'aid memoire' rather than an extra list of work needing to be ticked.

'I think it's a bit messy in these boxes, and I think it would be much simpler just to have a checklist, a list, and you just read straight down it' (Participant 1).

The time spent doing the checklist was perceived by some staff members as an additional workload.

'At present it has a disruptive effect in the beginning of the operation in that everybody has to stop doing what they're doing, which I think they see as being disruptive' (Participant 3).

'I think the main barrier is that it's, it takes people a bit more time before they, to do what they're doing' (Participant 3).

7.4.2.3 Team Factors.

Several team factors also emerged as barriers to the use of checklist in the theatres. Seniority gradient within the theatre team and the ability to challenge the system's hierarchy can affect how the checklist is being conducted. It emerged that some junior nurses did not feel empowered to question the senior nurses, surgeons, and anaesthetists or persuade them to use the checklist. Use of the checklist during the operating list is particularly difficult if the senior staff in the theatre is averse to its use.

'but I don't think all of the senior scrub nurses yet buy into it, or feel that they can be forceful enough to make everyone do it' (Participant 5).

Team introductions were also seen as major deterrent to the checklist as some team members felt that it trivialised the importance of the checklist. Introductions were also perceived to question the hierarchy of the senior members.

'I think the bit that embarrasses people most and they're most resistant to is introducing everybody. Everybody has to go round and say their name' (Participant 1).

'I think shyness and not necessarily just on behalf of junior staff, but I think it's a very different way of communicating for a lot of people and a lot of people who are introverts, and some surgeons are introverts, find this quite difficult, and find it quite difficult to stand up and say hello, I'm so and so, I'm the consultant surgeon' (Participant 5).

'you're introducing yourselves and everybody's saying who they are but then either not going to be there the next day, the next list, the next week or eve the next operation. So not that they shouldn't do it, I feel it's a little bit of a negative feeling it inspires. It puts you off the checklist' (Participant 1).

Some surgical teams were familiar with each other as they had been working together for some time and they did not see the rationale behind the team introductions but even in those theatre sessions there were many participants who were not known to the team such as locum staff, medical students attending the surgery or the researchers present in the theatres and this would on some occasions create confusion when the staff would not be sure about their roles. One nurse put it quite correctly that *" I always wondered who these people were in the theatre that I was working with sometimes but being busy you wouldn't approach them but you know that they are part of team.........now (with WHO checklist use) I understand their role better."*

7.4.2.4 Individual Factors.

Staff need to be trained in order to understand the aims of the checklist. The training delivered has to dissipate any doubts about when and why the checklist needs to be performed.

'Have we really got to do this and this is a bit miserable because we don't trust each other and we don't trust ourselves and we have to have a list that we have to check ourselves against' (Participant 1).

'making sure that people understand how this works, briefing people, making sure that they're aware of what's going on and contacting them about it to make them either attend or understand what it's about, that's one aspect' (Participant 3).

'And I think also some people are just going to refuse to accept that there is a need for it. They've never had that problem, so why should we do it?' (Participant 4).

If staff are not informed about the benefits that has been incurred after implementing the WHO checklist, or any surgical incidents that have been avoided in practice following the use of the checklist, then it will be difficult to motivate staff to use the checklist.

'If they can see a benefit in it then I think it makes it more worthwhile. So if people see that by doing this they're going to get a better, more attentive set of, operating team essentially, then I think they would do it' (Participant 3).

'There are a few issues first of all people will look to evidence, so people will want to be convinced that what they're doing is making a difference or is improving things, if they are not convinced of that they will stop doing it' (Participant 6).

'The other thing is people need continual feedback, so there needs to be some reward, you need to feel that by doing something you've actually achieved a better outcome or you've actually improved the way you've done something' (Participant 6).

The aim of the checklist is diluted if its done in a robotic way and staff is not motivated and does not pay attention to its objectives. Theatre teams might perform the checklist merely as a tick-box exercise without realizing its actual use or benefits.

'The biggest shortcoming is that actually people go through the motions without necessarily doing the actions, so for instance you might confirm that the nursing team might say yes all the equipment are in place, but actually unless you spell out what equipment you need are in place then the item might be yes or it could be that it isn't in place' (Participant 6).

'it's going to be hard work to convince people of the need to do it without them just ticking the boxes and not really doing it, because there is the danger that's that what they'll do and actually we'll have yet another form with lots of ticks down it and actually nobody has really done it properly' (Participant 6).

Staff may feel that the checks required do not apply to them, as they are not specific enough.

'So in the developed world, checking that the pulse oximeter on the, functioning, is almost, that's almost superfluous, it's almost, that's just, that always happens. But, it was actually something that anaesthesiology as a specialty pushed really hard for. Because there are, in large parts of Africa there's virtually no equipment available. In many ways I'd almost say that it would be better to check that you actually had oxygen, rather than a pulse oximeter' (Participant 4).

7.4.2.5 Task Factors.

Some elements of the task itself may prevent or discourage staff from conducting the checklist. Staff may feel that there is duplication of work and may not be willing to perform the same task over and over again.

'A lot of this communication does at the moment take place, but it takes place in a completely unregulated piecemeal way. And so putting it all here means that there will be some repetition to, between the tasks' (Participant 3).

'But I don't think for us it's necessarily beneficial in stopping mistakes happening because most of these things are already done somewhere along the line with checklisting,… so you're doing this but you're also doing exactly the same on another piece of paper which is a bit strange.' (Participant 5)

'This is being introduced in addition to those which are already there, there are already a lot of checklists going on and this is going to be yet another layer.' (Participant 6)

The time of performing the checklist may also be a deterrent as the checklist tasks may be competing with other important tasks that the teams need to perform.

'And I actually think that timeout should be before the patient's asleep, because the way it's written, the surgeon doesn't come in to this until the patients are already asleep' (Participant 4).

'I think the equipment, particularly the equipment issues or concerns should all be done before the patient goes to sleep. Again, because if you haven't got the equipment, you shouldn't put the guy, you shouldn't anaesthetise the patient' (Participant 4).

'in terms of the critical unexpected steps in an operation I would hope to have discussed that before with a surgeon, before you even get into the operating theatre because I

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would need to know do I need a central line? Do I need an arterial line? Before the state that the patient's ready to have their skin incision, I need to know that long before' *(Participant 6).*

Staff may feel that the checklist is too prescriptive; this may encourage them to cut corners.

'And so making sure that people stop and do this checklist, that's going to be the main problem, is compliance,' (Participant 3).

There was a perception that the checklist should be more aligned to NHS practices and allow further flexibility for different specialties. The timing of the Time-out checks could potentially prove to be a challenge. Some respondents suggested that this should be undertaken prior to induction of anaesthesia rather than the skin incision.

Table 7.2 Summary of factors identified as barriers to checklist.

Classification of contributing factors with themes and examples of verbatim quotes.	No of Subjects who said this and number of quotes.
Organisational and Management Factors Themes identified: • The culture within the organisation • Ill defined responsibilities and accountabilities '*The barriers are the culture which is at the moment, people's lack of belief that it will actually bring about a useful change, people questioning the evidence base on which this is built, people being resistant to change, people being resistant to introduction of more protocols*' (Participant 6).	S=2, A=4, N=3 Total Subjects = 9 Quotes = 12
Work Environment Themes identified: • Availability of checklist in the notes • The design of the • Workload '*it's time consuming and it's another, for want of a better word, another checklist for the, at the current time it's the nursing staff and the anaesthetist has to also fill out the form as well, it's another piece of paperwork to undertake*' (Participant 9).	S=2, A=0, N=3 Total Subjects = 5 Quotes = 7
Team Factors Themes identified: • Hierarchy • Existent communication practices '*I think the bit that embarrasses people most and they're most resistant to is introducing everybody. Everybody has to go round and say their name*' (Participant 1).	S=1, A=1, N=1 Total Subjects =3 Quotes =5
Individual (staff) Factors Themes identified: • Lack of training • Lack of awareness of benefits of the checklist • Reluctance to take on responsibility '*And I think also some people are just going to refuse to accept that there is a need for it. They've never had that problem, so why should we do it?*' (Participant 4).	S=3, A= 3, N=2 Total Subjects = 8 Quotes = 16
Task Factors Themes identified: • Duplication of work • Timing of checklist • Additional workload '*I mean the biggest problem is that there's a lot of overlap a lot of these things are on the anaesthetic checklist anyway*' (Participant 6).	S=1, A=4, N=1 Total Subjects =7 Quotes = 17

(S= Surgeon, A= Anaesthetist, N= Nurse)

7.4.3 How to improve checklist compliance and resilience.

The participants were asked questions on how to improve the checklist compliance and ensure that the checklist is resilient and does not go out of use once the initial study period is over. Table 7.3 presents the summary of emergent themes.

All participants were of the opinion that for the theatre staff to use the checklist in its true spirit, it is essential that they are convinced of the benefits of using the checklist in terms of patient safety and also in improving theatre efficiency.

'If they can see a benefit in it then I think it makes it more worthwhile. So if people see that by doing this they're going to get a better, more attentive set of, operating team essentially, then I think they would do it.' (Participant 3)

'there are a few issues first of all people will look to evidence, so people will want to be convinced that what they're doing is making a difference or improving things, if they are not convinced of that they will stop doing it'(Participant 6).

'staff have got to perhaps see that it's good and see that it works and see that it makes a difference to their personal practice before they will necessarily completely buy into it' (Participant 12)

Participants understood the need for patient safety interventions but at the same time pointed out that the checklist has to be practical and user-friendly.

'once you've refined this down to being a friendly, easy to use checklist and it becomes established theatre protocol, and that's down to the surgeon, the anaesthetist and the theatre nurse' (Participant 1).

'Anything you do it's got to be responsible, practical, right. Not longwinded and not laughable' (Participant 11).

The checklist tool has to be used in the right way in order to achieve its objective and intended benefits. Theatre teams should be provided structured training in the use of WHO checklist. For example, in the absence of proper training, staff may be confused about the right point in time to initiate the checklist and therefore may find it intrusive in carrying out their routine tasks and become reluctant.

Adequate time needs to be allocated to complete the checklist and also spread the awareness that two minutes well spent doing the checklist may actually improve their efficiency.

'There's another disadvantage is it takes a wee bit of time, but in actual fact, I don't care about the time in terms of utilisation because it's a vital part of the role in getting patients safely treated' (Participant 8).

'I know a lot of surgeons, oh I don't want to do the checklist, because well for one thing it takes time' (Participant 11)

It was also widely believed that in order to improve checklist compliance it should be made mandatory and hospitals should include its use in their working policy.

'And I think if we've got, if we're going to use it, it has to be brought in, unfortunately in this country people are paid a salary and they know the salary's going to come in at the end of day. Whereas for instance if you compare it to the United States, people will lose their ability to be able to work in a hospital if they don't conform to the way things are supposed to happen' (Participant 8)

'There must be a policy on that and make it, make it compulsory' (Participant 10)

To encourage staff to use the checklist, they need to be provided with regular feedback on how the checklist is achieving its aims.

' People need continual feedback, so that there needs to be some reward, you need to feel that by doing something you have actually achieved a better outcome' (Participant 6)

'feeding back information to the teams is often a useful way of enthusing them. And I actually think that it would be useful to highlight things that have been identified or prevented as a result of the checklist' (Participant 12)

The use of the checklist can be positively influenced if it is endorsed by professional institutions and is subject to media and political pressure.

'I think probably at least making it part of professional recommendations by the Royal Colleges … if we had media pressure and political pressure then that would happen.' (Participant 5)

Table 7.3 Themes identified to improve checklist compliance and usability.

Indentified themes and examples of verbatim quotes	No of Subjects who said this and number of quotes.
Staff should be convinced of the benefits ' I do think that once people are enthusiastic about it and once people have understood the benefits, or potential benefits of it, then I think that there will be more staff to buy in' (Participant 12)	S=2, A=2, N=2 Total subjects = 6 Total quotes = 7
The checklist has to be practical and user-friendly 'once you've refined this down to being a friendly, easy to use checklist and it becomes established theatre protocol, and that's down to the surgeon, the anaesthetist and the theatre nurse.' (Participant 1)	S=2, A=0,N=1 Total subjects = 3 Total quotes = 4
Adequate training in checklist use 'Once we become confident in using it people won't take that seriously, so I think it's more, yes about having a checklist, but it's about having the right people doing the right job as well' (Participant 9)	S=0, A=0,N=3 Total subjects=3 Total quotes=4
Make checklist use mandatory 'There has to be a policy. There must be a policy on that and make it, make it compulsory'(Participant 8)	S=0, A=0,N=2 Total subjects = 2 Total quotes = 2
Regular feedback on checklist use ' people need continual feedback, so that there needs to be some reward, you need to feel that by doing something you have actually achieved a better outcome' (Participant 6)	S=0, A=2, N=0 Total subjects = 2 Total quotes = 2
Recognition by professional institutions **Media and political pressure** 'I think probably at least making it part of professional recommendations by the Royal Colleges … if we had media pressure and political pressure then that would happen.' (Participant 5)	S=0, A=1, N=0 Total subjects = 1 Total quotes = 1
Checklist Modifications to make it more relevant to NHS "It sounds a bit artificial sometimes. Its trying to be everything to every nation and to every standard of medicine"	S=3, A=3, N=2 Total subjects= 8 Total quotes= 8

(S= Surgeon, A= Anaesthetist, N= Nurses)

7.5 Discussion.

The study clearly shows that the surgical checklist is necessary to improve patient safety in surgery; however, it also highlights the need to ensure that its implementation is well planned. The NPSA has issued an alert mandating the use of checklist across the NHS in England and Wales. The NPSA alert will encourage the Trusts to make the checklist a part of hospital policy but there is also a need to ensure that the NHS staff are made aware of the relevance of the checklist and provided training into the checklist use. This training could be decisive in ensuring appropriate use of the checklist and prevent it from turning into a tick-box exercise. Although staff awareness and training are crucial, the importance of good leadership and role of champions in driving the checklist cannot be emphasised enough. Good leadership will ensure that hierarchy does not interfere in the nurses' involvement in the checklist process and could also generate mass consensus on its use thereby converting individuals that may have been resistant.

Questions remain whether "carrots and stick" would be the driving force for the checklist but it is clear that in the present times the attitudes of patients toward healthcare have undergone a transformation, which could be comparable to a renaissance in healthcare. The media coverage and adverse event data available in public domain has made the patients well informed as well as concerned. These days it is common for patients to question and demand better patient care. This would make healthcare personnel not only morally responsible for using the checklist but could also have an impact on the indemnity covers in future.

One dominant theme that emerged in this interview study was that the checklist has to be modified to be more relevant to NHS. Following the interview study, we suggested some modifications for the WHO checklist (Box 7.1). These changes have been incorporated in the NPSA modification of the WHO surgical checklist for England and Wales (Appendix 3).

Box 7.1: Suggestions for modifying the WHO checklist.

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Sign in:

- Omission of Pulse oximetry

- Amalgamation of Anaesthetic checklist with the WHO checklist

Time out:

- Confirmation of patient identity using two point check as recommended by NPSA

- Inclusion of DVT prophylaxis check

- Inclusion of Patient warming check

Sign out:

- To be performed before any member leaves the operating theatre once the surgery is complete

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An important theme that emerged from this interview study was the need to demonstrate the impact of checklist on teamwork, patient safety and theatre efficiency. While, the international data suggested a significant reduction in post-operative morbidity and mortality with the use of checklist, the results from UK study (chapter 6) did not

demonstrate a clinically significant correlation between checklist use and clinical outcomes. This led me onto the next chapter that describes the design of a framework to measure intra-operative teamwork failures, equipment failures and technical failures as markers of patient safety and theatre efficiency. These markers will be used in subsequent chapters to assess the impact of WHO checklist.

7.6 Conclusion.

The WHO checklist has the potential to improve patient safety and teamwork in the operating theatre. Through this study, the checklist was modified to be more suitable for NHS. There needs to be some flexibility in terms of timing of some checks. The checklist challenges the prevalent cultures in the operating theatres and to convince theatre teams of its benefits, its impact on patient safety, teamwork and theatre efficiency needs to be further assessed.

Chapter 8

Design of an ethnographic framework of teamwork failures to understand patient safety and efficiency in operating theatres

8.1 Introduction.

The interview study described in Chapter 7, highlighted that theatre staff did not perceive any significant benefit of the WHO checklist on their clinical practice, theatre problems or efficiency. While the WHO checklist study (described in chapter 6) showed an improvement in patient safety processes such as antibiotic use, patient identity confirmation, no significant impact was demonstrated on clinical outcomes. For the WHO checklist to be sustainable in operating theatres, surgeons, nurses, anaesthetists and other theatre staff should be able to perceive a positive impact of such a teamwork intervention on intra-operative patient safety and theatre efficiency. There is a need, to develop measures of team-working and patient safety, which can be used to evaluate the WHO checklist's impact on operating theatre problems and its efficiency and safety. These markers can be broadly identified as teamwork failures in the operating theatres, technical failures in the performance of surgical procedures, equipment problems and theatre efficiency.

This study uses a prospective ethnographic approach to understand surgical systems and study teamwork failures in operating theatres and their association to technical failures and equipment failures in operating theatres.

My study aims to schematically capture various teamwork failures, explores their association with technical failures and equipment failures and describes the impact on patient safety and theatre efficiency.

8.2 Aims.

The aims of this study are:

- Development of a framework and a methodology to study teamwork in the operating theatre.

- Quantify the extent of teamwork failures in complex surgical procedures.

- Study associations between teamwork, equipment problems and technical failures.

8.3 Methods.

8.3.1 Design.

A prospective observational study was conducted to examine failures related to surgery in operating theatre.

8.3.2 Participants and materials.

20 major gastrointestinal (GI) surgery cases were studied between December 2008 and July 2009. Both minimally invasive and open procedures were included. I chose to observe complex surgical procedures as there is already some research on the observations on less complex open and minimally invasive surgery (Undre, Healey et al. 2006; Mishra, Catchpole et al. 2009) and I also hypothesized that teamwork failures were likely to threaten patient safety in complex GI surgical procedures.

8.3.3 data collection.

I developed and trialed the ethnographic observation framework and methodology. For 5 cases another trained observer (KN) also collected data simultaneously to ensure reliability of data collection. The quality of such an observational study depends on the expertise of the observers. Both myself and KN were surgical trainees, with more than five years of surgical experience and more than one-year experience of patient safety and human factors research. I was trained and supervised by a faculty surgeon and a Patient safety psychologist.

I entered the operating theatre before the patient arrived. Data collection commenced when the anaesthetised patient arrived in the operating theatre and ended when the patient was transferred off the operating table after the procedure. In the UK, it is a common practice to conduct anaesthesia in a separate anaesthesia room in comparison to the USA and some other countries where patients are anaesthetised on the operating table.

I systematically collected field notes involving all the events that occurred in the theatre. No attempt was made at this stage to classify these events or assess their impact on

safety or flow of the surgery. Detailed field notes were taken for subsequent review and data analysis using a framework I developed for this project as described below.

For each of the 20 procedures, surgeons were asked to rate the perceived teamwork on 1 to 5 likert scale where 1 indicated very poor teamwork and 5 indicated very good teamwork.

8.3.4 Data analysis

Following data collection, the field notes were systematically entered into an excel spreadsheet. In the first instance, the field-notes were examined and the potential failure events were extracted from the data set. These failure events were independently categorised by two assessors: Myself, the primary researcher and a senior surgeon and patient safety expert (KM). The categories used were based on the failure events framework. KM was blinded to the procedure, the operating team, and the outcome of the procedure to establish the validity and reliability of the framework. The impact on safety and flow of surgery was assessed by myself and KN through consensus. This was done to establish the validity and reliability of the framework.

8.3.4.1 The Operating room- failure events framework.

Data was analysed, using systematic thematic coding of the events into failures and distractions. I coded the failures into three major themes: Teamwork failures, Technical failures, and Equipment failures. Teamwork failures were further classified into communication failures, co-ordination failures, situational awareness failures, shared mental model failures, and failures due to lack of planning and knowledge. The teamwork failure classification I developed for this study was based on the Dickenson and McIntyre model of teamwork (Dickinson 1997)(Table 8.1). External interference in

the form of distractions such as phone calls, non-team members entering the theatre etc. were also analysed. Any discrepancies and conflict of opinions were mutually discussed to have a consensus on the type of failure and its impact. If an event was falling into more than two categories, the assessors (Myself and KM) discussed the event to reconstruct the event situation and classified it under the category that best represented the event description.

Table 8.1 Definition of different failure events (Dickinson 1997).

Event classification
Communication failure: Failure in active exchange of information between two or more members of the team, as well as an individual team member providing information to others in the appropriate manner.
Co-ordination failure: It reflects failure in the execution of team activities such that members respond as a function of the behaviour of others. Successful co-ordination implies the effective operation of other components of teamwork. In this way, the actions of individual members are merged to produce synchronised team performance.
Situational awareness failure - refers to failure in 'awareness' of the 'situation.' "Situation awareness" is the correct term for the field of study that concerns the knowledge and understanding of the environment that is critical to those who need to make decisions.
Shared mental model failure: Lack of organized way for team members to think about how the team will work; helps team members understand and predict the behavior of their teammates.
Technical Failure: Failure in performing the procedural tasks appropriately. For example- slipped ligature, redoing a tie or an anastomosis, iatrogenic injury etc.
Equipment failure: An equipment failure was defined, as any situation where equipment was not available, was not working, or staff did not know how to use it.
Distraction: Interference from the external environment that may distract the surgical team from performing their primary tasks in the operating theatre.

Surgical equipment was any resource used to perform a surgical procedure. It includes the instruments needed for the procedure, any type of machinery e.g. suction machine or diathermy machine, and any resource such as sutures, surgical drains or irrigation fluids etc. An equipment failure was defined, as any situation where equipment was not available, was not working, or staff did not know how to use it.

The failures were rated to assess their impact on safety and flow of surgery. I recorded the perceived severity of each failure for its threat to patient safety into no threat, minor threat, moderate threat, patient harm or potential adverse event, and adverse event (Table 8.2). The impact on the flow of surgery was measured in terms of time delay the failure event had on the procedure. There were five options: no impact, minor (less than 5 minutes' delay), moderate (delay of 5 to 30 minutes), severe impact (more than 30 minutes' delay), and surgery cancelled (Table 8.3).

Table 8.2 Threat to patient safety classification.

Threat to patient safety	Example
1. No threat	Phone rings in the theatre, surgeon continues to operate
2. Minor threat- failure could indirectly lead to patient harm	Scrub nurse did not know how to assemble harmonic scalpel. Circulating nurse has to put on sterile gloves to show her how to do it. She only put the sterile gloves without hand washing or gowning. Surgeon waits while nurses sort it.
3. Moderate threat- failure could directly lead to patient harm	Surgeon wanted artery forceps, nurse gave scissors
4. Patient harm or potential adverse event	To repair a bleeding vessel, surgeon given taper cutting needle. Surgeon realised when bleeding from needle site.
5. Adverse event- leading to prolonged hospital stay or disability or death	

Table 8.3 Impact on flow of surgery classification.

Impact on flow of surgery	Example
1. **No impact**	Phone rings in the theatre, surgeon continues to operate
2. **Minor impact**- Surgery interrupted for less than 5minutes	Phone rings again, surgeon irritated asks ' can someone answer the phone.'
3. **Moderate impact**- Surgery interrupted for more than five minutes but less than 30 min or poses frequent interruptions	Scrub nurse did not know how to assemble harmonic scalpel. Circulating nurse has to put on sterile gloves to show her how to do it. She only put the sterile gloves without hand washing or gowning. Surgeon waits while nurses sort it.
4. **Severe impact**- Surgery interrupted or delayed for more than 30 min.	Patient on the table. Surgeon not happy with the position. Asks sister if she has a beanbag, as he will be tilting the patient. Nurse brings it. Patient is lifted off the table beanbag placed. Delay in proceeding.
5. **Surgery cancelled**	

Statistical analysis was performed using SPSS version 18.0. Pearson's correlation coefficients were calculated to understand correlation between teamwork failures, technical failures and equipment failures. Correlation coefficients were also calculated to assess the reliability of assessment between the two assessors in categorising failure events. For the 25% of cases where two observers collected data to establish reliability in data collection, failure events noted were compared and percentage agreements

calculated. Pearson's correlation coefficients were also used to analyse associations between the teamwork reported by surgeons, nurses and anaesthetists and the failure events.

8.4 Results.

8.4.1 Case over view

20 cases were observed. A total of 140 hours of surgical procedure observations were carried out. Median duration of procedure was 6.5 hours (minimum- 1hr, maximum- 8.5hr). 13 were open procedures (including subtotal and total gastrectomies, open hemicolectomies) and 7 were laparoscopic procedures (Laparoscopic anterior resection, partial gastrectomy, fundoplication).

A total of 364 failure events were observed with a mean of 17.80±2.39 failures per case. Maximum numbers of failures observed per case were 44.0 and minimum were 3.0 per case. Out of a total of 340 failure events observed 58.6% (n=211) were teamwork failures, 7.14% (n=26) were technical failures and 13% (n=47) were equipment related failures (Figure 8.1) and 22% (n=80) were distractions. Table 7.5 illustrates the different types of failures.

Figure 8.1 Types of failures in operating theatre.

Failure distribution

Legend:
- Communication
- Coordination
- Situational awareness
- Shared mental model and planning
- Knowledge
- Equipment resources
- technical
- Distractions

For the 25% of cases observed by two observers, there was 90% overlap between the recorded field notes. There was a high degree of agreement (81%) between the two assessors on independent thematic coding of failure events with a high inter-rater reliability in identifying different types of failures (Table 8.4).

Table 8.4 Correlation between identification of different failures between assessors.

Type of failure	Coordination failure	Shared mental model failure	Communic ation failure	Situational awareness	Lack of knowledge	Equipment failure	Technical failure	Distractions
Pearson correlation	0.902 P: 0.000	0.570 P: 0.009	0.887 P: 0.000	0.695 P: 0.001	0.833 P: 0.000	0.936 P: 0.000	0.958 P: 0.000	0.998 P: 0.000

Table 8.5 Failures in operating theatres.

Type of failure	Example	Impact on Safety	Impact on flow
Communication failure	Anaesthetised patient transferred onto the table by nurse and anaesthetist. Surgeon not available at the time. When surgeon enters, he is not happy with the position. Asks sister if she had a bean bag as he will be tilting the patient. Nurse brings it. Patient is lifted off the table bean bag placed. Delay in proceeding.	Minor threat: Anaesthetitised patient had to be repositioned posing a threat of dislodging endotracheal tube or intravenous cannulae. But threat reduced due to careful attention of theatre team.	Severe: The surgery was delayed by more than half hour due to repositioning and duplication of associated tasks.
Situational awareness failure	Surgeon asks for forceps for ileostomy. It is a common knowledge that toothed forceps are not used to handle bowel but nurse gives him toothed forceps as she was not aware of the purpose of the forceps use. Surgeon notices and tells he wants Debakey's forceps.	Moderate threat: Tooth forceps can cause bowel injury which may lead to intra abdominal leaks and peritonitis.	No delay in surgery, as surgeon quickly noticed and corrected the error.
Shared mental model failure	Nursing staff unsure about further plan of surgery during a planned laparotomy, whether colostomy or end to end anastamosis would be performed. But prepares instruments for anastamosis without clarifying with the surgeon.	Minor threat: This event would have led to further confusion and disruption but unlikely to pose direct threat to safety.	Minor delay: as they had to open the colostomy set subsequently as the surgeon wanted to do a colostomy in addition to anastamosis.
Co-ordination failure	During the surgery nurse checks the cutting scissors and notices it is faulty but does do anything about it. Shortly afterwards surgeon asks for cutting scissor, nurse hands over the same scissors. surgeon tries cutting the suture with it but it doesn't work. Tells her its not working, and asks him to give him another pair of scissors. Nurse requests circulating nurse to provide another pair of scissors.	No threat: This event did not pose any threat to the safety.	Minor delay: The surgeon had to request another scissor and wait for it to be made available.
Technical failure	Surgeon had to open and redo the suturing of abdominal wound as he forgot to mark site of local invasion.	No threat: This event did not pose any threat to the safety.	Severe delay: as the surgeon had to redo a part of the surgical procedure.

8.4.2 Teamwork failures.

More than half of the failure events observed in the theatres were due to failures in teamwork. Teamwork failures were further classified into its various components; of which communication failures were the commonest (40.63%, n=78), followed by co-ordination failures (35.92%, n=69), situational awareness failures (14.06%, n= 27), shared mental model failures (9.38%, n=18) and planning and knowledge failures (9.4%, n=19).

8.4.3 Communication failures.

Communication failures were common in the theatre. They were responsible for 22.94% of all failure events. 24.35% of these failures had a moderate threat to safety in the operating theatre but did not lead to any harmful events. 24.35% of failures had a minor threat to patient safety and 47.44% of communication failures did not pose any threat to patient safety. One communication failure had a severe impact on flow of surgery causing a delay of more than half hour. 7.69% of communication failures lead to a moderate delay, 44.87% lead to a minor delay and 39.74% did not cause any delay in flow of surgery.

8.4.4 Co-ordination failures.

Co-ordination failures were the second commonest failures in the theatre responsible for 20.29% of all failure events. 14.49% of these failures had a moderate threat to patient safety, 34.78% posed a minor threat to safety and 49.27% did not threaten patient safety. On assessing the impact on flow of surgery, 13.04% of co-ordination failures led to moderate delays in the flow of surgery but majority (73.91%) led to minor delays and 11.59% caused no delays.

8.4.5 Situational awareness failures.

Failures of Situational awareness were responsible for 7.94% of all failure events but 14.83% of these failures lead to patient harm and 37.03% had a moderate threat to safety in the operating theatre, 14.81% of these failures had a minor threat to safety and 33.33% did not pose any threat. One failure lead to a severe delay in progression of surgery, 7.40% failures lead to a moderate delay, 51.85% lead to a minor delay and 25.92% did not cause any delay.

8.4.6 Shared mental model, planning failures and Knowledge based failures.

Shared mental model failures were uncommon, responsible for only 3% of all failures but 36.36% of these failures led to a major delay in case progression. Lack of knowledge/ training failures accounted for 5.59% of all failures. On one occasion they led to a severe delay in surgery.

8.5.7 Technical failures.

Technical failures were failures in performing the procedural tasks during the surgery. In 20 cases, 26 technical failures were observed, accounting for 7.65% of all failures observed. The average number of technical failures was 1.30±0.24 (range 0-3). Of the technical failures noted, 30% (n=8) had an underlying non- technical failure. Situational awareness failure was the most common underlying non- technical failure with co-ordination, communication, lack of planning and knowledge, and equipment failure responsible for one technical failure each. 23% of Technical failures led to patient harm, 34.61% had a moderate threat to safety. On two occasions they led to a severe delay in surgery and moderately delayed the surgery on as many as 42.30% of occasions.

8.4.8 Distractions.

Distractions are common during surgical procedures. As many as 23.52% of all failure events were distractions in the theatres. Most of the distractions (92.50%) did not threaten patient safety. 58.75% of distractions did not obstruct the flow of surgery but 40% led to a minor or moderate delay in surgery and one event severely delayed the surgical procedure.

8.4.9 Equipment problems.

An item of surgical equipment is defined as any resource, which is used to perform a surgical procedure. It includes the instruments needed for the procedure, any type of machinery e.g. suction machine or diathermy machine, and any resources needed for the progression of surgery such as sutures, surgical drains, irrigation fluids etc. Equipment problems occurred routinely during surgical procedures. Equipment problems were classified based on lack of availability, faults, wrong usage and knowledge based failures. A total of 47 problems were noted accounting for 14.11% of all failures in the theatre with a mean of 2.40±0.62 equipment failures per case. These equipment failures have been further described in detail in chapter 8.

8.4.10 Correlation between observed and self-reported teamwork.

There was a moderate correlation between surgeon's reported teamwork with the nurse and the observed number of teamwork failures (Pearson's correlation -0.69, P-0.001). There was also a correlation between reported teamwork and Equipment problems in the operating theatres (Pearson's correlation -0.519, P- 0.019). But there was no effect of Surgeon's or nurse's grade and number of failures. There was also no correlation found between teamwork failures and familiarity of the operating team.

8.5 Discussion.

This study shows that teamwork and technical failures are common in operating theatres especially in complex procedures. They lead to disruptions in workflow and patient harm. Furthermore, teamwork failures can potentially have a negative affect on technical performance.

Gawande et al have shown that communication errors are responsible for 70% of preventable harm in healthcare (Gawande, Zinner et al. 2003). Just as Lingard et al have shown, our study also shows that communication failures are very common in operating theatres and that these vary from those where communication did not occur to those where communication was not between the appropriate persons and on some occasions, untimely.

Similarly, coordination failures were found to be very common in the operating theatres and can lead to technical failures, equipment failures, disruptions and harm. In acute patient care settings, coordination is essential as teams may be put together on ad-hoc basis and may be working together for only a few cases (Manser, Howard et al. 2008). In addition, the teamwork in theatres may be seen as various crews interacting together (Gaba 2000) thus requiring a higher degree of coordination. Xiao et al conducted a video analysis of coordination tasks during emergency intubations and found that complex tasks were linked to higher degree of coordination needs and increased risk of coordination failures (Xiao, Hunter et al. 1996). In my study, I noted that coordination failures occurred between the surgeons and nurses during the swab/ instrument counts. Swab and instrument counts although necessary, often compete with other procedural

tasks. On occasions, the surgeon had to wait for an instrument while the nurse completed the counts or the nurse had to interrupt the counting to assist the surgeon with instruments. Christian et al in their observation study also found that auxiliary tasks such as swabs and instrument counts often competed with the primary tasks of other theatre team members (Christian, Gustafson et al. 2006).

Situational awareness was also found to be of key importance in this study as on a number of occasions, it posed a threat to the safety of patients. During the course of the study, I observed that these failures were associated with unwanted changes to equipment settings; specimen problems such as mislabelling and the potential for retained swabs and specimens.

This study shows that technical failures are common in operating theatres. Technical failures have traditionally been associated with the surgical skills of the surgeon; however, this study describes how technical failures may arise due to teamwork failures in the operating theatres. Situational awareness failures were the commonest cause of technical failures. In their observations of 50 laparoscopic cholecystectomies, Misra et al found a strong inverse correlation between technical errors and situational awareness scores of the surgical teams (Mishra, Catchpole et al. 2009).

Equipment failures emerged as a very important theme in this study. They were found to be common, occurring at a rate of 2 failures per procedure. Previous studies show that equipment problems may force the surgeons to work around the equipment problems, which could lead to technical difficulties and even patient harm (Christian, Gustafson et al. 2006). I also found a correlation between equipment failures and technical failures. Most of these failures can be minor and sometimes irritating but on occasions, they can

lead to harm and disruptions. On one occasion, the forceps being used by surgical assistant were faulty and punched out a minor hole in the glove. Although the assistant could feel the forceps digging into the thumb, did not pay attention to it and continued. When the surgeon applied diathermy to the forceps, it led to burn on the assistant's thumb. This situation not only led to harm to the staff but also resulted in surgery being interrupted for more than 5 minutes while the surgical assistant washed and changed her gloves. I observed that the theatre teams appeared to be accustomed to having equipment problems and considered some of them to be a part of normal occurrence and did not pay attention to them. To understand the type of failures more closely, I discuss some of the failures in table 8.5.

Though not a major focus of this study, I found that distractions occur frequently in the operating theatre. These findings echo previous research from our unit (Sevdalis, Healey et al. 2007) and suggest that they can be prevented to a large extent by a system of protocols for managing bleeps and phone calls. Other observed reasons for distractions are staff from other theatres seeking equipment and the simultaneous performance of administrative tasks that distract the circulating nurse and scrub nurse from their primary tasks. This often resulted in poor coordination between the operating surgeons and nurses.

This study successfully highlighted that teamwork failures, technical failures, and equipment failures are closely linked with each other, often resulting from a chain of events in a complex surgical system that could ultimately lead to patient harm and delays. Retrospective review of adverse events has been a commonly used approach to understand these failures and the associated system factors. However, a retrospective

analysis is only possible once patient harm has actually occurred. Increasingly, the feasibility of prospective observations of teamwork and patient care in the operating theatre is being explored in order to learn more about the factors that commonly underpin adverse events in surgery (Catchpole, Giddings et al. 2006; Christian, Gustafson et al. 2006; Lingard, Regehr et al. 2006).

In surgery, the scope of direct observations, either through people or via video capture and playback, is being explored. Our study shows that prospective observation and the use of a coding framework is a valid and reliable method of measuring teamwork and patient safety in theatres. However, these techniques require an open culture in the healthcare, where staff is not resistant to being observed for the fear of disciplinary action or litigation. Observation and recording offer us the opportunity to understand team interactions and communication barriers, which may not be revealed in retrospective case record reviews.

One limitation of an observation study is that it is time consuming and relies on the expertise of the observer. However, this study demonstrates the feasibility of training less experienced personnel to undertake observations with a high degree of reliability. Hawthorne effect, another limitation in this study, as with all observational research, has not been a significant factor in our research so far. Our experience has been that the personnel in our hospital have become accustomed to being observed for research purposes and it does not significantly affect the way they behave.

With this study, I aimed to identify a framework that can be used to assess quality of care in operating theatres. I have identified that intraoperative teamwork failures, equipment failures and technical failures are representative markers of patient safety and efficiency in operating theatres. They can be used to evaluate patient safety

interventions such as WHO surgical checklist. Using these surrogate markers, we can put forward a better case for theatre staff to use safety interventions and assess their impact locally. These could be more sensitive markers of patient safety than clinical outcomes. Theatre equipment failures emerged as an important factor associated with theatre teamwork. Given the paucity of literature on equipment failures, it is essential to further explore these failures in this thesis to understand their nature, prevalence and association to teamwork failures. This led me onto my next study that is described in the next two chapters. First I explore the prevalence and nature of equipment failures in UK through a multicentre survey and observation study and then I investigate the factors underlying these failures and their implications through an interview study.

8.6 Conclusion.

This study describes the failures in the operating theatres and their impact on flow of surgery and patient safety. It also gives us an insight into the markers of teamwork and patient safety in the theatres that can be used to design measures of patient safety in surgery. It also establishes that prospective method of observation can highlight areas of improvement in the operating theatres.

Chapter 9

Understanding teamwork related equipment problems and their impact on patient safety in operating theatres- a multicentre study

9.1 Introduction.

Teamwork failures play a major role in the operating theatre and they compromise patient safety. From the study described in chapter 8, it emerged that equipment problems are common in operating theatres and may arise due to underlying teamwork and communication factors. Therefore, it is essential that in order to understand the complex interplay of teamwork factors in theatre, I study these equipment problems in detail to understand their causation, role of contributory systems factors and impact of these problems on patient safety. In this chapter, I study the prevalence of equipment problems, their association with teamwork failures and impact on patient safety.

With this study I explore the reliability of equipment availability in the operating theatres, together with their implications on patient safety and flow of surgery.

9.2 Aims.

With this study, I aimed to achieve the following objectives:

To create a process map and task analysis describing how equipment is ordered and supplied to operating theatres.

To describe equipment problems in operating theatre.

To identify any variation between sites.

To explore the systems factors involved and underlying teamwork failures.

9.3 Methods.

I used a novel approach to understand equipment problems in the NHS by mapping out the equipment process, doing a self-report survey at multiple sites to understand the prevalence of problem and observing major surgeries to analyse the factors underlying equipment problems.

9.3.1 Study design.

A multicentre survey and observational study to understand equipment problems.

9.3.2 Participants and materials.

9.3.2.1 Sample.

The study was conducted in three hospital sites across the UK. Table 9.1 describes the site demographics. The sites were chosen to represent all types of NHS organisations in England in terms of size, quality of care and adverse incidents.

Theatres were recruited from each site to include different specialties: trauma and orthopaedics, general surgery and paediatric surgery. The study was conducted in three theatres at site A, and five theatres at sites D and four theatres at site F. The theatre managers on each site were initially approached regarding access and initial

management approval, together with a discussion of data collection strategies. Ethics approval was obtained from local research and development office at each site, to conduct the study.

9.3.2.2 Definitions.

An item of surgical equipment was defined as any resource which is used to perform a surgical procedure. These included the instruments needed for the procedure, any type of machinery (e.g. suction or diathermy machines), and any other resources needed for the progression of surgery such as sutures, surgical drains, irrigation fluids etc. It did not include drugs administered to the patient.

An equipment failure was defined, as any situation where equipment was not available, was not working, or staff did not know how to use it. A patient adverse event was defined as an undesired patient outcome that may or may not be the result of errors (Vincent 2001).

The impact on the flow of surgery was measured in terms of the time delay the equipment problem caused during the procedure. There were five options: no impact, minor (less than 5 minutes' delay), moderate (delay of 5 to 30 minutes), severe impact (more than 30 minutes' delay), and surgery cancelled.

The impact on patient safety was assessed using a five-point likert scale in increasing threat to patient safety: no threat, minor threat, moderate threat, potential adverse event, and potential severe adverse event.

9.3.2.3 Process mapping.

I conducted visits to the operating departments at each site with the help of a Research assistant (DV) and conducted one to one and group sessions with operating theatre staff. The research assistant's role was only to facilitate the meetings and networking for data collection at various sites, as he was involved in separate projects at those sites and helped in establishing the research network. I used the information received to design a process map detailing surgical equipment ordering and procurement process at each site. The main objective of the process map was to understand how the equipment was requested, ordered, and received and the related communication between the surgeons, nurses and the sterilisation services. The process map was circulated among the theatre staff to make additions and remove discrepancies.

9.3.3 Data collection.

Data was collected over a period of eight weeks, including weekends, in selected operating theatres on all sites.

9.3.3.1 Equipment Self report.

To measure the incidence of equipment failures in operating theatres, data collection forms were designed (Appendix 4) for the theatre staff to complete after each procedure. After each operative procedure, scrub nurses and surgeons were asked to discuss equipment problems and record them on the data form after each procedure, regardless of whether or not any equipment failures were identified. The forms were distributed to all the participating theatres and I regularly collected them and recorded the data on spreadsheets for subsequent analysis.

The form comprised the following sections:

Equipment Problem: Under this section, the theatre team was asked to document which item of equipment was the problem related to and which surgical procedure was being observed.

Type of equipment problem: There were four categories: not available, faulty, wrong use of equipment, and lack of knowledge on how to use the equipment.

How was the problem dealt with: This section was included to understand how equipment problems are dealt with in operating theatres. There were three options: equipment added, equipment replaced/ fixed, and work around the problem.

Did the problem impact on flow of surgery: The impact on the flow of surgery was measured in terms of the time delay the equipment problem had on the procedure. There were five options: no impact, minor (less than 5 minutes' delay), moderate (delay of 5 to 30 minutes), severe impact (more than 30 minutes' delay), and surgery cancelled.

Did the problem threaten patient safety .In this section the theatre team discussed and recorded the perceived severity of each failure using a five-point Likert scale in

increasing threat to patient safety: no threat, minor threat, moderate threat, potential adverse event, and potential severe adverse event.

9.3.3.2 Exploring the systems failures involved.

I independently observed a separate set of twenty major gastrointestinal surgeries to understand equipment problems and underlying human factors such as teamwork failures. I recorded field notes that were later analysed into emerging factors. Two expert reviewers (Myself and KM) systematically coded the field notes into emergent themes. This technique was also beneficial in understanding the under-reporting of equipment failures by theatre staff. The surgeon and the nurse were each given the equipment self report forms to individually report the equipment problems to assess under reporting and differences in the perceived impact of these problems on patient safety and flow of surgery. The detailed methodology of the observational part of the study has been described in detail in Chapter 8.

The theatre teams were also asked to rate the teamwork during that procedure on a likert scale of 1 to 5 where 1 was very poor teamwork and 5 was very good teamwork.

9.3.4 Data analysis

The data from the self-reports was collected and analysed anonymously with only the sites being identified. The individual cases, theatres and teams were anonymised through a system of case coding at the data entry stage. The data was analysed using SPSS 18.0 statistical software to calculate frequencies of problems and their categories. Intersite variations were evaluated using Kruskal Wallis test. Pearson's correlation

coefficient was used to assess correlations between observations and self-reports; and equipment problems and teamwork failures.

9.4 Results.

The sites were a mix of variable characteristics such as number of beds. Similarly, national reporting and learning system data on incidents per 100 patient admissions have been presented in table 9.1 to demonstrate that the sites were representative of the variability in the NHS.

Table 9.1 Description of the three sites.

Site	Number of beds	Theatres recruited	NRLS report
Site A	358	3	2.81
Site D	950	5	7.53
Site F	530	3	1.39

NRLS: National Patient Safety Agency's national reporting and learning system. Data presented per 100 admissions.

9.4.1 Process map.

The process map relating to all three sites is shown in Figure 9.1. All theatres had similar processes for the ordering of surgical equipment. Some equipment was 'owned' by the surgical department and some was acquired on loan when needed. Some equipment was obtained directly from the manufacturers (e.g. prostheses). All sites had

an onsite storeroom where equipment was stored and made available when required. Reusable equipment has to be sterilised before it can be used again. The sterilisation unit on site F was in-house while on sites A and D the sterilisation units were outsourced. Figure 9.1 also highlights the various problems (highlighted in red text) that may occur at various steps in the process.

Figure 9.1 Flowchart of process for obtaining surgical equipment.

9.4.2 Prevalence of equipment problems.

A total of 490 operations were included in the study, including 258 on site A, 67 on site D and 165 on site F. The different types of operations studied on each site were trauma, orthopaedics, general and paediatric surgery.

A total of 103 instances of equipment failure were reported with 19.2% (n=94) of surgeries affected with minimum of one problem and maximum 2 problems (average problem rate-1.09, median-1, range 1-2).

Types of equipment failures and how they were dealt with are summarised in Figure 9.2 and Figure 9.3 respectively. Of the 103 equipment problems, non-availability of equipment was the commonest problem (56%) followed by faulty equipment (38%). Equipment problems arising due to lack of knowledge were the least common accounting for only 1% of errors. In 52% of instances, surgeons had to work around the problem and equipment was added or replaced in 48% of occasions.

Figure 9.2 Types of equipment problems identified across all three sites.

	not available	faulty	wrong use of equipment	Lack of knowledge of how to use
■ all sites	56%	38%	5%	1%

Figure 9.3 How the equipment problems were identified, across all three sites.

	Equipment added	Equipment replaced/ fixed	Work around the problem
■ all sites	19%	29%	52%

The flow of surgery was affected by the equipment problem, resulting in varying amounts of delay in 51% of instances with equipment problems. Most delays were minor (30%) (Less than five minutes), 14% moderate (5-30 minute delay) and 7% led to severe delays of more than 30 minutes. No operation was cancelled due to equipment problems during the course of the study. Most of the errors were reported to pose no threat to patient safety (79%), 13% and 5% posing minor threat and moderate threat respectively and 3% led to patient harm.

9.4.3 Variability between sites.

Figure 9.4 shows the extent of variation between the three sites in terms of the prevalence of equipment failures. Site D had the highest incidence with 37% of operations having one or more equipment problems followed by site A and site F with 19% and 12% operations with equipment problems. Figure 9.4 shows the types of equipment failures at each site. Kruskal Wallis test was used to confirm that the differences were statistically significant (Chi-Square-18.659, df-2, P-0.000).

Figure 9.5 shows that at sites A and D, staff were most likely to cope with the equipment problem by working around the problem. At site F, the most common response was to replace the equipment or fix the item. Figure 9.6 shows that at sites A and F, the majority of equipment problems did not cause any delay on the flow of the surgery. However, at site D, the equipment problems most commonly caused a minor delay (less than 5 minutes). As figure 9.7 suggests, at all sites, most of the problems had no impact on patient safety however, at site A and D, they led to adverse event in 2% and 7% of instances.

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Figure 9.4 Types of equipment problem at each site.

	Not available	Faulty	Wrong use of Equipment	Lack of knowledge on how to use
Site A n=56	76%	20%	4%	0%
Site D n=28	33%	63%	0%	4%
Site F n=19	31%	53%	16%	0%

Figure 9.5 How the problem was dealt with at each site.

	Equipment added	Equipment replaced/ fixed	Work around the problem
Site A n=56	26%	22%	52%
Site D n=28	7%	30%	63%
Site F n=19	15%	50%	35%

Figure 9.6 Effect on the flow of surgery, at each site.

	No impact	Minor (< 5 mins)	Moderate (5 - 30 mins)	Severe (> 30 mins)	Cancelled
■ Site A n=56	58%	24%	15%	4%	0%
■ Site D n=28	30%	41%	11%	19%	0%
■ Site F n=19	53%	32%	16%	0%	0%

Figure 9.7 Threat to patient safety at each site.

	No threat	Minor Threat	Moderate Threat	Adverse Event	Severe Adverse Event
■ Site A n=56	82%	11%	5%	2%	0%
■ Site D n=28	67%	19%	7%	7%	0%
■ Site F n=19	89%	11%	0%	0%	0%

Threat to patient is measured as the potential threat to patient safety as perceived by the staff

9.4.4 Observational analysis equipment problems.

A total of 140 hours of observations were carried out. Mean duration of procedures was 6.5 hours. 13 were open and 7 were laparoscopic gastrointestinal surgeries. Equipment problems occurred routinely during surgical procedures. A total of 47 equipment problems were noted by the observer accounting for 14.11% of all events in the theatre with a mean of 2.40±0.62 equipment errors per case. The maximum number of equipment problems observed per case was 12.00 and minimum was 0.0. Surgeons and nurses collectively reported 42.56% (n= 20) of the observed problems with surgeons reporting 70% and nurses reporting the remaining 30% of problems.

On further analysis into the causes of these equipment problems, 40.42% had an underlying teamwork failures leading to the equipment problems. (Figure 9.8) shows the distribution of underlying teamwork failures responsible for the equipment problems. There was a moderate correlation between all equipment problems and teamwork failures (Pearson's correlation 0.575, P-0.008). There was also a correlation between reported teamwork scores and equipment problems in the operating theatres (Pearson's correlation -0.519, P- 0.019). But there was no effect of Surgeon or nurse's grade on number of errors. The observer's perceived impact of equipment problems on patient safety and flow of surgery was compared to surgeons' and nurses' perception. I found that there was a strong correlation between observer and surgeon's perception of impact on patient safety (Pearson's correlation coefficient 0.827, P- 0.000) but no correlation on impact on flow of surgery (Pearson's correlation coefficient 0.110, P-0.7). Nurses' perception of impact on patient safety did not correlate with the observer's

perception but there was a moderate correlation in nurses' perception of impact on flow of surgery with that of the observer but it did not achieve significance (Pearson's correlation coefficient 0.539, P 0.6). Table 9.2 illustrates some equipment problems and underlying teamwork failures.

Figure 9.8 Teamwork errors leading to equipment errors.

Table 9.2 Examples of equipment failures their impact and underlying systems factors.

Equipment failure	Associated non-systems failure	Effect on surgery	Effect on safety
During laparoscopy, someone accidentally turned off the CO2 gas insufflator, sister had to reconfigured it	Situational awareness failure	Led to 10 minutes delay in the procedure	Minor threat to safety
Circulating nurse turned harmonic scalpel on. Went out of room without checking if it is functioning. Harmonic not working. She had to be called back in to readjust the settings.	Coordination failure	Led to 7 minutes delay in the procedure	Minor threat to safety
During vascular procedure, no one knows how to operate duplex scanner. Have to call ODP. ODP cannot be found immediately so they wait while the ODP returns.	Planning and knowledge failure	Led to 10 minutes delay	Moderate threat to patient safety
ligasure not working, scrub nurse and circulating nurse do not know how to rectify it. Nurse incharge not available. Surgeon had to work without ligasure.	Planning and knowledge	Procedure prolonged by more than half hour as surgeon had to alter his technique of surgery	Moderate threat to safety

9.5 Discussion.

This study shows that equipment problems affected one fifth of the operations and often surgeons had to work around these problems, which not only leads to delays, but also threatened patient's safety.

Analysing the data acquired in this investigation produced a variety of interesting results, some as predicted and some unexpected. I suspected that equipment failure would be common. The data supported this: 19% of procedures were associated with one or more equipment problem. The majority of equipment problems related to equipment not being available. This was unexpected as the team had previously suspected that faulty equipment would be the main type of equipment problem. However, the picture was not the same on all the sites. Most equipment problems on site A were due to equipment not being available, while on sites D and F, most equipment problems were due to faulty equipment. Unavailability of equipment may signify a bigger problem in theatres e.g. miscommunication between doctors and nurses, especially if scrub nurses were not aware of all the equipment required for the procedure.

It is concerning that in most cases, staff had to work around the problem, possibly contributing to an already stressful environment. The surgeons had to cope with the missing surgical equipment and deliberately deviate from the way they intended to perform the procedure in case the equipment was available. For example, I observed that a faulty tourniquet strap used in a knee replacement had to be worked around when it came undone in the middle of surgery. This could have increased the risk of bleeding and put the patient's life in danger. Some other examples of equipment problems and their impact are described in Table 9.2.

Workaround is a necessary violation whereby an operator has to improvise in order to get the job done. According to Reason, necessary violations are commonly provoked by the organisation failing to provide the adequate working condition for the staff at the sharp-end, for example not providing adequate tools and equipment when and where needed (Reason 1997). In other High Reliability Organisations (HRO), working conditions that provoke staff to workaround and improvise have been found unsafe and have led to some major incidents (Aviation Safety Network). In order to reduce workarounds, HROs have implemented Safety Management Systems whereby emphasis is placed on learning from critical incidents and implementation of actions to reduce the recurrence of those incidents. In cases where incidents and near misses occur frequently, the processes implemented through a Safety management System can be relied upon to produce continuous improvement and achieve reduction in associated risks (Reason 1997). In healthcare there is a lack of such systems and theatre staff are used to coping with equipment problems by working around them.

 In addition to the potential threat to patient safety, equipment failures can have a detrimental economic impact, which has not yet been studied. Estimating that the mean cost of an hour of operating theatre is £1055 in UK (Scotland 2009) and from our study where I found that 7% of operations with equipment problems were subjected to a delay of 30 minutes or more; we can extrapolate the equipment failures cost the NHS close to £57.6 million per year. This is without taking into consideration the indirect costs of patient harm from equipment failures.

 Lack of knowledge on how to use equipment only caused 1% of the problems, allowing one to conclude that most staff was adequately trained in using the relevant surgical equipment. Wrong sutures and needles were common types of equipment failure and

these put patients at risk of having complications after surgery. Scissors and blades not cutting properly delay the flow of the procedure and add unnecessary stress upon all staff. Due to the inevitability of equipment failure, it is essential that staff is prepared for these situations. In most cases, staff had to work around the problem, possibly contributing to an already stressful environment.

From this study many factors were identified that led to these equipment problems. The causative factors behind equipment problems were a complex interplay of communication errors, lack of training and orientation and organisational factors such as design and technology. There is a need for further exploratory study to understand the contributory factors and solutions to these equipment failures, which will be addressed in the next chapter.

To my knowledge, this is the first study that describes equipment problems in operating theatres in such detail and assesses their impact on flow of surgery and patient safety. The study covered multiple centres representing the surgical systems across the UK, thereby supporting generalisability of the findings. There may potentially have been an under reporting by hospital staff as suggested by the observational data. Staff may have been more likely to fill in the data sheet when they have encountered major equipment problems (as they are used to filling in incident forms) and may have forgotten to complete the data sheets when they encountered any minor problems. This would also highlight the prevalent culture in healthcare where we are so used to errors that some of them may not even be perceived as problems but a part of the system.

9.6 Conclusion.

Equipment problems are common in operating theatres and often surgeons have to work around these problems, which compromise patient safety and cause disruptions in operating theatres. There is a need to put in place interventions that add redundancy to the system and provide training support to team members.

Chapter 10

Addressing equipment problems in operating theatres- an interview study to explore underlying factors and solutions

10.1 Introduction

Chapter 9 describes the nature of equipment problems in operating theatres. It highlights the association between teamwork failures, equipment problems, and their potential for patient harm. However, I needed to understand the factors that cause equipment related problems. Therefore, alongside the equipment problem self report study, I conducted an interview study at the three sites to further explore these problems and the contributory factors, understand the surgeons', nurses', and anaesthetists', perceptions regarding equipment problems and discuss possible solutions to these systems problems and the role of WHO checklist in addressing these problems..

10.2 Aims.

To explore factors underlying equipment problems occurring in operating theatres.

To understand theatre teams' perceptions regarding the occurrence of these problems.

To make recommendations and propose systems interventions for reducing equipment problems.

10.3 Methods.

10.3.1 Study design.

Semi- structured interviews were conducted with surgeons, nurses and anaesthetists to explore equipment problems in the operating theatres.

10.3.2 Participants and materials.

13 healthcare professionals participated in the interviews, of which four were surgeons, three were anaesthetists and six were nurses. Nine staff members were interviewed at site A (4 Surgeons, 3 Anaethetists and 2 Nurses), two staff members from Site D (2 Nurses) and two staff members from site F (2 Nurses). The sites were the same as described in the previous chapter. This study sample was chosen to cover the different phases of the surgical equipment pathway and to capture the staff perception on various contributing factors at different stages of the process that may influence surgical equipment problems in theatres.

Ethical approval was granted initially for the quantitative data collection for chapter 9 study. For the qualitative data collection a separate substantial amendment form with further details of the interviewees, interviewers, and interview questions was subsequently submitted and approved. I gained approval from each local research and development office to conduct the study at each site.

10.3.3 Data collection.

Semi-structured interviews were conducted using a topic guide that I developed to explore the factors underlying equipment problems. I carried out all the interviews at site A (n=9) and research assistant (DV) carried out the interviews at site D and F (n=4). DV had received prior training in interview techniques and attended 5 interviews that I

conducted to attain a common understanding of the topic guide and interview questions. The reason to choose DV to conduct interviews at the two sites was his familiarity with the theatre staff at the sites. Therefore they were more likely to be at ease with and answer the questions without any inhibitions and fears. Thirteen healthcare professionals of varying levels of experience, including surgeons, anaesthetists and theatre nurses participated in the study. Participants were selected using a qualitative sampling frame (Marshall 1996) to ensure a broad spectrum of demographic and professional characteristics and were also identified by snowball sampling techniques (Miles MB and AM 1994). Sampling ceased when saturation was achieved (i.e., no new themes were emerging from the interviews). All interviews were audio taped and transcribed.

I prepared a topic guide, which provided a framework for the interview (Appendix 5). The topic guide was designed to explore the surgeons, anaesthetists and nurses' views on the following topics:

1) Common equipment problems faced in the operating theatres.

2) Factors and underlying causes for these problems.

3) Possible solutions to address equipment problems.

 Relevant topics were initially identified and possible issues between the topics and any contributing factors became the basis for more specific questions during the interview in order to explore and identify the causes of equipment problems.

10.3.4 Data analysis.

I used Data management software (NVIVO 8) to manage the interview data. The software was used to classify, sort and arrange data according to the different attributions under the adapted Vincent's framework described in chapter 2 (Vincent 1998) to understand the systems factors underlying equipment problems. The List of Attribution coding (Tree Nodes in NVIVO 8) was as follows:

1. Organisational and Management Factors.

2. Work Environment.

3. Team Factors.

4. Individual (staff) Factors.

5. Task Factors.

10.3.5 Coding reliability.

The consistency (reliability) and confirmability (validity) of data analysis and interpretation was assessed using two techniques. Firstly, external validation of all stages of coding and interpretation of transcripts was performed independently by two experienced qualitative researchers (myself and DV). The results were compared and there were no significant inconsistencies. Secondly, member checking was carried out to ensure accurate interpretation of the data.

10.4 Results.

The interview coding of the causes of surgical equipment problems was performed in

accordance with the classification of contributory factors proposed by Vincent et al.(Vincent 1998) Most of the causes, I identified fell within the levels as proposed by the framework. Table 10.1 summarizes the main findings from the interviews.

Table 10.1 Equipment problem contributory factors.

Classification of contributing factors with examples and verbatim quotes	No of Subjects who said this and number of themes.
Organisational and Management Factors Limited resources and funding. Complex service agreements and tiers in the procurement and service process. Outsourcing of services such a Sterilisation services, Staff culture and priorities. *'Lack of funding, we've got, the equipment, we've got some very old equipment and some of it is really ancient and it's really hard to get service contracts on some of them and we find the service contracts are worth more than the equipment itself'*	S=1,N=3 Total Subjects = 4 Themes = 8
Work Environment Design, availability and maintenance of equipment Workload and shift patterns, Lack of specialized staff *'probably not having enough staff really and they feel pressured to just get doing things that they're not really ready to do because there aren't enough people and they're another number, which they're accounted for in the theatre. So if they're there they feel like they have to just get on and do it, get on with it'*	S=2, A =1, N=7 Total Subjects = 10 Themes = 5
Team Factors Poor communication between surgeons and nurses *'A basic mention of surgical equipment because surgical equipment like, the common problems we have is that the diathermy isn't working or the patient has, these days we use devices like LigaSure, it's not available, or there is a laparoscopic instrument that isn't required on this set and it's not there or the suction's not working.'*	S=2, N=3 Total Subjects = 5 Themes = 8
Individual (staff) Factors Knowledge and skill of the staff Lack of training *'really gynaecology trained theatre nurses, I think that would be the biggest advantage because very often they can't find the equipment we need so we have to compromise and use something which is probably not unsafe but maybe not as good and I think'*	S=2, N=4 Total Subjects = 6 Themes = 6
Task Factors Lack of checks to detect or highlight equipment problems Lack of clear task distribution *'No-one ever checks the diathermy, to make sure it works, before they need it.'*	S=2, A=2, N=3 Total Subjects = 7 Themes = 4

(S= Surgeon, A= Anaesthetist, N= Nurses)

10.4.1 Organisational and Management Factors.

Organisational and financial constraints were perceived to be a limiting factor for the availability of up to date surgical equipment. Some expensive equipment gets damaged easily and poses a financial burden for its replacement. These instruments may be in limited circulation and need to be shared between different theatres during surgery. As a result timely availability of these equipments also emerged to be a problem. Further, prior clear communication was necessary for booking such equipment and often it was not available for surgery due to lack of communication between surgeons and nurses or short notice as during an emergency surgery. In areas where equipment sterilisation has been outsourced, it was not clear whether theatres or the sterilisation units were responsible for replacing broken or missing equipment from the trays. Consequently, missing equipment was not replaced and incomplete surgical trays were packed and dispatched to theatres for use.

Financial resources and constraints may affect the availability of certain equipment. Due to financial restrictions, up to date and occasionally used equipment cannot be procured which may pose safety risks.

'It could be old equipment, we don't have the most up to date things that are available because of expenditure.' (Nurse 1 Site F)

'Occasionally you will find that if you've got somebody who comes in with a trauma injury, and it will be unique stuff that we use may be two or three times a year that we wouldn't buy to have on the shelf, but that you would hire in.   That would be the

occasional time whenever you should have something that's not available.' (Nurse 2 Site A).

In the current economic climate, NHS is being transformed to reduce costs. Some of these involve merging trusts and outsourcing service provisions. Some trusts have outsourced their sterilisation unit. On site D, the responsibility for replacing missing equipment is blurred between sterilisation unit and the theatres, which leads to problems and confusion. There is a mismatch between the goals of the outsourced sterilisation unit and the needs of the operating theatre. There was certain resentment among theatres staff to the outsourcing as it prevented them from having a control over the equipment turnover and dependence on an outside organisation for equipment repair and timely sterilisation. Further, the system was primarily working towards identifying and documenting the problems, rather than finding a solution. There was lack of shared responsibility in ensuring that correct equipment is available.

'they are there to do a certain job of making sure that it's sterile for us and that tray is like it should be, but they have no interrelation of what the surgical need is.'
………………

'So as a scrub practitioner you've got to be adaptable to start with, but say you'd open a tray and the diathermy lead's there but with no forceps, you can't use it, you cannot use the diathermy without the forceps, they go together. But on the outside it'll say diathermy forceps missing. What you want is a system in place that if the diathermy forceps are damaged or missing, replace them, set out, it's simple to me.' (Nurse1 Site D)

Some problems are recurrent. Learning from mistakes is not part of the staff culture and priority or often-new information regarding equipment is not passed on. As a result similar problems arise repeatedly. This can be particularly frustrating for the surgeons who then had to face the same technical difficulty time and again due to the unavailable or faulty equipment.

'we always need a colposcope with that list, and time and time again it isn't there or it's broken or it isn't back or nobody knows where it is and-----------,'(Surgeon Site A)

10.4.2 Work environment.

The availability of on-site storage space limits the amount of items and equipment that can be made available in theatres. Equipment is shared between several theatres and at times, its availability is on a first come basis. Replenishment and topping up is not always adequate and can consequently lead to depleted stock and unavailability of minor items such as surgical swabs.

'You have three theatres needing particular equipment. Shall we say you've got three theatres, you've got only two sets of total hip replacement kits, ……If you've got three theatres who needs that, what would happen with the third theatre if you got only two? So it has to, someone in charge has to check the list first, not only your own list but what's going on to other theatres.' (Nurse 2 Site F)

'It's a nightmare. I shouldn't say that but it's not it's suboptimal. Not very good as in we don't have enough space I think, but perhaps that's always going to be a problem.'(Nurse 3 Site A).

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Lack of storage space led to chaos and disorganization in storage system as a result equipment would go missing or get damaged. This was a reason for discontentment among theatre teams and could also lead to hot arguments and hostility.

'No, none at all, none at all. You have it all in the corridors, as you can see out there, and everything goes on the shelf and instrument trays get ripped where they've been slapped on top of each other and there's no other place to store them so.' (Nurse 1 Site F)

Some participants also reported that teams are often understaffed and rushed between procedures and not enough time is allowed between procedures for pre operative equipment checks. As a result often equipment problems were detected during the surgery leading to stress and delays. Endoscopic procedures were particularly vulnerable due to high turnover and short patient transfer and anesthetic time.

'I think if people are very rushed for whatever lack of staff, maybe it's not, people have been cleaning from the case before and they've quickly got to set up for the next case. That might be one reason why someone might not, not that it's an excuse or a reason not to, but this might be why people might feel pressure, under pressure and may skip that step.' (Nurse 3 Site A)

10.4.3 Team Factors.

In theatres, staff works within teams and with other teams of staff (e.g. administration staff, nurses, surgeons and anaesthetists). Verbal and written communication breakdown can affect the flow of information and eventually things are not done. There

is a lack of communication at the planning stage of the procedure. In case of changes in patient list, sometimes the information is not passed on to the person in charge of the theatre and the required equipment is not ordered.

Operating theatre staff is unaware of any faulty or missing equipment in a sterilised tray before they open that tray for an operation. Inadequate labelling of the surgical trays from the sterilisation unit may be the source of some confusion when the tray reaches theatre.

'And have you had an example of those things happening, like the whole laparoscopic incident? Oh yes where it's been rewrapped and said it's fine when actually when you open it, it is damaged and you cannot use it.' (Nurse 1 Site D)

'What we struggle with from sterile supplies, is they don't always label it perhaps quite rightly, and perhaps we need to be more explicit about what we ask them to label it as.' (Nurse 2 Site D)

Some surgeons were concerned about not being informed prior to the commencement of a procedure, about a piece of equipment that is likely to be needed for that operation, but is broken or not available. On the other hand, the same surgeons recognise that theatre nurses are often not informed about the possible need of any specific equipment. Surgeons delegate job to junior surgeons who then may not communicate the exact information to the teams in the theatre. In case the patient list changes, sometimes the information is not passed on to the person in charge of the theatre. Sometimes surgeons do not have control of their own list and changes may not be communicated to the surgeons or theatre teams.

'So they don't take ownership of it, and they don't take responsibility for it, and what you need is the surgeon to take responsibility and ownership, and then to be communicating out to different people. And one of the things that you have to be very careful about is if they give it, if they give a job to one of their juniors, something gets lost in the translation, and it's like Chinese whispers. So I think it's really important that he (surgeon) communicates, or she communicates with whoever's in charge of that particular area, and then there's a communication to the entire team in theatre.' (Nurse 2 Site A)

'I don't think the surgeons are particularly good at communicating, and I think a lot of it revolves around the fact that they're not in control of their own lists, and they have somebody else deciding what's going on their list.' (Nurse 2 Site A)

However, according to two surgeons, relying only on a theatre list to determine which equipment may be needed may not be sufficient. The system should allow for enough flexibility in order to provide the surgeon with the specific equipment he/she may require at the point of need. One nurse identified that experience and knowledge of the nursing staff may help to overcome this.

'I mean, if you're working with all the experienced people, I mean, it does affect as well, because at least they know where to get the things from, they can anticipate delay and, like this, we can minimise this problem. (Nurse 2 Site F)

10.4.4 Individual Factors.

Surgeons, anaesthetists, locum staff and at times theatre nurses are expected to work on different sites within the same trust. One surgeon and two nurses pointed out that induction training and familiarisation with different sites within the same trust is not

adequate and may lead to staff not knowing which equipment are available at that site and where they are stored. Surgeons had individual preferences for certain equipment and techniques and while working with unfamiliar staff, there could be confusion regarding the equipments needed. There was also some discontentment expressed by nurses over being shuffled around from on specialty theatre to another without taking into consideration their preferences and expertise. Often these were management driven changes in the wake of staff shortages and redistribution of workforce.

'Just the way the work plans are, they've just changed things around, and it may be that they predominantly have done a list in one of the sites, and now through various changes, they're doing the list somewhere else. But it's not that frequent, and obviously they may not be as familiar with what they've got on that other site as their normal base site.' (Nurse 1 Site D)

10.4.5 Task Factors.

Protocols for specific tasks are not always adhered to. One surgeon, two anaesthetists and two nurses remarked that equipment is not tested or checked before the procedure. The task that the staff is meant to perform may itself be designed in such a way that it may affect the safety of the whole process. For instance, it is difficult to check sterile equipment before starting an operation because in order to maintain a sterile field the set will only be opened during an operation. The more complex the technology involved in a procedure, the more likely it is to have equipment problems. During endoscopic procedures, often the visual displays would be malfunctioning or the scope cameras not functioning properly. These problems were often detected only once the procedure had

begun. The staff had not checked or did not know how to operate the equipment if it had a software/ operational error.

'there is an intrinsic problem in that you can't actually check they're working before you've opened the set. But there is a step missing there in checking sterile equipment before it's used. Probably the only way you can do it is to actually open the sets before the patient's asleep and check the equipment's working.' (Anaesthetist 1.4 Site A)

'Well I think eventually it comes down to the surgeon, you're responsible for the equipment but obviously there are situations, so you're supposed to test everything before you start but no-one, including me, is doing that probably all the time, because these are routine things and you just assume that these things are set up properly by the team, but then not' (Surgeon 1 Site A)

'No-one ever checks the diathermy, to make sure it works, before they need it.' (Anaesthetist 1.4 Site A)

10.4.6 Proposed solutions for equipment problems.

All the participants agreed that equipment problems are unacceptable and solutions and interventions should be put in place to prevent them. Box 9.1 highlights the key proposal for preventing equipment problems

Box 10.1 Proposed solutions.

- Standardised communication protocol between surgeon, nurses and managers while planning an elective surgery.
- Checklists and briefings on the day of the surgery
- Structured training of nurses for equipment set up and organisation.
- Training Sterilisation unit staff
- A robust system of communication between sterilisation units and theatre staff
- Intelligent design of equipment trays to detect missing items and report faulty equipment

All respondents believed that there should be a good communication between surgeons and nurses during the period before the day of surgery. It emerged that theatre team briefings and surgical checklist "Time-out" can be a last minute communication check to discuss any equipment related problems and ensure that any specialised equipment needed for surgery is available and ready before the start of the procedure.

'A lot of it's down to communication, and if you have a member of the theatre team, and the consultant surgeon who's doing the operations communicating with each other, the week before the patients are due to come in. If the list changes, then I would expect the surgeon to be contacting the person in charge of that theatre to talk to them about the equipment that's required for the following week' (Nurse 2 Site A)

Another recurring problem was the communication and coordination between theatre staff and sterile services unit. Various proposals were suggested to improve supply and demand chain and improve the reliability of the system.

There should be correct and appropriate labeling of the equipments and faulty equipment should be labeled so that it can be picked up and rectified or replaced.

'What we struggle with from sterile supplies, is they don't always label it perhaps quite rightly, and perhaps we need to be more explicit about what we ask them to label it as.' (Nurse 2 Site D).

'I have been working in hospitals where they were putting on a tape or something on to the faulty equipment and so when the operation was finished, they sorted it out and they took it to the manufacturer or wherever to fix it' (Surgeon 1 Site A)

Tray design modifications such as transparent sterile sheets and graphic tray were proposed for sterilisation unit staff in order for them to better understand what is required by the theatre staff which will help the theatre staff to identify missing equipment quickly without opening the sets.

'The companies that you tend to get loans from are very good, because they'll send diagrammatic pictures as well, so it's very clear when you're checking things off, those are the things that you should have on your trays, and they're all the graphic trays, so it's quite easy to see if you've got a gap, what should have been there.' (Nurse 2 Site D).

Better and more specific scanning system may help to pick up missing equipment, locate various equipment and also help in maintaining correct counts of the instruments in the sets.

'Because you can get bar coders that you can just zap all the way down all the instruments.' (Nurse 2 Site A).

'I think there's probably something around scanning as well, because our trays are scanned when they leave the site, and they're scanned to say that they're in sterile supplies, and then they're scanned coming back out. But they're not scanned to

individual theatres or individual even sites, all we will know is that it's left sterile supplies and it's at Hospital A. Well, Hospital A's got ten theatres, and there's only five that are clustered together, the other five are quite separate. So that's been quite difficult for people, to find out well, where in the ten theatres has it gone back to? And even it may not have gone back to a theatre, it may have gone to an outpatients facility. So I think, and we are currently doing that work around doing almost that secondary scanning so that we can be more precise about where things are.' (Nurse 2 Site D)

Need for quality and structured training emerged as a major factor proposed to resolve equipment problems. Better training and exposure for sterilisation unit staff is need to improve their understanding of equipment needs of surgical procedures. Also better training of nurses is needed to ensure that the all equipment is assembled correctly and is running properly in the theatres.

'But on the back of that people have come and visited from CSSD (Sterile services unit) and that has helped. And it's a two way process, they've asked us to visit them as well. And I'm very much the, making sure that that happens.' (Nurse 1 Site D)

Allocation of tasks to specific person was suggested to maintain the storeroom. This would assign responsibility and establish a channel of communication the teams need to follow in securing equipment from the store.

'I think it's also the fact that, well in my opinion, a few people will share this, we don't actually have one person allocated to do that, to actually sort out the storeroom, neaten it up, unpack boxes, do this kind of thing, organise it really. I think the expectation is that everyone kind of does it and that doesn't work, doesn't seem to work at the moment

anyway. If we actually had, say, one person to do that then it would work. So there may not be lack of space if it was better organised.' (Nurse 3 Site A).

10.5 Discussion.

This interview study has identified some serious issues surrounding the equipment problems. As discussed in the chapter 9, equipment problems are very common in UK operating theatres and theatre staff, although accustomed to these problems, see them as a source of considerable inconvenience to the flow of surgery and a threat to provision of safe patient care.

Various organisational and work environment associated factors were highlighted in this study. There was the lack of a reliable system to process and circulate equipment for use in the operating theatres. In order to maintain a sterile field, nurses can only open the equipment pack just before the start of the operation and therefore may not be able to predict, if equipment is faulty or missing. In the interviews it emerged that outsourcing of the sterilisation services may also be responsible for certain missing equipment in the sets as there is a lack of appropriate communication channels between the theatre staff and sterilisation units. Nurses also reported that on a number of occasions, the instruments were missing from the sets. This was largely put down to incomplete sets being sent out from the surgical sterilisation units, as the staff there may not be adequately trained. Lack of training into the equipment needs of a procedure also came up as a contributory factor.

There is a lack of communication between surgeons and nurses regarding equipment needs for the procedures on the list. The nurses use an equipment kardex that lists each

surgeon's required equipment for a specific surgery but often these kardex are not updated. This may cause ambiguity and the surgeon may assume that the nurse would know his preferred choice of equipment. Locum and floating theatre staff members may not be adequately oriented to the operating theatre complex as a result of which they may not be able to locate the equipment required for the surgery. This was an underlying problem in a number of procedures when the surgeon needed equipment and he had to wait or work around while the theatre staff tried locating the required equipment.

Online portals may be useful to surgeons in communicating the equipment needed for their elective lists. This would not only remove assumptions but also be a learning and audit tool. To ensure that the equipment sets are not missing any instruments, there is a need to redesign the procurement system and the instrument sets to reduce human error by putting in place checks to ensure that the sets dispatched are complete. To ensure that the equipment available in the operating theatre suits is easily located and readily traceable, there is a need to redesign the storerooms where equipment is easily identified and located. GPS technology can be considered in locating expensive equipment that is shared between different theatres. To reduce human error it is essential that responsibilities are clearly assigned and redundancy added to the system supported by a training and orientation structure that supports new members of staff. Where the equipment is found to be faulty, a system should be in place to report these errors and ensure that faulty equipment is replaced or repaired. Also, the staff distribution should be such that in each theatre there should be members who are familiar with the equipment's functioning.

To resolve the problem of missing equipment there is clearly a need to improve the communication between the surgeons and nurses prior to the surgery. Verdaasdonk et al showed that a structured checklist could halve the incidence of laparoscopic equipment problems (Verdaasdonk, Stassen et al. 2008). Recently WHO surgical checklist has been mandated in UK, which provides an opportunity for theatre teams to ensure that the required equipment is available before initiating the surgery (Vats, Vincent et al. ; National_Patient_Safety_Agency(UK) 2009). The WHO checklist requires the theatre teams to discuss the equipment needs and ensure the availability of the required instruments before the surgery begins. The equipment studies described in this and the previous chapters have established equipment failures as a very sensitive marker for teamwork in operating theatres. Equipment failures arise as a result of poor teamwork and communication between theatre teams. As suggested in this interview study, the WHO checklist can improve communication between team members and reduce the incidence of equipment failures.

10.6 Conclusion.

Equipment problems are common in operating theatres. They are systems failures associated with poor teamwork and communication. These problems can be addressed by designing a system that maintains standard channels of communication, identifies errors and ensures certain checks for a reliable and consistent availability of equipments to perform safe surgery. Having established the framework of teamwork failures in operating theatres in chapter 8 and determined equipment failures as a sensitive marker teamwork and patient safety in theatres, in the next chapter, I present a study re-

evaluating the WHO checklist and its impact on teamwork failures and other markers of

patient safety.

Chapter 11

Effective WHO checklist use and its impact on teamwork, problems in operating theatres and patient safety

11.1 Introduction.

On 15th January 2009, National Patient Safety Agency rolled out a patient safety alert making the WHO surgical safety checklist mandatory for NHS. The purpose of the checklist is to improve teamwork and communication among the surgical theatre teams and to act as a memory aid to ensure that all tasks important for patient safety are carried out. The global WHO checklist study results showed a significant drop in postoperative morbidity and mortality: however, the UK site data did not show such significant reduction in post surgical morbidity and mortality. Therefore, as described in previous chapters, there was a need to develop a framework of surrogate markers of patient safety as described in Chapter 8, 9 and 10 to further evaluate the checklist use against these measures rather than clinical outcomes such as morbidity and mortality.

Currently the checklist is being implemented across the NHS but in the absence of any structured training for the healthcare staff, the use of checklist in the theatres can be variable. As discussed in Chapter 6, the WHO checklist can improve teamwork and patient safety practices in the operating theatres, if it is used appropriately. If the checklist were used merely as a tick box exercise, surgery would remain prone to the communication and equipment failures. If during the Time-out, the surgeon performs the

checklist but fails to inform the team about equipment needs or the plan for surgery, or the anaesthetist fails to inform the team about critical patients, the checklist may not have any beneficial effects. Therefore, it is important to assess the quality of information exchanged during Time-out. There is a need to further study the dynamics of the checklist use and understand its impact on theatre environment, failure profiles and pitfall in the use of checklist so that these issues can be addressed through structured training to improve checklist use and monitor its effectiveness in the NHS. The study described in this chapter fill this gap in the understanding of the checklist use.

11.2 Aims.

With this study I evaluate:

- The relationship of quality of checklist use to intra-operative failures.

- The relationship of quality of checklist use to theatre teams' perceived benefits of WHO checklist.

- The relationship of quality of checklist use to the theatre teams' perceived level of teamwork.

In order to assess the above relationships, I aimed to evaluate the use of checklist in the operating theatres to:

- Assess the variability in the use of the checklist in operating theatres.

- Assess the quality of information exchanged during the Time-out.

- Adherence to the use of checklist.

- Assess the impact of the checklist on teamwork failures, technical failures and equipment problems.

- Assess the impact of checklist on the team's perception of the benefits of checklist, teamwork and intra-operative complications.

11.3 Methods.

11.3.1 Study design.

Prospective observational study, which used field notes in combination with structured data forms and self report forms to assess use of WHO checklist and its impact.

11.3.2 Participants and materials.

The study was carried out at St. Mary's Hospital, London, in vascular surgery theatres.

11.3.2.1 Sample.

Sixty-five vascular surgery procedures were recruited for this study. The procedures included in the study ranged from lower limb thrombolectomies to aortic aneurysm repairs, open as well as endovascular procedures were included. Vascular surgery procedures were chosen for observation as they provided a good mix of short procedures such as lower limb thrombolectomies and more complex and high-risk procedures such as abdominal aortic aneurisms. These cases involved complex interactions between surgeons, nurses, anaesthetists and also radiologists in many instances, therefore the chances of teamwork failures were high. These failures could be studied and impact of WHO checklist would have been easier to assess as compared

to other surgeries where teamwork, communication and coordination is relatively infrequent. These cases were also commonly performed and easily recruited for the study. Advice was sought from the National research ethics committee and it was advised that as the project is a quality improvement programme to assess the adherence to the use WHO checklist which is an established patient safety intervention in the NHS, ethics committee approval was not necessary. Theatre teams were individually recruited for the study. The consent of the patients was not necessary as all data was kept anonymous and staff gave their implied consent by providing the information.

11.3.3 Data collection.

11.3.3.1 Observations.

As the WHO checklist is used in all operating theatres at St. Mary's Hospital, during the checklist Time-out, I collected the data on quality of checklist use through a standardised data sheet (Appendix 6). The data form collected information on the timing and duration of the Time-out, absence of members during the Time-out, adherence to checklist items, quality, and completeness of information exchanged between surgeon, nurses, and anaesthetists. The quality of information exchanged by the surgeons, nurses and anaesthetists was rated on a scale of 1 to 5, where 1 represented: exchange of information with resistance to checklist use, 2- minimal exchange of information with team members distracted by tasks at hand, 3- some information exchanged, 4- relevant

information exchanged and 5- good information exchange and encouraging other team members to share information.

I decided to study the Time-out part of the checklist in detail as it was the most critical part of the checklist and involved the entire theatre team. During the Time-out most of the information relevant to the pending surgical procedure is exchanged, therefore it provided a good opportunity to study the team interactions and dynamics. Also my previous study described in chapter 6 had suggested that, the 'Time-out' part of the checklist was the most poorly performed part of the checklist as it involved not just ticking the boxes but also an element of team briefing.

For 62% of sample cases (n=41), I also collected free hand field notes using the methodology described in chapter 8. The operative duration was noted as the time point when the patient entered the operating theatre until patient was transferred from the operating table. There were three primary observers (Myself, GB and MA). Both GB and MA were medical students who were keen to gain experience in research methodology under my supervision. GB was a 4[th] year medical student with a previous experience as theatre nurse and MA was a 4[th] year medical student. Both GB and MA received training in theatre observation methods and human factors under my (AV) supervision. I collected data for 31 cases. Of these, GB and MA co-observed 10 cases each with me. Therefore, reliability of the observations was assessed by parallel independent observation by myself for these with a 90%overlap in field note identification between observers. Once adequately trained, they independently collected data on 5 cases each.

11.3.3.2 Self report questionnaire.

For the 65 cases, surgeons, nurses and anaesthetists were asked to complete a self-report questionnaire (Appendix 7). The questionnaire was designed to collect information on staff's perception of usefulness of WHO checklist for the related surgical procedure. After each procedure the surgeon, nurse and anaesthetist were asked if they found the checklist useful in understanding: a) the surgical procedure being performed, b) the equipment needs for the procedure, c) the patient's condition and risks, and d) in running the operating theatre efficiently. They were also asked to individually rate the quality of information exchanged by the surgeon, nurse and anaesthetist during the time- out on a scale of 1 to 5. The teams were also asked to rate the teamwork in the operating theatre on a scale of 1 to 5 after each procedure.

11.3.4 Data analysis.

The field notes were analysed to classify them into various failure events using the theatre observation framework described in chapter 8. These were teamwork failures, equipment failures, and technical failures. WHO checklist usability score was calculated to assess the WHO surgical checklist use by theatre teams. The checklist score was calculated using 19 items on the checklist usability data form with the highest possible score of 30. The items included in the checklist score including patient identification, procedure and site verification, discussion of equipment needs, patient concerns, surgical procedure, anaesthetic risks and quality of information exchange. The quality of information was assessed using a Quality of information transfer score calculated by adding ratings for information exchanged by surgeon, nurse and anaesthetist during the

Time-out. Statistical analysis was performed using SPSS version 18.0. Pearson's correlation coefficients were calculated to understand correlation between the checklist and information scores and the failure events observed in the operating theatres. Correlations between perceptions of checklist benefits, reported teamwork, checklist usability score, information transfer scores and observer's information scores were also analysed.

11.4 Results.

11.4.1 Quality of checklist use correlates with intra-operative failures.

11.4.1.1 Variability in checklist use in operating theatres.

Sixty five surgical procedures were included in this study. The cases included carotid endarterectomies, femoropopletial bypass, lower limb arterial thromolectomies, and repair of aortic anerysms. I observed that the Time-out was performed in 94% of cases. The time of performing the checklist time- out varied between different cases. In most cases (55.7%) it was performed before draping the patient for the procedure of cases and just before the skin incision in 42.6% of cases. On one occasion, the Time-out was performed after the surgical procedure had started. The mean duration on the time- out was 2.5 min (minimum- 1.5 min, maximum- 10.5 min). In 78% of cases, the checklist was led by the circulating nurse, followed by ODPs in 6.6% of cases. Surgeons and anaesthetists led the checklist in only 2 (3.3%) cases each. Variability in the use of checklist is discussed Table 11.1.

Table 11.1 Variability in checklist use between surgical cases.

Variability measures	Percentage of cases
All items on the checklist completed	30.70%
Checks completed in correct order of the checklist	33.90%
All team members present at 'Time-out'	34.00%
Team members present in the theatre paused to listen and contribute to the Time-out	27.70%
Antibiotic prophylaxis discussed	69.20%
Venous thrombo-embolism prophylaxis discussed	52.30%
Equipment needs of the surgical procedure were discussed	66.20%
Information relating to anticipated difficulties, patient specific concerns discussed	78.50%

11.4.1.2 Quality of checklist use.

Over all WHO checklist usability scores were calculated using nineteen parameters from the checklist usability data form. The maximum score was 30. The mean checklist usability score was 18.83 (minimum score- 8, maximum score- 29). There was a marked variability in the quality of information transfer by surgeons, nurses and anaesthetists at 'Time-out'. The quality of information exchanged by these team members was rated on a scale of 1 to 5. The surgeons were rated lowest with a mean score of 2.9, nurses mean rating was 3.2 and anaesthetists were rated the highest for quality of information exchange with a mean of 3.4. In 12.5% of cases, surgeons were noted to be resistant to

the Time-out and did not volunteer any information to other team members. After the procedure surgeons, nurses and anaesthetists were also asked to individually rate the information transfer on a scale of 1-5 and it was observed that they generally gave a higher rating to the team members. Table 11.2 summaries the mean quality of information transfer ratings as rated by observer, surgeon, nurse, and anaesthetist.

Table 11.2 Summary of mean quality of information transfer scores.

	Observer rating	Surgeon rating	Nurse rating	Anaesthetist rating	Mean team rating
Surgical information transfer	3.20	4.09	4.14	4.07	4.10
Nursing information transfer	3.20	3.82	4.09	3.75	3.88
Anaesthetic information transfer	3.38	3.98	4.16	4.03	4.05

The individual surgical, anaesthetic and nurse ratings of the observers were summed up to calculate the overall quality of information transfer score with a maximum possible score of 15. The mean score was 9.63 (minimum score- 6, maximum score- 14). Similar scores were also calculated for the self reported ratings. Again, the teams' self reported information scores were higher than the observer's with a mean score of 13.0 (minimum score- 8.33, maximum score- 15).

11.4.1.3 Observed events and failures in operating theatres.

For 41 cases, extensive field notes were collected and analysed to identify failure events associated with the surgical procedures. A total of 117 hours of observations were carried out identifying 365 events. Of these events, 257 were identified to be failures directly related to the surgical procedure of which, 61.1% were teamwork failures, 32.7% were equipment failures, and 6.2% were technical failures. Teamwork failures occurred at a mean rate of 1.3 failures per hour (minimum- 0 and maximum- 12 failures per case). Equipment failures occurred at a rate of 0.72 failures per hour (minimum- 0, maximum- 5 per case). Technical failures being least common occurred at a rate of 0.14 failures per hour (minimum- 0, maximum- 2 per case). There was a moderately strong correlation between number of failure events and the duration of the surgical procedure (Pearson's correlation-0.612, P- 0.000). A mild to moderate correlation was also noticed between equipment failures and teamwork failures (Pearson's correlation-0.347, P- 0.02) and equipment failures and technical failures (Pearson's correlation-0.0.386, P- 0.00.013). On comparing the impact of checklist use on theatre failures, the WHO checklist usability scores and the quality of information transfer scores correlated well with the equipment failures in the operating theatres (Pearson's correlation-0.0.554, P- 0.000). Lower checklist scores were associated with higher number of equipment failures.

Therefore, it is evident that the quality of checklist use correlates with intra-operative failures.

11.4.2 Quality of checklist use correlates with theatre teams' perceived benefits of WHO checklist.

At the end of each procedure, surgeons, nurses and anaesthetists were asked if they found the checklist useful for that procedure. Their perceptions are summarised in table 11.3.

Table 11.3 Perceived benefits of the WHO checklist during a surgical procedure.

Question: Did you find the WHO surgical checklist useful for this case	Cases surgeon found the checklist beneficial (n=61)	Cases nurse found the checklist beneficial (n=61)	Cases anaesthetist found the checklist beneficial (n=60)
In understanding the surgical procedure being performed	62.30%	81.90%	31.70%
In understanding the equipment needs for the procedure	52.50%	81.90%	23.30%
In understanding the patient's condition and risks	65.60%	91.80%	45.00%
In running the operating theatre efficiently	67.20%	83.60%	48.30%

From the table, it is clear that the nurses found the checklist very useful in understanding the equipment and patient needs and it helped them in running the operating theatre smoothly. The nurse found the checklist to be most beneficial in understanding the patients' condition and risks, which would otherwise have not been discussed with the nurses. Surgeons found the checklist use most beneficial in running the operating theatre efficiently. Anaesthetists found the WHO checklist the least

beneficial. To assess if the perceived benefits of the WHO checklist were associated with the quality of checklist I performed Pearson's correlation test. There were moderate correlations between the reported benefits of the checklist and WHO checklist usability score (Pearson's correlation coefficient- 0.490, P-0.000) as well as with the information transfer score (Pearson's correlation coefficient- 0.517, P-0.001). Therefore, the team members found the checklist most beneficial when it was performed well.

11.4.3 Quality of checklist use correlates with the theatre teams' perceived level of teamwork.

Surgeons, nurses, and anaesthetists rated the teamwork in operating theatres for each case on a scale of 1 to 5 (1- very poor teamwork, 5- excellent teamwork between the surgeons, nurses and anaesthetists). Overall, nurses rated teamwork highly (mean teamwork rating – 4.11) followed by anaesthetists (mean teamwork rating – 3.90) and surgeons gave the lowest rating with a mean teamwork rating of 3.85. However, good correlations were observed between surgeons' and nurses' (Pearson's correlation coefficient- 0.442, P- 0.000) and surgeons' and anaesthetists' (Pearson's correlation coefficient- 0.606, P- 0.000) teamwork ratings. Although no significant correlation was seen between the reported teamwork ratings and observed teamwork failures, there was a moderate correlation between teamwork ratings and Quality of information transfer scores (Pearson's correlation coefficient- 0.537, P- 0.000) and also with the perceived benefits of the WHO checklist (Pearson's correlation coefficient- 0.577, P- 0.000). Therefore, the quality of checklist correlated with the perceived teamwork in the operating theatres.

11.5 Discussion.

11.5.1 Variability in checklist use.

Effectiveness with which the checklist was used was found to be variable. Checks may often be overlooked or may be done hurriedly without a pause for input from other team members. It was noted that checks might not be completed in order. This was more common when the checklist was performed mentally without a paper checklist in hand or there was a lack of attention towards the checklist items due to other competing tasks such as, setting up the instruments or preparing the patient on the operating table. Although it may seem to be inconsequential but the purpose of using a checklist is to add redundancy to the system and reduce the reliance on memory recall. If the checks were not completed, the beneficial elements of the checklist are dampened and it simply becomes a tick box exercise.

11.5.2 Impact of checklist use on failures in operating theatres.

This study showed that the quality of checklist use correlates with the intra-operative failures such as teamwork failures and equipment failures. Time-out is a team exercise and it is essential that all team members should be present for it. The Time-out creates an opportunity for the team to exchange important information related to the surgery and promotes shared mental model. However, if the team members are absent during the Time-out, the failures in teamwork due to lack of communication and shared mental model could still occur. The checklist has an element of briefing where surgeons, nurses, and anaesthetists can exchange important information regarding the patient and the surgery. This study shows that there is a significant association between the quality

of information exchanged and equipment problems faced during the surgical procedure. As discussed in previous studies (Chapter 8 and 9) these equipment problems are closely associated with teamwork failures. It is important that the team members are keen to use this opportunity to exchange important information during the Time-out. If the information relating to equipment needs is not communicated, it may lead to unavailability of equipment during the procedure in turn leading to delays and even patient harm. I found that severe delays during the surgical procedure show a moderate and significant association with teamwork. It confirms the common knowledge that most of the procedural delays are due to poor teamwork and coordination between the team members. It is also evident that checklist is beneficial in not only reducing these delays but also preventing some last minute planning failures due to unavailability of necessary equipment detected during the procedure.

11.5.3 Perceived benefits of WHO checklist.

Table 11.2 shows the usefulness of WHO checklist as perceived by the theatre teams. It is evident that nurses find the checklist very useful in understanding the surgical procedure, its equipment requirements and efficient conduct of surgical procedures. They also find the information exchanged during time-out useful in understanding the patient risks. This is due to the fact that time- out creates a platform for communication between the nurses, surgeons and anaesthetists, where questions pertaining to the procedure can be asked and necessary information obtained. As a result, assumptions are reduced and there is realization of shared goals and objectives in the surgical team. It was also noted that anaesthetists found the checklist least beneficial in understanding the surgical procedure being performed and equipment needs of the procedure. This could be due to an underlying feeling among the anaesthetists that discussion on

surgical procedure being undertaken and surgical equipment needs is primarily a responsibility of the nurses and surgeons. Although the type of surgical procedure could have an impact on the type of anaesthetic administered to the patient, the anaesthetist may not find the information exchanged during the time-out beneficial as the patient is already under anaesthesia. Therefore the low response of the anaesthetist to the benefit of WHO checklist may improve if the time-out is conducted prior to patient being anaesthetized.

11.5.4 Impact of WHO checklist on Teamwork.

This study shows that the quality of checklist use has direct correlation to the teamwork within the theatre teams. A well-performed checklist improves the perception of teamwork among the theatre staff. From the study described in chapter 9, it has been established that equipment problems are associated with teamwork failures in the operating theatres. It this study, although, a strong correlation between quality of checklist and teamwork failures was not seen, there was a strong association seen between quality of checklist use and equipment failures.

This study highlights that emphasis should be laid on ensuring that checklist is performed in a systematic manner and not just as a mandatory task. Theatre staff should be given dedicated training in performing the WHO checklist.

11.6 Conclusion.

A poorly performed checklist can lead to persistent teamwork failures and equipment problems thereby defeating the purpose of using the checklist. This is reflected in the perceived benefits of the checklist by the theatre teams. Team members clearly found

the checklist useful in understanding the procedure, equipment needs, patient concerns and running the theatre smoothly in cases where the checklist was performed well. They also rated the teamwork higher, when adequate information was exchanged during the Time-out. It is imperative that beyond the universal implementation of surgical checklist, emphasis should be laid upon how well the checklist is used by the theatre teams. This reflects the need for training healthcare staff in the correct use of the surgical checklist and increasing awareness among the healthcare staff of the importance of using the checklist in its true spirit.

Chapter 12

Conclusion

12.1 Summary of the project findings.

This research has led to some interesting findings.

The WHO surgical checklist was found to improve patient safety processes. It encourages teams to perform safety checks, which resulted in improvements in confirmation of patient's identity by the theatre teams, from 9.5% to 97%. Antibiotic prophylaxis improved from 57% to 77%. There was also a trend towards improvement in the rate of surgical site infections. However, the correlation between the use of checklist and outcomes was not clear.

The interview study further emphasized the need to establish a clear benefit of checklist use on intra-operative outcomes and theatre efficiency. There was consensus among the theatre staff on the role of the checklist in improving teamwork and communication between team members and promoting patient safety practices. However, the need for further modifications to the checklist was expressed in order to make it more relevant to the NHS and ensure a sustained uptake and compliance. Based on the interview study, the WHO checklist was modified for the NHS and this modified checklist was implemented by the NPSA across England and Wales.

The descriptive study of failures and problem events in operating theatres (chapter 8) highlighted some interesting facts. Teamwork failures are common in operating theatres

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accounting for 56% of all failure events in operating theatres. Technical failures occurred at a rate of one failure per case and 25% were associated with underlying teamwork failures. Equipment failures emerged as a major source of failures and disruptions in the operating theatres with strong associations to the existent level of teamwork in the operating theatres.

As equipment problems emerged as an important surrogate marker of intra-operative teamwork and patient safety, these were further explored in a multicentre study (chapter 9). Equipment problems are common in operating theatres occurring with at least one problem per case. More than half are due to unavailability of required equipment and in more than half of instances, the surgeon has to improvise and work around these problems leading to prolongation of operative period and patient harm. 40% of these equipment problems have underlying teamwork failures.

I conducted an interview study to further explore the systems factors underlying equipment failures (chapter 10) which revealed various organisational, work related and team factors. Communication failures between surgeons and nurses led to unavailability of critical equipments. Lack of co-ordination between theatre staff and hospital sterilization services led to missing equipment and re-circulation of faulty equipment. Respondents believed that there was a need to standardise communication between surgeons and nurses to pass information regarding the equipment needs prior to the day of the surgery as well as on the day of surgery. Teamwork and communication enhancing interventions such as team briefings and checklists were suggested to be beneficial in reducing these equipment problems.

Having defined intra-operative teamwork failures, technical failures and equipment problems as surrogate markers for teamwork and patient safety in the operating theatres, I evaluated the benefits of the WHO checklist use in the operating theatres and also the variability in the use of WHO checklist (chapter 11). The theatre teams were found to use the checklist variably. Some teams were performing the checks better than the others. Checks were completed in order using a checklist in only 30% of cases and all relevant team members were present during the Time-out in 63% of cases. The information exchanged during the time-out was closely associated with the equipment failures in the operating theatres. Poor information exchange between nurses, surgeons, and anesthetists was associated with higher number of equipment failures and also poorer teamwork. Cases where the checklist quality of information scores were high, theatre team members reported a significant benefit of the checklist in understanding the surgical procedure and its equipment needs and also found it helpful in running the operating theatres smoothly. The framework of intra-operative failures (Chapter 8) developed in this project established a convincing correlation between the quality of checklist use, intra-operative failures, theatre efficiency and patient safety.

It is now evident that few minutes spent using the WHO checklist in its true spirit, improves theatre teamwork and quality of information exchange and reduces equipment problems and associated threats to patient safety and interruptions in the flow of surgery.

With the studies I designed, I was able to answer the specific research questions that I posed at the outset.

Specific Research questions	Findings
Can teamwork interventions such as checklist improve patient safety and clinical outcomes?	Teamwork interventions improve patient safety processes in the operating theatres. There is a positive trend towards improvement in clinical outcomes however a very large sample size is required to achieve significant results. (Chapters 6 and 7)
What is the impact of teamwork failures in operating theatres?	Teamwork failures lead to equipment problems, technical problems, conflicts, patient harm, and theatre delays. (Chapters 7 and 8)
Can teamwork failures be measured using observational methods?	Yes, teamwork failures can be accurately measured and described using observational methods. (Chapter 8)
Can equipment problems and technical failures be measured using observational methods?	Yes, these problems can be measured, quantified and analysed using observational methods. (Chapter 8)
Are Equipment problems secondary to poor communication and teamwork?	Poor teamwork leads to equipment problems and equipment problems are a sensitive marker of teamwork failures in operating theatres. (Chapter 9 and 10)
Do Teamwork failures lead to equipment failures, technical failures and compromise patient safety?	Teamwork failures are strongly associated to equipment failures, technical failures and compromise

	patient safety and lead to theatre delays. (Chapters 8, 9, 10)
Can teamwork in the operating theatre be improved with the use of the checklist?	Yes, a well-designed and implemented checklist improves teamwork, reduces equipment failures and technical failures during surgery, reduces risk of patient harm and improves theatre efficiency. (Chapter 11)
Does the effectiveness with which the checklist is used have an impact on safety and teamwork in operating theatres?	

Therefore, this research project has proven the hypotheses that:

"Teamwork failures during surgery can lead to equipment problems, surgical delays and patient harm. A well-designed and implemented checklist intervention can improve teamwork; reduce equipment problems and patient harm during surgery."

12.2 Comments on Methodology.

In surgery, research on teamwork has been limited and predominantly based on methods and techniques used in aviation. For my studies, special emphasis was put on designing study methods that are more relevant to surgery and highlight outcomes and processes that can be used to assess surgical care at ground level. I carried out an extensive search of the literature on psychology database (Psych info), medical data bases (Pubmed, Ovid, Cochrane) and aviation (Google, psych info) to gain an insight into the current understanding of teamwork and various measures and methods used to assess teamwork. Although the concepts of teamwork are universal, I realized that assessment of teamwork has to go beyond the basic measurement or scoring of communication, coordination, leadership and its various other components described in

chapter 4. To realize the importance of teamwork in surgery, it was essential to describe the impact of these components or their absence on patient safety and efficient provision of healthcare.

The WHO checklist evaluation study was a pre-post study designed to assess the impact of a surgical checklist on patient safety processes and clinical outcomes. The theatre observation study was designed to gain insight into teamwork patterns and behaviors in operating theatres. The methods used in this study were adopted from the ethnographic methodology widely used in social sciences. Catchpole et al and Christian et al have previously used field notes to describe events and problems in operating theatres (Catchpole, Giddings et al. 2006; Christian, Gustafson et al. 2006). Similarly, Lingard et al have used field notes to observe and classify communication failures in operating theatres (Lingard, Regehr et al. 2006). However, my study has attempted to capture various problems in the operating theatres, evaluate the underlying teamwork failures, explore the association to technical failures and equipment failures and discuss the impact on patient safety and theatre efficiency, thereby assessing the entire climate of the operating theatre. Equipment problems emerged as a recurrent problem in operating theatres with strong association to teamwork failures. Therefore, it was imperative that I studied these problems more in-depth on a larger scale. The study on equipment failures described in chapter 9 is a novel study that describes these common teamwork related problems in detail combining self-reporting with field observations. The methodology was further strengthened by the use of interviews to explore the systems factors at play within the surgical systems. The quality of any observation or interview study is heavily dependent on the competence of the observers collecting the data. For this study, observers with a medical background who received training in theatre

observations, teamwork and systems factors carried out the observations and data collection. Additionally, psychologists and human factors experts contributed in refining the research methods and data analysis.

There were some limitations to these study methods that deserve a discussion. Firstly, presence of an observer within the operating theatre environment may introduce certain barriers. Hawthorn effect (Adair 1984) can be a challenge to any observation study. Acknowledging this limitation, the initial two weeks of the study period were dedicated to acclimatizing the theatre teams to the presence of an observer in the operating theatre. As predicted, initially the operating theatre teams were conscious of the presence of an observer but within a week they got used to the observer being present in the theatres and performed their tasks in the usual manner. Secondly, a dilemma faced by the observers was the necessity to intervene if an immediate threat to patient's safety was perceived. On a few occasions, I had to extend help during the surgical procedure. Although intervention on these occasions may have diluted the adverse effects of the event , such interventions were critical to patient safety and prevented adverse events. Moreover, these interventions helped the observers to blend into the theatre environment, further reducing the realization of an external observer being present.

12.3 Challenges.

12.3.1 Recruiting participants.

In healthcare, problems and error investigations have traditionally been a 'who's at fault' finding exercise. Although lately, healthcare has been moving away from the name and blame culture. Despite recent shifts towards a systems approach to errors, the staff continues to feel vulnerable and threatened. This project was essentially about exploring systems factors in operating theatres and assessing teams. In some cases, it could therefore be mistaken for an assessment of individual's performance and competence. Further, some surgeons, nurses and anaesthetists were averse to the idea of being observed. Therefore, it was very important that the purpose of the study be clarified and anonymity of data be assured. However, it was noticed that once the observer was present in the theatres with the teams for a specified trial period, they became more relaxed about being observed.

12.3.2 Implementing a quality improvement programme

Implementation of the surgical checklist during the study period and beyond was another significant challenge. In order to facilitate implementation and ensure its durability within the workflow of the operating theatre, the checklist has to be used effectively (Box 2). Three issues emerged in particular:

12.3.2.1 Developing local champions

In a healthcare system such as the NHS where the hierarchy at consultant level is rather flat, it was important to recruit local champions among surgeons and anaesthetists who would initiate the checklist in their own clinical practice and encourage their colleagues. These champions were pivotal in converting the general opinion in favour of checklist use in operating theatres. At the beginning of the process it was important to achieve a critical mass of 'positive adopters' to drive further adoption rather than insisting that everyone is engaged from the outset. 'Late adopters' were found to drop their objections to the checklist in their operating theatres over time. Forcing people to use the checklist at an early stage would only create a critical mass of influential 'negative adopters', which may lead to the checklist, or any other quality improvement intervention, falling out of use across the organisation.

12.3.2.2 Organisational leadership

The NPSA has mandated the use of the checklist but its adoption and durability is unlikely without senior leadership and backing within each organisation (Degani and Wiener 1993). Since, the trust mandated the use of the checklist within St.Mary's hospital, it is used in all the operating theatres for almost all surgical procedures. The clinical leads for various surgical departments in my trust were approached and engaged with in a discussion on how to best implement the checklist in their operating theatres. The checklists were further modified to address the specialty specific needs. Once the checklist became a hospital policy, the nurses were not only more regimented about using it but also prompted its use to the surgeons and anaesthetists more frequently as compared to the checklist study period.

12.3.2.3 Training

One of the problems encountered in the WHO checklist study was the limited time given to training and embedding the checklist. Practical issues such as confusion regarding the person who should initiate or lead the checklist, the timing of the 'Time-out' - can all be addressed by offering appropriate training in the use of the checklist. These issues may seem trivial but in our experience they can be of significant importance during the implementation stage. They can be resolved to a certain extent by the use of training videos (http://www.npsa.nhs.uk/nrls/improvingpatientsafety/anaesthesia-and-surgery/implementingthechecklist/) (NPSA 2009) and workshops led by local champions. However, ideally this should be supported through broader human factors and structured team training similar to Crew Resource Management (CRM) training in aviation (McCulloch, Mishra et al. 2009). Aviation has been using simulation-based team training to train and assess pilots and flight crews for decades.

12.4 Lessons learnt

Lessons learnt from this project are multifaceted. It is possible that the message that the checklist was modifiable by specialities and organisations was lost in our enthusiasm to drive the use of the checklist. There needs to be a stronger emphasis that the checklist is modifiable to align it to different organisations and specialities. This would address some of the scepticism associated with the checklist.

There is a possibility that the checklist may also exacerbate tensions in the operating theatre (Lingard, Regehr et al. 2008). The anaesthetists were of the view that surgeons

should be present for the 'Sign-In', while surgeons would consider that impractical as they are often either consenting (counseling) patients between cases or writing up the operative notes. However, team members should realise that checklist is only a first step in an effort to improve communication and teamwork in operating theatres. The research experience suggests that with time, as communication becomes more open with the use of the checklist, teams are likely to realise that the checklist will be more effective when some of the checks are performed before the patient is anaesthetised.

Operating theatre teams should be encouraged to measure the effect of the checklist on problems that they perceive within their daily work routine such as the equipment failures. This will facilitate increased compliance of the checklist and ensure its sustainability over years.

It is clear that as the WHO checklist is more widely disseminated and implemented, further research will be required. The use of the checklist would benefit from further evaluation on a national scale. Ultimately, sound evidence on its effectiveness along with a change in the work culture of the operating theatre could ensure successful adoption of the checklist.

12.5 Clinical impact.

Findings of this project reflect the importance of teamwork in operating theatres and how a simple and easy to use checklist can improve patient safety in operating theatres. It is encouraging to note the wide acceptance of the benefits of the checklist by the healthcare bodies such as the royal college of surgeons, royal college of anaesthetists and the NPSA, which has mandated the checklist use across all England and Wales.

Further, the studies on teamwork failures and equipment problems in operating theatres have highlighted the need for improving communication in UK operating theatres and generated a critical mass of clinicians and nurses who realize the extent and severity of teamwork related problems in operating theatres. This awareness has furthered the cause of introducing team briefings in operating theatres.

Measurement of teamwork has been largely an unexplored area of research in surgery. This thesis suggests an elaborate system of measuring teamwork in surgical teams across the NHS and highlight areas of improvement. Further, this thesis has identified surrogate markers of patient safety and efficiency in operating theatres such as technical errors, equipment failures and theatre delays that can be further developed into indicators for performance in hospital care.

12.6 Policy implications

In January 2009, NPSA announced a patient safety alert mandating the use of surgical checklist in England and Wales. The use of checklist has since become a hospital policy across the NHS. Therefore, non-adherence with the checklist may be considered a deviation from best practice, which may have medico-legal implications in case of future law suits. Similar to the use of pre-designed consent forms; surgical adherence to the checklist could potentially have an impact on the indemnity cover for hospitals and practitioners.

12.7 Future research

My thesis, which describes the extensive research undertaken on teamwork in surgery, adds onto the growing evidence on role of teamwork in making healthcare safe. Yet, the understanding of teamwork in healthcare is still in its early stages and there is further need to assess the impact of checklists and other teamwork interventions on systems factors on a national and global platform. Acknowledging this gap in the evidence, recently a national surgical checklist implementation project has been launched in UK using the measurement tools developed in this PhD research. Equipment failures emerged as a frequent and serious problem in operating theatres.

12.8 Conclusion.

This research shows that teamwork is crucial to working effectively in operating theatres. Simple interventions such as briefings and checklists improve patient safety processes, promote a culture supportive of good teamwork and make theatres safer for the patients. It questions some traditional cultural practices in healthcare and promotes an environment where patient safety is central to team functioning, blurring the boundaries and hierarchies between the healthcare professionals to promote cohesiveness and team spirit in working towards a safer surgical care provision. The interventions and measurement tools used in this project should initiate discussion and further research into the largely unexplored field of teamwork in healthcare.

The WHO surgical safety checklist is the first "team checklist" in surgery that has been developed, tested and implemented on a global scale. It could bring a change in the work culture in the operating theatre to one, which is more transparent, receptive to

quality improvement and driven by effective teamwork. The WHO checklist is not a final product but an intelligent tool that will adapt with time. Building on this project, further research, both national and international, is essential to ensure its transference to a wider clinical setting, establish its durability over time, and standardise teamwork measurement and training in surgery.

Appendices

Appendix 1: WHO surgical checklist data form

Patient Name   _____   Medical Record #_____   Study ID # _____

- -

Pre-Operative Data
                Study ID # _____

Date of Surgery __/__/____

Was the checklist used for this case?	Yes / No
Who led performance of the checklist?	Nurse Surgeon Anesthesia Provider Other:_____
Was this an urgent case (e.g. needed to be performed today or sooner)?	Yes / No
Was the wound dirty or infected?	Yes / No
Was there an open wound preoperatively?	Yes / No
Was there gross contamination of the wound (e.g. pus or stool)?	Yes / No
Were non-sterile instruments used or was there a major break in sterile technique?	Yes / No
Did patient have either two peripheral IV's or a central venous catheter with at least two ports prior to incision?	Yes / No
Was a pulse oximeter on the patient and functioning at the time of induction?	Yes / No
Was an antibiotic given?	Yes / No
If so, when? (circle one)	>60 minutes before incision 0-60 minutes before incision At or after incision
How was the patient's identity, procedure, and operative site confirmed prior to incision? (circle all that apply)	Not confirmed Confirmed in writing Confirmed verbally by the nurse Confirmed verbally by nursing, surgeon, and anesthesia

Post-Operative Data

	None Sponge Instrument Needle
Final counts performed (circle all that apply)	
Estimated blood loss (mL)	_____ mL
Lowest blood pressure after incision (mmHg)	_____ mmHg
Lowest heart rate after incision(beats/min)[†]	_____ Beats/minute

†If asystole or complete heart block occurred during the operation then mark "X" for heart rate

Did any of the following adverse events occur in the operating room?

Cardiac arrest requiring chest compressions or electrical shock   Yes / No
Unplanned intubation   or reintubation   Yes / No
Urgent tracheostomy/cricothyroidotomy   Yes / No
Placement of new central venous or arterial line after incision   Yes / No
Anaphylactic reaction   Yes / No
Malignant hyperthermia   Yes / No
Other event requiring a halt in the operation (explain): _____

Patient Name   _____   Medical Record #_____   Study ID # _____

- -
-

Additional Data
                    Study ID # _____

Patient Age   _____   Gender: Male / Female (circle one)

Surgeon _____

Procedure   _____

Mode of Anesthesia (circle one)   General anesthesia with ventilatory support

                                                            General anesthesia without
ventilatory support

                                                            Conscious sedation

                                                            Spinal, epidural, or regional

                                                            Local with sedation

Local without sedation

Other (please explain):

_____

Preoperative Diagnosis _____

Objective Airway Score   _____   1   2   3   4

        Unknown   Not Used

Which parts of the checklist were fully completed? (circle all that apply)	Sign In Time Out Sign Out

Length of Hospital Stay   _____ days

Surgical site infection (circle one)

       None / Superficial Incisional / Deep Incisional / Organ Space

Major complications (circle all that occur)

Wound Disruption	CVA/Stroke	Graft/Prosthesis/Flap Failure
Pneumonia	Coma > 24 Hours	Deep Vein Thrombosis
Unplanned Intubation	Cardiac Arrest Requiring CPR	Sepsis
Pulmonary Embolism	Myocardial Infarction	Septic Shock
On Ventilator >48 Hours	Major Peripheral or Cranial Nerve Injury	Return to Operating Room
Acute Renal Failure	Bleeding > 4 Units	Other Explain: _____

Death on day of operation

        Yes / No

In-hospital mortality

        Yes / No

Appendix 2: WHO surgical checklist interview topic guide

Participant Information Sheet

Improving teamwork in surgery

You are being invited to take part in a research study. Before you decide it is important for you to understand why the research is being done and what it will involve. Please take time to read the following information carefully.

What is the purpose of the study?

This project focuses on teamwork in the operating theatre to identify the areas for improvement in teamwork within the operation theatre. We aim to develop a briefing and checklist based intervention to enhance the team performance in the OT thereby avoiding error and improving patient safety.

As you know that St. Mary's Hospital is a pilot site to trial World Health Organisation's surgical checklist. With this interview we want to assess what are the expert users' opinion regarding WHO checklist as a patient safety improvement tool.

Why have I been chosen?

We hope to recruit a total of 15 members of theatre team. Surgeons, anaesthetists and nursing staff will be equally represented in our sample.

Do I have to take part?

It is up to you whether or not to take part. If you decide to take part, you will be given this information sheet to keep and be asked to sign a consent form. If you decide to take part, you are still free to withdraw at any time and without giving a reason.

What will happen to me if I take part?

You will be interviewed for approximately 30-45 mins on your experiences in the operation theatre. and your ideas for further improvement in patient safety.

What is the interview aiming to do?

This will provide information about the interventions that need to be developed to enhance teamwork in the OT.

What are the possible disadvantages and risks of taking part?

We do not foresee any disadvantages of taking part in the study, other than the time required for the interview.

What are the possible benefits to taking part?

The aim of the project is to provide an efficient environment in the OT where the team members can work in cohesion. In this way, performance will be enhanced thereby improving clinical safety. On an individual level, engaging in this discussion may help you think more about your personal responses to teamwork thereby increasing your own awareness.

What if something goes wrong?

We do not foresee anything going wrong. However if there are any problems, you are free to terminate your participation at any time

Will my taking part in this study be kept confidential?

All the data we collect from you will be anonymised by allocating you a code. Any paperwork containing your identity (consent form and registration form) will be kept separate to anonymised data collected during the study. If there are any audio or video recordings, they will only be used by the project team to supplement the study data collection and will be stored in a secure manner.

What will happen to the results of the research study?

The results will be presented in departmental meetings, international conferences and peer reviewed journals. All data presented will be anonymous.

Who is funding the research?

This research is funded by NIHR

Contact for further information

For more information, please contact;

Amit Vats

email: amit.vats@imperial.ac.uk

Krishna Moorthy:

Email: k.moorthy@imperial.ac.uk

DRAFT INTERVIEW SCHEDULE

EXPLORING THE CAUSES OF EQUIPMENT/ TECHNOLOGY FAILURES IN THE OPERATING THEATRE

DATE_____   INTERVIEW REFERENCE NUMBER_____

INTERVIEWER_____   CONSENT FORM SIGNED _____

PROFESSION OF INTERVIEWEE_____

INTRODUCTION

Themes

1. Identify key patient safety issues

   a) What are your concerns regarding the safety of the patients in the operating theatre?
   b) Have you faced any situations where your patient's safety was compromised due to lack of teamwork and communication in the OT? Can you give me a specific example and talk me through it.

2. Identify strategies to counter the issues

   a) Do you take any measures to ensure that you do not face similar situations again?
   b) What is the scope for improving teamwork and communication and thereby, patient safety in the theatre and how?

3. Relevance of Checklist

   a) What are the benefits of the WHO checklist in your experience?
   b) What are the shortcomings of the WHO checklist in your experience?

c) How do you think that checklist will improve teamwork, communication and patient safety in the theatre?
d) What are the barriers to implementation and long-term sustenance of checklist in the theatres?
e) What items would the checklist contain if you were to design it?
f) What stage of the checklist should these items be in?
g) Would you support a checklist that addresses the issues you are concerned about?
h) Who should conduct the checklist and when during the operation should it be used?

Appendix 3: NPSA adaptation of WHO checklist for England and Wales

WHO Surgical Safety Checklist
(adapted for England and Wales)

National Patient Safety Agency
National Reporting and Learning Service
NHS

SIGN IN (To be read out loud)
Before induction of anaesthesia

Has the patient confirmed his/her identity, site, procedure and consent?
☐ Yes

Is the surgical site marked?
☐ Yes/not applicable

Is the anaesthesia machine and medication check complete?
☐ Yes

Does the patient have a:
Known allergy?
☐ No
☐ Yes

Difficult airway/aspiration risk?
☐ No
☐ Yes, and equipment/assistance available

Risk of >500ml blood loss (7ml/kg in children)?
☐ No
☐ Yes, and adequate IV access/fluids planned

PATIENT DETAILS

Last name:
First name:
Date of birth:
NHS Number:*
Procedure:

*If the NHS Number is not immediately available, a temporary number should be used until it is.

TIME OUT (To be read out loud)
Before start of surgical intervention
for example, skin incision

Have all team members introduced themselves by name and role?
☐ Yes

Surgeon, Anaesthetist and Registered Practitioner verbally confirm:
☐ What is the patient's name?
☐ What procedure, site and position are planned?

Anticipated critical events
Surgeon:
☐ How much blood loss is anticipated?
☐ Are there any specific equipment requirements or special investigations?
☐ Are there any critical or unexpected steps you want the team to know about?

Anaesthetist:
☐ Are there any patient specific concerns?
☐ What is the patient's ASA grade?
☐ What monitoring equipment and other specific levels of support are required, for example blood?

Has the surgical site infection (SSI) bundle been undertaken?
☐ Antibiotic prophylaxis within the last 60 minutes
☐ Patient warming
☐ Hair removal
☐ Glycaemic control

Has VTE prophylaxis been undertaken?
☐ Yes/not applicable

Is essential imaging displayed?
☐ Yes/not applicable

SIGN OUT (To be read out loud)
Before any member of the team leaves the operating room

Registered Practitioner verbally confirms with the team:
☐ Has the name of the procedure been recorded?
☐ Has it been confirmed that instruments, swabs and sharps counts are complete (or not applicable)?
☐ Have the specimens been labelled (including patient name)?
☐ Have any equipment problems been identified that need to be addressed?

Surgeon, Anaesthetist and Registered Practitioner:
☐ What are the key concerns for recovery and management of this patient?

This checklist contains the core content for England and Wales

www.npsa.nhs.uk/nrls

Appendix 4: Equipment problem self report form

Equipment Problem	Type of equipment problem (please circle)	How was the problem dealt with (please circle)	Did the problem impact on flow of surgery (please circle)	Did the problem threaten patient safety (please circle)
	1. Not available. 2. Faulty. 3. Wrong use of equipment. 4. Lack of knowledge on how to use	1. Equipment added 2. Equipment replaced/ fixed. 3. Work around the problem.	1. No impact. 2. Minor (less than 5 min) 3. Moderate (between 5min and 30 min). 4. Severe (more than 30 min). 5. Surgery cancelled.	1. No threat. 2. Minor threat. 3. Moderate threat. 4. Adverse event. 5. Severe adverse event.

Reason for problem:

Equipment Problem	Type of equipment problem (please circle)	How was the problem dealt with (please circle)	Did the problem impact on flow of surgery (please circle)	Did the problem threaten patient safety (please circle)
	1. Not available. 2. Faulty. 3. Wrong use of equipment. 4. Lack of knowledge on how to use	1. Equipment added 2. Equipment replaced/ fixed. 3. Work around the problem.	1. No impact. 2. Minor (less than 5 min) 3. Moderate (between 5 min and 30 min). 4. Severe impact (more than 30 min). 5. Surgery cancelled.	1. No threat. 2. Minor threat. 3. Moderate threat. 4. Adverse event. 5. Severe adverse event.

Reason for problem:

Equipment Problem	Type of equipment problem (please circle)	How was the problem dealt with (please circle)	Did the problem impact on flow of surgery (please circle)	Did the problem threaten patient safety (please circle)
	1. Not available. 2. Faulty. 3. Wrong use of equipment. 4. Lack of knowledge on how to use	1. Equipment added 2. Equipment replaced/ fixed. 3. Work around the problem.	1. No impact. 2. Minor (less than 5 min) 3. Moderate (between 5min and 30 min). 4. Severe (more than 30 min). 5. Surgery cancelled.	1. No threat. 2. Minor threat. 3. Moderate threat. 4. Adverse event. 5. Severe adverse event.

Reason for problem:

Appendix 5: Equipment problems- interview topic guide

DRAFT INTERVIEW SCHEDULE

EXPLORING THE CAUSES OF EQUIPMENT/ TECHNOLOGY FAILURES IN THE OPERATING THEATRE

DATE_____   INTERVIEW REFERENCE NUMBER_____

INTERVIEWER_____   CONSENT FORM SIGNED _____

PROFESSION OF INTERVIEWEE_____

INTRODUCTION

As you know, we are studying the nature, frequency and causes of surgical equipment/ technology failures in theatre during surgical interventions. This is part of our study into the reliability of healthcare systems. The overall aim of the study is to identify the systems factors involved so that these equipment failures can be avoided. We are studying this in three different hospitals and interviewing a sample of staff in each of these hospitals. I would therefore like to ask you a series of questions about the factors due to which you feel equipment and technology failures occur in theatre. The interview should take around 20 minutes.

As the participant information leaflet explains, your participation is entirely voluntary and you are free to withdraw. If you do not wish to answer any particular question, then please just say so. There are no right or wrong answers and I am interested in your own personal point of view. The identities of all participants will remain strictly confidential and it will not be possible to identify individual members of staff, clinical teams or hospitals from the final results.

Would you mind if I taped our conversation so that I do not have to write everything down?

Do you have any questions before we begin?

QUESTIONS

Opening questions for non-medical staff

Can you tell me about your job in this department?

When did you start working for this department?

Opening questions for surgeons

How long have you been a surgeon here?

When did you start working in this specialty?

How often do you think surgeons have problems with surgical equipment during a surgical intervention (e.g. missing or broken equipment)?

[This question will allow us to explore the baseline point of view of the participant regarding the reliability of the system]

Could you give us an example of an incident during a surgical procedure that you have been aware of or witnessed whereby surgical equipment was missing or broken?

Why do you think this occurred?

Where do you think the system is going wrong in this specific example?

Is there any specific equipment or any specific specialty where this issue is particularly common?

At what stage along the process of ordering to delivery of an equipment to theatre you think there may be a problem? (e.g. TSSU, ordering, booking, storage, loan equipment etc.)

Why do you think this process is unreliable – where are things going wrong in the system?

What needs to be done to put it right?

Could you suggest any solutions?

Do you think there may be processes or systems missing or need improving? (e.g. reporting of missing or broken surgical instruments, better surgical instrument tracking during sterilisation, ordering of loan equipment by locum doctors etc.)

Why do you think this process frequently fails – where are things going wrong in the system?

What needs to be done to put it right?

Could you suggest any solutions?

These are some examples of surgical equipment/ technology failures we have found.

Why do you think these types of error occur?

Are there procedures to follow in order to book, order and check surgical equipment?
How useful are these?
Are they always followed [*if 'no' then explore why*]

Are there communication problems between departments that contribute to surgical equipment/ technology failures? [*explore where and why*]

Are there environmental issues – such as not enough equipment storage space within the theatre premises?

How reliant on staffing levels are the processes to order, check and maintain surgical equipment?
 How do you think these problems can be reduced or prevented?

ENDING

Thank you very much for your time and for being willing to talk to me. Your comments have been very helpful and will be used together with those of the other participants to gain an understanding of surgical equipment failures and why they occur.

Appendix 6: WHO checklist usability data form

1. Checklist used	Yes/ No
2. Time out	**Yes/ No**
a. Timing	Before prepping/ draping the patient Before skin incision After skin incision
b. All items completed using checklist	Yes/ No
c. Items checked	1) Patient ID 2) Procedure and site marked 3) Anticipated difficulties 4) Expected blood loss 5) Blood crossmatch/group and save needed or available 6) Special equipment/investigations required 7) Patient-specific concerns 8) Equipment required for procedure available 9) Antibiotic prophylaxis 10) Pressure point(s) check 11) DVT prophylaxis 12) Intra-operative warming 13) Essential/relevant imaging displayed
d. All items completed in order	Yes/ No
e. Time taken to complete Time out	
f. Who led the Time out (Circle)	Nurse Anaesthetist Anaesthesia trainee Surgeon Surgical assistant ODP Other
g. Members present for Time out (Circle)	Nurse Circulating Nurse Anaesthetist Anaesthesia trainee Surgeon Surgical assistant

	ODP Radiologist (expected?)
h. Did all team members pause to do Time out	Yes/ No
i. Team introduction	1. Not completed 2. Completed with team resistance or ridicule 3. Completed but not all team members introduced 4. Completed appropriately
j. Surgical information	1. Resistance from team members to exchange information 2. Team members distracted by tasks at hand 3. Minimal exchange of information 4. Relevant information exchanged 5. Good information exchange and encouraging other team members
k. Anaesthetic information	1. Resistance from team members to exchange information 2. Team members distracted by tasks at hand 3. Minimal exchange of information 4. Relevant information exchanged 5. Good information exchange and encouraging other team members
l. Nursing information	1. Resistance from team members to exchange information 2. Team members distracted by tasks at hand 3. Minimal exchange of information 4. Relevant information exchanged 5. Good information exchange and encouraging other team members

Appendix 7: Checklist usability self report form

NURSE TO COMPLETE

Did any team member suffer an injury?   Yes / No

Complete patient notes available before the procedure?   Yes / No

Signed consent form available prior to surgery?

Yes / No

Any investigation/imaging unavailable?

Yes / No

Did you find the WHO surgical checklist useful for this case:

    a) In understanding the surgical procedure being performed   Yes / No
    b) In understanding the equipment needs for the procedure   Yes / No
    c) In understanding the patient's condition and risks   Yes / No
    d) In running the operating theatre efficiently   Yes / No

For this case, on a scale of 1 to 5 (where 1 is poor information sharing and 5 is relevant or good information sharing), how would you rank?

The information exchanged by the surgeon during the time out	1-------2-------3-------4-------5
The information exchanged by the Anaesthetist during the	1-------2-------3-------4-------5

time out	
The information exchanged by the Nurse during the time out	1------2------3------4------5

SURGEON TO COMPLETE

Name   of   Procedure   performed
_____

Any team member missing when required?   Yes   /   No

Did you need to revise any critical surgical steps?

(E.g.:   redoing   anastamosis/   retying   slipped   knots   and   sutures)
        Yes / No

Please
mention_____
_____

Any   iatrogenic   injuries   during   the   surgery?
        Yes / No

Please
mention_____
_____

More than expected blood loss?   Yes / No

Was it a difficult surgery?   Yes / No

Did the surgery take longer than expected time to perform?   Yes / No

What was the reason for the difficulty or increased duration of the procedure?

    a) Patient anatomy
    b) Equipment problems
    c) Poor scrub nurse assistance
    d) Poor surgical assistance
    e) Any   other   (Please   explain   briefly)

    _____

Did you find the WHO surgical checklist useful for this case:

    a) In understanding the surgical procedure being performed   Yes / No
    b) In understanding the equipment needs for the procedure   Yes / No
    c) In understanding the patient's condition and risks   Yes / No
    d) In running the operating theatre efficiently   Yes / No

For this case, on a scale of 1 to 5 (where 1 is poor information sharing and 5 is relevant or good information sharing), how would you rank

The information exchanged by the surgeon during the time out	1-------2-------3-------4-------5
The information exchanged by the Anaesthetist during the	1-------2-------3-------4-------5

time out	
The information exchanged by the Nurse during the time out	1------2------3------4------5

ANAESTHETIST TO COMPLETE

Section 1

Patient's ASA grade   1   2   3
4

Did the patient have an unplanned hypotension or tachycardia during the procedure which was difficult   to   control   ?
       Yes / No

Unplanned   intubation/   airway   problems   during   the   surgery?
       Yes / No

Unplanned   I/V   access   required   during   the   surgery?
                                                                Yes / No

Did the patient have hypothermia during the procedure?   Yes / No

Any other anaesthetic problems/ complications in this case?   Yes
/ No

If yes to any questions please explain briefly

_____

_____

Did you find the WHO surgical checklist useful for this case:

    a) In understanding the surgical procedure being performed   Yes / No

    b) In understanding the equipment needs for the procedure   Yes / No

    c) In understanding the patient's condition and risks   Yes / No

    d) In running the operating theatre efficiently   Yes / No

For this case, on a scale of 1 to 5 (where 1 is poor information sharing and 5 is relevant or good information sharing), how would you rank

The information exchanged by the surgeon during the time out	1-------2-------3-------4-------5
The information exchanged by the Anaesthetist during the time out	1-------2-------3-------4-------5
The information exchanged by the Nurse during the time out	1-------2-------3-------4-------5

Appendix 8: Snapshots of theatre observation spreadsheets (Chapter 8)

Case 1	Agree	Distraction	Communication	Situational awareness	Shared mental	Lack of Planning	Lack of Knowledge	coordination	Technical Failure	EquipmentFailure	Effect on surgery	Effect on safety
one screen not functioning	1									1	2	1
1:35pm Readjustment of the screens	1							1			3	2
1:36pm, someone accidentally turned off the insufflator, sister reconfigured it	1			1						1	3	2
Surgeon asked about certain endoGIA, not available. Nurse had to go out to check in stores	1				1					1	1	2
Screens need repositioned	1				1						1	1
Scrub nurse did not know how to assemble harmonic scalpel.	0						1			1	3	2
Circulating nurse has to put on sterile gloves to show her how to do it.Se only put the sterile gloves without hand washing or gowning. Surgeon waits while nurses sort it.	1							1			3	3
Harmonic scalpel, still not working, controls adjusted. Problem fixed.	1									1	3	2
(S-N-C) confusion regarding the type of Endo GIA needed, whether Universal or reticulated. Unclear communication.	1		1								2	2
No small refills available for endoGIA. Alternate refills used.	1				1					1	2	2
N checks the cuttig scissors and notices it is faulty. S asks for cutting scissor, N hands over the same scissors. SA tries cutting the suture with it but it doesn't work. Tells her its not working, give me another one.	1							1			2	1
Faulty cutting scissors	1									1	2	1
S asks for 2-0 vicryl, not available, works around with altrnate suture	1									1	2	2
S asks for forceps but doesnot specify which ones	0		1								2	3
S asks for froceps, for ileostomy, N gives him toothed forceps. S notices and tells he he wants Debakey's forceps	0			1				1			1	3
S wants 3-0 moncryl with round body needle for ileostomy suture, not available, uses another suture but not happy as the alternate suture not ideal.	1									1	2	2
Wrong patient sent for but Surg Reg available who rectified the mistake	1		1								2	2
confusion regarding availability of HDU bed which led to case delay	1		1								3	1
Surgeon and Reg not available at patient transfer to table. 5min delay	1							1			2	1
Surgeon did not know who was assisting him for the case. HO informed That Reg will be helping	1		1								1	1
Surgeon wanted to tape the patient to the table but he and Anaesthtist not sure how to. Asked sister if she knew how to but she didn't.They improvised.	0			1							2	2
Patient on the table. Surgeon not happy with the position. Asks sister if she had a bean bag as he will be tilting the patient. Nuse brings it. Patient is lifted off the table bean bag placed. Delay in proceeding.	1		1								4	2
Surgeon tried retaping patient to table, no tape available, nurse gets it from outside.	1									1	1	1
Theatre manager came to talk admin with the sister during the case	1	1									1	1
Surgeon briefed research fellow instead of the wholw team	1		1								3	3
4 different conversations going on in the theatre, none related to surgery	1	1									1	1
1:50pm, consulting surgeon also srubbed to assist as case difficult. Different conversations going on in the theatre while surgeon taking opinion. He had to as them to be quiet.	1	1									3	1
C asks N why did you not tell me that you had put the harmonic on hand settings. N told C that she didn't know	0							1			3	2
HO comes to discuss case with SA, he told her, I cn't right now discuss, come later			1								1	1

Appendix 9: Snapshot of equipment problem analysis spreadsheet (Chapter 9)

Case	Site	Theatre	Date	Procedure	NO of problems	Equipment Problem	S	Type	S how dealt with	impact on surgery	S Impact on safet
1			06/07/2009	reconstruction R knee			0	1	0	0	0
226	A	2	04/08/2009	orth			0	1	0	0	0
227	A	2	04/08/2009	orth			0	1	0	0	0
228	A	2	04/08/2009	orth			0	1	0	0	0
229	A	2	04/08/2009	orth			0	1	0	0	0
						Missing screw	1	1	1	2	2
230	A	2	02/08/2009	orth	2	Bipolar lead & forcep	1	2	1	4	3
						Wrong Screw Driver	1	1	3	4	4
231	A	2	14/09/2009	orth	2	not enoug h wires available	1	1	3	2	1
232	A	2	11/09/2009	orth			0	1	0	0	0
						Anthroscopy telescope	1	2	2	3	3
233	A	2	04/09/2009	orth	2	Shaver	1	2	2	2	2
234	A	2	25/08/2009	orth			0	1	0	0	0
235	A	2	21/08/2009	orth			0	1	0	0	0
236	A	2	20/08/2009	orth	2	Retractor Root missing & lead bipolar	1	1	3	1	1
237	A	2	25/08/2009	orth			0	1	0	0	0
238	A	2	25/08/2009	orth			0	1	0	0	0
239	A	2	21/08/2009	orth	1	osteotomy stille 6mm missing	1	1	3	1	1
240	A	2	21/08/2009	orth			0	1	0	0	0
241	A	2	21/08/2009	orth			0	1	0	0	0
242	A	2	20/08/2009	orth	1	Glalabin Missing	1	1	3	1	1
243	A	2	17/08/2009	orth			0	1	0	0	0
244	A	2	18/08/2009	orth			0	1	0	0	0
245	A	2	18/08/2009	orth			0	1	0	0	0
246	A	2	18/08/2009	orth	2	46x16MWA246 missing & Template M'	1	1	3	1	1
247	A	2	19/08/2009	orth			0	1	0	0	0
248	A	2	19/08/2009	orth			0	1	0	0	0
249	A	2	17/08/2009	orth			0	1	0	0	0
250	A	2	17/08/2009	orth			0	1	0	0	0
251	A	2	13/08/2009	orth			0	1	0	0	0
252	A	2	14/08/2009	orth			0	1	0	0	0
253	A	2	14/08/2009	orth	1	Quiver Diatheramy missing	1	1	3	1	1
254	A	2	14/08/2009	orth	1	Quiver Diatheramy missing	1	1	3	1	1
255	A	2	13/08/2009	orth			0	1	0	0	0
256	A	2	12/08/2009	orth	1	Zimmer Clip Missing	1	1	3	1	1
257	A	2	08/09/2009	orth			0	1	0	0	0
258	A	2	08/09/2009	orth			0	1	0	0	0
259	A	2	08/09/2009	orth			0	1	0	0	0
260	A	2	02/09/2009	orth			0	1	0	0	0
261	A	2	04/09/2009	orth	1	Samll fragment 6+7 hole plate missing	1	1	3	2	2
262	A	2	12/08/2009	orth			0	1	0	0	0
263	A	3	03/11/2009	EUA			0	1	0	0	0
264	A	3	03/11/2009	EUA			0	1	0	0	0
265	A	3	26/10/2009	TAHBSO			0	1	0	0	0
266	A	3	26/10/2009	MYOMECTOMY			0	1	0	0	0
267	A	3	21/10/2009	TCRF	1	Irrigation Flow Unsatisfactory	1		3	3	2
268	A	3	21/10/2009	LAP CHOLE	1	Laparoscopic Graspers	1	2	1	2	1
269	A	3	21/10/2009	Lap Ant Resection			0	1	0	0	0
270	A	3	13/10/2009	Debridement, Skin Graft			0	1	0	0	0

Appendix 10: List of research subject related publications/ submitted manuscripts

Vats A , Deelchand V , Nagpal K , Burnett S , Franklin BD, Vincent CA, Moorthy K. Equipment related problems in UK operating theatres - A multicentre study. Revision and submission to BJS.

Vats A, Nagpal K, Albayati M A, Sevdalis N, Darzi A, Vincent CA, Bicknell CD, Moorthy K. An observational study of teamwork failures in operating theatres. Previously submitted to Annals of surgery.

Vats A, Vincent C, Nagpal K, Davies R, Darzi A, Moorthy K. Practical challenges of introducing WHO surgical checklist: UK pilot experience, British Medical Journal, Jan 2010

Vats A, Nagpal K, Moorthy K. Surgery - a risky business. Journal of Perioperative Practitioners 2009.

Haynes AB, Weiser TG, Berry WR, et al. A surgical safety checklist to reduce morbidity and mortality in a global population. New England Journal of Medicine 2009.

Nagpal K, Vats A, Lamb B, Ashrafian H, Sevdalis N, Vincent C, Moorthy K. Information transfer and communication in surgery: a systematic review. Ann Surg. 2010.

Morbi AH, Hamady MS, Riga CV, Kashef E, Pearch BJ, Vincent C, Moorthy K, Vats A, Cheshire NJ, Bicknell CD. Reducing error and improving efficiency during vascular interventional radiology: implementation of a preprocedural team rehearsal. Radiology. 2012.

Nagpal K, Arora S, Vats A, Wong HW, Sevdalis N, Vincent C, Moorthy K.Failures in communication and information transfer across the surgical care pathway: interview study.BMJ Qual Saf. 2012.

Nagpal K, Abboudi M, Fischler L, Schmidt T, Vats A, Manchanda C, Sevdalis N, Scheidegger D, Vincent C, Moorthy K. Evaluation of postoperative handover using a tool to assess information transfer and teamwork. Ann Surg. 2011.

Haynes AB, Weiser TG, Berry WR, et al Group.Changes in safety attitude and relationship to decreased postoperative morbidity and mortality following implementation of a checklist-based surgical safety intervention. BMJ Qual Saf. 2011.

Nagpal K, Vats A, Vincent C, Moorthy K. A systems approach to errors. Surgery 2009.

Nagpal K, vats A, Ahmed K et al. A Systematic, Quantitative Assessment Of Risks Associated With Poor Communication In Surgical Care. Archives of Surgery 2010.

Nagpal K, Vats A, An Evaluation of Information Transfer Through the Continuum of Surgical Care: A Feasibility Study. Annals of Surgery 2010.

Nagpal K, Arora S, Vats A et al.Failures in communication and information transfer across the entire surgical care pathway: a systematic qualitative study. Annals of Surgery 2010.

Appendix 11: List of relevant subject related international presentations

Teamwork errors in surgery lead to technical errors disruption of surgery and patient harm. Vats A, Bicknell C, Blanco GA, Nagpal K, Moorthy K. ASGBI 2010, Liverpool

Evaluation of the WHO checklist on patient safety in surgery-pilot study. Vats A, Nagpal K, Davies R, Vincent C, Darzi A, Moorthy K. ASGBI 2009, Glasgow

Evaluation of the drivers and barriers to successful implementation of the WHO surgical checklist. Vats A, Nagpal K, Ahmed K, Benn J, Davies R, Darzi A, Vincent C, Moorthy K. International Forum, 2009, ICC, Berlin

Effect of WHO surgical checklist on teamwork and operating theatre efficiency. Vats A, Nagpal K, Sevdalis N, Vincent C, Moorthy K. International Forum, 2009, ICC, Berlin

Does teamwork improve with WHO surgical checklist. Vats A, Nagpal K, Sevdalis N, Vincent C, Moorthy K.SARS 2009, Bristol

Interactive gaming based E-learning curriculum- A novel technique to improve patient safety awareness in medical schools. Vats A, Sacks M, Nagpal K, Moorthy K. International forum on Quality and Safety in healthcare 2010, Nice, France

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