Team Performance in the Operating Theatre

A thesis presented for the degree of Doctor of Philosophy (PhD) at the University of London

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This thesis is dedicated to my mother Padma Undre who sadly is not with us anymore to share this achievement. I know this would have made her very proud.

Abstract

Teamwork in surgery is one of the important aspects of good practice and important for safety in surgery. For team work to be optimised, assessment measures and training interventions are necessary. High reliability organisations have stressed the importance of teamwork for safety and regularly provide such training to their team members. This thesis discusses important aspects of team research in high risk environments and discusses its application to surgery. It also describes the development of a comprehensive assessment for teamwork in surgery – namely the Observational Teamwork Assessment for Surgery (OTAS). This tool was tested it in 50 general surgical and, following extensive modification, in 50 urology procedures. The OTAS tool comprises a task checklist centred on patient, equipment and communications tasks, and ratings on team behaviours, namely: communication, co-operation, co-ordination, shared-leadership and monitoring. Results showed that in the task completion, a number of communication and equipment/provisions tasks were not routinely performed. Regarding teamwork-related behaviours, adequate reliability was obtained in the scoring of behaviours. In sub team behaviours, anaesthetists and nurses obtained their lowest scores on communication. Surgeons' scores revealed a more complex pattern. In addition to low scores on communication, surgeons' teamwork behaviours appeared to deteriorate as the procedures were finishing. These findings indicate that there is room for improvement in teamwork in surgery. Several training interventions such as the use of crisis simulations during simulated operations for team training, pre-operative team briefing and check listing have been developed and piloted. They are also discussed in this thesis. Team training interventions such as briefing can be easily applied to routine surgery to enhance communication and team working in theatre. Above all it is hoped that this thesis provides a first step towards developing successful team training programs based on a systems theory to improve safety and efficiency in surgery.

Contents

Overview

Surgical competence consists of various facets. Dexterity or technical skills, decision making and team skills are some of them. All of these factors have been poorly assessed but most emphasis is placed on knowledge which was the only component that could be tested until recently. This is usually done by oral and written components of a formal exam. The rest of the assessment traditionally tends to be subjective and based on the perceptions of the tutors or head of department where the trainee surgeon works. Many surgical units across the globe have realised the importance of the need to assess the other factors if surgical outcome has to be improved on the whole. Much of this stems from litigation and increased public awareness and expectation and also from a desire to be fairer on the trainees that are being assessed. Furthermore doctors are also expected to be revalidated which further increases the need for assessment methods in the various competencies.

Our unit has adopted the systems view that there are different contributory factors which leads to a successful or unsuccessful surgical outcome. Much work has gone into developing assessment tools for surgical skill in terms of technical ability or dexterity. Teams have been studied extensively in other high risk environments such as aviation, nuclear power plants, oil rigs and air traffic control, following an increase in numbers of accidents in those fields, in an attempt to reduce errors and improve safety. There is yet much work to be done into team work in surgery. Only recently has there been some development of research into the other important factors including team work in surgery.

The main aim of this thesis was to study the work done in teams in other industries and study the various methods of teamwork assessment and training in an attempt to develop team assessment measures for surgery. I hope to develop a model of teamwork assessment which would be applicable to any branch of surgery and with some modification. The further aim of this thesis was to test the feasibility of this assessment method and conduct reliability studies. The ultimate aim of this line of work is to develop team training interventions to enhance team performance in the operating theatre and improve safety.

The future direction of this thesis and indeed work which will emerge out of this thesis and follow on will be to further develop team training interventions to improve the safety and efficiency in surgery. The team assessment tool will be also be used to test the effect of various interventions to improve teamwork in surgery.

In the following chapters I will cover the important aspects of surgery, surgical skills, surgical outcome and adverse events in surgery. To enable the reader to fully grasp the issues involved I will briefly cover subjects such as the history of surgery, and team composition concentrating mainly on theatre teams and not teams in general in healthcare. This will be followed by a literature review on subjects pertaining to teamwork, such as the nature of teams, mental models, human factors, team dynamics, and Crew Resource Management (CRM). The thesis will then go on to discuss the development of measures of team performance and describe the development of our team assessment tool along with feasibility and reliability studies.

The empirical chapters start with describing an interview study which was the first study conducted. I first set out to assess the current perception of team work in the operating theatre groups of our hospital. A semi structured interview was designed, based on the important factors from other industries that had assessed team work. Diagrams of models representing team structures were added to aid the participants. The interviews were conducted by a single interviewer with strict interviewing protocol which was laid down in writing. The participants were recruited on a voluntary basis. Each interview took approximately 20 minutes. 24 interviews were conducted with 6 members from each of the operating theatre group (surgeons, nurses, operating department practitioners and nurses). Following the analysis of the interview data it was evident that there was no defined team structure nor was there any agreement on what the ideal team structure should be. Most people did agree that communication was a key aspect of good team work yet it was deficient in certain areas. The interview questionnaire is attached in the appendix and the details of the study are described in detail in chapter 5.

Following the interviews and after reviewing the literature available on team work assessment a model of team work was developed. The reason for developing a new model was that there was no model available in the literature which could be directly translated into healthcare or surgery. The team assessment tool was developed after extensive research into existing guidelines, protocols and current practices in theatre. Further insight was gained from the perceptions of good team work from the interview data. We chose to work from an input process-outcome-model using and divided the tool into a task based checklist and a behavioural component which were designed to be assessed by a surgeon and a psychologist. Tasks were developed by domain knowledge and after consultation with other domain experts along with pilot observations and the use of multiple sources on best practice. The behavioural constructs were adapted from similar research in other high risk domains. The dimensions we chose to assess were communication, coordination, cooperation, leadership and situation awareness or monitoring. The operative phase was divided into stages and phases to facilitate data collection. After the initial familiarisation with the theatre environment and explanation of the various stages and phases the two observers collected data from 50 operations from a single theatre in a single teaching hospital. The operations were a mix of general surgical operations both open and laparoscopic of varying complexity. For the purpose of simplification of the process we set cut of times for the duration of the operation between a minimum of 30 minutes to a maximum of 4 hours. The details of what observer 1 and observer 2 collect are in the OTAS manual in the appendix. Data was collected from this series of 50 operations. The details of OTAS developments and results are described in chapters 6 and 7. The distractions and environmental aspects of the original assessment tool OTAS were extracted and converted into an independent study the details of which will not be covered by this thesis.

After analysis of those results the checklist and behaviour constructs were modified to enable ease of transfer to other specialities. Following the initial data collection the OTAS tool was modified for ease of use. To ascertain if the checklists were adequate for the purpose interviews were conducted with 3 surgeons 3 anaesthetists and 3 senior nurses. The original task list was presented to the participants along with specific instructions on the inclusion and exclusion criteria. The details of the criteria are included in appendix of the thesis. The behavioural aspects were retained and made simpler by adding examples and demonstrative scenarios so that the behaviours could be scored by another observer after a minimal training period. These were constructed after extensive discussion between 2 surgeons and 3 psychologists familiar with the original behavioural dimensions. The constructs are described in appendix. The new version was called OTAS II and was tested in a different theatre setting (urology theatre).

As part of the training process other observers were also trained in the use of this tool. A brief explanation of the training process for the human factors observer along with some reliability studies have been discussed in chapter 8. Training for Observer 1 also took place and data was collected for yet another study called the integrated project which encompassed all the various aspects of research from the clinical safety research group but the results from this study have been excluded from this thesis.

Alongside the analysis of results from the first 50 cases and completion of that phase of the research, began the development of the interventional aspects of team work and team training in the operating theatre. The first step of this consisted of development of a briefing survey questionnaire. Questionnaires were distributed to the various groups of theatre personnel. They was further distributed to two other centres in the UK to establish differences in perceptions and attitudes to such an intervention across the country, the results of the briefing survey have been excluded from this thesis. The briefing questionnaire however is available in the appendix and the study has been briefing described in chapter 10.

Based on work carried out in our department previously using the virtual operating theatre and simulation based training I recruited a core group of theatre personnel responsible for training of the various domains. The simulation group consisted of a consultant anaesthetist, consultant surgeon, ODP trainer, senior nurse trainer, two psychologists. The group was coordinated by me and the aim was to develop a multi disciplinary simulation based team training module for theatre staff. The scenario used was previously validated sapheno-femoral junction ligation using bleeding as a crisis for the surgeon. The manikin that was used was a moderate fidelity anaesthetic simulator called SimMan (Laerdal, UK). Pre determined crises were used for the entire team such as 1) difficult intubation or rapid sequence anaesthesia for the anaesthetic trainees; 2) faulty tubing, missing valves and air in the drip set for the ODP; 3) unsterile instruments, missing swabs and faulty equipment for the scrub nurse and 4) bleeding for the surgeon. Further the entire team was given a crisis such as on table cardiac arrest to deal with at a defined point in the simulation. Trainees were given feedback on their performance and the group received team feedback after the session. Further details are described along with the results in chapter 10.

Developing the simulations further and drawing on the information from the briefing questionnaire and drawing on CRM training in other industries such as aviation we developed a briefing and check-listing simulation module which consisted of 2 simulations with a training session on briefing and check-listing between the two. The full description of the briefing and check listing simulation based training and the results will not be described in this thesis but it has been written up for publication in a peer reviewed journal. A brief description and summary of the results are available in chapter 11.

Future research to which will emerge from this work is validation of the OTAS tool, assessment of the effect of using team training interventions such as briefing and check-listing in real theatres, assessment of the effect of crisis simulations. The ultimate aim of the interventions should be an overall improvement in safety attitudes of personnel and improved surgical outcome which may be difficult to measure and is outside the scope of the current thesis. Further aspects to be studied include the assessment of sub team and intra team behaviours which has been explored to some extent in the urology study. In addition the team training will have to be developed further and standardised so that it may be included as part of the core curriculum for various stages of training for operating theatre teams. I hope that the team assessment tool will be of benefit to anyone wishing to study teams. Furthermore the team interventions will also be a valuable asset to theatre teams wishing to train teams and improve efficiency and outcome. The key findings and future direction of this work will be discussed fully in the last chapter.

Thesis Aims

1. To understand the nature of teams and draw on teams research in other high risk industries such as aviation.
2. To understand surgical outcomes and errors and the need to study surgical teams.
3. To understand the components, models and measurement of teamwork.
4. To understand the principles of CRM and team training programs in other industries.
5. To explore the current perceptions of team work among the members of the operating theatre team (Surgeons, Anaesthetists, Nurses and ODPs). This will be conducted by means of a semi-structured interview.
6. To carry out a task analysis of the surgical process and gain understanding of the guidelines and protocols for standard operating procedures in theatre.
7. To develop an observation assessment tool for teamwork in theatre which will be capable of capturing the essentials of the surgical process, team behaviours and deviations from standard safe practice.
8. To assess the feasibility of such an assessment tool and to test the reliability, trainability and transferability of the team assessment tool.
9. To develop and pilot a team training module for the use in the simulated operating theatre incorporating multi-disciplinary crisis simulations
10. To develop team interventions for the improvement of team performance in the operating theatre such as briefing and check-listing.

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1: Chapter One: Nature of Surgery

1.1: Introduction

Teamwork and communication are highlighted by the General medical council in its guidance for doctors (General Medical Council of UK 2001). Effective teamwork is increasingly recognised as an important mechanism for enhancing the safety of healthcare. It is particularly important in high risk environments such as the operating theatre (OT) which is a dynamic, high pressured, fast-paced environment. Surgical teamwork involves complex interdisciplinary interactions between highly specialised professionals, namely anaesthetists, nurses and surgeons, working together to ensure a successful outcome of the surgery for the patient. Yet there is no training provided to enhance this aspect of surgical teams or to ensure the effective working together of these groups. Each team member is trained in an independent manner mostly on the technical aspects of the job and the group only working together when dealing with real patients. While this problem has been recognised by many surgeons it is not reflected by the current form of training in surgery which lacks any formal team training. Recent surveys conducted in Scotland showed that consultant surgeons expect their trainees to possess a variety of qualities not only technical skills but important aspects such as application of knowledge, team work and communication (Baldwin *et al.* 1999). Further surveys showed that the trainees also agreed with the importance of these qualities and attached a greater importance to them than the consultants (Driscoll *et al.* 2003). Other high risk industries have stressed the need for assessing and training individuals and teams in not just the technical aspects of the job but also non technical aspects such as communication, decision making, leadership and vigilance. In addition they train teams to work together effectively especially during a crisis.

In this thesis I aim to develop a method for the assessment of surgical teams. This will identify how teams currently function and the quality of surgical teams. Furthermore it will act as a template to guide how team training should be developed in conjunction with the traditional skills that are part of the repertoire of every surgeon and the surgical team. I also aim to develop some aspects of team training and other team interventions to improve team work in surgery.

In this chapter I will outline how surgery and surgical training has evolved over the years and what the current format of training is and why team training is important. I will then go on to describe the structure of the surgical team and the function of the different members that comprise this team. I will then go on to address what the needs of the surgical team are and how this is fulfilled in current practice.

1.2: History of surgery

Surgery has changed over the years from the early 15^{th} century to the present day. The early surgeons in the western world consisted of barber surgeons. The physicians of that time were thought to be the more intellectual and respected while the surgeons were thought of as mere craftsmen. As time progressed and the royal colleges were established and surgery was then looked upon far more favourably. The most dramatic event favouring surgery and increasing the esteem of surgeons was the operation on King Edward the VII two days before his coronation in 1902 (Jackson 2005). The surgeons functioned autonomously for the most part and there were regulated by the barber-surgeons company which was the fore runner of the royal college of surgeons. The surgical team referred to the chief surgeon and his trainees. The structure of the surgical team was primarily hierarchical with juniors being unable to question the actions of the seniors. This hierarchical structure has continued into the modern day. As research evolved it became more and more evident that surgeons must work within a team to function effectively. Until recently the surgeon was considered to be the leader of the team and was not questioned by anyone.

1.3: The Surgeon

Celsus once said: “A surgeon ought to be in early manhood, or at any rate not much older; have a swift and steady, never faltering hand, and no less skill in the left hand than the right; have sharp and clear eyesight; appear undistressed, and compassionate inasmuch as he wishes to heal those whom he treats, but does not allow their cries to hurry him more than circumstances require, or to cut less than is necessary, and permits the patients groaning to make not the slightest impression on him or anything he does"(Celsus 1935). The personality or desired qualities of a surgeon has changed over the years. The surgeon is now expected to be competent and an expert at performing surgery while also having all the other qualities of a leader and a teacher. At the same time as described by the GMC’s good medical practice guide, a good doctor must be able to communicate effectively with patients, relatives and colleagues (General Medical Council of UK 2001). They must be honest, reliable, punctual, and trustworthy and keep their knowledge up to date. So the emphasis has shifted from someone who merely had technical skills to a much more rounded person who possesses several qualities and is able to fit within a wider team. This wider team consists of people who are essential to the care of the patient and for the successful running of any hospital. They include nurses both on the ward and in theatre, occupational health therapists, physiotherapists, radiographers, anaesthetists, ODPs, porters, laboratory technicians and doctors from other specialities. Hence the surgeons need to be team players to function effectively on a day to day basis.

1.4: Skills of a Surgeon and Current assessment Methods

The skill of a surgeon encompasses knowledge, decision making, team working and technical ability all of which are thought to be important (Baldwin *et al.* 1999). While knowledge can be imparted in the format of courses and didactic teaching, many other skills are acquired purely by chance. Recently more emphasis has been laid on the acquisition of technical skills or surgical dexterity following some high profile medical errors (Martin *et al.* 1997;Bann *et al.* 2003). Work has been done on the assessment and on the acquisition of knowledge and technical skills but on the whole there is a scarcity of work on teams and decision making.

1.4.1: Knowledge

Knowledge is gained through books, lectures and through experiences. Knowledge is one facet which can be easily tested by way of examination. One is expected to keep surgical knowledge up to date by reading peer reviewed journals, attending relevant courses, symposia and conferences. The royal colleges strive to maintain standards by ensuring that each trainee has the Membership of the Royal College of Surgeons exams (MRCS) before progressing to higher surgical training and having the FRCS final exit exams before becoming an independent consultant. In addition the in training assessments hope to pick up deficiencies in training and compensate for them before the trainee completes the required specialist training. However recent studies have shown there is not necessarily a correlation between knowledge and technical skill in some surgeons (Scott *et al.* 2000).

1.4.2: Technical skill

Technical skill or dexterity is considered an important component of surgical competence. However the reduction in the training hours and the changes in the training process require trainees to acquire these skills in half the time. Higher surgical trainees must undergo an annual RITA (record of in-training assessment) appraisal to evaluate progress. At no point, however, is there a formal or objective assessment of technical ability during the training process (Darzi *et al.* 2001).

1.4.3: Team work

Communication failures have been implicated as a contributing factor to adverse events in surgery (Lingard *et al.* 2004) and as an important reason for medical litigation (Rogers, Jr. *et al.* 2006). It has now been recognised that communication is an essential part of being a doctor and not just a surgeon. Many medical schools have now included communication as part of the curriculum and many royal college exams also have included communication skills as a key component. However more work will need to be done to improve the standard across the board so the effects are measurable. There are other aspects of team work which are equally important which have not been taught or assessed to a great extent in medicine. These include factors such as leadership, coordination, situation awareness and cooperation with other team members. These aspects have been studied in other industries such as aviation, military and nuclear industries and will be covered in further detail in the following chapters.

1.5: Current training in Surgery

1.5.1: Structure of training Programme:

The training in general surgery was previously based on the Halsteadian master-apprenticeship model. The saying "See one, Do one, Teach one", has been passed down for many a generation. However recent events and increased public awareness along with high profile litigation suits have forced the medical profession to re think its training structure. A major change was brought about by Calman in 1996. A structured training programme was introduced to stream line training and to produce adequately trained consultants in a process that was fair and objective. That new reform again did not incorporate into the curriculum the essentials of teamwork.

The training programme was not clearly defined and would range in number of years and in quality. Following graduation most doctors would complete a year as a pre-registration house officer. During this period they usually complete six months in medicine and six months in surgery. Once they are fully registered practitioners the individuals then have to make a choice with regards to their future career. In surgery then went on to become a senior house officer (SHO). Following the SHO rotation and the MRCS exam they applied by competitive entry for a training number in a specific branch of surgery that they choose. This was a six year programme in a specific branch of surgery and at the end of it one hoped to have produced a competent independent surgeon. It took approximately 10 years from novice to expert in the field of surgery. However nowhere along this training period was there any set method to assess or teach other skills such as communication, team work or decision making which were also essential elements of being a good surgeon. One was just expected to pick these skills up on the job or by osmosis but there needs to be a more structured method of acquiring these skills which have an important part to play in the development of a good doctor and also for patient outcome.

Further changes in the working patterns and the introduction of the European working time directive will have to bring more changes to the training schemes. Shortened programmes will force the profession to re think the way training is delivered. It will no longer be an ad hoc system where the trainees will be responsible for ensuring that they acquire the necessary skills before they take on their own practice. There is a concern from some authors about whether the new style trainees will actually possess the same level of skills as consultants in the old training scheme (Skidmore 1997). Recently, further changes called Modernising Medical Careers (MMC) have come into place in an attempt to streamline training even further and provide a structured competency based curriculum.

The eventual aim of any training program is to produce a competent surgeon who possesses all of the above skills. The ultimate test of the surgeon's capabilities is successful surgery and performance outcomes which are compared to published national standard and other peers. However surgical outcomes are also dependant on a wide range of variable factors such as communication, teamwork, operative environment and decision making which have been poorly studied until recently

(Vincent *et al.* 2004). These factors will be discussed in greater detail in the next chapter.

1.6: The Nature of Teamwork in Surgery

The operating theatre is a complex system. There are various types of highly technical surgical machines along with complex laparoscopic equipment consisting of camera stacks and light sources. Further more there is other electrical machinery such as like diathermy, laser generators and coagulators. The tasks themselves are varied and operations and patients vary form case to case. In addition to this complexity, heavy workloads, high turnover, fatigue and time pressures, makes surgery vulnerable to errors and adverse events. However most cases are performed with a high degree of care and safety, highlighting the resilience of individuals and surgical teams to the potential adversity of the setting (Vincent *et al.* 2004).

To function efficiently the surgeon has to rely on several other members that comprise the surgical team. Members from different sectors of the profession must come together at various times almost like a well rehearsed play to ensure a successful outcome. However no such training or rehearsals are provided. One simply learns with time and hence there is also diversity in surgical styles across the board. The Institute of Medicine's (IOM) report, *To Err is Human* states that although care is delivered by teams of people, yet training often remains focused on individual responsibilities, leaving practitioners inadequately prepared (Kohn *et al.* 1999). Each hospital may have their own protocols, if any, in place and the different members must cope with whatever they face. Since team training is not a routine part of day to day professional development, in the different specialities, there may be a wide variation in the surgical teams across the country and even within each hospital. Communication is a vital part of the daily smooth running of any theatre team and it is up to each team member to transfer relevant information to the other team members. To ensure a satisfactory outcome every member must share a common goal and work towards that to the best to their ability. Any weak links, while they may be compensated for to some degree by other members, have the ability to jeopardise the entire team function.

In some hospitals the surgical speciality has now moved into super specialisation or sub-specialisation, where surgeons perform only a select number of procedures and may have specialised teams. This leads to the development of specialist centres which are particularly applicable to cancer surgery. There are further specialist centres which may only deal with children or with certain highly specialised subjects such as neurosurgery or orthopaedic surgery. Many hospitals or specialised centres may have a dedicated theatre team or anaesthetist attached to a particular surgeon. Studying these specialised teams may give us an insight into how ad hoc teams can be trained to function just as efficiently. However currently, most hospitals still function with variable teams where members are constantly changing. This highlights the importance of training such teams similar to the training of ad hoc teams in aviation where the objective is to standardise training to such a degree that efficient team function can occur no matter which team one is placed within. In the next section I will outline the skills of the various team members and how they are crucial to the function of the other team members.

1.6.1: Skills of the Surgical Team

The teams involved in surgical process are complex and their composition is of a transient nature, varying in the identity of personnel between and even within cases. Despite variation among surgical teams, they usually comprise of three main generic disciplinary groups, surgeons, nurses and anaesthetists. Much of the work is routine, such as verbal confirmation of the chosen surgical or anaesthetic procedure among personnel, the verifying of patient identity, surgical site laterality and the checking of instrument and swab counts. This work in general has a certain amount of predictability.

The surgical team comprises of the Surgeons and their juniors or surgeons in training, the Anaesthetists and their trainees, Scrub nurses and operating department practitioners or anaesthetic nurses. In addition there are radiographers, recovery nurses and porters all of who are essential to a successful operation. A breakdown in any one facet can lead to a complete halt of procedure and hence it is important for the team to share a common goal to ensure the smooth working of the system. A brief outline of the responsibilities of each team member, in relation to surgery, is described in the following paragraphs. Having so many members functioning at different levels, it is not surprising that the chain can quite easily become disrupted and team function could be adversely affected. Although the surgeons are in contact with other members of the hospital during the course of their work for the purposes of this thesis I have restricted the discussion to teams involved in the process of the surgery itself.

Surgeons - and their juniors (Registrar, SHO, PRHO) are responsible for allocating appropriate patients for surgery. These patients may have been seen several weeks or months prior in outpatient clinic and will have been put on the waiting list by a member of the team. Prior to admission to hospital, the patient may attend a pre-assessment clinic to ensure that she/he is medically fit for surgery and to carry out any investigations that they may require. On admission to hospital, the surgeons obtain informed consent and ensure that the patient still requires the booked procedure and is fit for the proposed operation. Special equipment is booked with theatres and provisions such as ITU or HDU are also made if required. The surgeons must submit the operating theatre list a day before surgery. The lists will be ordered according to age of the patient, conditions such as diabetes, urgency of the operation, and length of the operation. The surgeons and their team also liaises with the anaesthetic team to inform them of any patient condition which may require special preparation or which may alter the order of the list. They also evaluate the bed status and prioritise the admissions according to the urgency of the procedure. The various team issues are mainly surrounding transfer of information to the various team members and providing up to date knowledge about the patient.

Scrub nurses - along with the theatre manager/senior nurse ensure that all the necessary equipment for the operation is available for the list and autoclaved. They are also responsible for ordering special equipment and prostheses for specific cases. The surgeon should inform the theatre manager of special requirements in good time before the operation. The scrub nurses will already have a rota for the members due to perform the surgery the next day. It is the theatre manager's duty to ensure that an adequate number of nurses are available for the operating lists at the same time providing for the needs of the nurses such as breaks etc. They also ensure that the persons assisting for particular cases are aware of the procedure and have prepared instruments in accordance with the surgeons' specification. The theatre nurses also liaise with the ward staff in terms of preparation of patients. The nursing team works closely with the surgeons and consists of the theatre manager, scrub and circulating nurses of varying levels of expertise. Scrub nurses especially the theatre manager are also responsible for ordering supplies and consumables for the theatre (gloves, sutures, washing material, bags, sharps etc).

Anaesthetists –are co-ordinated through an anaesthetist manager who is responsible for allocating anaesthetists for all the theatres daily. The anaesthetists are responsible for assessing the patient preoperatively and ensuring that the patient is fit for the type of operation and the type of anaesthesia they propose to use. They are responsible for liaising with the surgical team if they require any special investigations or evaluation by other specialists before the procedure (e.g. cardiologists). They also note relevant past history for the patient and record information such as prostheses or dentures or special conditions to be watched for during the surgery (e.g. pace makers and metal work to know which side diathermy plate should be applied). The anaesthetists should raise any concerns about the patients and they also prescribe pre-medication, where necessary, which is given on the ward prior to patient arriving in theatre. The anaesthetists are responsible for ensuring that the anaesthetic equipment works and that all the drugs required for the procedure are available at hand including any emergency drugs. They will communicate to the ODP any special requirements that any particular patient may have and order the medication required for the anaesthesia of each patient.

ODA - The ODA/ODP or Anaesthetic nurse works closely with the anaesthetists providing necessary drugs, checking the equipment and helps throughout the peri-operative period. They also liaise with the anaesthetists regarding special equipment for the patient for any difficulties that they may encounter. Along with the anaesthetists they are responsible for checking the anaesthetic equipment, gases, drugs etc. Scheduled drugs are also checked twice daily by an ODP and another member of staff. The details are recorded in a drug book. The ODPs also maintain a log of the Anaesthetic equipment dates and times that is was checked and when certain components need to be replaced. In addition to these key members the team must liaise with nurses in recovery room about the post-operative care of the patient.
Radiologists/ radiographers: may be required for certain procedures. The surgeons must inform the department in advance to ensure that the imaging equipment and a radiographer are available for the date and time required. The radiographer ensures

that all the members of staff who are present in theatre are adequately protected from radiation. They are also responsible for maintaining a record of exposure time and amount. They become an integral part of the theatre team while they are in theatre and will follow theatre protocol for which they have received prior training.

Recovery Staff: these are dedicated nurses who receive the patient in the recovery room following their operation. They are responsible for ensuring that the patient is comfortable and has adequate analgesia and that the vital functions are stable. They attend to the patient and ensure that the patient is awake and completely stable before returning to the ward. They also ensure that drains etc are functioning properly and are secure before being transferred. They liaise with the ward staff and arrange transfer and handover of the patient. Due to the limited number of beds and staff in recovery it is essential to time the arrival of the patients to recovery and their transfer form there back to the wards.

Porters: There are theatre porters whose main job is to transfer patients from the wards to theatres and vice versa. They are be given a slip of paper with the patient details and ensure that the correct patient is brought to theatre along with a nurse from the ward who hands over patient details and special conditions to the receiving staff in theatre. The porters may also be asked to take blood samples to the laboratory for processing, or bring blood from the blood bank for transfusion if required.

The responsibility for tasks in the surgical process, for all staff lies mainly in their respective disciplines and in their organisation. Throughout the process, the members of the surgical team ensure that all special requirements and patient condition is communicated to the team. As outlined above there is a lot of coordination and communication that must take place to ensure that this process is as smooth as possible. There is no set system to achieve this efficiently among the team. There are no clear guidelines and protocols how each member should communicate, with whom and what each member needs to do to ensure that coordination is optimal. This is not just important for improving the safety and outcome for the patient but also important to run an efficient service.

1.7: Conclusion

The operating theatre and the surgical team are a complex and dynamic system, one which requires effective communication and coordination to function optimally and safely. It is surprising that there is, as yet, no system to effectively train and measure these elements. These team work elements need to be part of the curriculum in the medical and nursing domains to enhance the way that surgical teams work to improve patient outcome. Team work is now recognised as an essential component of good surgical care and while most cases are carried out successfully this can certainly be improved upon, similar to the incorporation of such training into other high risk industry where it has had a huge impact on attitudes and safety.

The surgical community has concentrated on providing skills courses which aim to provide knowledge of surgical procedures and to some extent dexterity. Many of these courses are now mandatory before progression form one grade to another and before achieving completion of training certification. However nowhere along this training period is there any set method to assess or teach other skills such as communication, team work or decision making which are also essential elements of being a good surgeon. One is just expected to pick these skills up on the job or by osmosis but there needs to be a more structured method of acquiring these skills which have an important part to play in the development of a good doctor and also for patient outcome. With the changing training structure and the loss of the traditional team structure it becomes all the more important that all the team members are able to function efficiently in any team. This will ensure a standardised effective method of performing various procedures and following protocol especially during a crisis. I have attempted to outline the complexities involved in the surgical process and in the teams involved within it. The importance of these measures in improving safety will be discussed in the following chapters. We must realise the importance of incorporating team training alongside surgical skills training. In this thesis I will make a case for attempting to develop measures for assessing the surgical teams and for providing the first steps for improving and training teams in surgery.

2. Chapter Two: Understanding Surgical Outcome

2.1: Introduction

Surgical success is measured by various factors the most important being patient outcome following surgery be it in terms of post operative recovery, oncological outcome or complications. In the past a huge burden lay upon the shoulders of the individual surgeon and surgical outcome was primarily seen as the success or failure on the part of the surgeon. However recently following research in other high risk domains, such as aviation where a similar responsibility lies with the pilot, it is understood that a wide range of factors influenced outcome (Helmreich and Foushee 1993). Similarly it is now thought that patient outcome depends on a variety of factors other than the skill of the surgeon and the patient's condition or constitution, and in particular team performance. Team performance is increasingly recognised as one of the foundations of good surgical care and key to achieving safe efficient care. This has also been highlighted in the Kennedy report which followed from the Bristol enquiry into neonatal cardiac surgery. For example in its recommendations it stated that "people failed to communicate with each other, and to work together effectively for the interests of their patients". Further they found that there was a lack of leadership, and of teamwork which had implications for performance and outcome (Bristol Royal Infirmary Inquiry 2001).

This chapter reviews studies on error and adverse events in healthcare and particularly surgery. I will describe what the surgical outcomes are and the methods for measuring them. I have outlined a few studies in detail to show the various factors that were thought to be important as contributors to outcome. I will then discuss the systems approach, which depicts the contribution of other factors to safety and outcome, in high risk environments and how this may be applied to surgery. I will go on to the relevance of human factors in the causation and prevention of surgical errors. As in other industries, in surgery, the systems theory emphasises the importance of other factors, such as teamwork, that may contribute towards a successful outcome for the patient. Hence any objective measurement of surgical performance that is developed should extend to the whole team. Lastly I will talk about how teamwork can influence the outcome of surgery.

2.2: Addressing Errors and Adverse Events in Surgery

Studies conducted around the world suggest that approximately 10% of patients admitted to hospital suffer some kind of harm due to medical intervention (Wilson *et al.* 1999;Brennan *et al.* 1990;Thomas and Brennan 2001;Vincent *et al.* 2001) The Harvard medical practice study found that 3.7% of hospital admissions led to adverse events(Brennan *et al.* 1991). Similar rates were found in a study from Colorado and Utah (Gawande *et al.* 1999;Thomas and Brennan 2001). The quality in Australian healthcare study identified adverse events in 16.6% of admissions, half of which were considered preventable (Wilson *et al.* 1995). This study included a wider range of adverse events of minor and moderate severity. Although a majority of events are minor some may lead to permanent disability or even death.

	Criteria for defining Adverse Events
1	Results in unintended injury or complication
2	Results in temporary or permanent disability &/or increased length of stay or death
3	Caused by healthcare management and not by the disease process

Table 2.1: Adverse events can be defined as events that satisfy three criteria outlined above adapted from the results of the Harvard Medical Practice Study (Brennan *et al.* 1991)

A significant percentage of errors that were identified in many studies were related to a surgical procedure. Not all surgical adverse events were directly related to intra-operative events. Some of these were due to post operative or ward based complications. However technique related complication and bleeding produced nearly half of all surgical adverse events. In the U.K, complication rates for some major operations are in the range of 20-25% with a mortality rate varying between 2% and 9% depending on the type and site of surgery along with other patient factors (Al Ruzzeh *et al.* 2003;Wilson *et al.* 1999;Tekkis *et al.* 2003). In addition 20-25% of major complications are thought to be avoidable (Healey *et al.* 2002).A wide variation in outcomes, complication rates and mortality across the different centres further supports a view that outcome is related to many different variables.

Surgical adverse events can range from intra-operative mishaps such as removal of the wrong sided organ, amputation of wrong sided limb, operation on the wrong patient, to poor post operative ward care. They may occur at any stage of peri-operative patient care. A study of surgical records by Neale et al identified events such as pressure sores, chest infections, poor care of urethral catheters and drug errors (Neale *et al.* 2001). Many of these were preventable and were attributed to poor post operative ward care. Failure to remove swabs, instruments and needles from the operative site has been a major problem in surgery and continues to pose a risk. Retained foreign bodies result in considerable morbidity including the risk of added surgery and even mortality (Gawande *et al.* 2003). The costs of re-treatment, additional surgical time, increased hospital stay and subsequent litigation are considerable. Several protocols and guidelines exist in an attempt to minimise such occurrences, however human error may still occur. Though wrong side and wrong site surgery must be avoided and many protocols exist to try and prevent it (Rao *et al.* 2005), there is no lack of high profile cases that continue to occur on a regular basis.

2.3: Surgical outcomes

Surgery has advanced over the years in terms of outcome, mortality and morbidity with most cases being completed safely with good outcome. Anti-sepsis, modern antibiotics and new advances in technology have allowed operations to be performed which would never have been possible a few decades ago. Improvement in oncological surgery means that people are surviving cancers and are living longer despite their illnesses. Laparoscopic surgery has developed in the past decade and allows complex surgery to be performed through small incisions, giving better post operative recovery, reducing the need for analgesia and earlier return to work.

The care of the patient undergoing surgery is designed to achieve 4 objectives (Cuschieri 1995)

1. Reduction in mortality and morbidity form the surgery and anaesthesia
2. Safety of patients and staff during the operation
3. Pain relief
4. Smooth convalescence and early rehabilitation

To fulfil this there has to be careful selection of patients and assessment of preoperative risk factors. Furthermore the fitness for anaesthesia and surgery has to be assessed and any deficiencies of fluid, blood or nutrition should be corrected.
Use of antibiotics, DVT prophylaxis and adequate preparation of the patient will prevent some post operative complications. Well designed operating theatres with laminar air flow systems, use of anti bacterial skin preparation and strict aseptic protocols further reduce the risks of surgery to the patient.

Outcomes are measured in terms of; return to work, pain – analgesia requirement post op, time to discharge, time to eat and drink, mobilisation, requirement of ITU, long term morbidity, disability, restoration to full function. For inpatient procedures and more complex cases post operative outcomes are usually measured in terms of length of stay in hospital, pain control and use of analgesia, amount of blood loss and transfusion rate, cost of procedure and of in patient stay, post operative quality of life and other post operative complications such as infection, lung complications, cardiac complications, deep vein thrombosis, systemic sepsis, haemorrhage, anastomotic leaks or re-operation.

Surgical success can be monitored by the process of quality assurance in the form of audit where individual or organisation outcomes are measured against standards and performance is regularly reassessed and improvements made. These are then compared to the national standards or guidelines and improvements are made to constantly improve the service provided to the patients and for the organisation. Only through monitoring will adverse events and short falls be picked up so lessons can be learned and preventative measures instituted. Through constant monitoring and advances in skills, technology and training the mortality rates of major operations which were as high as 50% have now come down to a fraction of those figures. The introduction of asepsis in 1867 helped reduce these rates to about 15%. Current operative mortality rates for even major surgery such as coronary artery bypass grafting (CABG) is roughly 2-4% and for major liver surgery is approximately 1-5% (Allen and Jarnagin 2003)

2.4: Systems approach in other high risk areas

High error rates are not unique to surgery. A variety of other fields including aviation and anaesthesia have experienced similar error rates but have been able to reduce them by using well designed error reduction systems based on systems theory (Helmreich 2000;Reason 1990;Calland *et al.* 2002). Systems theory states that there are several factors and components which are interdependent on each other (Moray 1994). Complex systems such as aviation acknowledge that cultural and economic factors contribute to the final outcome. Change in one or more of the factors or components ultimately filters through and affects the entire system. Hence the design of any system must consider all the aspects of the tasks at hand from specific instruments to factors such as team performance (Calland *et al.* 2002). The team itself is vital to the efficient and safe functioning of any system.

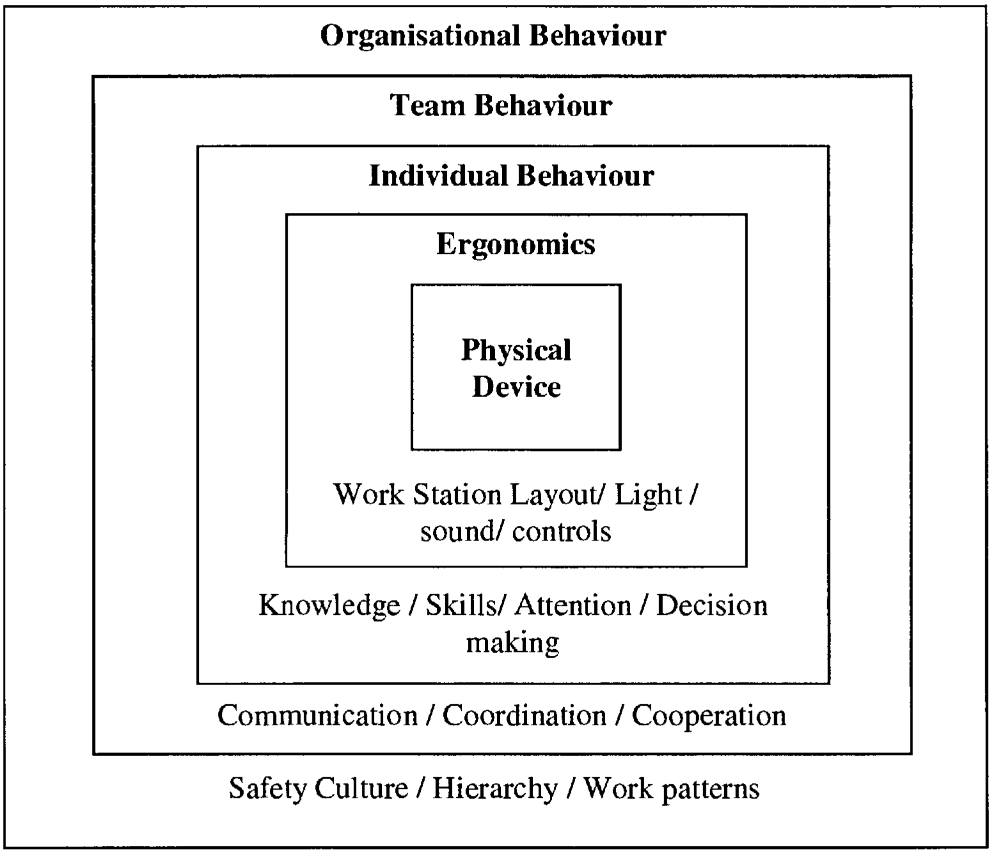

Figure 2.1: An example of Using a Systems Approach Design: adapted from Moray 1994

A system's view of performance is increasingly important to healthcare, for improving efficiency, patient safety and reducing adverse events (Donaldson 2002;Vincent *et al.* 1998). Safety, from the systems perspective, is achieved by improving the functioning of system components and their interaction; and fitting tasks and technology to people rather than relying solely on individual performance. While the systems approach has been widely adopted in high-risk domains, such as aviation and the nuclear-power industry, few studies in healthcare have examined interactions between humans and their environment (Reason 2000). The other difficulty is the lack of domain specific measures to examine these factors (Vincent *et al.* 2004).

Human factors can also affect performance and have been studied and applied to aviation and medicine (de Leval *et al.* 2000;Schaefer *et al.* 1994;Paris *et al.* 1999;Reason 2001). For any high risk task the supervisors must be capable of ensuring that each person involved is mentally and physically prepared especially if the task is a difficult one. Operators of high risk tasks may be affected negatively if they are sleep deprived or have had a recent bad experience (Calland *et al.* 2002;Taffinder *et al.* 1998). In addition there may be multiple environmental distractions and team performance may suffer.

Once a system has been designed there should be a method for analysing the components and how they interact to ensure that the system functions safely and efficiently. Anaesthesia has successfully used this theory to deal with errors and adverse events. Through study of operations and critical incidents improvements have been made in clinical practice. Cooper et al studied peri-operative and anaesthetic mishaps using critical incident techniques used by Flanagan in 1954. Data was collected by way of interviews with staff and residents in anaesthesia which were tape recorded. His work had a far reaching effect in improving the practice of anaesthesia which recognised safety in the late 1970's (Cooper *et al.* 1978).

Similarly in surgery one can apply the systems theory and make improvements in performance and safety by studying these factors and in particular the team aspects. The team which consists of the surgeons, the nurses, the anaesthetists, the ODPs and other ancillary staff are responsible for not only the well being of the patients but for the control of a variety of surgical and electrical equipment too. Staffing issues, inexperience of any of the members of the team, breakdown in communication, equipment failure, time pressures and lack of management or supervision can lead to failure of optimum team work which may impact on surgical outcome.

2.5: Systems approach to surgery

Lessons learnt from aviation and other high risk organisations that have successfully applied the systems theory to study errors and safety of similar systems may be applied in healthcare. Surgical errors can be classified as latent or active. Active or operator errors are those committed by individual practitioners at the point of care (for example the surgeon in the operating theatre). Typically these errors are identifiable as errors at the moment that they occur. Latent errors are circumstances that predispose to error (Reason 2001). Examples of latent errors in surgery would be sleep deprivation, inadequate supervision of junior doctors or unclear procedures and guidelines. It is these latent errors which can be identified and prevented by adequate team monitoring and correct use of guidelines and protocols (Reason 2001). These errors can also be classified as diagnostic, treatment, preventive and other (Leape 1994). In the category of other, failure in communication is important and relevant to team function and team contribution to the prevention of error. Since surgery is also a high risk, complex environment it seems that it would be logical to presume that several factors and variables play a part in error reduction and safety.

The primary determinants of surgical outcomes were generally thought to be the patients' condition and the skills and performance of the individual surgeon. The early studies on surgical outcome presumed that patient factors played a large part in determining surgical outcome. Operative mortality will naturally vary between secondary care units for multiple reasons; case-mix, co-morbid disease, type of presentation etc being the most relevant and important measure. Sub-optimal surgical care despite considerable recent media interest is not the only reason for varying mortality rates. Risk stratification by the use of mortality prediction models has the potential to compensate for the above factors and therefore allow a better means of comparing performance between hospitals.

Despite the low mortality and the advances in all the surgical specialities it is clear from the high profile news reports that adverse events do occur. Where there are humans, machines and a high risk environment, errors are to be expected. Adverse events in surgery are again not the act of the individual surgeon but are incidences which have a multi-factorial origin. The team has an important role to play in the occurrence and prevention of such errors. Based on this, we can assume that surgical outcome is not solely dependent on patient risk factors or indeed a combination of patient risk factors and technical skill of the surgeon. A more comprehensive operation profile suggested by Vincent et al is much more appropriate for studying surgical outcome (Vincent *et al.* 2004). The operation profile includes the operative environment, patient factors, distractions, decision making, team performance, type of procedure, technical skills and intra operative events (Figure 2.2). The development of the operation profile is one of the ways surgery can be looked at as an entire system and not just an entity on its own. All systems have certain characteristics. They involve technology, people and the interaction between the two. Management of a healthcare system includes human components (such as doctors, nurses and managers), hardware components (computers, equipment), policies and economics. To prevent errors it is essential that the system is designed correctly as a whole with appropriate relation between the people and the components (Moray 1994)

In what follows I will elaborate on the systems approach to surgery and describe the various factors that contribute to surgical outcome and the methods for evaluating them.

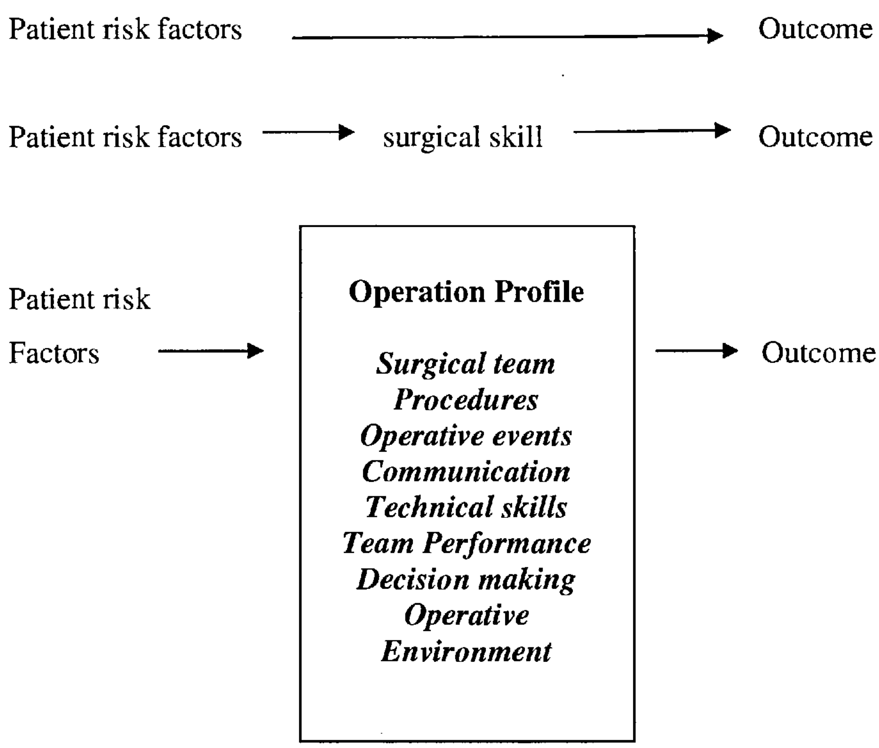

Figure 2.2: Model of Surgical outcomes from a systems view (Operation Profile from Vincent et al 2004) which describes outcome as a result of a number of factors including team performance and communication.

2.5.1: Patient Factors

Success is usually measured by the outcome being as close to the predicted model for each type of operation, after taking into account the common complications and acceptable risks for the procedure. For example the expected recovery after a complex vascular operation such as abdominal aortic aneurysm repair may vary from a few days to several weeks and may include a period of stay in the intensive care whereas for a simple day case hernia repair the patient would go home the same day.

Some patient factors for anaesthesia and surgery are generic and can be applied to any operation. Factors such as high body mass index, co-morbidities such as heart disease and extremes of age increase risk of poorer outcomes (Copeland *et al.* 1991). In the elderly co-morbidities contribute further to the risk. Factors such as smoking, obesity, alcohol intake, cardiovascular disease, respiratory disease, Diabetes Mellitus, immuno-deficiency, drugs and length of operation also contribute to outcome. Furthermore certain types of operations by their very nature carry higher risk of mortality and morbidity than other procedures such as major cardiac surgery or emergency surgery in extremes of age. There are a number of scoring systems which can be applied to calculate post operative outcomes according to the criteria they fulfil. Some of the stratification systems are discussed below.

2.5.1.1 Surgical Risk Stratification Systems:

Morbidity and mortality is one way of comparing outcomes between surgeons and centres. This is one aspect of the patient factors which may affect outcome. Meaningful comparisons however require accurate risk stratification of the patients being analysed. Various surgical grading systems are in place for different procedures and specialities and can help calculate the operative mortality. This may indirectly be able to predict surgical outcome in terms of patient factors. Some of the grading and scoring systems include ASA grading (American Society of Anaesthesiologists), POSSUM *(Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity)* scoring and the APACHE II scoring systems (Acute Physiology And Chronic Health Evaluation).

APACHE II (Acute Physiology and Chronic Health Evaluation System) scoring

This scoring system gives a score which is based on acute physiology, age and chronic health points. The acute physiology score includes variables such as blood pressure, pH and respiratory rate. Based on this system a mortality rate can be calculated (Cuschieri 1995)

ASA (American Society of Anaesthesiologists) grading

The ASA grading facilitates the division of patients into one of five categories based on their general medical history and examination without requiring any specific tests. The drawback of ASA is that it is subjective and therefore open to manipulation. The following table shows how mortality varies with ASA grade in two different conditions. Mortality also is dependent on the age of the patient being worse at extremes of age (Smith and Tekkis P 2006).

ASA	Grade definition	Mortality in general	Large bowel obstruction due to colon cancer
I	Normal healthy individual	.05	2.6
II	Mild systemic disease that does not limit activity	0.4	7.6
III	Severe systemic disease that limits activity but not incapacitating	4.5	23.9
IV	Severe systemic disease that is life threatening but not moribund	25	42
V	Moribund, not expecting to survive 24 hours with or without surgery	50	66.7

Table 2.2: The ASA grading system. The different grades show the difference in expected mortality in general and in cases of bowel obstruction due to cancer outlining the importance of the different variables (Adapted from Smith and Tekkis, Riskprediction.org.uk)

POSSUM (Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity) scoring:

POSSUM (Physiological and Operative Severity Score for the enUmeration of Mortality and Morbidity) scoring system (Copeland *et al.* 1991) was developed by multivariate analysis and is a means of predicting morbidity and mortality. This system uses a 12-factor, four grade physiological score and a six-factor, four grade operative severity score which compensates for the specific operative procedure. Although this system has been well validated in a variety of surgical procedures it has a tendency to over predict mortality rates in low risk groups. Further modifications to this scoring system such as the p POSSUM have been utilised as well as other systems for evaluating surgical patients.

All of the systems for patient stratification have limitations which limits the use of them in routine general surgical practice. They also only consider one aspect of many which contribute to outcome. While these predictors are essential they should be used in conjunction with other models such as assessment of surgical technical skills and teamwork so that a comprehensive and more real estimation for risk and outcome can be made.

2.5.2: Technical Skills of the Surgeon

Technical skills or dexterity is considered to be one of the important determinants of surgical outcome. The UTAH and Colorado study showed that technique related complications, wound infection and post operative bleeding form nearly half of all surgical adverse events (Gawande *et al.* 1999). Traditional methods of assessing surgical competence has been hampered by the lack of objective methods and therefore relied on subjective analysis by individual trainers.

The skills of the surgeon and the other team members are vital to ensure a good surgical outcome. Technical skill is an important aspect however that was very rarely assessed in current practice (Darzi *et al.* 2001). Recently emphasis has been placed on measuring the technical skills of individual surgeons and much work has gone into developing assessment tools for surgical skill in terms of technical ability or dexterity. Recent advances have made the objective assessment of surgical skills possible but have mostly concentrated on bench models or virtual reality simulators. Several assessment methods including observation of skills and motion analysis such as ICSAD (imperial college surgical assessment device) have been developed to attempt to address this aspect of surgical competence (Martin *et al.* 1997;Datta *et al.* 2002). Global rating scales such as the OSATS has been used to assess the technical skills of surgeons on bench models and was shown to be a better predictor than specific checklist scores (Martin *et al.* 1997). Other methods include MOMS (Multiple Objective measures of Skills) described by Mackay et al for assessing the technical ability of basic surgical trainees(Mackay *et al.* 2003). Global rating scales have been used extensively by other authors in an attempt to provide objective assessment for surgical technical skills and transfer of skills from bench models to live operating (Datta *et al.* 2004). For laparoscopic surgery since the skills set required is different to that of open surgery several virtual reality trainers have been developed to teach these skills. Assessment and training of skills using laparoscopic virtual reality simulators such as MIST-VR (Minimally Invasive Surgical Trainer –

Virtual Reality) and ADEPT (ADVANCED Dundee Endoscopic psychomotor trainer) is now possible (Hanna *et al.* 1997;Gallagher *et al.* 1999;Francis *et al.* 2001).

2.5.3: Other Factors Contributing to Outcome

Focussing only on patient factors or technical skills neglects a wide range of other factors that are also thought to be important. Drawing on the wider literature on safety and quality in healthcare, as described above, it has be suggested that other factors also play a role in surgical outcome. Research in other high risk areas has highlighted the importance of these factors in achieving safe, high quality performance. These industries have made effective use of systems approaches and studies of errors in complex environments. These factors also include team co-ordination and leadership (Sexton *et al.* 2000), ergonomic factors (Rajan 1997) and decision making (Flin *et al.* 1997). Other factors contributing to poor surgical outcome and surgical adverse events may be due to poor communication, poor technique, technical failures of equipment and cognitive errors due to stress.

2.5.3.1: Experience, caseload and supervision

Inexperience, inadequate supervision and poor training may also contribute to poor surgical outcome. Porter et al described the One such study looked at variations in outcome between patients with rectal cancer treated by specialist versus non specialist colorectal surgeons, and independent of that, high versus low volume of work (Porter *et al.* 1998). The analysis showed that the risk of local recurrence was increased and disease specific survival was lower in patients treated both by surgeons not trained in the colorectal surgery and by surgeons performing less than 21 procedures. Thus best results were obtained from the trained surgeon performing a high volume of work. Further Begg at al showed similar findings in a study comparing outcomes for radical prostatectomy. In their study of more than 11500 patients they found that high volume hospitals and in particular surgeons who performed large number of the procedures had a better post operative outcome and lower complication rates (Begg *et al.* 2002). Knowledge and trainee supervision also contribute to outcome as shown by the number of complications when surgery is performed out of hours by inadequately trained and unsupervised personnel (Gray 2000).

2.5.3.2: Fatigue, Effect of Noise and Stress

A study by Taffinder et al found that sleep deprivation similar to that of being on a night on call for surgical trainees increased the error rate of a surgical task by 20% in a simulated surgical task (Taffinder *et al.* 1998).

The effect of noise on performance has been realised in many instances. Noise in theatre can lead to deterioration in the ability to communicate, increase stress levels and affect complex motor skills. One study by Hodge et al likened the noise in theatre to that of a motorway. There were loud intermittent bursts of sound added to excessive speech highlighting the added difficulties of the surgical team when communicating vital information (Hodge and Thompson 1990).

Stress among hospital staff can also adversely affect outcome. In a survey of junior doctors up to 50 % suffered ill effects of stress and many of them believed that this had adversely affected patient outcome (Firth-Cozens 1987;Firth-Cozens and Greenhalgh 1997).

2.5.3.3: Ergonomics

Ergonomics is another aspect that is an important contributory factor to the system. If workers must use tools which are difficult to grip or manipulate, handle, see or access there is a potential of unintended actions and outcomes. Similarly instruments and monitors have an influence on performance and successful task performance. For example Hanna et al studied the influence of the location of the display monitor on performance of an endoscopic task. They found that time and quality scores improved depending on where the monitor was placed with a frontal view, below the head and close to the hands, being ideal (Hanna *et al.* 1998). Equally important are the questions of instrument availability, room layout, and arrangement of data displays (Calland *et al.* 2002).

2.6: Teamwork as the foundation of good surgery

Effective teamwork is essential for safe, high quality surgery. The team can help to compensate for weaknesses in any link of the chain to prevent errors. The team members of varying expertise together make up one safe, competent unit that then has to perform to an acceptable standard. In high profile errors such as wrong sided surgery the rest of the team including the anaesthetists have been questioned about their involvement too and not just the surgeon (Kaufman 2003). This highlights the fact that the team is important not just for the functioning but for safety issues too.

Factors like communication have been studied in the context of the operating theatre but no direct correlation has been made to surgical outcome. However studies have shown that in the occurrences of medical error a regular contributing factor is poor communication. In a report by the Joint Commission on Accreditation of Healthcare Organisations they found that nearly two thirds of the cases that they analysed communication was a contributing factor to the adverse event (Joint Commission on Accreditation of Healthcare Organisations 2000). Communication is one of the vital teamwork factors and has been studied extensively in various areas and shown to be linked to outcome and error causation e.g. the scrub nurse handing the surgeon wrong instruments, incorrect counting of swabs and instruments, unchecked equipment or equipment failure. Preoperative delays due to miscommunication between surgical and nursing staff, delays and lack of results being available etc are other team factors which may lead to errors and subsequently outcome. On the other hand clear communication among team members and efficient running of the lists, following protocol etc can improve the outcome for even complex cases.

The current pursuit of a complete assessment of the surgical process and for a comprehensive understanding of surgical outcomes should be extended to the study of team performance in the operating theatre. This includes studying aspects of interdisciplinary teamwork, an understanding of the surgical process and an understanding of how teams function in general. This will be discussed in greater detail in the following chapters both in the context of healthcare and other high risk industries and the lessons that can be learned.

2.7: Conclusions

While most operations are carried out safely there are still several adverse events and errors in surgery which occur, many of them preventable. Every operation carries a risk and mortality rate however a better understanding into the various factors that influence outcome may help in improving these figures. There are several facets to surgical outcome, patient condition, surgical technical skills, operative environment and team performance being some of the key ones. Communication failures have been uncovered as important contributory factors to many errors. This thesis supports a systems theory which stresses the importance of factors other than technical skills and patient factors in measuring surgical outcome. One of the foundations of good surgical care and key to implementing inter-disciplinary systems is team performance and this is the basis of this thesis. Team work is one of the key elements in performing safe surgery and for good surgical outcome. In the next two chapters, I will concentrate on the essentials of teamwork and describe the various elements that make up this very important component of surgery.

3. Chapter Three: Study of Teams

3.1: Introduction

The preceding chapters have outlined how a systems approach necessitates the study of other factors that may impact on surgical outcome. Most importantly teamwork can contribute in several different ways to optimise effective functioning, improve safety and outcome. This chapter considers how these teams are studied and what is actually understood about team work?

The literature on teams is extensive, with most of it having been conducted in industries other than healthcare. For the purpose of this thesis the search has been directed to specifically reveal literature that would lead to the study of surgical teams and to the development of teamwork models in surgery. This chapter considers those aspects of the teams literature that are of particular relevance to teams research and team training in surgery. As a prelude to a detailed study of teamwork related to healthcare and surgery this chapter will review the different approaches to studying teamwork. This chapter will also outline the concept of shared metal models, which is the essence of effective teamwork. The chapter will then describe the various methods by which team work can be measured and some of the work that has been done to train high performance teams such as in aviation. The chapter will conclude by describing the principles of crew resource management and how it has become a part of essential training in the airline industry. The application of such training to medicine will be covered in detail in the following chapter.

Extensive searches were carried out through Medline (1966-2006), Embase (1966-2006), Psychinfo (1967-2006) and ISI web of science (1970-2006) using the search terms outlined in the appendix. Further sources such as conference proceedings (healthcare, psychology and human factor related), bibliography from relevant articles and book chapters were used. An overview of the literature search, along with details of search terms is given in the appendix 1.

3.2: What is a Team?

Teams are more than merely a collection of individuals and teamwork is more than the aggregate sum of their behaviours (Paris *et al.* 2000). Katzenbach and Smith assert that groups become teams when they develop a sense of shared commitment and strive for synergy among members (Katzenbach and Smith 1993). One cannot expect to put together a group of individuals and hope that they will automatically function as a team. A team, therefore, consists of two or more individuals who interact and work towards a common goal. They share and communicate and adapt to each other. They achieve goals through an interactive, interdependent process (Morgan *et al.* 1986). Individuals sharing similarity or a common relation may be viewed as a group. If a group collaborate in their work or in a particular task, sharing the benefits and costs of achieving common goals, they become a *team.* Essentially, the team's work [*teamwork*] is interdependent, requiring interaction among team members to fulfil team function.

3.3: The Study of Teams

Study of team work started in the 1950's and 1960's on military teams, to try and make them function more effectively under conditions of extreme stress and pressure (Paris *et al.* 2000). Needless to say none of the work carried out in the industry and various business arenas would be possible without efficient teams. The literature on teams has evolved considerably in the last 50 years or so and has been to a large extent on the theory of teams. Most of the studies began as descriptive research but now provide more practical information about how to guide team research and team training in particular (Paris *et al.* 2000).

Researchers have over that past few decades struggled to agree on which skills are most important to help teams coordinate and communicate effectively, so that they can fulfil their roles and achieve their goals. In the 70's literature more emphasis was placed on team orientation, resource distribution, timing and vigilance. For example in a technical report from NASA by Russell-Smith simulations were observed and data such as heart rate, communication and vigilance was recorded. They found that vigilance was a better predictor of errors than heart rate (Ruffell-Smith 1979). As team research progressed into the 90's different behaviours and constructs were considered to be most important. These varied from self correction, to cohesion to team orientation. Driskell et al in their study stated that researchers suggest that collective or interdependent behaviour is a critical component of team interaction. Furthermore some team members are less collectively oriented than others and that the tendency to ignore task inputs from others is one factor that contributes to poor team performance. Their experimental results confirmed that collectively oriented team members were more likely to attend to the task inputs of other team members and to improve their performance during team interaction than were egocentric team members (Driskell and Salas 1992). Teams research in the 90s had another major development which underpins a lot of the current team work. This was the concept of shared mental models. Mental models allow team members to implicitly and effectively coordinate their behaviours. They allow members to recognise individual responsibilities and the needs of other team members. They enable members to diagnose deficiencies and provide information and support as needed (Paris *et al.* 2000). Shared mental models will be discussed in further detail in the sections that follow.

3.4: Characteristics of High Performance Teams

Effective teamwork is fundamental to safe and efficient work in high-risk environments (Helmreich and Foushee 1993). It is important not just for the safe design of complex systems but has a vital role in preventing and managing error (Sasou and Reason 1999). The teams literature has largely discussed what makes an effective team yet there is hardly any published literature on how best to measure the effectiveness of the team. There has been research on theories of teams and developing models of team performance yet there is no agreement on which skills are most relevant for a team to be effective.

In general, highly effective teams tend to share certain characteristics. Effective teams have clear team goals. They leave aside individual priorities and focus on the team. The team, to be effective, should comprise of members with the necessary skills and knowledge required to complete the task at hand. The members should share a mutual trust and should be facilitated through an open, honest and collaborative organizational culture. Similarly, good communications and negotiation skills through which each member can understand each other is also imperative and all these processes should be led by an effective team leader who can motivate team members even in difficult situations (Veneeva 2006).

Communication is one aspect of teamwork which is thought to be crucial to the functioning of the team and for fulfilling the other dimensions of team work such as cooperation and coordination. Also crucial to the performance of high performance teams are the abilities and behaviours of the team members and the roles of the members. Successful team work depends on the knowledge, skills and attitudes for individual task performance and also on the traits of the team members that facilitate team interaction, such as learning ability and initiative. (Paris *et al.* 2000).

In an ideal world and as a result of reviewing the literature, Millitello et al proposed, under hypothetical circumstances an ideal, highly effective, team one would expect to see the following characteristics (Militello *et al.* 2000):

- Smoothness in the ability of the team to meet, share information and move forward
- The team would explicitly state roles and functions as they relate to the work plan
- Project leaders would engage other team members from the beginning
- The team would compensate by filling in for sick members and help inexperienced ones and minimise interpersonal differences
- The team would articulate and agree on goals and set realistic time lines for achieving them
- The team would provide mechanisms for the team to share and exchange views regarding progress.
- The team would monitor the progress towards goals and also effectiveness of both team and individual processes.
- They will identify ineffective processes and modify them to become more effective

These characteristics have been described largely in team behavioural terms. However, a deeper understanding of teamwork can be achieved by considering the cognitive aspects of team performance. It has been hypothesised that efficient teams can be distinguished from less efficient ones, by studying shared cognition or team mental model.

3.5: Shared Mental Models

In recent years studies of high performance teams has seen a stronger emphasis on the cognitive aspects of team work. Effective teams are said to have a shared mental model. Rentsch suggested that team members hold team *schemas:* shared representations about how the team operates and accomplishes tasks (Rentsch and Klimoski 2001). Rouse, Cannon-Bowers & Salas (1992) propose that teamwork depends among other things on the expectations and understanding of each other's functional roles and objectives (Rouse *et al.* 1992). They propose cognitive mental-models held by members of the team form the mechanisms underlying those factors. Therefore, the level of team performance depends on whether team members share similar mental-models.

According to its original definition, a mental model is as a set (or as a network of sets) of cognition organised into a coherent knowledge structure (e.g. Johnson-Laird, 1986). The mental models that the team members hold allow them to describe, explain, and predict their complex working environments (Klimoski and Mohammed 1994;Rouse and Morris 1986;Rouse *et al.* 1992). Team mental models encompass three distinct sets of cognition. They relate to tasks and procedures, equipment and the environment in which the team performs. These knowledge structures support the interface between team-members in their environment (Klimoski and Mohammed 1994). The working hypothesis has been that, in more successful teams, mental models are more widely shared among team-members than in less successful teams (Orasanu and Salas 1993).

Mathieu, Heffner, Goodwin, Salas, and Cannon-Bowers (2000) investigated ad hoc dyadic teams who had to fly a series of missions on a computerised flight-combat simulator (Mathieu *et al.* 2000). They used a network-analysis programme in order to measure the sharedness of the team-members' mental models. They found positive correlations between the convergence of team- and task-related mental models and team performance. These findings demonstrate empirically the importance of the sharedness of mental models among team-members for effective teamwork.

Extending this research, Marks, Zaccaro, & Mathieu (2000) investigated ad hoc triadic teams who had to accomplish a series of missions on a computerised tank-combat simulator (Marks *et al.* 2000). They used "team-interaction concept maps" to measure mental models and they operationalised sharedness as the degree of similarity between the different team-members' concept maps. Marks et al. (2000) also measured the accuracy of mental models (using experts' judgements) and they found that the correlation between mental model sharedness and team performance was stronger for the triads that held inaccurate mental models of their mission than for the triads that held accurate ones – in other words, team performance, mental model accuracy, and mental model sharedness interacted. Taken together, these findings demonstrate empirically the importance of the sharedness of mental models among team-members for effective teamwork.

In summary, researchers have failed to agree upon which skills are most important for effective team work. There is now a stronger emphasis to study the cognitive aspects of teamwork and that the level of team performance also depend on whether team members share similar mental-models. It is possible to distinguish efficient teams from less efficient ones, by studying the team mental model and successful teams more often share the same mental model. Researchers typically assess team performance by *observing* behaviour or output of individuals or teams. However knowledge, beliefs and attitudes also determine team behaviour to some extent. Yet to study teams it is useful to have a model which can help guide the assessment process.

3.6: Models of Team Performance

A teamwork model serves as a representation a particular process, allowing us to map a network of relationships between particular input, process and outcome factors. Choosing a model and defining measures of teamwork is complex and there is no firm consensus on what, when and how to measure teamwork, due to the lack of empirical data to validate them (Komaki 1997). In setting out a model of performance it is important to realise that while most teams are judged by the outcome they put out a similar comparison may not be possible in healthcare due to the number of variables. Outcomes in healthcare are relatively less clear compared to the military for example where the end point is more defined. In surgery perhaps it would be better then to merely try improving the process of team work, training aspects and attitudes and that the outcome would improve though it may not be directly measurable.

Researchers commonly refer to one of the most commonly published model in the literature; the INPUT-PROCESS-OUTPUT model (McGrath 1964). This model is established in aviation (Helmreich and Foushee 1993), the NHS (West *et al.* 1998), and in other team theory literature (Cohen and Bailey 1997;Gladstein 1984;Guzzo and Shea 1992). The basic model of team performance often adopted for work systems follows the principles of an input-process-output system (Annett *et al.* 2000;Gladstein 1984). Such a model dictates that inter-professional teams need certain infrastructure, resources and competencies, collectively termed as team input factors. Although the input variables are important determinants of team performance, team work components and their measures are also required to explain the way in which input factors affect performance. Team process amounts to all the interactions between the main input factors. It refers to the behavioural application of the team, its physical interaction with technology and its internal social interactions. This will include the team behaviours, which are needed over and above the behaviours for task completion, such as recovery from error (Sasou and Reason 1999) and leadership (Edmondson 2003). Team output refers to the product of the team. It can also refer to the outcome for the team, perhaps in terms of learning and innovation. To be effective members from all groups that compose a team must share some understanding about the team's processes and functions (Klimoski and Mohammed 1994;Rouse *et al.* 1992)

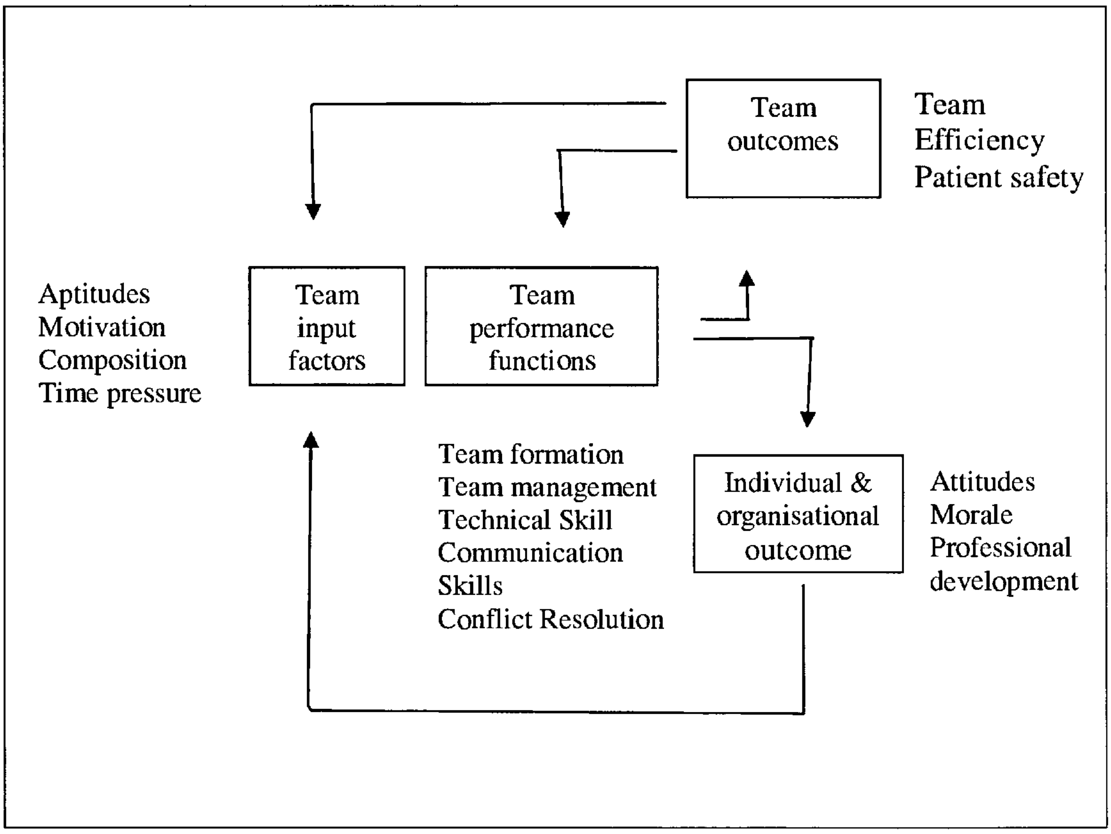

Figure 3.1: A model of team performance (adapted from Helmreich & Schaefer 1994). The different input, process and outcome factors are shown and how they link back into each other.

Figure 3.1 shows a basic model of team performance; it permits predictions concerning relations among team factors. For instance, in their application, to fulfil function, the team requires certain conditions, resources and competencies, collectively termed as input factors (Helmreich and Schaefer 1994;Cohen and Bailey 1997;Guzzo and Dickson ;Paris *et al.* 2000). Some factors are based on design, such as team structure (Stewart and Barrick 2000) and composition or equipment provided. Other factors, such as knowledge, skills and competency exist in the memory and cognition of individuals. Shared cognition, in expectation and understanding among team members, underpins teamwork in team process (Klimoski and Mohammed 1994;Kraiger and Wenzel 1997;Rouse *et al.* 1992) and is manifest in quality and quantity of communication, co-operation and co-ordination behaviour.

Similarly in the operating theatre the surgeons and the nurses should have a shared mental model about the procedure they are about to perform. This is even more likely if they have worked together as a team or the surgeon has a standardised method of performing the surgery. In some cases surgeons have a card of information specific to each procedure which included what sutures they use, what type of drains and any special instruments if needed. Additionally in the input factors would be an appropriate staff rota where a nurse who is familiar with that procedure would be rostered for that case. The surgeon and anaesthetist are appropriately experienced to carry out the procedure and if they are not then they should be appropriately supervised by more senior colleagues. The team structure should be appropriate for the task with adequate numbers of qualified members to perform the task i.e. the operation of the patient safely and efficiently. Figure 3.2 shows a team performance model for operating theatre teams adapted by Healey, Undre et al from McGrath 1964 who described an input- process-outcome team performance model (McGrath 1964).

In relation to surgery it is the measurement of the process of team performance that is most crucial and which is most likely to give us the most valuable information. The team process will also help shaping the assessment methods. Hence for the purpose of our study we have laid more emphasis on the process aspect of the teamwork model and will be discussed in more detail below.

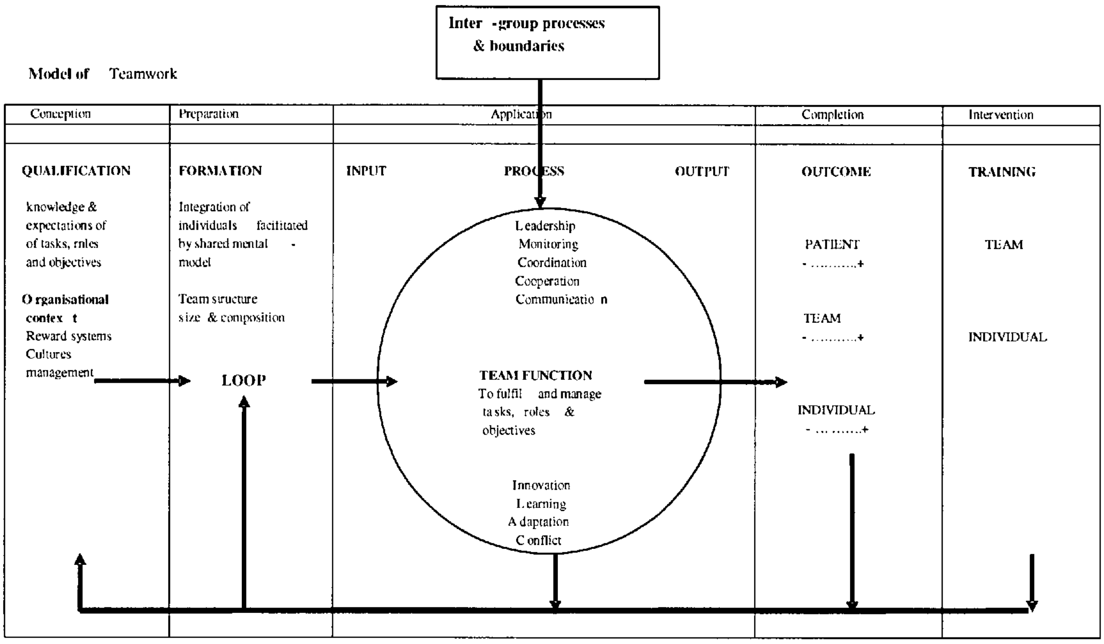

Figure 3.2: Input-process-output model of team performance in Surgery *(Healey et al 2004, Modified from McGrath 1964)*. The circle denotes the team and the various team components.

3.7: Components of the Models of Teamwork

Teamwork components vary depending on the model. Brannick & Prince (1997) reviewed the assessment tools used for cockpit teamwork and they concluded that overall, researchers fail to reach agreement on the constructs for measuring teamwork because they do not derive their measurement tools from a unifying theory (Brannick and Prince 1997). Different teamwork models comprise of similar constructs, some difficult to observe and measure, such as attitudes, team cohesion (Militello *et al.* 2000), affective tone (George 1990), team climate (Andersen and West 1994) and team role self-perception (Belbin 1981). However, many models commonly refer to constructs such as co-ordination, communication, leadership, situation awareness, co-operation and decision-making; but note that there are many more (Militello *et al.* 2000).

3.7.1: Behavioural Components

Militello, et al (2000) designed a generalised, four-component model based on the common denominators of several teamwork models. These included team identity, planning and decision making, team competencies and self management (Militello *et al.* 2000). For example in a surgical context understanding an aspect of team identity would be the extent to which the nurses understand the role of the ODP or vice versa. Further in the team identity section a good example for the compensating aspect would be when a senior scrub nurse or surgeon in theatre is training a more junior member and compensating by helping them if they do not understand or do what is expected of them. Similarly in the planning and decision aspects in articulating expectations for example if there is bleeding or the operation is particularly difficult then a discussion between the team about how much longer the case will take and what other special equipment or assistance will be required. In the team self management section effective time management would be the ability of the surgeons anaesthetists and nurses working effectively to coordinate and finish the operating list on time without any cancellations or delays.

	Team component and dimension	Definition and key concepts
	IDENTITY	The extent to which member conceive the team as an interdependent unit and operate from that perspective
A	Defining roles, functions and resources	The extent to which team members understand task responsibilities, expertise and roles of other members
B	Engaging members	The extent to which members participate in the teams work and take responsibility for achieving the team goals
C	Compensating and coaching	The extent to which members shift resources to cover areas such as teaching of inexperienced members
D	Interpersonal aspects	Harmonious or conflicting styles of members
	PLANNING AND DECISION MAKING	
A	Envisioning goals	Teams ability to operate as an intelligent entity, solves problems and makes decisions to meet task demands
B	Maintaining focus	Teams ability to focus planning and decision making within appropriate time span. Focus ahead to anticipate events
C	Shared situation assessment	Teams ability to form a shared understanding of the situation.
D	Articulating expectations	The extent to which team articulates it expectations about the progress of a course of action
E	Evaluating course of action	Teams ability to use collective experience to coordinate and conduct a plan and visualise areas where problems may occur
	TEAM COMPETENCIES	Proficiency of members and personality of the team.
A	Member leadership	Ability of each member to perform their task. The leaders ability
B	Shared practices	Team effectively implements shared procedures. The quantity and quality of practice team uses to become proficient with SOP
	SELF MANAGEMENT	The teams ability to observe its performance processes and make adjustments to reach a higher level
A	Monitoring	Teams ability to examine itself for effective and ineffective behaviours
B	Detection and adjustment	Teams ability to change strategies if ineffective. Teams ability to anticipate changes, recognise and handle inconsistencies
C	Time management	Teams ability to meet goals on time

Table 3.1: A generalised, four-component model based on the common denominators of several teamwork models as described by Militello, et al 2000.

A very important piece of work was that conducted by Dickinson and McIntyre. Following a substantial review of the teamwork literature they advocated that measures should be based upon a model. They proposed a model of team work that had 7 components which were generic to all team tasks; team orientation, leadership, communication, monitoring, feedback, backup behaviour and coordination (Dickinson and McIntyre 1997). This model was the one that helped shape our own team behaviour components in the development our own team assessment tool and it is this aspect of the process that the discussion will concentrate on. They summarised that teamwork requires team members who have positive attitudes towards the team and the team tasks, provide direction and support for the other members and have a good knowledge of their own tasks and that of the other members. Throughout their proposal it seems that focussing on the teamwork aspects, rather than individual successes and outcomes, will lead to a better overall outcome.

Having a defined model is important when one needs to specify what exactly one needs to assess or observe. It also helps shape the development of measures. In particular it provides a guide for developing observational measures in surgery. Table 3.2 summarises their 7 components of team work along with description and examples. In what follows, a few studies on the various components will be discussed mainly communication, coordination and leadership.

Component of Teamwork	Description and examples
Team Orientation:	Attitudes that team members have towards each other and to the team task. For example members who willingly participate in all the team activities.
Team leadership:	Can be shown by any member of the team and refers to the provision of direction and support for other members. For example explains to the team exactly how to perform a task or to complete the assignment.
Communication:	Refers to the exchanges of information between the members in an appropriate manner. For example members acknowledge and repeat message for clarification
Monitoring:	Refers to team members observing others work and providing back up where necessary. For example a member recognising another performing a task correctly
Feedback:	Refers to providing and receiving information about performance. For example one member accepting suggestions by other member to save time.
Backup behaviour:	Refers to members understanding each others roles and being able to seek and provide assistance when necessary. For example a member filling in for another member, who cannot perform a task.
Coordination:	Refers to members performing their tasks in a integrated manner. For example one member facilitating the action of another.

Table 3.2: The 7 components of teamwork as described by Dickinson and McIntyre with the description and examples of each component. (Dickinson and McIntyre 1997)

3.7.1.1: Communication

Communication is regarded as one of the most important components of teamwork as it is essential for exchange of information, coordination, monitoring of the teams performance, providing feedback, creating plans and strategies, and developing a shared mental model (Rasker *et al.* 2000). Communication involves exchange of information, be it verbal or written, between the members of the team. Communication is a component which links together all the other components such as coordination, monitoring and feedback (Dickinson and McIntyre 1997).

Research in aviation attempted to capture team performance through analysis of communication between crew members. Williges et al studied the communication of 32 teams using a simulated radar controlled task. They found that communication facilitated performance in the absence of standard operating procedures (Williges *et al.* 1966). Kanki et al looked at the differences in communication made by teams, through analysing transcripts, based on the number of errors committed. They found that for the low error teams there was a consistent pattern of communication such as more commands from the captain and set response patterns. The high error crews on the other hand demonstrated a more erratic communication pattern. They further concluded that using conventional patterns of communication would enhance team coordination (Kanki *et al.* 1989).

Brannick and Salas evaluated multiple measure of team performance using two person teams flying a simulated F-16 aircraft mission. This study also showed that communication was related to effectiveness but the way that this communication is gathered affects the meaning of it. Furthermore this also showed that cooperation and giving suggestions also correlated with outcome and hence are good variables to use for predicting team performance (Brannick and Salas 1993).

3.7.1.2: Coordination

Brannick and Prince in their overview of team performance state that coordination is the central feature of teamwork where coordination is defined as an adjustment of one sort or another by the team members to achieve the team goal (Brannick and Prince 1997).

A number of other studies have examined the relationship between coordination and outcome for example Stout, Cannon-Bowers et al utilised a simulated model to observe and study the relationship between crew coordination and successful mission. They found a significant correlation in that teams that performed better overall also had higher coordination ratings (Stout *et al.* 1990). In addition there was an effect of the type of training with skills based practice being better than lectures.

In summary highly effective teams demonstrate a high degree of communication and have a more consistent or standard pattern. Coordination tends to be also related to performance where well coordinated teams can compensate for other members and improve overall performance.

3.7.1.3: Leadership:

Leadership contributes to outcome in several different ways. Edmonson raised the possibility that teams that had good leadership had an atmosphere which made it easier to report and learn from errors. Therefore they were more likely to prevent such errors occurring in the future (Edmondson A. 1996). Teams also have to participate in learning processes which needs to be led by effective leaders. Further more effective leaders help teams to learn by promoting the ease of speaking up through good communication. For example Edmonson found that using this technique was associated with success when implementing new technologies in cardiac surgery (Edmondson 2003).

Effective leadership has shown to have beneficial effects on the safety and performance in high risk environments such as aviation and energy production (Flin and Yule 2004). It is possible that they may similarly affect surgery and have an impact on surgical outcome.

3.8: Measurement of Team Performance

Measures of teamwork are important to improve inter professional teamwork (Dickinson and McIntyre 1997). They are needed to provide feedback during training and to evaluate attempts to improve teamwork. There are several methods of measuring teamwork. These include questionnaires, surveys, interviews and observation.

Measures of teamwork vary in their design and properties according to the object they measure and their purpose (Brannick and Prince 1997). The object of assessment in any system might be the individual a team or sub-team (Paris *et al.* 2000). The purpose of measurement might be to assess how team input and process factors might cause or affect team performance. These might include new technology, team composition or the work environment. Similarly in the operating theatre we may observe effects of new equipment or technology impacting on the team. The environment such as a noisy theatre or one that has inadequate lighting may also affect team performance. Whatever the object or purpose of measurement, teamwork measures must measure what they purport to measure and ideally account for the technical and behavioural dimensions of teamwork (Annett *et al.* 2000).

There are several reviews on the research conducted to enhance the synergistic potential of teams in organisations. Tesluk et al (1997) and Annett (2000) have tabulated the main methods of assessing teams and cited relevant references where researchers have used questionnaires/surveys, interviews, self reports, audits, observational studies and simulations. Some surveys have even been conducted in the healthcare setting such as ORMAQ (Annett *et al.* 2000;Tesluk *et al.* 1997) and will be discussed more in detail in the next chapter. However there is still no consensus on the best methods for studying this subject. Perhaps the more common form of team assessment, in high-risk environments in particular, is observation of behaviour.

3.8.1: Observational Assessment of Teamwork or Components of Teamwork

There have been several studies that have used observation as a means of assessing entire teams or components of team work. These may be either through observations of real performances or during simulated scenarios. The benefit of simulations is that the scenarios are pre planned and set events can occur for evaluations to be made. In real environments there is no guarantee that a set behaviour may be required especially if an event does not occur.

Observations may be through direct observation with one or more assessors or through review of audio and video recordings of taped performances. There are advantages and disadvantages of both systems. For example when observing teams online there may be certain aspects missed when the observer is making notes. Secondly in certain cases more than one observer may be required if the especially if the team to be observed is quite large. On the other hand audio and video recordings such as the RATE (remote analysis of team environments) tool described by Guerlain et al, may overcome this problem and recordings can be watched again if anything is missed (Guerlain *et al.* 2002). However this again has a few difficulties with safe storage of sensitive data. Secondly equipment failure may occur and data may be lost. Thirdly there may be technical errors which may fail to capture some aspects of the measurement.

The TARGETS (Targeted Acceptable Responses to Generated Events or Tasks) method of team performance measurement was originally developed to evaluate team performance in complex environments such as air crew coordination training (Fowlkes *et al.* 1994). By inserting specific events into training scenarios and having acceptable responses for each of them it was possible to capture team processes for training exercises. The advantage of this form of assessment is that specific events and behaviours must occur according to each scenario and the observer can score them objectively without previous responses creating a bias in the same scenario (Dwyer *et al.* 1997). The disadvantage is that a large number of scenarios and checklists have to be developed. The other disadvantage is that it may not be so helpful in real scenarios where specific events may not occur and the behaviour then cannot be scored.

Observational assessment has been used extensively to study team work and team work components in other high risk environments and is one of the important methods of evaluating teamwork. This method is well established in the military (Annett *et al.* 2000) and aviation (Helmreich and Foushee 1993).

Observational assessments may consist of rating of behavioural markers such as those used in aviation (for a review on the criteria of markers see Klampfer, Flin, Helmreich, Hausler, Sexton, Fletcher et al, 2001) (Klampfer *et al.* 2001). In rating behaviours observers seek to match and rate statements to observed behaviour 'on-line' during process, or retrospectively from memory or video replay. Behavioural statements apply to particular components of a given teamwork model; they are used as measures of performance. For example the NOTECHS rating evaluates non technical skills of pilots by observing behavioural elements (Avermate van J.A.G. and Kruijsen E.A.C. 1998). The main skills assessed are leadership and management, decision making, co operation and situation awareness. This is to ensure that pilots have the necessary skills as individuals to fit into and work effectively within a team i.e. with their crew.

A similar system which utilises an observational method is the Line Operations Safety Audit (LOSA). This system utilizes trained observers riding in cockpit jump seats to evaluate several aspects of crew performance and collect safety related data. These observers record the various threats encountered by aircrew, the types of errors committed, and they record how flight crews manage these situations to maintain safety (Klinect *et al.* 2003).

Observational assessment has been used to measure one or more components of teamwork such as leadership, communication and coordination. Some of the principal studies have been summarised in Table 3.3. Notably some of these have been in healthcare based on other research conducted in aviation and other high reliability organisations.

Construct measured				
Leadership	Communication	Monitoring	Backup	Coordination
NOTECHS behavioural markers- Helmreich et al	Communication in theatre- Lingard et al 2002	NOTECHS behavioural markers-	NOTECHS behavioural markers- Helmreich et al	Field notes technique- Hawryluck et al 2002
TARGETS method and HTA Annett et al '00	Field notes technique- Hawryluck et al 2002	University of Texas behavioural markers	University of Texas behavioural markers	TARGETS method and HTA Annett et al '00
University of Texas behavioural markers	Multiple measures in simulated flights Brannick & Salas 1993			Observation in training Stout et al '90

Table 3.3: Different teamwork components that have been assessed by different studies using an observational method of assessment.

3.8.2: Distinguishing Team from Individual Assessment

In any measurement of teams there is always a danger of measuring individual performance rather than that of the team. It is common that researchers and practitioners fail to distinguish behaviours and tasks of individuals from those of the team (Brannick and Prince 1997). Consequently, assessors are prone to infer team attributes from individual attributes (Tesluk *et al.* 1997) when pooling individual scores to obtain team scores.

Foushee suggested that when a team fails to correct an individual team member's error, the error becomes a team error (Foushee 1984). That statement is noteworthy because it implies team performance depends on factors other than individual performance. On the other hand, assessing the team alone assumes each individual contributes equally when they may not and interventions for team improvement may fail to resolve problems concerned with individual's roles and contribution to the team effort (Tesluk *et al.* 1997). Similarly when developing measures for surgery it is important to ensure that the assessment is for the team and not for attributes of individual people. However there are instances where individual behaviours are essential for the whole team to be effective. For example in surgery where the surgeon fails to inform the team about bleeding which has just begun. If the team is vigilant they may notice it themselves or the surgical assistant may inform the rest of the team and thereby compensate for the surgeons lack of communication.

The purpose of developing these measures is ultimately so that team performance may be improved in surgery. Overall it should bring about changes in attitudes to safety and teamwork along with improvement in patient safety and surgical outcome. In addition to the development of measures it is important to develop in parallel training interventions to enhance teamwork as has been done in aviation and then adopted by various other industries. With measures to assess teamwork the impact of team training interventions can be evaluated and assessment of improvements in safety and outcomes may be possible.

3.9: Team Training and CRM (Crew Resource Management)

Most of the research that has been conducted over the years stemmed from accidents that were in some way related to team failures such as airplane crashes and military accidents. Similarly in medicine high profile cases such as the Bristol enquiry and the study of adverse events has prompted teams research in these high risk areas (Bristol Royal Infirmary Inquiry 2001;Vincent *et al.* 2001). In aviation research into teams was prompted following the recognition of the importance of crews and their interaction with one another in achieving safe efficient flights. Human error is often implicated in high profile accidents and for disasters in the air, railways, in other high risk environments and in surgery (Vincent *et al.* 1998). The context in which errors evolve and occur plays an important role in human performance and a number of solutions are offered. While a particular error may be the cause of an incident closer analysis ususally reveals series of preceding events and deviations from safe practice each of which may be influenced by the working environment and wider organisational factors. High reliability organisations have understood the importance of examining and addressing the whole system along with its design and management. Teamwork is fundamental to safe operation and several teamwork factors have been implicated in accidents.

As seen from the literature and the previous sections, the aviation industry has given particular emphasis to teamwork. Not only are they geared towards improving teamwork but also to addressing error recognition, prevention and reporting (Calland *et al.* 2002). In studying all factors related to safety they have uncovered several related components which are contributory. For example in many cases of error studied, pilot fatigue has emerged as a factor or predisposing condition (Dinges *et al.* 1997;Torsvall and Akerstedt 1988). The aviation industry has also realised that it is not only the equipment but how each member interacts with it and with each other. This team interaction in itself can have huge implications on safety and help to minimise errors rates.

Aviation accident analyses, simulator research, and cockpit voice recordings revealed that unsafe flight conditions were frequently related to failures in pilots' non-technical (cognitive and social) skills, rather than a lack of technical knowledge, flying ability, or aircraft malfunction. Aviation safety experts have collected and analysed a large amount of safety related data. They showed that human error has caused or contributed to over 50% of avaition accidents. In an analysis of 35000 reports of incidents 50% were due to a flight crew error and an additonal 35% due to air traffic controller error (Billings and Reynard 1984). Root cause analysis by experts have shown that these errors occur because flight crews fail to effectively manage the reseources available to them. Naval aviation reports similar results with one study attributing 59% of serious errors to some degree of air crew factors (Weingmann and Shappell 1999).

The study of errors in industries such as aviation has led to specific training, targeted at the team for error prevention strategies. This kind of training is termed crew resource management (CRM). The crew concept originated from the airline industry and following several name changes is now known as crew resource management (CRM) due to the recognition of the importance of the team members who are not in the cockpit. The training includes instruction about human vulnerability under stress, nature of errors and counter measures. CRM was designed to provide safety training which focussed on effective team management. Improvements in avaition safety maybe be in part due to this training. The concept originated in response to a NASA workshop that examined the role of human error in airplane crashes (Cooper *et al.*

1980). CRM emphasises the role of human factors in high stress, high-risk environments and is defined as "using all available resources, information and people to achieve safe and efficient flight operations (Helmreich *et al.* 1999). CRM encompasses team training as well as simulation, interactive group debriefings and measurement and improvement of aircrew performance. The primary components of effective CRM are safety, efficiency and morale. The CRM programmes usually consist of a number of different interventions (e.g., education about human error, stress management, assertiveness, briefings to standardise communication of key information, and debriefings) (Salas *et al.* 2001). More recently, the key principles of CRM have been adapted to create CRM programmes that address the needs for individual and team training of staff, working in diverse fields such as offshore oil rigs (O'Connor and Flin 2003) and different areas of medicine. CRM and team training has been modified and successfully used in anaesthesia and emergency medicine (Gaba *et al.* 1998;Morey *et al.* 2002). These applications will be discussed more fully in the following chapter

Several studies have utilised proxy tools to test the effectiveness of CRM (Helmreich 1991). One study looked at the attitudes of crew members before and after the training. Crew behaviours were also analysed by trained observers and they found that following training the percentage of above average behaviour increased and the percentage of below average behaviour decreased. Superior pilots shared many common attitudes (awareness of personal limitations and diminished decision making capacity during crises). In addition they encouraged crew members to question their decisions and actions, were sensitive to the personal problems of other crew members, and recognised the need to verbalise plans and train other crew members (Helmreich *et al.* 1990).

Along with intensive programs for training, airlines are equipped with black boxes in every cockpit. These devices record the aircrafts parameters and conversations in the cockpit enabling experts to use this information to analyse and review the parameters surrounding events in cases of deviations from normal flight parameters and in event of a near miss or crash (Helmreich 1998). In the interest of improvement, aviation safety experts rigorously evaluate processes, policies and devices related to airline travel prospectively and retrospectively after crashes and near misses.

3.10: Conclusions

The preceding review shows that effective teamwork is fundamental to safety and efficiency in high-risk environments (Helmreich and Foushee 1993;Sasou and Reason 1999). Efficient teamwork requires the team members to have a positive attitude towards the team and its task, have adequate direction and support for achieving the goal and have knowledge of their own tasks and that of other members of the team. This allows the team members to coordinate their activities by monitoring the performance of other members, communicating with them and providing back up and feedback when needed. Successful teams and team leaders focus on improving teamwork rather than individual success and performance (Dickinson and McIntyre 1997). Good teams therefore monitor their performance and self correct; they anticipate actions and needs of other team members and coordinate their actions. Crucial to the performance of teams are the abilities and behaviours of the team members and the roles of the members. Successful team work depends on the knowledge, skills and attitudes for individual task performance and also on the traits of the team members that facilitate team interaction and functioning (learning ability, initiative, adaptability etc). Also importantly for a team to be effective they must share a mental model or have a shared goal and work collectively towards achieving that goal. However to evaluate if a team is effective, proper assessment measures are required. A lot of the team literature failed to provide solutions for training teams or on how to select team members and promote effective teamwork. Part of this difficulty again stemmed from the fact that there were no effective measures for assessing teamwork (Salas *et al.* 1992).

This chapter has given us an overview of the literature that is relevant to developing measures and effective training mechanisms for surgical teams. It helps us to understand the basic nature of teams and allows us to draw on team research in other high risk industries such as aviation. Working from the input-process-outcome framework it seems that it may be possible to alter or enhance the input factors to improve safety and outcome. Hence enhancing the input and process factors such as team structure, cognition and behaviour may help improve outcome. The development of assessment measures for surgical teamwork based on this model will be discussed further in a later chapter. Further this chapter has given us insight into CRM and team training in other high risk environments which have been instrumental in attitude shifts and in improvement of safety and team working. Using the principles of CRM will help us to develop and pilot a team training module for surgery incorporating multi-disciplinary crisis simulations.

4. Chapter Four: Teams in Surgery

4.1: Introduction

The importance of team work in surgery has been emphasised in many reports and studies by many different professional organisations. The National Confidential Enquiry into Peri-operative Deaths CEPOD report- 2002 states that the 'continuity' of quality patient care throughout the patient's journey depends largely on interdisciplinary teamwork (National Confidential Enquiry into Perioperative Deaths 2002). The Kennedy report which followed the enquiry into the Bristol heart scandal also highlighted many issues pertaining to teamwork (Bristol Royal Infirmary Inquiry 2001). For example in its recommendations it stated that "people failed to communicate with each other, and to work together effectively for the interests of their patients". Further they found that there was a lack of leadership, and of teamwork. The poor teamwork and this had implications for performance and outcome. The crucial importance of effective teamwork in complex surgery was very widely recognised. Yet there was a lack of effective teamwork and inter professional relationships were poor. The report also highlighted that the ineffective teamwork was brought about through a lack of effective clinical leadership.

In studying teams in theatre one assumes that surgical teams are unitary, cohesive entities. This assumption is also found in the recent work on the "non-technical" skills that clinicians must possess in order for medical teams to function effectively (Flin and Maran 2004;Fletcher *et al.* 2003) At first glance, the "single team" assumption does not appear unreasonable. On the one hand, the minimal social-psychological requirement of a "team" is the presence of a common goal that is salient to all its members. Surgical teams have a very obvious such goal: the delivery of the best possible intra and peri-operative care to the surgical patient. *Descriptively*, therefore, surgical teams fulfil the "single team" criterion. However, everyday clinical practice and anecdotal evidence of people's actual behaviours in OTs challenges both description and prescription. OT professionals often complain that their colleagues do not understand their priorities or they seem to be pursuing conflicting goals. The training literature also suggests that OT professionals need systematic, post-medical school training in order to develop the skills that enable such teamwork to take place effectively (Flin and Maran 2004). Thus the following paradox arises: whereas OT teams are by definition unitary, cohesive entities, the members of which work towards an explicit common goal, simultaneously these team-members (i) often report the lack of such cohesiveness in their everyday clinical experience and (ii) seem to be in need of additional extensive training in order to function effectively within their teams' boundaries.

To enhance the teamwork and to develop efficient training programs it is important to understand how to study teamwork in surgery and how team training can be applied in surgery. This chapter will identify the different methods of studying teamwork and attitudes to team work in the healthcare and surgical setting. It first describes the studies on attitudes to teamwork in healthcare. It will then describe the experimental studies of team work and team performance in surgery. The chapter will then go on to describe the applications of team training and CRM in surgery including the use of simulations and other interventions to improve safety and enhance teamwork in the operating theatre.

4.2: Attitudes to Teamwork

A number of studies have addressed the attitudes of operating theatre staff to teamwork, addressing factors such as error, teamwork and attitudes towards the effects of stress. Sexton et al demonstrated different perspectives on teamwork among medical staff in a cross sectional survey of operating theatre and intensive care unit team members. In this survey comparing attitudes to safety between staff working in aviation and medicine, over 80% of 1033 medical staff felt that briefings defined as preoperative discussions, are an important part of safety in teamwork, yet reported that they very rarely happen in practice. Medical staff also reported that improvements in teamwork would be achieved by improvements in communication between team members (Sexton *et al.* 2000). Their results also showed that surgeons and anaesthetists (surgeons much more so) were more likely to deny the effects of fatigue on performance as compared to pilots (pilots 26%, surgeons 70% and anaesthetists 47%). In regard to whether junior staff should question the decision of seniors they found the consultant surgeons were less likely to reject steep hierarchies, rather they preferred not to be questioned by juniors. In contrast 94% of cockpit and intensive care staff advocated flat hierarchies. Further problems included differing perceptions of teamwork among team members and reluctance of senior theatre staff to accept input from junior members.

Helmreich and Schaefer adapted flight attitudes questionnaire to study behaviours and to survey attitudes to teamwork in the operating theatre teams. They initiated surveys such as the ORMAQ (operating room management attitudes questionnaire) and investigated peoples attitudes to stress, hierarchy, teamwork and error (Helmreich and Schaefer 1994). They collected data from 53 surgeons, 45 anaesthetists, 32 nurses and 22 anaesthetic nurses using this tool which contained 64 multiple choice questions and 2 open ended questions. They had a response rate of 60%. The results showed that there was agreement about the importance of communication and coordination for safety and efficiency. However they found that surgeons and nurses supported a culture where juniors were less likely to question the decisions made by their seniors. The findings also suggested that the staff do not agree on how team activities should be coordinated and that this was probably due to the fact that medical training focuses largely on technical aspects and not on team training. Furthermore the anaesthetists and anaesthesia nurses were more accepting to the idea of pre operative briefing and felt that such communication would enhance team work. This also highlights the need for such training in the surgical field.

In another attitudes survey study relevant to surgery, Flin et al., (2003) assessed 222 anaesthetists in 11 Scottish hospitals on their attitudes to teamwork and safety. The anaesthetists' mean ratings of quality of teamwork and cooperation/communication they experienced with other professions on a 5 point scale (where higher scores indicate better quality), ranged from 3.2 for consultant surgeons to 4.2 for consultant anaesthetists. Although these results indicate fairly good perceptions of teamwork they suggest that there is room for improvement in communication especially between anaesthetists and surgeons (Flin *et al.* 2003).

Attitudes to CRM training has also been assessed in a variety of clinical teams form emergency medicine and the operating theatre (Grogan *et al.* 2004). Grogan et al evaluated the human factors attitudes following CRM training in 338 participants. They found improved attitudes towards team building and communication and team decision making. Further the participants agreed that such training would reduce errors and improve patient safety.

In summary these surveys have highlighted the differing attitudes between the various personnel involved in operating theatres. There was agreement in most of the surveys that communication was critical for teamwork and for improving safety in the operating theatre. However there were issues with hierarchy and speaking up with seniors. The cross sectional surveys interestingly showed that pilots followed by anaesthetists had the better attitudes towards team work and error than surgeons. Perhaps this is due to the fact that CRM and team training is extensively carried out in aviation and to some extent in anaesthesia. CRM training has shown to create a shift in attitudes to error and team work. This makes a case for similar methods to improve team work and communication to be adopted for surgery and operating theatre teams.

4.3: Assessment of Non Technical Skills

Behavioural markers or non technical skills have been used for several years by the aviation industry for assessment of pilots. Some progress has been made in assessing person-related factors by observation in healthcare, such as the anaesthetists behavioural input. Anaesthetists have been leaders in the field of assessing the non technical skills in healthcare. Following the initiation of anaesthetic crisis resource management (ACRM) courses by Howard and Gaba et al to assess the non technical performance of anaesthetist especially in a crisis setting, several studies have looked at team work components under this heading (Howard *et al.* 1992). Anaesthetists are now being assessed on these skills and this forms part of their overall assessment of competence which is mandatory in some centres.

Fletcher et al reviewed the literature studying the role of non technical skills in anaesthesia (Fletcher *et al.* 2002). They used several data sources to identify these critical behaviours such as incident reporting, observational studies, attitude surveys and theoretical models. The non technical skills fall under the categories of (i) cognitive or mental skills such as planning and decision making and (ii) social or interpersonal skills such as team working, communication and leadership. They identified incident reporting, observational studies, attitude questionnaires and theoretical models as good data sources for evaluating non technical skills in anaesthetists. They also discussed in their review, key issues for training and assessment and discuss the limitations of the various sources available.

Fletcher et al developed measures such as the Anaesthetist's Non-technical Skills Assessment (ANTS) which focuses on the team skills of only anaesthetists and does not extend to the rest of the team. These are designed for training programmes carried out primarily within professional groups, yet with regard to interactions across professional boundaries. Other observational tools are designed to measure certain elements of teamwork between particular agents within professional groups, such as communication among surgeons (Xiao et al., 2003), or among several professional groups in surgery (Lingard et al., 2004).

An important study done in Scotland by Baldwin et al highlighted the importance of non-technical skills in assessing surgical competence. Using a Delphi technique, using anonymous postal questionnaires, was used. All consultant surgeons in South-East Scotland were asked to identify the skills they expected of surgical trainees. The qualities identified fell into five domains: technical skills, clinical skills, interaction with patients and relatives, teamwork, and application of knowledge. Contrary to expectation, consultant surgeons value many generic skills more highly than technical skills, indicating that they value well rounded doctors, not just those with technical ability. The characteristics identified are being used to develop an assessment tool for use on basic surgical trainees surgical (Baldwin *et al.* 1999),

Following on from the development of anaesthetic non technical skills Yule et al proposed a taxonomy for non technical skills of surgeons which consists of a combination of interpersonal skills such as communication, leadership, teamwork along with cognitive skills such as situation awareness and decision making (Yule *et al.* 2006).

4.4: Observational Studies of Teamwork in Surgery

Observational research has been used extensively to study teams in other high risk industries such as aviation. Some may simply assess non technical skills in individuals as described in the section above. Others may assess components of teamwork but restrict it to groups of individuals and not necessarily the whole team.

Observational studies may be structured or unstructured. Unstructured studies include those which provide a narrative of work processes or vignettes of communication failures. A number of research studies have carried out observations of the entire team yet some of these have not made use of a formal assessment instrument (Roth *et al.* 2004;de Leval *et al.* 2000;Lingard *et al.* 2004). For example Roth et al studied team performance using a field notes technique. Two observers, one surgeon and one human factors expert studied 10 complex operations to identify latent factors that could complicate the cognitive and collaborative team performance and which may lead to adverse events (Roth *et al.* 2004).

Structured observations are needed to measure teamwork or any other system property systematically. For example Carthey evaluated the role of structured observations in theatre (Carthey 2003). They collected data from 173 neonatal arterial switch operations (ASO) in paediatric cardiac units across 16 centres in the UK. Data was collected by two trained human factors specialists who were the observers in this study. They watched the entire operation from induction of anaesthesia until the patient was transferred to the intensive care unit. They made a note of errors, problems and notable aspects of good performance. The observer's interpretation was checked with the operating theatre team after each case and a summary report was written. The authors stated that observers using well structured and well defined measures can be trained more rapidly and achieve a good understanding of what they are meant to observe. Therefore these observers achieve much higher levels of reliability (Carthey 2003).

There are a variety of observational tools designed to assess some element of teamwork in surgery. For instance, Objective Structured Assessment of Technical Skills (OSATS) developed in Toronto by Martin et al is primarily designed to assess the technical skills of the surgeon, but contains some teamwork elements such as effective use of assistants (Martin *et al.* 1997).

In a surgical context de Leval et al have suggested that the team components have an important role to play in the study of errors in surgery. Error recovery strategies are just as important as error prevention measures. They conducted an observational study of errors during paediatric cardiac surgery. They found that the surgeons diagnostic skill, knowledge of various strategies to correct problems and communication with the rest of the team were important for error compensation (de Leval *et al.* 2000). This shows the importance not just of communication but the particpation of the rest of the team in managing such problems.

Mackenzie et al also used recordings of trauma resuscitations to attempt a study of team performance in emergency medicine setting (Mackenzie *et al.* 2003). They found that recordings had considerable advantages over observation as they could reuse the recordings to extract qualitative and quantitative data. They also mention however that it was much more time consuming than actual live observations. Additional benefits of video were the capture of behavioural and verbal interactions that were missed at the time of the resuscitation.

The same group observed emergency admissions and interviewed specialists to study effectiveness and leadership. They found that there were differences according to the severity of the patient condition and according to the level of expertise of the team involved. They concluded that directive leadership was more effective if patient was more critical and if the team was inexperienced (Yun *et al.* 2003).

Mackenzie et al also used video studies to observe emergency intubations. They found that in stressful situations many errors were committed which were knowledge based and included drug dosage errors (Mackenzie *et al.* 1996). There were differences in the errors observed and that which were reported. They further suggested that training would be beneficial for effective team communication.

Catchpole et al studied a series of paediatric cardiac operation using an observational technique. They had a single observer in theatre making notes as well as recordings of the procedures which were reviewed later. While their study was primarily a threat and error model to study failure they did assess a few team work components as part of the process especially where the failures involved components such as communication and coordination which occurred in a high number of cases (Catchpole *et al.* 2006).

Helmreich et al, based on behavioural markers developed for aviation, developed a checklist to assess teamwork in the operating theatre (Helmreich *et al.* 1995). This operating room checklist (ORCL) consisted of observable behaviours divided into three sections team concerns, decision making and communication and management of the work situation marked on a 4-point scale. They used it to collect data on team behaviours in a hospital in Europe and initial results showed that there was wide variability in the behaviours observed with upto 40% being below standard (Helmreich and Davis 2007).

4.4.1 The Study of Communication in Surgery

Communication failures have been uncovered at the root of several accident reports in various settings including healthcare (Kohn *et al.* 1999). Furthermore studies as outlined above have shown that communication in the operating theatre is often poor (Sexton and Helmreich 2003). The AIMs anaesthesia study also identified that a number of errors result from failure of communication between the surgeons and the anaesthetists (Ludbrook *et al.* 1993). These are just a few of the studies which stress the importance of good communication and the need for assessment and training of communication skills in surgery.

Communication has also been assessed in medical students (Lang *et al.* 1998), operating room staff (Lingard *et al.* 2002b;Guerlain *et al.* 2002;Adams and Bohan 2000;Grommes 2000) and intensive care unit staff (Hawryluck *et al.* 2002). In the intensive care setting Hawryluck et al studied interactions from 36 sessions at two hospitals by using field note technique. They studied communication patterns in a constantly shifting environment. They also suggested that there are certain catalysts which could lead to collaborations or conflict. These included knowledge, education, patient needs and time.

Research indicates that in the context of medicine and surgery appropriate and timely communication of key information seems to be particularly challenging (Lingard *et al.* 2004;Sexton and Helmreich 2000). Studies done by other researchers have pointed out the importance of communication and many have linked the occurrence of complications and adverse events to these failures in communication (Lingard *et al.* 2002b;Lingard *et al.* 2004). Medical negligence cases also highlight the fact that many errors whether preventable or not are attributed to miscommunication or lack of communication.

Lingard et al, studied team communications in the operating theatre and explored the nature of the communication and the impact on novices (Lingard *et al.* 2002b). They collected data from 35 procedures in four surgical specialities. Paired observers, independently recorded communication using field note techniques. Their results captured a variety of events and were divided into themes. Overall their results suggested that inter-professional communication patterns associated with tension can be transmitted to novices and that this may intensify rather than resolve conflict within the team.

In a subsequent study Lingard et al., used trained observers to conduct an in-depth study of communication failures in the operating theatre with the aim to describe and classify them (Lingard *et al.* 2004). They observed 90 hours of operations, recording 48 procedures in general and vascular surgery (total staff observed N = 94). The data were observers' field notes that were analysed using ethnographic methods (i.e., the constant comparative approach). Two rounds of analyses were conducted: the first used a rhetorical framework to define communication failure evaluating communication events for content, audience, purpose, and occasion; the second round of analysis classified events identified in each rhetorical category for trends in type of exchange and effects on system processes. They categorised from a total of 421 events, 129 (30%) as communication failures; of these failures 36.4% had observable effects on system processes such as inefficiency, team tension, resource waste, work-around, delay, patient inconvenience and procedural error. They suggest that the findings can be used to develop training interventions aiming to improve communication skills of OT team members.

Helmreich and Schaefer used an observational technique to study live operations (Helmreich and Schaefer 1994). They measured factors such as teamwork and communication similar to the ones used in aviation and assessed their relation to adverse events and errors. They observed failure of coordination and numerous delays. Furthermore they observed failure to check anaesthetic machines and distractions. There was poor communication between the anaesthetist and surgeons even in critical situations for example the surgeon failing to tell the anaesthetist that he was using a local anaesthetic with a vasoconstrictor which led to a rise in blood pressure. Overall they suggested that there was much room for improvement and that effective training could improve communication and team work in theatre.

Sexton, in a panel presentation given at the 2000 Aerospace Medical Association, highlighted the fact that communication in the operating suite is often poor (Sexton 2000). Their observational markers which were used for both the operating room and in the cockpits showed striking differences. For example he found that Briefings were below the standard in 90% in the operating theatre as compared to only 23% in the cockpit. Similarly in establishing a team environment 66% were below the standard as compared to only 8% in the cockpit.

The AIMs anaesthesia study identified that a number of errors result from failure of communication and inadequate preoperative planning or evaluation (Kluger *et al.* 2000). The communication failures were due to missing or unclear case notes, process problems such as failure to follow instructions or to communicate management plans or orders. Furthermore a majority of cancellations occurred due to inadequate communication between surgeons and anaesthetist, anaesthetist and anaesthetists or indeed due to communication problem between the patient and the anaesthetist.

These studies on communication highlight the importance of studying the various aspects of team work and how they relate to safety and outcome. They also indicate that current weaknesses in communication in theatre may derive from a lack of standardisation and team integration. Theatre teams do not often meet to discuss the case beforehand and may lead to loss of crucial information. While this may still lead to adequate outcome during routine surgery, a completely unacceptable or unsafe result may ensue if the team has to also deal with some sort of crisis (Lingard *et al.* 2004). This makes a case for the regular assessment of these skills and for the implementations of training interventions designed to improve communication and teamwork.

4.4.2 Assessment of the Performance of Entire Surgical Teams

Team performance is dependent upon behavioural factors that are difficult to observe and to measure. Teamwork measures may be highly task or procedure specific, or reflect properties of the team relating to behavioural interaction among members. As we saw in the previous chapter teamwork has been studied extensively in other high risk environments. However research that has addressed team performance in surgery has mostly remain focused within-discipline, namely anaesthetists (Fletcher *et al.* 2002), surgical (Baldwin *et al.* 1999), or their students (Lang *et al.* 1998) and has not addressed the performance of the whole teams.

Other researchers have studied components of team work or the working environment, based on the systems theory that these factors affect teamwork and may affect outcome. The little research that has addressed interdisciplinary teamwork tends to focus on a single behaviour, most often communication, in isolation to other behaviours (Hawryluck *et al.* 2002;Lingard *et al.* 2002a;Thomas *et al.* 2003;Grommes 2000). While communication is considered a very important component of teamwork, other approaches are needed to capture the characteristics of the whole surgical team.

Some groups such as Christian et al studied teamwork using an observational field notes technique. While they did study the team performance as such the main aim of their study was to evaluate the effect of communication breakdown and the impact of team performance on patient safety (Christian *et al.* 2006). Their observations were carried out by a team of human factors experts and surgeons, studying 10 complex general surgery operations. They recorded minute by minute events that occurred in theatre and later coded and analysed them. They found that problems in communication negatively impacted team performance and patient safety.

Guerlain et al developed a recording and analysis system for observation of teamwork in the operating theatre (Guerlain *et al.* 2002). Their objective was to develop a system which was able to study the operative environment communication and team performance. The RATE (remote analysis of team environments) tool was used to observe 10 laparoscopic cholecystectomies. They used Eubanks scoring for technical performance and a 24 item tool for assessing situational awareness. Their system has the potential for identifying areas for improvement in team work such as pre operative briefing which were absent in the cases they studied.

Based on observational research carried out by de Leval et al, Carthey et al developed a framework to study individual and team factors in theatre (Carthey *et al.* 2003). They used the concepts of using behavioural markers to study successful aviation crews and applied them to surgery. They studied the behaviours of 16 surgeons and provided a surgical excellence score and two outcomes were predicted; death and/or near miss. Procedural excellence scores were derived from multivariable logistic regression. Results showed that those surgeons with the best scores had better behavioural markers scores than surgeons with lower scores. They suggested that behavioural markers may be used to explain the difference in performance between different surgeons and teams.

In summary team performance is dependent upon various factors that are difficult to observe and to measure. Most of the research done in the past has not fully addressed the true interdisciplinary team and tends to remain focussed within single disciplines very often focussing on limited aspects of teamwork. Further more, most 'whole team' measures tend to be relatively unstructured. Teamwork has an important role to play in error causation and error reduction and may ultimately impact on surgical outcome. It is vital to understand the different components of teamwork by observation in theatre so that team training interventions may be targeted to enhance the team working in theatre.

4.5 Developing Team Training in Surgery

High-risk organizations such as aviation and the military have applied human factors research to develop safety programs through simulation, ensuring each member of the team has the capacity to perform a defined role (Billings and Reynard 1984;Paris *et al.* 1999). In medicine, it has been difficult to train team members in the operating room due to the effects of patient and disease variability.

As described in the previous chapter, the study of accidents and the drive to reduce these errors in aviation and other high risk industries led to research into human factors and the development of training interventions to help overcome these technical problems especially during a crisis. Several studies have looked at various aspects of team training and the development of such training programs especially in the aviation industry. These studies can be broadly divided into those which use simulation and team training such as CRM and modified CRM training and other studies consisting of other interventions such as briefing and check-listing. These training programs can be modified and applied to different branches of medicine and surgery in an attempt to enhance team work.

4.5.1 Simulations and Team Training

While surgery and aviation is different in many ways there are common factors and common problems and important lessons can be learned from their experience. Surgeons just like pilots work in environments that are stressful and potentially high stakes situations. There is a degree of unpredictability and situations may change without much notice and may need immediate decisions and actions. Both surgeons and pilots are reliant on the expertise and knowledge of the other team members especially during a crisis. While some people have better people skills than others, the basics of these components can be taught through better understanding of human factors and incorporation of crisis training alongside regular surgical training. This section describes the various applications of CRM in medicine which will be used as a template for developing similar training for entire teams in surgery.

4.5.1.1 Simulations in Anaesthesia

Anaesthetists were the first speciality to take on simulations from pilots and have successfully been able to demonstrate the benefits of simulations (Gaba *et al.* 1998). Based on the principles of aviation and CRM Gaba et al adapted the line/LOS checklist and rated anaesthetist's technical and non technical skills. They used simulated scenarios to assess the performance of anaesthetists. Raters scored the videotapes of 14 different teams that were managing two scenarios: malignant hyperthermia and cardiac arrest. Both technical performance and crisis management behaviours were rated. In addition inter rater reliability was assessed. They found that most teams had high technical ratings. However their crisis management behaviour ratings varied, with some teams being rated as minimally acceptable or poor. Inter rater agreement was found to be fair to excellent. They concluded that technical and behavioural performance can be assessed from videotapes of simulations and that these performance assessment tools might be useful for educational research or for tracking a resident's progress (Gaba *et al.* 1998).

4.5.1.2 Simulations in Emergency medicine

Using the ACRM template Reznek et al developed and piloted the Emergency Medicine Crisis Resource Management (EMCRM) programme using simulation-based crises (participants = 13 emergency medicine residents) (Reznek *et al.* 2003). The course consisted of didactic sessions on human error and crisis management followed by a simulated crisis. It included preparatory reading on Crisis Management on Anaesthesiology, a 5 minute video of flight-simulator re-enactment of an actual commercial airline crash, a 15 min lecture on human error theory and the 10 key crisis management behaviours of EMRCM; actors played the roles of the other team members. Facilitated debriefing, focusing on the principles of crisis management, took place after each of the two training simulations. Participants evaluated the programme positively and suggested that it should be repeated on average every 8 months.

On the same lines the Medteams project was designed to improve team coordination, communication and reduce error (Morey *et al.* 2002). It was developed in response to a retrospective study of malpractice incidents. They found that 54 of the incidents could have been prevented by better teamwork. Moorey et al. (2002) developed and evaluated the Emergency Team Coordination Course™ (ETCC) providing training for teamwork behaviours for emergency department (ED) staff (N = 684), who were organised into caregiver teams in 9 hospitals. Their outcomes were in the domains of team behaviour, ED performance, attitudes and opinions. Trained observers rated ED staff team behaviours and made observations of clinical errors as a measure of ED performance. Staff and patients in the EDs completed surveys measuring attitudes and opinions. The results showed that there were significant improvements in quality of teamwork for the experimental group following training, although no change on subjective workload was observed. The clinical error rate significantly decreased for the experimental group and their attitudes toward teamwork improved significantly as did their assessments of institutional support following the intervention. The core of this teamwork system therefore included teaching of teamwork behaviours and skills, development of teamwork habits, and creation of small work teams. They hoped that improving teamwork skills would reduce errors, improve care quality, and reduce litigation risks. Furthermore the med teams project pointed out the effectiveness of formal teamwork training for improving team behaviours, reducing errors and improving staff attitudes among ETCC (emergency team coordination course) hospitals.

Shapiro, Moorey et al., (2004) followed up this work by conducting a further small study with four teams (total N = 20 participants) who received ETCC training in the Morrey et al., (2002) study (Shapiro *et al.* 2004). They investigated whether the addition of a one day training programme using high fidelity simulations with feedback on teamwork from experts and the trainees would improve participants' teamwork skills further. All teams were observed for set periods in normal work conditions before and after training using a subset of measures from the previous (2002) study. There were no significant differences between the two groups at baseline with the intervention group showing a trend towards improvement in the quality of team behaviour. Participants in the simulations rated positively the simulations as a useful educational method.

4.5.1.3 Simulations in Surgery

Simulations have also been used to develop both clinical (technical) skills (Seymour *et al.* 2002;Gallagher *et al.* 1999) and crisis management in surgery. Moorthy et al., conducted a study assessing feasibility of developing training in procedural simulations for surgeons using simulations in the UK (Moorthy *et al.* 2005). Junior and senior surgeons' performance in carrying out a surgical scenario (a sapheno-femoral junction high-tie procedure on a synthetic bench model) was assessed. Performance on generic surgical skills was assessed using a global rating scale, the Objective Stuctured Assessment of Technical Skills (OSATS) (Martin *et al.* 1997) . Teamwork skills were evaluated using a modified version of the LOSA checklist (Helmreich *et al.* 1999) previously developed for aviation, choosing elements relevant to surgery. The simulations were recorded on a DVD, and rated blindly by two surgeons for technical skills, and a psychologist and a surgeon rated teamwork skills and provided feedback to participants. Participants rated face validity of different aspects of the simulation using an 11 item questionnaire designed for this study. The results showed that participants overall rated the training as realistic and gave high ratings for its relevance for the development of both clinical and teamwork skills. Junior surgeons found significantly more useful the feedback on technical skills than senior surgeons. Further simulations utilising crisis scenarios were also developed for surgeons (Moorthy *et al.* 2006).

Communication programmes are well established in nurse education. The focus of programmes is most often on communicating with patients with less attention paid to inter-professional communication or skills essential for working in specialised settings. Nestel et al by means of interviews explored communication behaviours for effective practice in the operating theatre as perceived by nurses and serves as a basis for developing training. Their results showed that listening, clarity of speech, being polite and courteous were deemed important aspects and suggested that Inter-professional training for operating theatre staff based in part on the key issues identified in this study may help to create clarity in roles and focus attention on effective teamwork and promote clinical safety (Nestel and Kidd 2006).

4.5.2: Team Interventions in Surgery

The purpose of studying the various factors that affect outcome and safety is ultimately so that training intervention may be designed to improve and enhance these factors. These interventions may simply be in the form of feedback after every performance so that the members can reflect and learn. It may however occur in a more formalised manner by way of communication interventions such as briefing, check listing and de briefing as in common in the aviation industry. This has been adopted by several high risk industries and recently by emergency medicine and surgery. These are important issues as they helped shape the training and intervention section of this thesis and will be discussed in detail below.

4.5.2.1: Checklists to Enhance Team Performance

Human factors are responsible for many operator errors that are committed within any system, including surgery. Such errors can be minimised by creating protocols for the team to follow that would help in preventing operator errors. Pilots are also trained to avoid error by extensive use of check lists. Such devices help aviators to ensure that critical steps during take off and landing sequences are not omitted or performed out of sequence (Degani and Wiener 1997). The use of protocols such as mandatory repetition of commands between the control tower and crew members also minimise the potential for miscommunication (Weiner *et al.* 1993). An example of this could be a checklist of events for a particular operation. The development of such a checklist would lead to the standardisation of surgical procedures would improve patient safety for two reasons:

1) the checklist would serve as a memory aid to prevent omission of critical steps
2) it would enhance communication among the surgical teams

Procedural checklists in high-risk environments reflect domain specific implementation of standard operational procedures and guidelines of best practice. Implementation of best practice or standard operational procedures is in itself a measure of a team's effectiveness. However, checklists alone may fail to capture and measure the interactive, synergistic, nature of teamwork.

In a pilot study by Lingard et al a check list was developed to promote safer operating room communication. The checklist was developed by a team of exerts including psychologists, surgeons, anaesthetists nurses and research staff. The checklist was designed to prompt a preoperative discussion among the team. They successfully implemented their checklist in 18 surgical procedures. They found that more detailed information was exchanged, ambiguities were clarified, urgent issues were communicated and discrepancies were resolved. All participants agreed that the benefits of this form of checklists outweighed the inconveniences. The preoperative team checklist shows promise as a feasible and efficient tool that promotes information exchange and team cohesion (Lingard *et al.* 2005).

4.5.2.2: Briefing

Ineffective communication has been identified as a prominent factor in medical error in surgery. In an analysis of reports to the Joint commission for hospital accreditation they found that communication failures are the root cause of adverse events and patient harm. Following this and several cultural surveys Leonard et al described a simple method for enhancing communication. They called their tools and concepts SBAR (situation, background, assessment and recommendation) (Leonard *et al.*

2004). They found that SBAR was very effective in bridging the gaps in the communication styles between doctors and nurses and also helped to create a shared mental model. This in addition to appropriate assertion can help enhance patient safety.

Further Leonard et al in their paper describe the experience form the Kaiser Permanente. The Kaiser Permanente is a non-profit health system in the United States of America. They have done a lot of work in the area of improving patient care through improved communication for example they have implemented standardised communication at shift changes with all the doctors and nurses present. They also use the SBAR model for communication. Dr Cuygkeng et al at Kaiser Fontana implemented the use of a checklist to help improve transfer of patients from the hospital to nursing facilities. They implemented two checklists one to be completed in hospital by the physician and the other by the skilled nursing facility. Any gaps in information were covered by a telephone briefing between the nurses form the sending and receiving centre. This resulted in reduced hospital readmissions. Orange county Kaiser introduced formal per operative briefings. They have shown a decrease in wrong side surgery and an increase in team morale and satisfaction (Leonard *et al.* 2004).

A team briefing would include a face to face communication, using a simple synchronised formula that takes place on a regular basis and usually lasts about 5 to 10 minutes. Its purpose would be to convey information about relevant work issues, provide explanation, clarification and feedback. This format in a surgical context would involve the members of the theatre team including surgeons, nurses, anaesthetists and their assistants who could meet prior to each operating list. There would be an opportunity to ask questions and gain responses and clarifications to important issues. The briefing would be chaired by the team briefer who usually is the team leader or a dedicated professional who would facilitate this briefing (McGeough 2007).

In summary the study of these interventions helped lay a foundation for the development of team training interventions in surgery. The development and the results from the intervention studies will be described further in the empirical sections.

4.6: Conclusions

The preceding sections have highlighted the importance of team work and realise that teamwork is fundamental to effective surgery. Yet there are currently no measures of teamwork to help evaluate team interventions or assess the impact of teamwork on outcomes. Formal team training is not offered routinely in most institutions yet teams in theatre are expected to function efficiently, safely and to a high standard. To improve team performance we need both effective and accurate assessment methods as well as robust training programs that are incorporated into each of the specialities curriculum.

Various groups have studied aspects of teamwork and many have even studied several team components but in restricted groups. We feel that if team performance assessment has to be accurate it must involve ratings of the entire team as they interact with each other. Further more any training that is suggested also should incorporate the whole team together.

The preceding chapters showed that the literature suggests that communication is often poor and might be improved by more standardisation through the use of briefings and cross-checking procedures. These are common elements of standard operating practice and of training programs such as CRM in high reliability industries. These scenarios can be learnt and rehearsed using simulations so members are fully prepared should such a scenario arise in the real operating theatre.

Simulations have already been shown to be beneficial in the training of technical skills for laparoscopic surgery. Based on the principles of CRM in aviation and using the CRM programs in anaesthesia and emergency medicine a similar training program can be developed for human factors and team training in surgery. This will enable the team to enhance the communication and coordination, understand the principles of CRM and be more prepared in a crisis situation should it arise. This form of training should be incorporated within the surgical curriculum and taught on a regular basis alongside skills teaching to develop these skills in surgery.

Many authorities suggest that team training is likely to be an effective means to reduce human error in the operating theatre. The problems however are that very few guidelines exist to help guide and implement these training exercises. Any program designed to improve team skills are a new concept for medicine particularly for doctors who are trained largely to be self sufficient and individually responsible for the care of their patient. While many departments acknowledge the need for such training, the development of such programmes will take several years to implement.

Summary of the Introduction & Aims of the Empirical Studies

The operating theatre and the surgical team are a complex and dynamic system, one which requires effective communication and coordination to function optimally and safely. The surgical community has concentrated on providing skills courses which aim to provide knowledge of surgical procedures and to some extent dexterity. However nowhere along this training period is there any set method to assess or teach other skills such as communication, team work or decision making which are also essential elements of being a good surgeon. The systems theory stresses the importance of factors other than technical skills and patient factors in measuring surgical outcome which include patient condition, surgical technical skills, operative environment and team performance.

Successful teams and team leaders focus on improving teamwork rather than individual success and performance (Dickinson and McIntyre 1997). However to evaluate if a team is effective, proper assessment measures are required. Working from the input-process-outcome framework it may be possible to alter or enhance the input factors to improve safety and outcome. For team performance assessment to be accurate it must involve ratings of the entire team as they interact with each other. Further more any training that is suggested also should incorporate the whole team together. Team training is likely to be an effective means to reduce human error in the operating theatre but very few guidelines exist to help guide and implement these training exercises and formal team training is not offered routinely in most institutions. Communication could be improved by more standardisation through the use of briefings and cross-checking procedures.

Although team performance is now recognised as one of the determinants of good surgical outcome, following the literature review it was clear that there was very little work done on teams in surgery compared to those done in other safety critical industries. To understand team performance and to develop team training, reliable and valid measures of team performance are necessary yet no measures were directly applicable to surgery. Interdisciplinary teamwork in surgery currently lacks models and objective measures of performance which are important for assessment and

feedback in practice. These models and training interventions are also necessary for training and for developing surgical teams of the future.
The first aim of this thesis is to understand the team performance in theatre, explore the current perceptions of teamwork in theatre teams and to develop an observational assessment of teamwork designed to capture the essentials of the surgical process. A specially designed semi structured interview will be used to explore the current perceptions of team work among the members of the operating theatre team (Surgeons, Anaesthetists, Nurses and ODPs). Following this, a task analysis of the surgical process will be carried out to gain understanding of the guidelines and protocols for standard operating procedures in theatre.

Following the literature review it was clear that there were no models of teamwork that were directly applicable to surgery. A more appropriate model will therefore developed using a bottom up approach. The aim of this assessment tool for teamwork in theatre is its ability to capture the essentials of the surgical process, team behaviours and deviations from standard safe practice. The feasibility and reliability of this instrument will be tested in the empirical studies. The other studies will include training of observers and assessing transferability of the team assessment tool.

The other aim of this thesis and one which is clinically relevant is to develop team training interventions in an attempt to improve one aspect of surgical outcome. I hope to develop and pilot team training interventions using a combination of surveys and simulated studies. Team training interventions will include a team training module for the use in the simulated operating theatre incorporating multi-disciplinary crisis simulations. Further studies will include development of team interventions such as briefing and check-listing to improve teamwork in surgery. The eventual aim for any such research will be whether or not these interventions actually translate to real practice and whether it is possible to improve team work and communication and effectively measure the change.

5: Chapter five: Current Perceptions of Teamwork in the Operating Theatre

5.1: Introduction

Teamwork in an operating theatre (OT) is carried out by a team of highly specialised professionals, namely anaesthetists, nurses (scrub nurses & circulating nurses), operating department assistants/anaesthetic nurses (ODPs), and surgeons. Yet despite the complexity of both the environment (e.g. patient-physiology, illness-related factors, the range of pharmacological and surgical treatments, & equipment) and the team itself, existing research on teamwork in the OT is rather scarce. Recently, however, OT teamwork has been steadily gaining the attention of clinicians involved in it and also that of safety researchers.

To attempt a comprehensive study of teams in theatre one must understand the existing perceptions of the team in theatre. Previous studies have shown that theatre teams do not have a consensus on how the team activities should be coordinated and led (Helmreich and Schaefer 1994) which makes it difficult when implementing training interventions. We aimed to investigate how teamwork in the OT is perceived by the members of the four different specialties (i.e. surgeons, anaesthetists, ODPs, & nurses). Concepts derived from the team mental models and team performance literature, such as perceived team structure (actual & ideal), perceived professional roles, perceived quality of communication, and perceived quality of the teamwork itself were used. If the OT team is unitary and coherent, we expected to observe convergence of the mental models of it held by the different specialists. In other words, the members of the different specialties should agree on their perceptions of their teams' structure, the level of cross-specialty role understanding, the quality of team communication and teamwork. If, however, the OT team is more "diffuse", then the mental models of it held by the different professionals need not match necessarily. We aimed to assess the current perceptions of teamwork among the theatre groups.

5.2: Aims of the Study

The assessment was done using semi-structured interviews. The aim of this study was to tackle the following questions:

1.) How do members of the four different specialties (i.e. anaesthetists, operating department assistants, nurses, and surgeons) perceive the structure of the OT team as a whole? Is the current structure the ideal one?

2.) How do members of the different specialties perceive their own role and also the other specialists' roles?

3.) What do members of the different specialties think of the quality of their teamwork in the OT?

4.) What do members of the different specialties think of the quality of communication across specialties in the OT?

Overall we hoped to gain an understanding of the current perceptions of teamwork in the operating theatre along with the quality of communication and team work that currently exists. We hoped that this would provide valuable insight into the team performance would shape the future development and provide a basic framework for the structure of the teamwork in surgery observational assessment tool.

5.3: Method

5.3.1: Design:

Semi structured interviews were conducted to examine participants' perception of core constructs of teamwork.

5.3.2: Participants:

Six participants from each one of the four OT specialist groups (surgeons, anaesthetists, ODPs & nursing staff) with varying levels of expertise volunteered to participate in the study (total N = 24).

5.3.3: Materials:

All the interviews were carried out by the same surgeon interviewer (SU). There were instructions for the interviewer to follow and the interviews were carried out according to a strict interview protocol (appendix C). The interviews were structured for content and time in the following manner: the interview consisted of a total of 11 questions in different sections and had a set period of time allocated per section. Opening section, question 1 and 2 on teamwork (4mins); perception of team structure including team structure with diagrams, question 3, 3a, 4 and 4a (10mins); role perception, questions 5 and 6 (4mins); perceived quality of communication, questions 7, 8 and 8a (4mins); and perceived quality of teamwork, questions 9,10 and 11 (8mins).

Examples of the questions that participants were asked:

- Team structure: "Do you think theatre staff work together as a single team or as multiple teams?"
- Role perception: "Please rate how much the following understand your role in the theatre: a) anaesthetist b) surgeon c) scrub nurse d) ODP e) circulating nurse"
- Communication: "Please give six examples of a) good and b) poor communication in theatre"
- Teamwork: "Please give six characteristics of a) a good and b) a poor team"

Close-ended questions were answered on six-point scales, anchored at 0 ("poor") and 5 ("good").

Perception of team structure was assessed with five diagrams, each one of which represented a possible structure of an OT team (see Appendix E). These structures were 'overlapping' (where the anaesthetic, the surgical & the nursing sub-groups share a proportion of OT work), 'hierarchical' (where one of the three sub-groups leads the other two), 'independent' (where all three sub-groups work independently, with no sharing of OT work), 'sequential' (where one group's work follows the completion of another group's work without sharing it), and 'driven' (where there is sharing of the work between specific sub-groups in the OT but not between all of them but they are still dependant on the other groups and are linked either directly or indirectly). The different structures were presented to the participants, who subsequently chose the one they thought most closely represented the actual and the ideal structure of the surgical team. The participants' were also probed about their perceptions of teamwork in their chosen structures in order to ensure that they perceived what the experimenters intended. In all cases, their perceptions matched the descriptions we gave above.

5.3.4: Procedure:

The interviews were arranged at a time and place convenient for the participants. They were conducted in a quiet room where there would be no disturbances for the duration of the interview. The purpose of the interview was specified and it was commenced. Each participant was interviewed individually for approximately 30 minutes each. During the interview every effort was made not to influence or bias the interviewees in any way. Clarification for any difficult question was provided if requested. The interview answer sheets were anonymised and coding was used to indicate the different professions. Randomisation was not possible due to the small sample size and availability of personnel.

5.3.5: Statistical analyses

Various statistical techniques were used to analyse and model the data, both parametric and non-parametric. Operating theatre professionals' perceptions of the current and of the ideal structure of their teams were assessed via Kruskal-Wallis tests. Their ratings of their understanding of their team-mates' roles and, conversely, of their team-mates understanding of their own role were analysed via Wilcoxon signed ranks tests. Finally, a number of univariate Analyses of Variance (ANOVAs) were performed to assess operating theatre professionals' perceptions of the quality and importance of the communication and of the quality of the team-work among them.

The questionnaire, answer sheet and instructions are available in the appendix (Appendix C, D & E).

5.4: Results

5.4.1: Perceptions of Team Structure

Participants were asked to indicate their ideal team structure and the structure they thought that they encountered most commonly in real practice. Table 5.1 summarises participants' responses. These were based on the diagrams on 5 different team structures that were thought to be appropriate and applicable to surgery.

Team Structure		**Team Member**			
		Surgeon	***Anaesthetist***	***ODP***	***Nurse***
Overlapping (1)	**Current**	1	3	3	4
	Ideal	4	2	4	2
Hierarchical (2)	**Current**	1		3	2
	Ideal				1
Independent (3)	**Current**	2			
	Ideal				1
Sequential (4)	**Current**	1			
	Ideal				
Driven (5)	**Current**	1	3		1
	Ideal	2	4	2	2

Table 5.1: Current and ideal team structures chosen from the five options by members of each professional group (See figure 5.1).

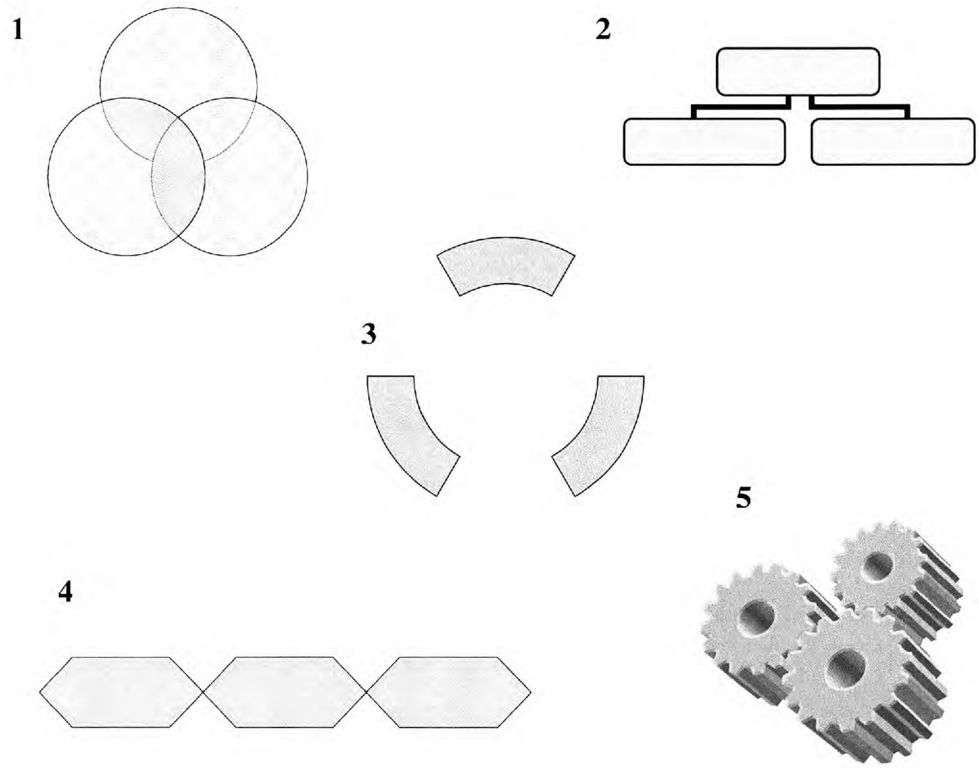

Figure 5.1: The diagrams for teamwork structure question for both the ideal and current team structure. 1-Overlapping, 2-Hierarchical, 3-Independent, 4-Sequential, 5-Driven

Seventy five per cent of the participants indicated that the team structure they most often encounter in OTs is not the ideal. However, OT professionals failed to reach agreement regarding the current structure of the surgical team. Of the 24 participants, eleven thought that the current team structure is "overlapping", five thought that it is "driven" and five thought it is "hierarchical". Some disagreement was observed in the perception of the ideal team structure too, with 12 participants thinking the ideal structure is "overlapping" and 10 thinking that it is "driven". Interestingly, the two structures that accounted for 22 out 24 participants' preferences for the ideal OT team ("overlapping" and "driven") involve some level of shared work but no hierarchy.

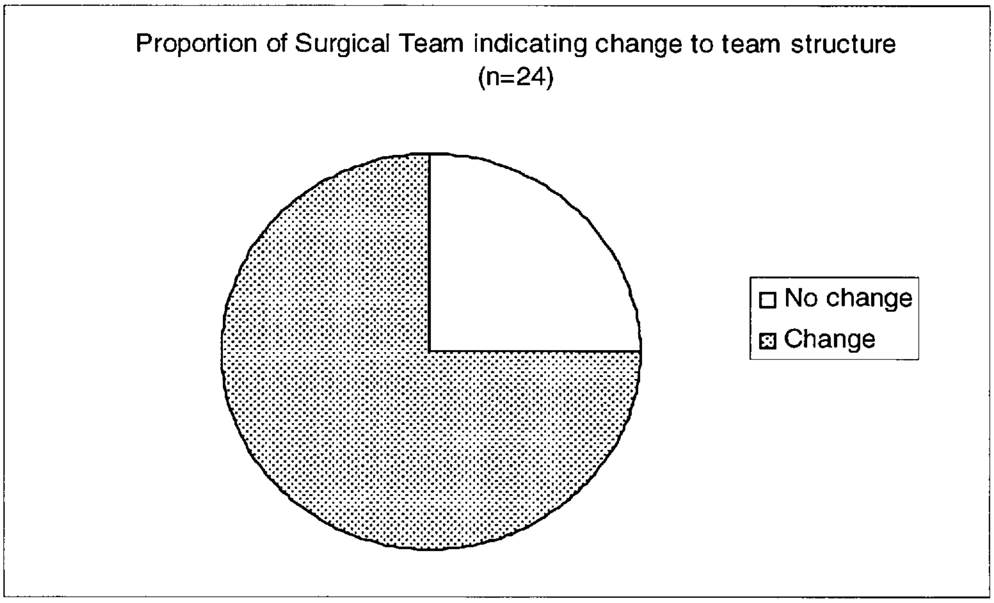

Figure 5.2: Pie chart showing the proportion of the whole interview group whom indicate a change to the current team structure.

There was significant disagreement among groups on whether OT professionals work as a single team or as multiple teams (Kruskal-Wallis χ^2 (3) = 9.37, $p < 0.05$). Whereas 67% of the nurses thought that that OT professionals work as a single team, only 33% of the ODPs and none of the surgeons or the anaesthetists agreed. Instead, these professionals' perception was that OT professionals work in multiple, highly specialised teams. These findings seem to suggest that there is a general disagreement between professional subgroups about the structure of surgical teams. In addition, these findings suggest a desire for change in the structure – although different professional groups do not agree about which structure would be the most effective.

5.4.2: Own Role and Others' Roles

Each group's ratings of their own understanding of the other professionals' roles are presented in Table 5.2; their ratings of the other professionals' understanding of their own role are presented in Table 5.3.

We aggregated the ratings of others' understanding of own role and compared them to the rating for the own understanding of others' roles in Figure 5.3. Inspection of the figure suggests that all professional groups thought that they understood their colleagues' roles better than their colleagues understood their own role. However, the difference reached significance only for the surgeons (Wilcoxon $Z = -1.96$, $p < 0$ .05); whereas the surgeons attributed to themselves a high level of understanding of others' roles, the others' judgements of the surgeons' understanding were significantly lower.

		Roles			
		Surgeon's	***Anaesthetist's***	***Nurse's***	***ODP's***
Rater	***Surgeon***	---	4.33 (0.82)	4.17 (0.75)	3.50 (1.22)
	Anaesthetist	4.67 (0.52)	---	3.67 (1.03)	4.17 (0.75)
	Nurse	4.33 (0.88)	3.58 (1.16)	---	4.17 (0.98)
	ODP	3.17 (0.75)	4.83 (0.41)	4.00 (0.89)	---

Table 5.2: Mean ratings of each members own understanding of others' roles (SDs in parentheses)

		Roles			
		Surgeon's	***Anaesthetist's***	***Nurse's***	***ODP's***
Rater	***Surgeon***	---	3.67 (0.52)	3.67 (1.21)	2.67 (0.82)
	Anaesthetist	3.67 (1.03)	---	3.50 (1.05)	4.17 (0.75)
	Nurse	3.58 (1.46)	2.92 (1.20)	---	3.75 (0.88)
	ODP	2.50 (1.52)	4.83 (0.41)	4.00 (1.10)	---

Table 5.3: Mean ratings of the perception of others members understanding of own role (SDs in parentheses)

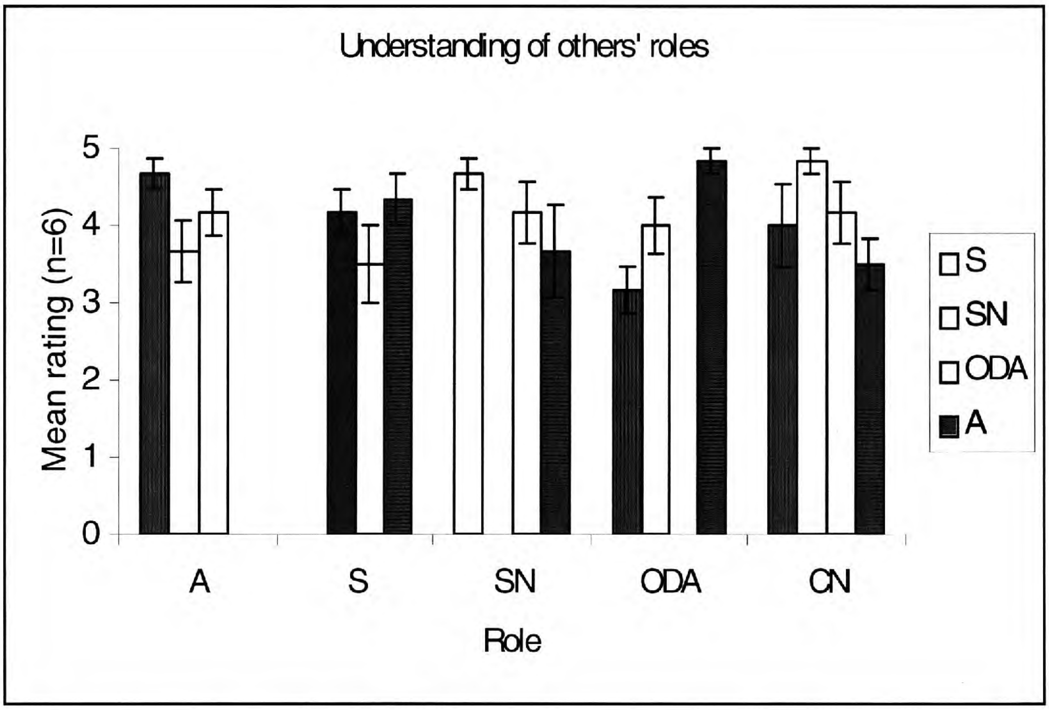

Figure 5.3: Group comprehension ratings of others' roles

5.4.3: Quality of Teamwork

Participants' answers to the open question about the characteristics of good and poor teams were content-analysed (all the emerging categories are available from the authors). Good communication (20 participants), constructive and blameless feedback on performance (14) and expertise (13) were the three most cited features of good OT teams. In contrast, poor communication (19) and lack of expertise (13) were described as the defining features of poor OT teams.

Participants' perceptions of the quality of teamwork in the OT did not differ significantly across the four professional groups. The overall rating across the groups was 3.42 (SD = 0.83). This rating was significantly higher than the midpoint of the scale (2.50; $t(23) = 5.41$, $p < 0.001$). We take this finding to indicate that participants were, on the whole, satisfied with the quality of the teamwork in the OT, but that they believed there was scope for improvement.

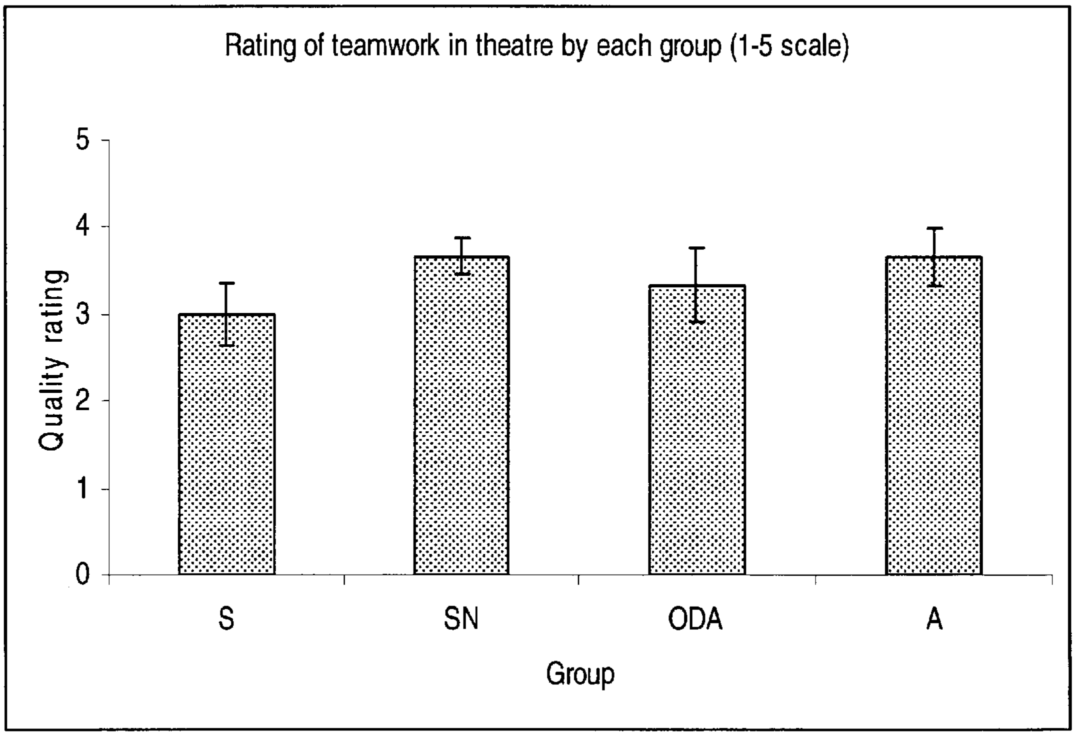

Figure 5.4: The rating of theatre teamwork quality by four groups: S = surgeons, SN = scrub-nurses, ODA= operative day-care assistants, A = anaesthetists.

5.4.4: Quality of Communication in the OT

Participants' answers to the open question about the features of efficient and inefficient communication in the OT were also content-analysed (all the emerging categories are available from the authors). Good communication between the surgeon and the anaesthetist (11 participants), clear and precise instructions from one professional to the other (6) and knowledge of the procedures that should be followed in the OT (5) were the most commonly cited features of good communication. In contrast, not being aware of what was going on in the OT (10), unanticipated changes in the list of patients (9) and patronising tone or intimidating comments (8), were described as the defining features of poor communication.

Ratings of the quality of communication between pairs of professionals are depicted in Figure 5.5. We submitted these ratings to a Group (Surgeons vs. Anaesthetists vs. Nurses vs. ODPs) x Pairs (all working pairings of the four professionals; eight pairings in total) mixed model analysis of variance (ANOVA). The analysis yielded an effect of Pairs ($F(7, 133) = 64.92$, $p < 0.001$), such that the quality of communication between A-ODP, SN-CN and S-SN was perceived as better than the one between S-ODP, A-SN and SN-ODP. This effect was qualified by the significant Group x Pairs interaction that the analysis also revealed (F (21, 133) = 2.92, p < 0.001). Essentially, the interaction reveals that the quality of communication between the pairs A-SN and SN-ODP is perceived as markedly lower compared to the quality of communication between all the other pairs. However, this finding alone does not give an accurate picture of the perceived quality of communication in the OT for reasons that we explain in the next section.

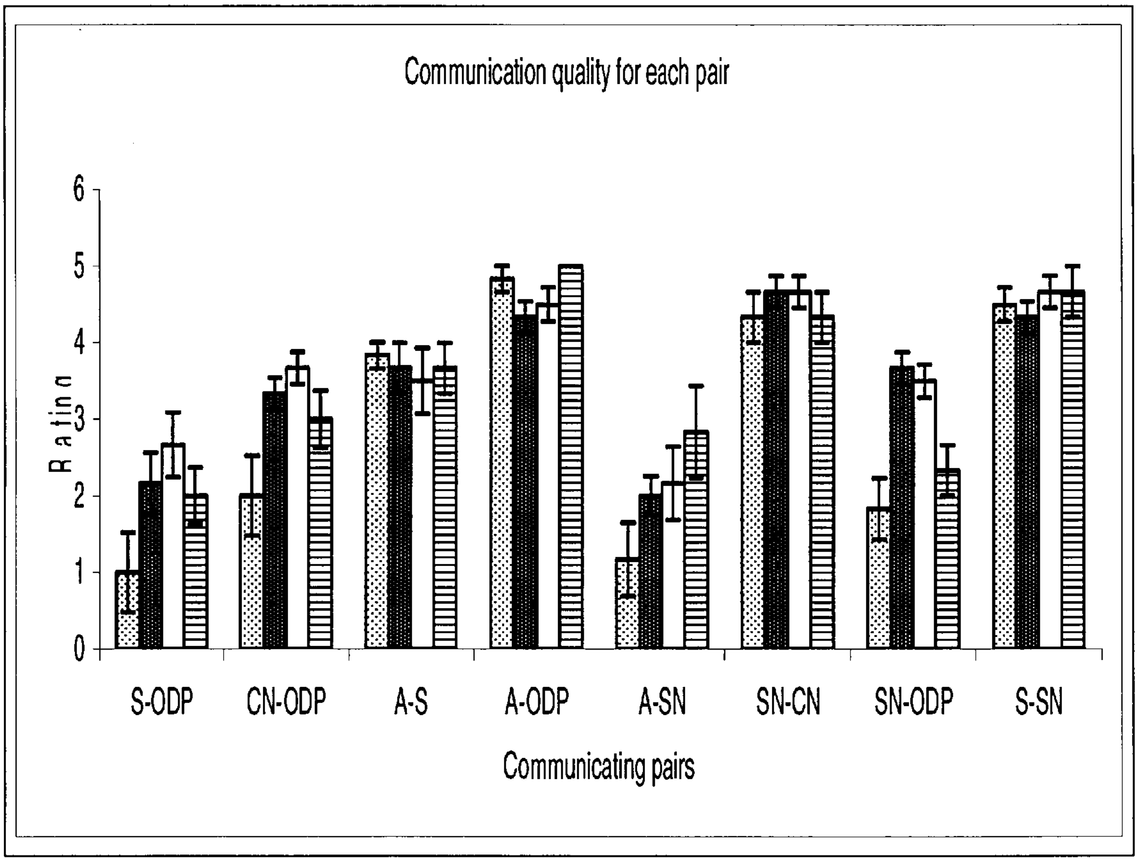

Figure 5.5: Rating of the quality of communication between pairs of theatre professionals

5.4.4.2: Quality and Importance of Communication between Professional Groups

Given the high level of professional specialisation in the OT, not all pairs of professionals are expected to communicate to the same extent during a routine operation. In order to capture our participants' awareness of this reality, in the interview we asked them to rate not only the quality but also the importance of good communication between pairs of them for the success of the surgical outcome. Their responses to this question can be seen in Figure 3. These responses suggest that there was some consensus across professional groups about the relative importance of communication among them. A Group (4) x Pairs (the eight working pairings) mixed model ANOVA confirmed this impression, as the analysis failed to reveal any significant interaction effects.

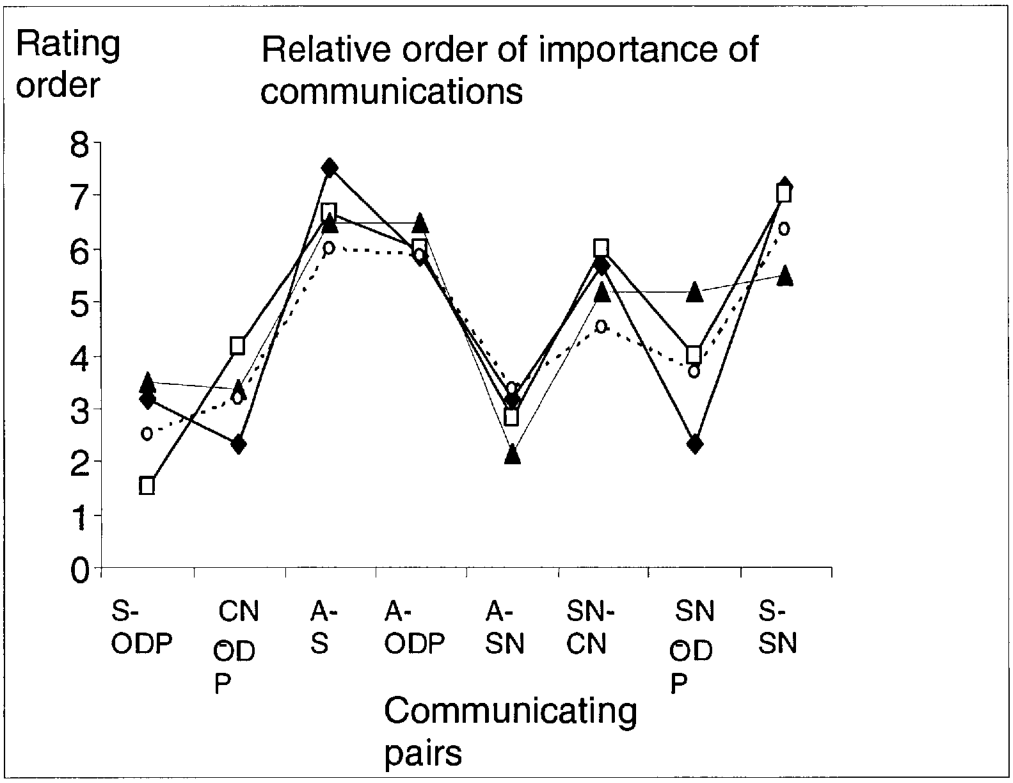

Figure 5.6: Rating of the relative order of importance of communicating-pairs in relation to overall success of surgery.

Finally, we combined the ratings of the quality of the communications with the ones of its importance in Figure 5.7. As it should be expected in a team of highly specialised professionals, perceived quality appears to be following perceived importance. In other words, the communications that are essential for surgery seem to be performed well within the OT team. This pattern is present for the pairs A-SN and SN-ODP that were rated lower than the others in the quality of their communication, thus demonstrating our participants' shared perceptions of importance and quality for those pairs. As is clear from Figure 5.7, the same patterns holds for all the other pairs of communicators too, except the A-S one. This pair showed some discrepancy. This impression was confirmed by a Group (4) x Pairs (8) x Dimension (importance vs. quality) mixed model ANOVA. The significant Pairs x Dimension interaction ($F(7, 140) = 5.71$, $p < 0.001$) that the analysis revealed demonstrated that the importance rating of the A-S pair significantly exceeded the quality rating of the same pair. In other words, the perceived quality of the communication between surgeons and anaesthetists did not match its perceived importance.

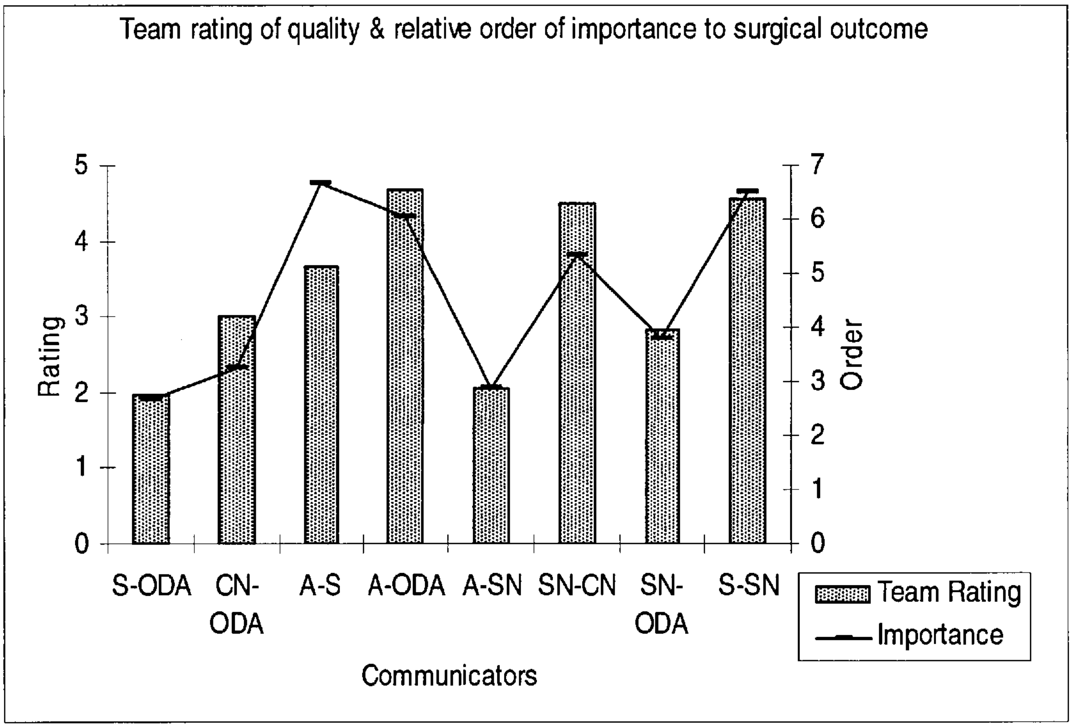

Figure 5.7: Combined data from ratings of quality and of order of importance of communicating-pairs.

5.5: Discussion

Using semi-structured interviews, we assessed OT professionals' perceptions of the actual and ideal structure of their teams, their roles within the teams, communication between them and the other professionals involved in those teams and the quality of the produced teamwork. The participants did not agree on the current structure of their teams. Some of them perceived it as "overlapping", others as "driven" and still others as "hierarchical". We found more agreement though on our participants' perceptions of an ideal OT team, with the two most co-operative and least hierarchical structures ("overlapping" & "driven") attracting 22 out of 24 responses. Moreover, 75% of the team members indicated a desire for change from the current team structure. Taken together, these findings seem to suggest that OT professionals would like to see their teams becoming more collaborative. This finding, however, is complicated by the fact that the current perceived structure of OT teams was debatable. It is also complicated by the fact that team members were not in agreement about the nature of their teamwork.

Specifically, nurses tended to view the OT team as one single entity, ODPs slightly disagreed and surgeons and anaesthetists totally disagreed. In surgeons' and anaesthetists' perception, the OT consists of multiple, highly specialised sub-teams. Related to this is the finding that there appears to be some role misperception in the OT. All team members overestimated their understanding of their team-mates' roles and the surgeons did so to a considerable degree. Other industries where teamwork is important for smooth performance and safety (e.g. aviation) have described the effects of cross role training in the enhancement of role understanding (Salas *et al.* 2001). We interpret our findings as an indication that, if cross role training were appropriately modified, its incorporation within surgical team training could enhance role understanding across the different specialties.

Although OT professionals appeared to be somewhat critical of their peers' understanding of their role in the OT, they judged the quality of their teamwork as satisfactory, but with room for improvement. We take this finding to illustrate the multi-dimensionality of teamwork in the OT. Role understanding is one of its facets, but not the only one. Another important aspect of teamwork in the OT is the communication between the different professionals. In the present study, different pairs of them obtained different ratings for both the quality and also the importance of the communication between them. Importantly, team members agreed regarding these ratings. These findings are not surprising, given the high level of specialisation in the OT team. For instance, in routine operations, the interactions between the surgeon and the scrub nurse are more numerous, and arguably more important, than the interactions between the anaesthetist and the scrub nurse. On the whole, the ratings of the quality of the communications closely followed those of their importance. In other words, OT professionals thought that the important interactions are performed reasonably well. The sole exception to this pattern was the communication between the surgeon and the anaesthetist, where importance was judged paramount by the interviewees yet falling short in relative terms.

These findings suggest a possible additional dimension to medical / surgical training. The curriculum of both medical school and medical training currently focuses exclusively on the acquisition of task-specific skills while "non-technical" (i.e. team-related) skills training is not offered to OT professionals at any stage in their careers. The interplay between these two factors seems to contribute to the lack of cross-professional understanding. The design of teamwork training programmes should start with an assessment of how the team members conceptualise their team and what they think of their teamwork. There would not be much advantage in devoting valuable resources to training clinicians in team skills without first determining their understanding and approach to teamwork. From there on, the trainer (s) should build on the revealed perceptions of the team in order to tailor their training to the team's needs, thus maximising its effectiveness. For instance, some teams may have spent a substantial amount of time working together and a shared understanding may have evolved. These teams would be more likely to have established teamwork routines that enhance team functioning. Consequently, their training could be more focused in how to incorporate new team-members without breaking an effective routine. In other teams, however, clinicians might be expected to work with many different colleagues (due to rotation, emergency etc); these teams would have different training needs. Team training could focus on how to establish the minimum requirements for efficient and conflict-free teamwork by standardisation of procedures. To begin with it is important to realise that effective measures of team performance are necessary if we are to develop and implement any training programmes with the hope of improving safety and teamwork in the operating theatre.

5.6: Conclusions

This study helped in the understanding of the current perceptions of teamwork among the different professional groups in theatre. The insight gained from this study provided a valuable first step towards the development of team assessment in surgery. The development and further testing of this team assessment tool has been described in the following chapters.

6 Chapter Six: Development of an Observational Team Work Assessment for Surgery

6.1: Introduction

The previous chapters have described the importance of teamwork and the need to study teamwork factors. The interview study shed light on the current perceptions of team work in theatre and the need for interventions to improve team performance. Furthermore it laid the foundation for the development of a measure of team performance. A thorough assessment of a team should comprise a combination of data from multiple sources, with conventional and novel methods, addressing all disciplines and their inter- and intra-relationships (McCallin 2001). As discussed in the previous chapters many different team measures are cited in the literature (Militello *et al.* 2000), which reflect the variety of team goals, tasks and functions. Measures of such dimensions as co-ordination, communication, leadership, co-operation and decision-making are commonly referred to when assessing teamwork in any domain. However simply assessing these team work dimensions may not give a complete picture of the complex nature of team work, and the specific checks which must also occur to ensure that safety and efficiency is maintained. This may require a separate check list component in addition to behaviour in order to get a more complete assessment.

This chapter discusses the development of an observational method for assessing team performance in the operating theatre. Following an initial background discussion the chapter will go through the stages in the development process of the tool. It will then describe the sources and methods used for the development followed by the structure, including the tasks and the behavioural aspects and the process of using the OTAS prototype. Implications for observational assessment of teamwork will be discussed. The data collected with the first version of OTAS will be described in detail in the following chapter.

6.2: Observational Measurement

Since we chose to develop an observational assessment for team work in surgery, I will reiterate a few salient points about observational research before going on to discuss the development of our assessment tool. As we saw in the preceding chapters observational research is particularly useful for researching complex work systems such as the operating theatre. However as we have seen in the introductory chapters some observational studies could be unstructured. To measure team work systematically we feel that structured observations are needed such as those proposed by Carthey et al (Carthey 2003). To develop such a structured assessment it is necessary to specify the structure of teamwork, based upon a formal model of teamwork and by detailed account of tasks and processes that the team is carrying out.

An important issue in the development of measures is to consider the balance between actual observation and the scoring process. Scoring should be as simple as possible, so that notation can be carried out without disrupting the process of observation of the team. One can imagine a marker or task-list so long that the majority of a case is taken up by viewing the assessment form rather than the team being assessed. An excess of prescribed markers for a large system of teamwork will inevitably detract the observer from observing the events that occur in real-time during a case, especially if the scoring itself is time-consuming or demands complex judgements.

Operating theatre teams can be of a transient nature, varying in composition and identity of personnel within and between cases. Nonetheless, surgical teams are usually comprised of four generic disciplinary groups, surgeons, nurses, ODPs and anaesthetists, complemented by other specialists, such as radiographers, when required. Tasks required in team process might be carried out by individuals or by several members within an interdisciplinary group or between two or more groups, simultaneously or serially. Observational team assessments usually involve the rating of predetermined teamwork behavioural components, or measurement of teamwork and its output against predefined criteria, such as task completion, safety checks or quality of product achieved. In recognition of the lack of team performance models and measurement criteria for surgery, and in recognition of its unique nature, a bottom-up approach was adopted to develop the assessment. Of course, there is considerable variation in teamwork derived from differences between types of surgery, hospitals and other demographics. Nonetheless, there are basic practices and behaviours to be expected in all operations. OTAS is a preliminary step toward assessing that safe practice; it addresses concurrently *what* surgical teams do and *how* they do it.

Completion of any task depends on behaviour and observational teamwork assessments and usually involves the rating of a set of general dimensions or constructs of behaviour rated by quality and/or quantity as outlined in the previous chapters (Brannick and Prince 1997;Dickinson and McIntyre 1997;Klampfer *et al.* 2001). Assessments of behaviour may vary in their specificity from overall team performance to very specific tasks or events. Measures for observing teamwork in surgery vary in their specificity from low technical specificity and broad system scope to high technical specificity and narrow system scope. For example we might observe a surgical team over the course of a long operation and make a broad assessment of co-ordination and communication over several hours. Measures of this kind may be quite broad and low in technical specificity, yet account for a wide system of inter-professional teamwork. At the other end of the spectrum, we might observe a particular individual carrying out a defined set of tasks, important for the work of the whole team, but quite circumscribed in nature. Measures of this kind may be highly technical in specification, but fail to account for other members of the team in which the individual plays a part. Neither type of measure is necessarily better than the other; each measure demands a different design according to its purpose.

The aim of this study was to develop a tool which would have a simple mix of broad dimensions as well as more specific task checklists to capture the entire surgical teamwork process. We set out to assess *routine* interdisciplinary teamwork by observation and to test the validity of a team assessment within a model of team performance. From a patient safety perspective, we adopted the approach that an observational assessment of team performance should account for essential routine tasks relating to team process and patient safety.

6.3: The Development Process of OTAS

The teamwork assessment was developed over a period of 6 months, working along with a post-doctoral research psychologist. The work followed on from preliminary interviews which have been discussed in the previous chapter. The interview study provided valuable insight into how the teams currently perceive themselves and additional information on what the qualities of good teamwork and communication should be. This was a great influence in constructing and shaping the team assessment tool. The reason for developing a new model was that there was no model available in the literature which could be directly translated into healthcare or surgery. Further insight was gained from the perceptions of good team work from the interview data. Procedural checklists in high-risk environments reflect domain specific implementation of standard operational procedures and guidelines of best practice. The aviation industry particularly has used checklists as a method for reducing errors and improving flight safety (Degani and Wiener 1997). However, checklists alone may fail to capture and measure the interactive, synergistic, nature of teamwork. A behavioural assessment, which included communication, co-operation, co-ordination, shared-leadership and monitoring, was therefore designed to accompany the checklist to provide a balance between objective element and subjective whole assessment. The behavioural constructs were adapted from similar research in other high risk domains. We chose to work using the systems approach and divided the tool into a task based checklist and a behavioural component which were designed to be assessed by a surgeon and a psychologist. After the initial familiarisation with the theatre environment and pilot data collection the assessment tool prototype was developed and ready for testing.

The actual process and the sources used have been discussed in the relevant sections in more detail, however a brief account of the actual steps of the process are outlined below. Further information on the sources used is available in the Appendix (Appendix A & B)

6.3.1: Development Process: Stepwise Summary

- Discussions with experts by way of a semi structured interview designed to evaluate the perceptions of teamwork in the operating theatre. Further insights were gained into what the team considered important factors relating to communication and team work.
- Comprehensive review of all the theatre guidelines such as The Department of Health (DOH) Modernisation Agency *Step Guide to Improving Operating Theatre Performance* (2001) provided a valuable template. www.doh.gov.uk

- Review of recommendations and guidelines from the Royal College of Anaesthesia (RCA), Association of Anaesthetists of Great Britain and Ireland (AAGBI), Association of Peri-operative Nurses (AORN). For example, a recent publication by the Association of Anaesthetics of Great Britain & Ireland highlights key elements in the efficiency in the operating room (2003)
- Review of literature regarding sharps handling, infection control and the environment in theatres (Stringer *et al.* 2002;Dharan and Pittet 2002) www.aorn.org/proposed/clean.htm
- Review of standards and guidance for good practice. Review of existing theatre policies and protocols for our hospital.
- Review of a series of documents on the safety, quality and efficiency of surgical care.
- Study of independent research on equipment design, surgical procedures, team performance, ergonomics, human factors and infection control etc for obtaining guidelines of best-practice
- Construction of preliminary task lists for the entire surgical process by division of the process into stages and phases consistent with NHS theatre systems.
- Subsequently hierarchical task analysis by based on previous knowledge, pilot observations in theatre and consultation with a group of experts.
- Preliminary task list piloted over a period of two weeks and further modified till the stages, phases and task list reached a workable prototype.
- Expert advice from consultant surgeons, anaesthetists and scrub nurses regarding content of the prototype checklist.
- Discussion with other psychologists regarding the behavioural constructs.
- Decision regarding which behaviours to measure and constructing the scale for its assessment along with details about how to record supplementary information to justify the behaviour scores.
- Further development of exemplars and demonstrative scenarios in conjunction with surgical experts and psychologists to help with training and to enable ease of scoring in a surgical environment.
- Pilot observations in theatre and refinement of the checklist

6.4: Prototype OTAS Design Summary

OTAS has two main components: tasks and behaviours in order to measure the elements of a team's performance and to measure the whole team's performance, separately. This distinction is important because the elements of performance, such as tasks or markers, do not necessarily amount to the sum of team performance. It is quite feasible that a sample of teams may complete a similar number of routine tasks, but vary in the quality of their communication and co-ordination. Therefore, global measures, which are supported by an open format for recording performance, serve an important role in assessment; they may capture behavioural variations, which a fully structured questionnaire might not allow for. However, for behavioural measures to be reliable and valid, they need to relate to a model of teamwork, which is represented in OTAS by five teamwork behaviours and the content of the rating scales and associated behavioural markers.

6.4.1: OTAS Stages and Phases

OTAS divides the surgical process into three meaningful phases (see table 6.1). The three phases, namely: pre-operative (pre-op) intra-operative (intra-op) and post-operative (post-op). Pre-op includes everything up to the point of the actual operation, intra-op from the point of incision to the point of closure, post-op from the point of closure to recovery. Each phase consists of three distinct stages. Operative stages are separated by crucial teamwork events, such as patient enters the operating theatre under anaesthesia for transfer to the operating table. Such events signify the transition from one team state to another, for example, pre-operative preparation is a different stage to that associated with the surgical operation (intra-op) proper.

This staging method is similar in principle to the template used for patient process mapping that is advocated by the UK NHS Theatre Modernisation Programme: Step-guide to improving operating theatre performance. With a staged process, it is possible to record the length of time from one stage to another - simple yet potentially invaluable information. For instance, we can then apply the measure of theatre capacity utilisation, which is calculated as the anaesthetic plus operating time as a percentage of total actual theatre time available. OTAS stages are also consistent with numerous operating theatre IT management systems, used internationally, for example the AORN patient record files and UK NHS systems, such as 'ORSOS' and

'Theatre-kit'. There is clear benefit from attempting to integrate such frameworks for potential data integration into future research and training.

Phase	Stage 1	Stage 2	Stage 3
1 PRE-OP	pre-op planning and preparation	patient sent for to anaesthesia given	patient set-up to op-readiness
2 INTRA-OP	Opening / access to contact of target Organ	op-specific procedure	from prepare to close to complete closure
3 POST-OP	anaesthetic reversal to exit from theatre	recovery & transfer to the ward	Feedback and self-assessment

Table 6.1: The three phases and stages of OTAS. The checklist structure of OTAS is determined by transitions from one stage to another.

6.4.2: Development of the Task Checklist

The task list was constructed for each stage and phase of the operation. The task list was constructed with the help of theatre protocols, recommendations for good practice, domain knowledge and expert advice. A total of 203 tasks plus checks for the members of staff in theatre were compiled. Further discussions with experts were carried out before the lists were finalised. Tasks were placed into three categories: namely, patient, equipment and communications tasks. Patient-centred tasks comprised either actions or information associated directly with the patient such as safe transfer to operating table and patient notes present. Equipment-centred checks included checking and counting of surgical instruments. Communication-centred tasks included information such as operative site laterality confirmation. The criteria for items on the checklist were marked yes or no depending on the nature of the task. For example, under the category of equipment preparation, diathermy machine preparation was scored positive if they were switched on and tested prior to the operation. Likewise, the anaesthetic machines were deemed checked if the anaesthetist on duty was observed to be running through the standard testing. If the operation was the second case of the day, all the machines were scored as checked on the presumption that they had been working appropriately for the previous case. However, if the equipment had not been used for the first case, then the same criteria as the first case would apply.

6.4.2.1: Task Organisation

Task organisation across stages were designed to reflect task-management.– The criteria for including a task (e.g, task A) at any given stage is that other tasks (B, C, D, etc.) or objectives in the immediately proceeding stage depend on task-A completion. For instance, 'op-readiness' is a crucial point in process, it occurs before the surgeon makes incision and commits to surgery proper. It is valid to state that before incision X tasks and Y communications must have been carried out. We worked through each stage several times, exhausting ideas for task inclusion. We also used sources providing guidelines and recommendations for best practice from sources cited in the ***Appendix.***

6.4.2.2: Task Categories

Tasks are defined at each stage, under categories of Patient tasks, Environment tasks, Equipment & Provisions tasks and Communications tasks. Within and across stages, the observer can assess task management, using simple yes or no checks. However, in future development it is possible to incorporate ratings for specific tasks, particularly communication tasks.

6.4.2.3: Patient Condition

Anaesthetists' machines monitor patient condition automatically, but we include a check for monitoring by staff. This includes the checking of physiological factors such as cardiac output, temperature, level of anaesthesia etc

Evidence from Critical Incident Reports and interviews (Qadir *et al.* 1998;Forrest *et al.* 2005;Ludbrook *et al.* 1993) showed that incidents and annoyances in, or associated, with surgery arise from delays to operations and pre-op problems, often due to lack in preparation and failures in communication. They create problems during operations, such as missing or insufficient information on patient condition, identity and consent and lack or failure of equipment and missing instruments. That evidence justifies an emphasis on assessing preparation, equipment condition, sterility practices and potential hazards to patient and team. A separate study looking specifically at the environment and the effect of distractions has been set up and conducted but is out of the scope of the current thesis.

6.4.3: Development of the Team Behaviour rating scales

Behaviour that collectively determines teamwork performance is complex and interdependent. Teamwork behaviour usually involves one or more individuals providing communication or action to one or more other members. Communication might take the form of instructions, requests and questions. Actions might take the form of observation, manual assistance in moving the patient, or joint handling of instruments and provisions. Communication and actions provide observable examples of team co-ordination and co-operation, from which one may infer levels of awareness and leadership. To measure teamwork performance by observation it is common practice to reduce teamwork behaviour to a set of distinguishable dimensions, also called 'behavioural constructs'. The teamwork model used for OTAS was adapted from that of Dickinson & McIntyre (1997) which comprised 7 behavioural dimensions: This has been discussed more fully in a previous chapter but essentially but is outlined below in brief:

- ***Team orientation*** accounts for the attitudes and cohesion of the team.

- ***Team leadership*** refers to the provision of direction, assertiveness, and support among team members

- ***Communication*** refers to the quantity and quality of information exchanged among members of the team.

- ***Team monitoring*** refers to observation and awareness of team process.

- ***Team-feedback*** refers to the quality of information provided in response to communication and performance of others.

- ***Backup behaviour*** involves assistance provided to team members, supporting others and correcting errors.

- ***Co-ordination*** refers to team's performance resulting in enhancement of function through management and timing activities and tasks.

For the purpose of assessment in theatre we had to find behaviours that were not only observable but also relevant to surgery. Further more they had to be behaviours that one could be trained to observe them in the context of surgery by added demonstrative scenarios and exemplar behaviours. Starting off from the seven dimensions proposed by Dickinson & McIntyre we concluded that Team orientation is difficult to observe, but is closely related to co-operation hence could be incorporated into that dimension. Backup behaviour also, we have regarded as an aspect of co-operation and hence incorporated within it. Similarly, team-feedback could be viewed as a component of communication. We therefore began with five behaviours that we felt were applicable to surgery and which could be assessed by observation:

- Communication: This refers to exchange of information which is related to the operation being performed.
- Leadership: This refers to provision of direction and support to team members.
- Co-ordination: This refers to management and execution of tasks in a timely manner.
- Awareness / Monitoring: This refers to observing the other team members activities and being aware of team members' behaviours.
- Co-operation: This refers to assisting team members, acting on requests and compensating for others weaknesses

Details of these scales along with their anchors are found in Appendix F.

Further support for using the behavioural dimensions were based on preliminary interviews described in the preceding chapter and from other measures of team work in the literature (Dickinson and McIntyre 1997;Gaba *et al.* 1998;Helmreich *et al.* 1995) many of which incorporate dimensions such as leadership, communication, coordination and awareness and monitoring including those used by Fletcher et al. They modified a scale used in aviation NOTECHS to rate anaesthetists non technical skills (Avermate van J.A.G. and Kruijsen E.A.C. 1998;Fletcher *et al.* 2003). Their team working dimension consisted of coordination, extracting information, using authority, supporting others and assessing capabilities. In terms of relating this to our own dimensions extracting information is related to communication and using authority represents leadership. For the purposes of the first study sub teams (nursing, surgical, and anaesthetic teams) were not scored individually but an aggregate score for the whole team was used. Behavioural summary scales on a 7 point Likert scale were used. Each scale-point related to a certain level of quality and quantity of a given teamwork component, determined by various descriptive elements. Notes were also taken on effective and ineffective behavioural exemplars/markers during each case, which provided support for behavioural ratings given. Likert scales of 5 points are commonly used in surgery as global rating scales (eg OSATS) and for measuring non technical skills in aviation and anaesthesia (Gaba *et al.* 1998;Klampfer *et al.* 2001;Martin *et al.* 1997). The reason for using a 7 point scale as opposed to typical scales were that it was felt that it would provide further accuracy of the measurement although further studies may focus on comparing different scales to determine the best one for assessing team work behaviours.

6.4.3.1: Teamwork Behaviour Scales

The five teamwork behaviours are rated with the following scales, guided by exemplar behaviours and demonstrative scenarios that help indicate levels of behaviour typical of effective or ineffective performance. Behavioural summary scales are used to rate performance with broad summary statements of behaviour. The summary scales are ordinal: each scale-point relating to a certain level of quality and perhaps quantity of a given teamwork component. Determined by various descriptive elements of a component; the scales were designed with certain rules:

1. Behaviour rating scales are for assessing routine interdisciplinary teamwork in general surgery.

2. Each behavioural rating scale relates to a single function, namely *interdisciplinary* 'team function'.

3. The scales should not be too specific to scenario, group or event. They should be equally applicable to all disciplinary groups in any operative phase.

6.5: Observation Process

6.5.1: Practical Issues

During the pilot phase two observers, a psychologist and surgeon, collected data. A combination of PDA and paper and pen was used to record observations of events and behaviours. We found that the criterion for task checks between stages could be based upon 'when they should ideally be carried out' and 'when they must be carried out'. We decided upon the latter. The provisional assessment we designed was found to be practically difficult because we were ambitious in the range and quantity of data collection. It was clear during piloting that observer attention would often be divided. It was therefore essential to rearrange data fields in the sequence they would probably occur within each stage. We began by assessing behaviour in relation to each stage, but decided to apply them to the three operative phases and recorded at each final stage of each phase of the operation. We continued with a process of piloting and construction of the assessment tool until we were satisfied with the content and feasibility of collecting specified data. We adopted a strategy for data collection, using stage-cues, to move from one stage to another and to organise data points in an order that reflects the sequence of events throughout surgical team process. We refrained from interacting with staff but it was useful to ask for certain information, particularly regarding communications. To begin with we intended the assessment to be general to all operations. However, given the amount of data we were collecting we found that very short diagnostic operations occurred too quickly for us to collect necessary data. We found that the assessment was restricted to operations of lasting at least 40 minutes in length.

6.5.2: Observational Teamwork Assessment for Surgery (OTAS): An overview of the process of assessment.

In this section, we briefly outline the OTAS process. Two observers, (Observer 1 and 2), enter the operating room before the patient arrives. Thereafter, both Observer 1 and Observer 2 record each stage start-time, they confirm stages in the procedure, serving as a double check on times. The following describes more fully the task checks and behaviour recording in more detail, table 6.2 shows categories of data acquisition for Observer 1 and 2. The following provides further detail on those categories, as do table 6.2 and 6.3.

6.5.2.1: Pre-Operative

Observer 1 begins checking pre-operative planning tasks, namely whether the correct patient is on the list, has been allocated a bed, and whether patient notes are prepared. Observer 1 also checks whether appropriate equipment and instruments are available and whether the anaesthetic equipment logbook is up-to-date. Communications, among staff, concerning patient-consent, co-morbidity and special requirements, such as allergy to latex are also checked. In Pre3 Observer 1 checks for specific tasks that must be carried out during patient set-up ready for incision, such as the fitting of Ted-stockings, arm-boards, warming blanket and pressure point protectors. Equipment readiness is also checked, such as diathermy and suction apparatus.

Observer 2 then begins observing and noting teamwork behaviour as they occur using a form with the abbreviation key and headings below. Teamwork behaviours usually involve one or more individuals providing communication or action to one or more other members. Communication might take the form of instructions, requests or questions. Actions might take the form of observation, manual assistance in moving the patient, or joint handling of instruments and provisions. Communications and actions provide observable examples of team co-ordination and co-operation, from which one may also infer levels of awareness and leadership. Observer 2 also records actors' role-identity together with the event or incident and their corresponding behaviours. In Pre3, the final preoperative phase, Observer 2 uses the behaviour summary scales (see appendix F for scales) to provide ratings for the overall impression of each behaviour construct displayed by the team according to that observed, supported by the specific behavioural events recorded.

6.5.2.2: Intra-Operative

Observer 1 and Observer 2 continue with checks and behavioural event recording during the intra-operative phase. Intra-op1 is a crucial stage, where the whole team must be fully prepared for incision. Observer 1 checks that the patient has been appropriately draped and painted with Betadine, whether equipment settings and placement are correct and organized appropriately. Observer 1 also checks that the surgeon and anaesthetist confirm verbally that the incision can be made. Meanwhile, Observer 2 continues with recording task-related behaviours. Observer 2 also checks for environment conditions, such as sterility boundaries, tidiness, and notes any obvious problems with usage of space around the operation table and patient. During Intra-op 2, the operation proper, Observer 1 checks for hands-free sharps handling if bleeding occurs, whether correct instruments are used, whether there are sufficient swabs and sharps and whether patient condition is monitored. Observer 1 also checks for essential communication tasks between surgeon and anaesthetist. During the Intra-op stage Observer 2 continues recording behaviours, which are usually somewhat stable as the surgeon operates with assistance from the scrub-nurse, supported by surgical assistants and circulating nurses. During Intra-op 3 Observer 1 checks for blood-loss analysis, swab and instrument checks, correct suturing and dressing and essential communications between surgeon and anaesthetist. Observer 2 continues as before and toward closure, rates team behaviours with the behavioural summary scale.

6.5.2.3: Post-Operative

From closure and anaesthetic reversal, Observer 1 records patient 'set-down', specifically whether the patient's airway is maintained, pressure and diathermy areas checked and oxygen-mask fitted and patient cleaned. Safe transfer form the operating table to the trolley or bed is also recorded by Observer 1. Observer 2 continues with behaviour recording, noting particularly the availability of team members to assist in safe patient transfer. Post 2 is the final observation stage where the patient is transferred from the OR to recovery. Observer 1 and Observer 2 follow the anaesthetist and accompanying nurse to the recovery room where transfer is observed. Observer 2 enters the recovery room before the patient to observe the action and communication provided by the recovery team upon patient and OR staff entry. Observer 1 checks that patient notes and x-rays accompany the patient, that adequate fluids and analgesia have been administered to the patient. Observer 1 also checks that the patient is comfortable and that essential information is handed over from the anaesthetist, scrub-nurse to the recovery nurse, namely, information regarding the operation carried out, relevant patient history, drugs administered, fluids given, and post operative analgesia requirements. Observer 2 records the observed behaviour among the relevant team members and rates team behaviours for the post-operative phase accordingly. Feed back and self assessment of the team will be developed further following training during the next phase of the team research.

6.6: Conclusion

At the end of this extensive developmental process we had a fully comprehensive team assessment tool which was designed to be used by two observers. This tool consisted of 203 tasks divided into patient, equipment and communication tasks. Further data on times, and number of personnel in theatre per stage was also recorded by observer 1. We also started off with five behaviours that measured the overall team behaviours across the phases. Data on staff movement and noise etc was also recorded by observer 2 in this prototype OTAS. This tool was now ready for testing in the real operating theatre. The first 50 cases that were observed using the OTAS I prototype will be described in the next chapter.

7. Chapter Seven: Testing the OTAS Prototype in General Surgery

7.1: Introduction

Teamwork is one of the essential aspects of successful surgery and efficiency yet there were no measures of teamwork available to guide training, evaluate team interventions or assess the impact of teamwork on outcomes. Currently there is a wide variation in practice in surgery with very little standardisation. Although there are guidelines and recommendations for standard practice in the operating theatre they are very often overlooked or not adhered to strictly. Formal team training is not offered routinely in most institutions and teams in theatre are expected to function to a high standard with not many guidelines or protocols about how the team should function. Critical incident reporting shows that equipment failures occur too often. Staff may be able to prevent some intra-operative failures by performing pre operative checks on the equipment yet this is not routinely carried out. Assessing deviations form best practice and the reasons for this may give us some insight into error causation and adverse patient outcomes. However to implement changes, effective team work measures are necessary which are capable of capturing the entire process in an objective and structured manner.

Observational research has been used in many other high risk domains effectively and recently for assessing communication and errors in the operating theatre (Carthey *et al.* 2001;Lingard *et al.* 2004). Our teamwork assessment tool which has been described in the previous chapter was developed from basic principles adapting concepts of measurement from previous research, while adopting a bottom-up approach to measurement construction. The aim of this work was to develop a practical method of assessing teamwork in theatre able to capture the most important behavioural dimensions of surgical teamwork and task completion. The aim was to test the feasibility and practicality of systematic observations in the operating theatre evaluated a framework for measuring team performance and report preliminary in this study using the OTAS (observational teamwork assessment for surgery) instrument.

7.2: Aims of the Study

- To test the feasibility of assessing teamwork in theatre.
- To test if the tool was able to capture the essentials of the surgical team input, in composition and process of the interdisciplinary team in the operating theatre.
- To record deviations from normal or protocol or indeed standard published guidelines.
- To record critical incidents in an attempt to analyse predictors for negative surgical outcome.
- To evaluate the patient records in an attempt to correlate surgical process with patient outcome.

It was hoped that this data would be utilised to structure training programmes for operating theatre teams in the future with special attention to crisis management. It was also predicted that if behaviour ratings were valid in discriminating varying performance they would correlate with the objective assessment of task completion. We also predicted that a high level of task completion or behaviour score would relate to effective teamwork and thus contribute to positive patient outcomes, in terms of post-operative condition/complication.

Information leaflets and notices for theatre personnel and gaining necessary permission prior to commencing actual data collection. The information notices and consent forms for staff are available in the appendix. Theatre staff were also informed about the nature of our research prior to data collection and were assured that all data would be used for research purposes only and not as surveillance for individual staff performance.

7.3: Method

7.3.1: Sample

Data was collected 50 general surgery operations (29 open and 21 laparoscopic) in a single operating theatre at our institution. The identity of anaesthetists, nurses and surgeons varied from case-to-case and sometimes within case. However, there was considerable consistency of personnel in the sample. The OT was dedicated mainly to general surgery, and for the three days of data collection, three corresponding consultant surgeons ran their case lists. Particular nurses and OT assistants were allocated to the OT and there was some tendency for anaesthetists to work with particular surgeons, though not as a strict rule. For this sample we limited the duration of the operation used for the purposes of data collection from 30 minutes to 240 minutes.

7.3.2: Patients

There were 24 female patients and 26 male patients (age range 20yrs - 91yrs).

7.3.3: Procedure

The general surgical process was divided into phases and stages as described in the previous chapter. Team work was assessed by a combination of tasks and behaviours. A trainee surgeon (observer 1) and post-doctoral psychologist (observer 2) collected data on tasks and behaviours, respectively. Other measures taken included operative stage times, team composition in theatre, level of supervision of trainees, environment recordings and a record of any critical incidents.

7.3.3.1: Task checklist

A total of 203 tasks plus the checks for the number of team members in theatre were recorded. The tasks for each stage and phase of the operation are outlined in the appendix. Tasks were assessed in the three categories described previously: namely, patient, equipment and communications tasks. Patient-centred tasks comprised either actions or information associated directly with the patient such as safe transfer to operating table and patient notes present. Equipment-centred checks included checking and counting of surgical instruments. Communication-centred tasks included information such as operative site laterality confirmation. There may be some discrepancy in how checklists are scored but maybe simplified by some of the following examples. Diathermy machines were scored a yes if they were present in the theatre and easily accessible. If they were physically checked i.e. switched on and tested prior to the operation it was deemed as ready and checked. Like wise the anaesthetic machines deemed checked if the anaesthetist on duty checked them. If the operation was the second case of the day all the machines were scored as if they had been checked.

7.3.3.2: Behaviours

Team performance was also assessed on a set of teamwork behaviours as described in the previous chapter. The teamwork model we used was the input process output model and the team behaviours comprised of shared-monitoring, communication, co-operation, co-ordination and shared leadership. Behavioural summary scales were used, with each scale-point relating to a certain level of quality and quantity of a given teamwork component, determined by various descriptive elements of a component (see the behavioural scales in the appendix). Notes taken on effective and ineffective behavioural exemplars/markers during each case provided support for behavioural ratings.

A retrospective analysis of the notes was carried out 6 months later to assess the immediate, peri-operative and late complications and follow up for these patients in an attempt to correlate team performance with outcome.

7.3.4: Data analysis

A mixture of parametric and non parametric tests was employed to analyse the data. We carried out ANOVAs to assess the differences in the rate of task completion or behaviour ratings across the operative stages. In addition we calculated Spearmans rho rank order correlation coefficients between rates of task completion and behaviour rating across stages. Finally we used chi square tests to explore the possible relationships between behaviour ratings, type and duration of the operation and post operative outcomes.

7.4: Results:

7.4.1: Task completion

Table 7.1 summarises the task data, with total number of tasks checked (N) and the mean, minimum and maximum number of tasks completed per operative phase for the 50 operations sample. Overall task completion was high (above 60%), when averaging all three task types (Figure 7.1). The mean for the patient tasks was PREOP=89.6, OP=93.4, POSTOP=97.3. A two-way repeated measures ANOVA, conducted on task-type (3) and phase (3), showed that task type differed significantly overall across the three phases [$F(2, 48) = 249.47$, $p<0.000$], with communication tasks [68.64, SE ± 1.44] lowest, followed by equipment tasks [75.9, SE ± .656] and patient tasks [93.48, SE ± .639] highest. There was also a main effect of phase [$F(2, 48) = 252.81$, $p = 0.000$], whereby task completion was higher in the OP phase [76.76, SE ± 1.1] than in PRE phase [68.93, SE ± .9] and even higher in the POST phase [92.33, SE ± .69]. That linear-trend reached significance [$F(1, 49) = 477.38$, $p<0.000$]. The ANOVA also showed that the difference in task-type was different between phases, in a significant interaction of phase and task-type [$F(4, 46) = 114.90$, $p=0.000$]. That is shown in Figure 7.1, illustrating that patient tasks were consistently high across phases, whereas communication remained lower in both PRE and OP phases compared to the POST phase, while equipment task completion increased across phases. *While there was an interaction noted in the ANOVA there were a different number of tasks in the varying categories across the stages which may account for some of these differences. There was no significant difference between open (29) and closed (21) operations on task type in a three-way, operation (2) x task-type (3) x phase (3) repeated measures ANOVA [$F<1$].*

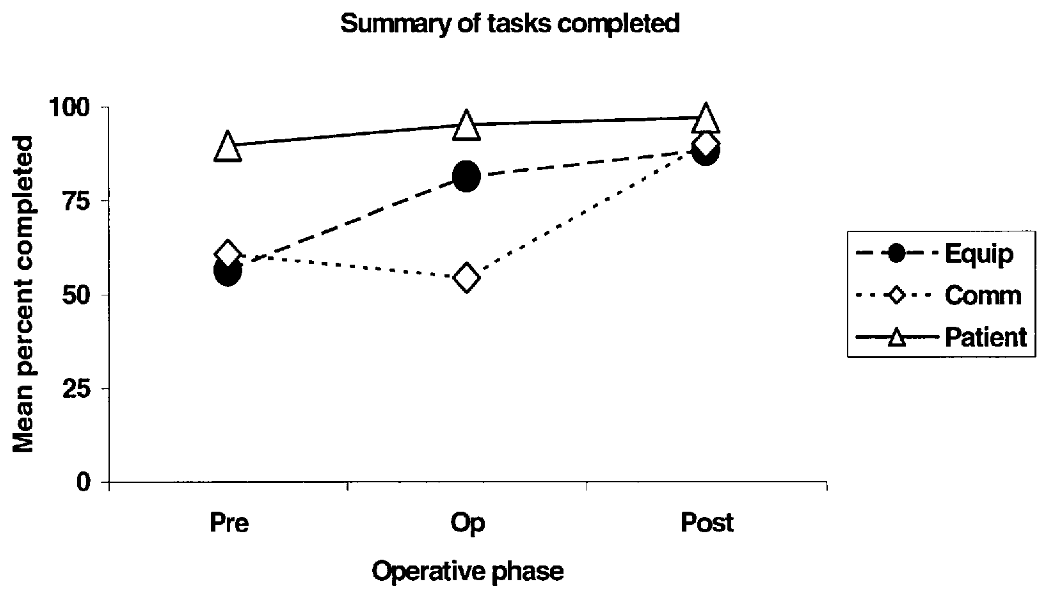

Figure 7.1: Overall task completion per phase of operation. Patient tasks were relatively high throughout. Equipment tasks were low in the pre op phase and higher in the other phases. Communication tasks were low in the pre and intra op phases.

Task type	Pre-op			Intra-op			Post-op		
	Mean SE	min% max%	range N task	Mean SE	min% max%	range N task	mean SE	min% max%	range N task
Equipment	56.46 1.38	42.11 80.95	38.84 22	81.94 1.02	52.17 100	47.83 26	89.29 0.66	75 100	25 10
Comm.	60.72 1.99	12.5 86.67	74.17 18	54.84 2.65	22.2 100	77.78 10	90.34 1.44	61.54 100	38.46 14
Patient	89.60 0.95	68.75 100	31.25 18	93.49 1.56	64.29 100	35.71 14	97.36 0.68	73.33 100	26.67 16
Overall mean **Overall N task**	68.93		58	76.76		50	92.33		40

Table 7.1: Summary of task completion per phase and task type

7.4.1.1: A Focus on Individual Tasks

While there were a large number of tasks across the phases of the operation most of them were completed for a majority if the cases. However some tasks which we believe are clinically relevant were not completed and will be discussed further. For example the anaesthetic machine had been checked by the anaesthetist in 80% of the cases, surgeon asks if it is ok to start in 65.3%, the diathermy machines had been checked in 30% of the cases, suction checked and ready in 37%, procedure confirmed verbally 32%, notes present in 88% cases, changes and delays occurred in 71% of the cases. While these figures seem relatively high it is the ultimate responsibility of the surgeon or anaesthetist using the equipment that these are checked prior to each case and are in working order hence we would expect a 100% completion rate for these particular tasks. The table 7.2 shows the % of these tasks completed and those not done regularly.

Checks	% carried out	% not done
Anaes. machine checked	80%	20%
Log book available	63%	37%
Log book up to date	28%	72%
Documented in notes	18%	82%
Signed in notes	4%	96%
Diathermy ready & checked	30%	70%
Ready but not checked		52%
Not ready		18%
Communication		
Ready for op	26%	74%
Ok to start	65%	35%
Acknowledged	65%	35%
Patient confirmed verbally	35%	65%
Procedure confirmed	32%	68%
Changes or delays	71%	29%
Briefing	4%	96%
Notes with patient	88%	12%

Table 7.2: Key findings of clinically relevant tasks that are not done regularly.

7.4.2: Team Behavior Ratings

Across the three phases, the overall behaviour ratings were consistently high (>4) (Figure 7.2). A two-way repeated measures ANOVA, conducted on behaviour (5) and phase (3), showed that behaviours differed significantly overall [F (4, 46) = 54.45, p<0.000], with communication [4.56] rated lowest, followed by leadership [5.20], shared-monitoring [5.41], co-ordination [5.48] and co-operation [5.77] rated highest. There was also a main effect of phase [F (2, 48) =3.93, p = 0.020], where ratings were significantly higher in the OP phase [5.4] than in PRE [5.25] and POST [5.21] phases. The ANOVA also showed that the difference in behaviours was different between phases, in a significant interaction of phase and behaviour [F (8, 42] = 3.83, p=0.002]. Communication and co-ordination were rated higher in the OP phase than in PRE and POST phases, whereas leadership, co-operation and shared-monitoring were comparatively more consistent across phases (Figure 7.2). As with task-completion, there was no significant difference between open (29) or closed operations (21) on behaviours in a three-way, operation (2) x behaviour (5) x phase (3) repeated measures ANOVA [F<1].

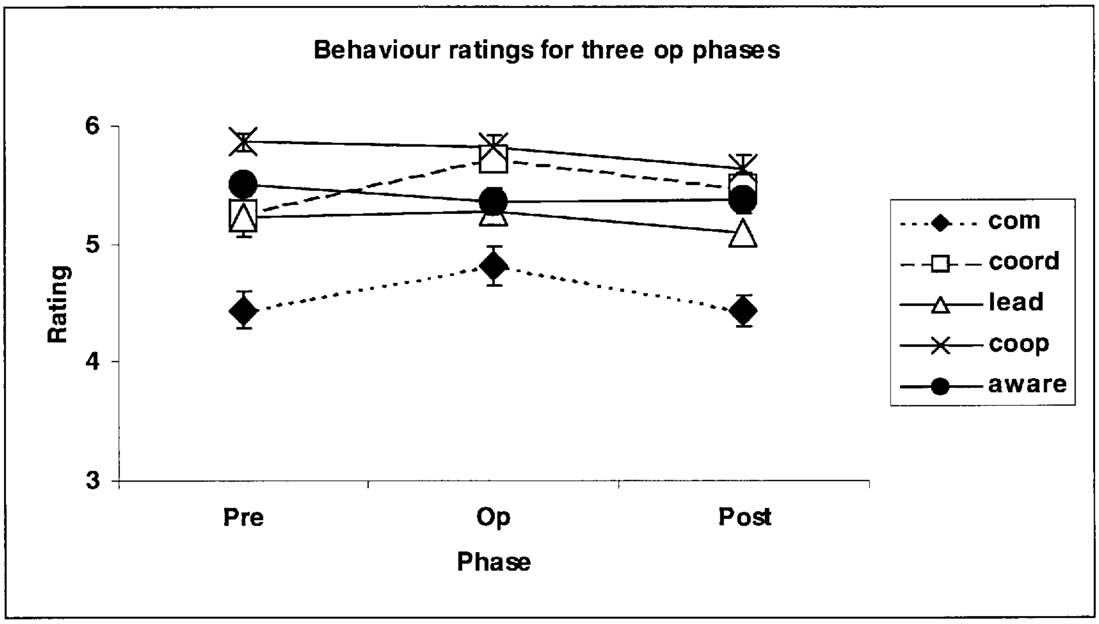

Figure 7.2: behaviour ratings for the phases of the operation.

7.4.3: Relations between Behavior and Task Completion

	Task-type	Comm	Coord	Lead	Coop	Monitor
Pre-op	Equip	.151 .147	-.182 .103	.110 .223	.122 .199	.173 .144
	Comm	.415** .001	.050 .364	.233* .051	-.029 .420	-.059 .341
	Patient	.198 .084	.146 .156	.143 .162	.145 .157	.135 .175
Intra-op	Equip	.109 .225	-.103 .225	109 .226	-269* .029	-.012 .466
	Comm	-.001 .496	-.079 .294	-.003 .491	.019 .447	.009 .476
	Patient	.139 .166	-.070 .315	.209 .073	.077 .299	-.235 .050
Post-op	Equip	.049 .368	.321 .011	-.107 .230	.078 .295	-.162 .131
	Comm	.308* .015	.107 .231	.161 .132	-.126 .192	.137 .172
	Patient	.107 .230	.038 .395	.193 .090	.088 .271	.181 .104

Table 7.3: Correlation matrix of five rated behaviours and completion of three task-types for the pre-op (PRE), intra-op (OP) and post-op (POST) phases. N =50. Spearman's rho, correlation is significant at the 0.01** and 0.05* levels (one-tailed). Columns contain correlation coefficients then significance levels in rows.

After aggregating tasks into mean % task scores, we tested whether any of the behaviour ratings related to overall task completion in each phase. Spearman's rho correlation analysis showed a highly significant positive correlation between communication rating and overall task completion in the PRE phase [r_s =.468, p<0.000] and in the POST phase [r_s =.345, p=0.007], but not in the OP phase. We also tested whether there were any relationships between completion of the separate task-types and ratings of separate behaviours (Table 7.3). In the PRE phase behaviour ratings did not correlate significantly with equipment task or patient task completion. However, there was a highly significant positive correlation between communication tasks and rating on communication behaviour [r_s =.415, p=0.001] and a marginally significant positive correlation between communication tasks and rating of leadership [r_s =.233, p=0.05]. Furthermore in the OP phase there were no positive correlation between ratings and tasks. This may be due to the fact that tasks and behaviours were both high in the OP phase with much less variation and hence were less likely to correlate. In the POST phase communication, again, positively correlated with communication task [r_s =.308, p=0.01] and co-ordination positively correlated with equipment task completion [r_s =.321, p=0.01]. There was correlation among behaviour ratings, indicating inter-relationships among rated behaviours in team process. There was significant positive correlation (Spearman's rho: r_s) among all behaviours, except between communication and co-operation in the PRE phase, between co-operation and shared-monitoring in the OP and POST phases and between leadership and co-operation in the POST phase.

7.4.4: Team Composition

The Figure 7.3 illustrates the team composition throughout the various stages and phases of the surgical process. The operating surgeons were present during OP2 stage for all the 50 cases (100%) but in only 44% during the POST1 stage. The nursing presence was consistently high at 100% throughout PRE3 through to OP3. Likewise the anaesthetists had a consistently high level of presence over 82% throughout. The ODP were present 88% in the PRE2 & 84% in the POST1 stage. Through the rest of the procedure they were not present more most of the stages. Of note they were only present in 24% of the OP2 stage

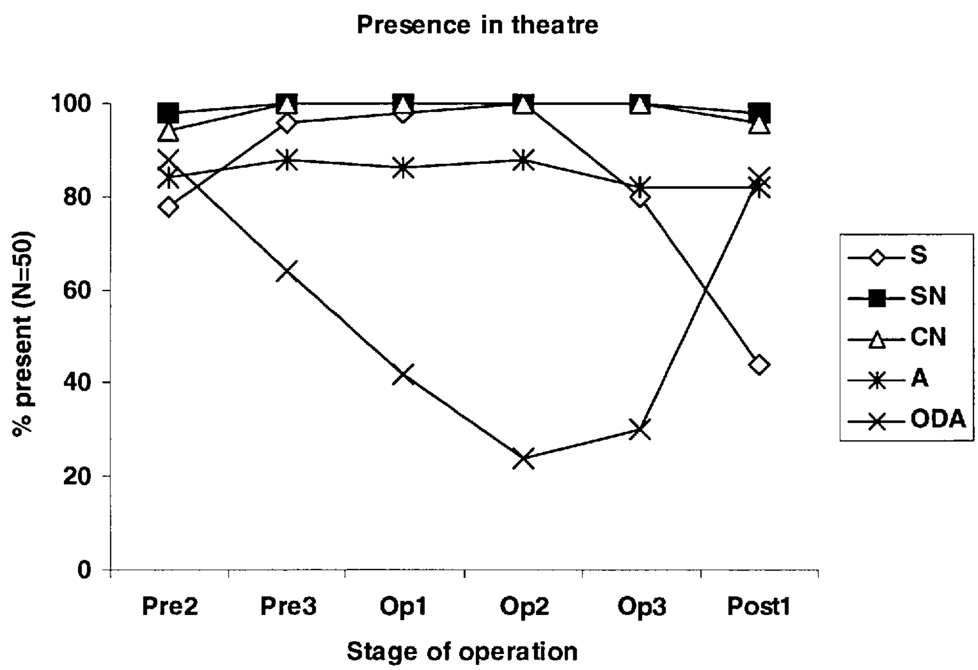

Figure 7.3: Team composition through the operative phases

7.4.5: Other Factors which may Impact on Team Performance

7.4.5.1: Surplus Staff and Door openings

We found in our 50 cases that there was a wide variation in the number of staff in theatre at any given time. The mean was PRE3=4.70, OP1=4.94, OP2=5.26, OP3=4.78, POST1=3.49 with a range of min 1 and max 15. Of note there was a maximum of 15 during the OP2 phase (Figure 7.4). Furthermore, we found that the mean door opening frequency during the main operative phase was OP1=5.04, OP2=20.8, OP3=7.4. This equates to an average door opening frequency of approximately 1 per minute in OP2. (Table 7.4 & Figure 7.5)

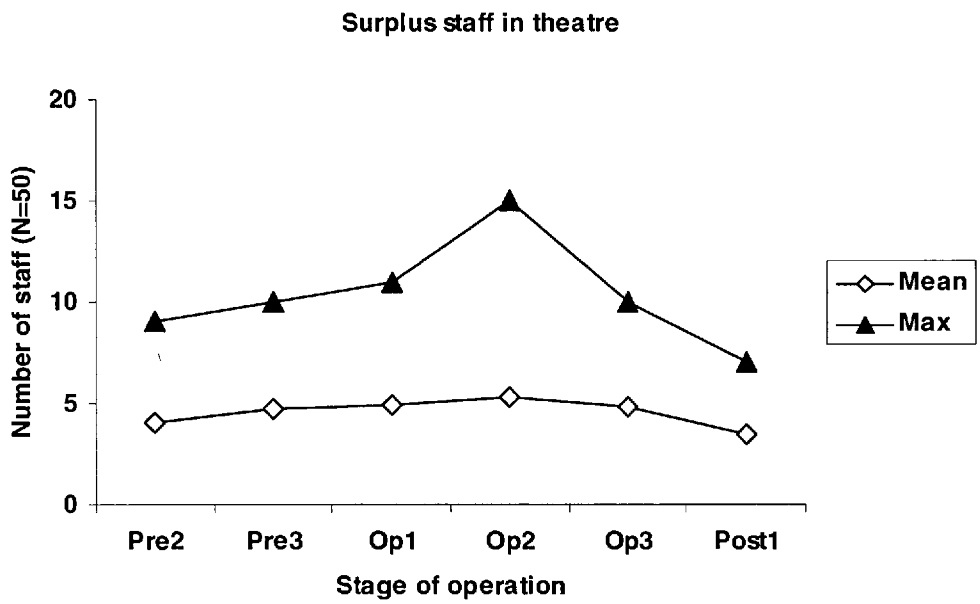

Figure 7.4: mean and maximum number of surplus staff during the different stages

	Intra-Op 1		Intra-Op 2		Intra-Op 3	
Factor	mean	SE	Mean	SE	Mean	SE
Door opening	5.04	0.42	20.8	2.4	7.4	1.07
Stage duration	8.94	0.77	39.10	6.6	15.18	1.88
Opening/duration of operative stage	0.65	0.06	0.97	0.26	0.57	0.07

Table 7.4: Movement of staff reflected by door opening frequency.

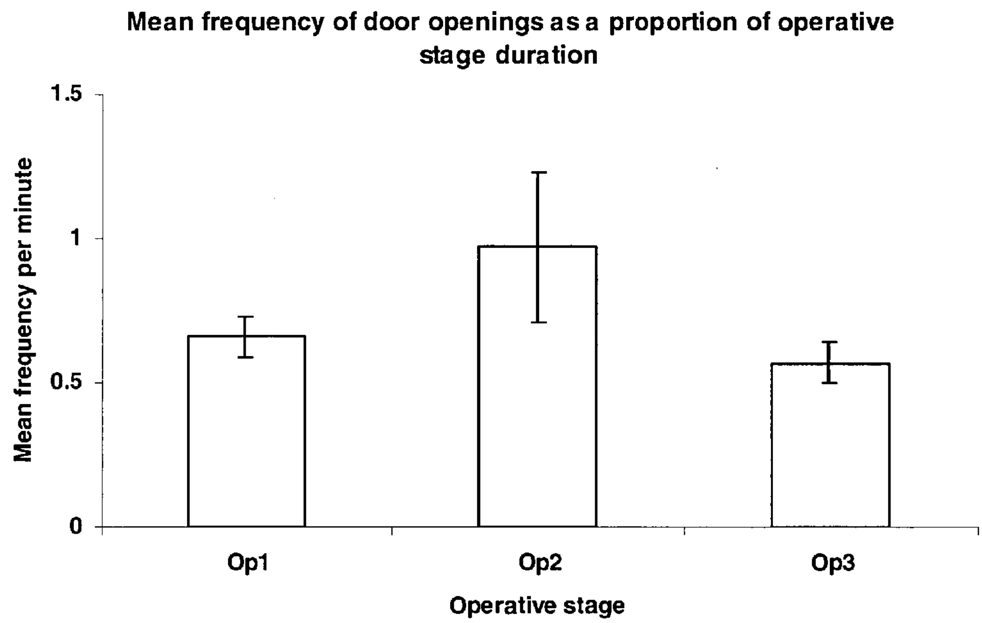

Figure 7.5: Door opening frequency during OP phase

7.4.6: Operation Duration

The overall mean duration of the operations was 135.72 (range 61 minutes to 240 minutes). The breakdown of duration for the various phases and stages is outlined in Figure 7.6.

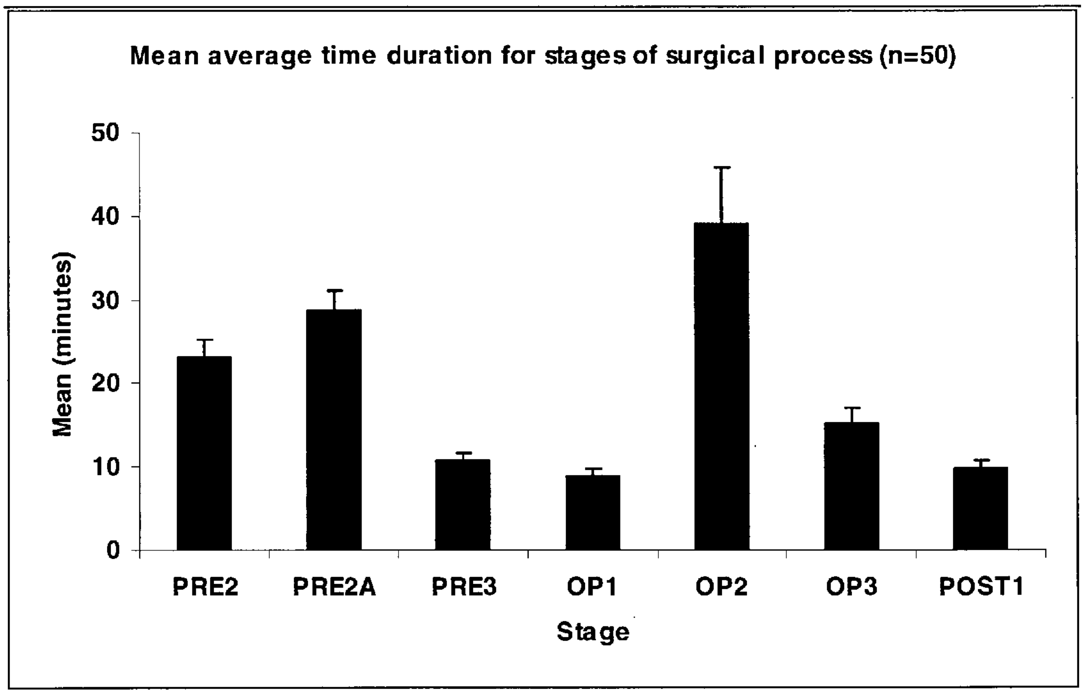

Figure 7.6: mean duration of the various phases of the operation

For simplification of the results we further divided the PRE2 phase into PRE2 and PRE2A where PRE2A denotes the actual anaesthesia time. The mean duration for the stages were PRE2A=28.78, PRE3=10.8, OP1=8.94, OP2=39.1, OP3=15.18, POST1=9.72. Furthermore a two-way ANOVA showed that there was no difference between operative type (open or laparoscopic) and operative duration for any stage of the procedure (table 7.5).

Descriptives

		N	Mean	Std. Deviation	Std. Error	95% Confidence Interval for Mean		Minimum	Maximum
						Lower Bound	Upper Bound		
PRE2A	open	29	29.8621	18.42887	3.42215	22.8521	36.8720	10.00	73.00
	closed	21	27.2857	13.19145	2.87861	21.2810	33.2904	8.00	61.00
	Total	50	28.7800	16.33238	2.30975	24.1384	33.4216	8.00	73.00
PRE3	open	29	11.6897	4.55995	.84676	9.9551	13.4242	4.00	21.00
	closed	21	9.5714	6.64508	1.45008	6.5466	12.5962	2.00	28.00
	Total	50	10.8000	5.56960	.78766	9.2171	12.3829	2.00	28.00
OP1	open	29	8.2759	5.57351	1.03498	6.1558	10.3959	1.00	23.00
	closed	21	9.8571	5.32246	1.16146	7.4344	12.2799	4.00	26.00
	Total	50	8.9400	5.47130	.77376	7.3851	10.4949	1.00	26.00
OP2	open	29	44.6207	58.68220	10.89701	22.2992	66.9422	3.00	240.00
	closed	21	31.4762	20.33622	4.43773	22.2193	40.7331	3.00	82.00
	Total	50	39.1000	46.68533	6.60230	25.8322	52.3678	3.00	240.00
OP3	open	29	17.3103	15.88149	2.94912	11.2693	23.3513	2.00	80.00
	closed	21	12.2381	8.12345	1.77268	8.5403	15.9358	5.00	30.00
	Total	50	15.1800	13.32129	1.88391	11.3941	18.9659	2.00	80.00
POST1	open	29	9.4138	7.40905	1.37583	6.5955	12.2320	2.00	37.00
	closed	21	10.1429	5.32246	1.16146	7.7201	12.5656	3.00	24.00
	Total	50	9.7200	6.56223	.92804	7.8550	11.5850	2.00	37.00

Table 7.5: ANOVA on operation type and duration

We have not reported the times for PRE 1 or POST 2. PRE 1 was preoperative planning and did not have a set time frame and POST 2 was the recovery period where the patient was left with the recovery nurse and monitored in a separate area outside theatre. Once the handing over of the team and the communications were recorded there was no further team activity and the observers did not record further data in the recovery bay.

7.4.7: Factors Relating to Post-Operative Complication

Of the 19 cases with complication, only four were in the MAS operation category, whereas 15 were in the open operation category. Of the 31 cases with no complication, 17 were MAS and 14 were open. A Chi square test ($\chi^{2)}$ on that data showed a significant result [χ^2 5.52, df 1, p=0.019, two-tailed], indicating that closed operations were associated with less complication than open. As there was no overall significant difference between open and MAS operative duration (table 7.5) that suggests the complications associated with open operations were not due to operative duration per se, but to the intrinsic nature of the operation, perhaps in more operative difficulty and the invasiveness. However there was a relationship between duration of operative stage Op2 only, showing that there was less likelihood of complication with any operation below the sample mean duration than above the sample mean duration.

We found no significant relationships between task-completion and complication. Table 7.6 shows that overall sum behaviour ratings were associated with complication occurrence, as a Chi-square test showed that operations below the sample mean of behaviour ratings (26.44) had more likelihood of complication than operations above the sample mean [χ^2 6.2, p=0.01]. A similar result was found with separate behaviour dimensions, communication [4.08, p=0.04] and co-operation [χ^2 5.63, p=0.02].

Factor	Mean	Criteria	Complication		χ^2 Value	Sig. (2 tailed)
	0-6		No	yes		
Communicate	4.50	< mean	9	11	4.08	**0.04**
		> mean	22	8		
Co-operation	5.77	< mean	9	12	5.63	**0.02***
		> mean	22	7		
Co-ordination	5.49	< mean	11	11	2.40	0.15
		> mean	20	8		
Leadership	5.20	< mean	12	11	1.74	0.24
		> mean	19	8		
Monitoring	5.41	< mean	14	12	1.52	0.25
		> mean	17	7		
SumBehaviour	26.44	< mean	10	13	6.20	**0.01***
		> mean	21	6		

Table 7.6: The relationship between behaviour ratings and complications

We have not carried out detailed analysis in terms of risk stratification etc so the complication has to be interpreted with caution. We have outlined the type and number of complications that were found in the post operative period and up until six months following the data collection in table 7.7.

Peri-operative Complications	No of patients
Multiple organ failure and death	2
Splenic Injury requiring Splenectomy	2
Post op Pleural effusion	1
L. Insular cortex infarct, anastomotic leak, peritonitis, further procedure, sepsis, MODS and death	1
Post operative pain	7
Post operative cardiac arrhythmia	1
Urinary retention	1
Bladder injury	1
Post operative rectal bleeding	1
Tracheostomy	1
Post operative apnoea requiring transfer to HDU	1
Wound infection	2
Scrotal bruising	1
Oliguria	1
Post operative pyrexia	2
Incisional hernia	1
Recurrence of hernia following repair	1
Recurrence of fistula	1
Chronic discharge / wound infection	2

Table 7.7: shows some of the post operative complications that were encountered during the retrospective analysis. Some patients encountered more than one of the complications hence the numbers may appear higher than that quoted in the text.

7.5: Discussion:

We measured various teamwork input and process factors, collecting substantial data on team performance in theatre. The results obtained support the argument that observational assessment in operating theatres is feasible, purposeful and informative similar to findings from other such studies (Carthey *et al.* 2001;Lingard *et al.* 2004). Task completion and rated teamwork behaviours were generally high. Despite overall high scores on performance measures, recommended practices and behaviours were variable. Overall, evidence from observation suggested that the operating theatre teams sampled performed routine practice, but not as systematically as might be expected of highly reliable teams.

While overall task completion was high throughout operative phases, deviation was clearly evident. Anaesthetists had not checked their machines themselves in 20% of the cases. Suction was checked prior to the operation in just 37% of cases, procedures confirmed verbally in 32% of cases and patient notes absent in 12% of cases. Perhaps the most salient finding was that there was no communication regarding the readiness to start in 35% of the cases, consistent with the study by Lingard et al (2004) showing that communication failures occur frequently in the OT. Behaviour ratings overall were also high across the three phases, attributed in part to the consistency in the main composition of teams assessed. However, differences were found between cases in behaviour and within cases among behaviours rated. Notably, communication was rated lower than other behaviours, particularly in the pre-operative and post-operative phases. That was due in part due to the fact that interdisciplinary communication is less formalised and more distributed before and after the actual operation. There was a positive correlation between communication rating and overall task completion pre-operatively and post-operatively, but not intra-operatively. There was also a positive correlation between communication tasks and rating on communication behaviour and leadership. The correlation results provide initial support for convergent validity of the behavioural measures.

There was variation in the times taken for the various phases and stages to be completed. We found that delays and changes to the case-lists occurred in over 70% of cases. That was due to the patient journey to theatre, busy ward staff or porters and bed allocation processes. Considerable time elapsed in the anaesthetic room once the patient had arrived for various reasons: the patient's condition, the surgeon or anaesthetist's absence both contributed to extended duration. Other factors included staff being unfamiliar with stock locations, coupled with a lack of compensatory supervision. There were also incomplete notes, lack of equipment, lack of blood results, and patients not being starved on wards. It is important to consider the effects of delays. Staff can become bored or tired, negatively affecting performance during an operation, particularly later in the day. On the other hand, delays provide staff with additional time to do certain checks on equipment and instruments. However, in some cases time was not used so effectively, checks were still not carried out and communications, in particular, were variable. That suggests an inefficient and uneconomical use of time due to inadequate co-ordination. When small deviations from best practice occur repeatedly or in combination may lead to a potentially dangerous situation through their cumulative effects. The teams sampled did encounter equipment failures and instruments and not being at hand intra-operatively.

Post-operative complications included pain, pyrexia, wound infection, urinary retention, splenic-injury and death. We found no significant relationships between task-completion and complication. However, overall sum behaviour ratings were associated with complication occurrence, providing initial support to the internal validity of the team performance model. The precise relations are unknown, but we may speculate from the results of the checklist. For instance, we found that verbal communication confirming antibiotics was observed in only 53% of cases, which may have influenced infection outcome. Moreover, blood loss analysis and monitoring did not occur in every case. Caution must be exercised in concluding that relations between behavioural measures and outcome are direct. As the sample was not large, many other factors may have influenced results, such as the patients' initial condition, additional morbidity and ASA grade. In particular, we did found a higher incidence of complications with the open operation group, but given that we found no significant difference in behaviour ratings between operation types, it is feasible that the behavioural assessment captured aspects of performance important for operative outcome.

7.6: Conclusions

As discussed previously we can assume that patient outcome depends on a variety of factors other than the skill of the surgeon and the patient's condition or constitution and that some aspects of team performance may influence outcome. If deviation from recommended practice and lacking teamwork protocol are common to general practice in surgery then intervention such as briefing and checklists in theatre and team training are necessary to improve teamwork. We predict that enhancing the input and process factors in our model, perhaps in team structure, cognition and behaviour may help improve patient outcome, and OTAS provided the framework for measurement.

The fact that we found only some significant correlations between the task and the behaviours leads us to believe that the two aspects of OTAS are measuring different things. It was clear in the development of OTAS that a full list of predetermined behavioural markers detracts from the observation of the fluid and varied processes of teamwork in surgery and observers can spend valuable observational time reading from such lists of behaviour. That compromises holistic assessment of teamwork because time is spent reading from a list of fixed behaviours rather than observing teamwork process. That argument supported the rationale for using both a predetermined list of task checks and a separate overall behavioural assessment. However we did realise that the OTAS prototype comprised of many tasks and some of them may be redundant or not required. The next step in this development would be the refinement of the tasks and behaviours. Secondly the author and the psychologist involved in the first 50 cases had clearly gained experience in doing so. We have to then test the trainability of this assessment tool which would be important if this tool is to be available for broader use. The next chapter describes the refinement and the some of the training aspects of the OTAS scales.

8. Chapter Eight: Refinement of the OTAS Prototype and Training Issues

8.1: Introduction

Following the first 50 cases and analysis the OTAS instrument was reviewed by those involved in the researched. It was felt that there were a lot of redundancies in the task list and that a modification and refinement of the assessment was necessary. Refinement of this prototype OTAS tool was then designed. The objective of this process was to produce a much more compact system and one which would be easily modified for use in other specialities. This process was conducted in two stages. The first was an interview format for the modification of the task list and the second was the development of the demonstrative scenarios and exemplar behaviours for rating the behavioural aspects.

8.2: Refinement of Tasks

The aim of the revision of the task list was to address the following issues:

1. There was some redundancy in the list
2. There was a tentative agreement that the task list could be condensed to some extent for ease of use without substantial loss of descriptiveness

8.3: Method

8.3.1: Design:

Semi structured interviews were conducted with members of the key groups of professionals working within theatre. Simultaneously two surgeons familiar with the research constructed an independent task list based on previous data and experience with use of the tool.

8.3.2: Participants:

Three participants from each of the key OT specialist groups (surgeons, anaesthetists, & nursing staff) with experience of 10 years or more volunteered to participate in the study (total N = 9).

8.3.3: Materials:

8.3.3.1: Criteria for the task list revision

We established the following criteria for the revision using domain experts such as surgeons, nurses and anaesthetists to include or exclude tasks from the original prototype task list. Empirical criteria were added to supplement judgemental ones by domain experts. According to these criteria, tasks should be included or excluded on the basis of some domain expert judgement coming from clinicians from all OT specialties who had not been involved in the development of the task list in the first place. The criteria were as follows:

Inclusion Criteria (Any of the Below)

1. Task contributes to patient safety or quality of care
2. Task contributes to surgical outcome positively or its omission would contribute adversely to surgical outcome
3. Task is essential for team work or enhances team working
4. Task makes an important contribution to the whole system

Exclusion criteria

1. Task which is duplicated or covered by another task
2. Task which is irrelevant to any of the above inclusion categories
3. Tasks which are inherent to the procedure
4. Task which is not clinically important

8.3.4: Interview process

Three professionals from each specialty were individually interviewed. These were experienced practitioners with more than 10 years of experience in their respective fields. These included surgery, anaesthesia and theatre nursing. They were asked to review the OTAS Task list independently and indicate Tasks which they regarded as essential for the purpose of scoring team performance.

The interviewees were shown the list and they judged, according to the specified criteria set out above, whether each individual task should be definitely included or excluded. If they were not sure, they stated their uncertainty ("maybe") along with some detailed comments. Further room for free text and suggestions and comments were also provided. The interviews took place in a quiet room without any disturbances at a set time according to the convenience of the participants. Experts were chosen voluntarily from the pool of staff with the necessary expertise in their fields. The interviews took approximately 20 minutes each. They were all conducted by a single interviewer (SU).

Participants were given instructions regarding the assessment tool and why the refinements were being carried out. They were asked to score the task list according to the criteria set out below.

The participants were further asked to comment about the stages and phases of OTAS and whether they felt that the tasks were in the appropriate category. If anyone felt that certain tasks needed to be moved to other phases then comments about the same were invited. The instructions to the participants and the full task list prior to modification are available in the appendix (Appendix F & G)

8.4: Results of the Task List Revision Interviews.

8.4.1: Task Exclusions:

We found that there were no tasks that all of the participants agreed on excluding from the list. (Tasks that all respondents (9 / 9) agreed on excluding from list (count = 0))

At least six participants agreed on excluding 15 tasks from the entire list. (Tasks that all respondents (6-7 / 9) agreed on excluding from list (count = 15)). These were primarily to do with patient condition. See table below for details (Table 8.1).

PRE 1	**OP 1**	**POST 1**
None	*Condition of patient*	*Condition of patient*
	Anaesthetised	Anaesthetised
PRE 2	Temperature within range	Temperature within range
None	Urine output within range	Urine output within range
	Cardiac output in range	
PRE 3	A-ODA (patient-specific requirements)	
Equipment and provisions		
DVT device	**OP 2**	
	Condition of patient	
	Anaesthetised	
	OP 3	
	Condition of patient	
	Anaesthetised	
	Temperature within range	
	Urine output within range	
	Cardiac output in range	
	A-ODA (patient-specific requirements)	

Table 8.1: Tasks that at least 6 participants agreed should be excluded from the list

At least four of the nine participants agreed on excluding 25 tasks from the list (Tasks that 4-5 / 9 respondents agreed on excluding from list (count = 25)). These were predominantly to do with the critical incidents and some for equipments and provisions. See table 8.2 for details.

PRE 1	**OP 1**	**POST 1**
None	*Critical incidents*	*Patient*
	Critical incident	Drapes removed
PRE 2	Critical incidents reported	
Patient	Hazards to patient	*Critical incidents*
Booked operation time		Critical incident
	OP 2	Critical incidents reported
Equipment and provisions	*Equipment and provisions*	Hazards to patient
Gowns and gloves prepared	Diathermy	
	Suction attached	**POST 2**
Condition of patient		None
Urine output within range	*Critical incidents*	
	Critical incident	
PRE 3	Critical incidents reported	
Equipment and provisions	Hazards to patient	
Surgical instrument covered till operation		
Anti-pressure devices prepared	**OP 3**	
	Critical incidents	
Condition of patient	Critical incident	
Anaesthetised	Critical incidents reported	
Temperature within range	Hazards to patient	
Urine output within range		
Cardiac output in range		
Critical incidents		
Hazards to patient		

Table 8.2: Tasks that 4-5/9 decided should be excluded from the list

8.4.2: Task Inclusions:

There were 31 tasks that all the participants agreed on including in the final task list. (Tasks that all respondents agreed on including in the list (count = 31)). See table 8.3 for details.

PRE 1	**OP 1**	**POST 1**
Patient	*Equipment and provisions*	*Patient*
Patient notes prepared	Pedals to surgeon	Drains catheter safely positioned and working
Equipment	Adjusting light	Ensure airway maintained
Specific equipment available		Patient protected on trolley for transport
Specific instruments available	**OP 2**	
Communication	None	*Equipment and provisions*
A informs of special needs		Oxygen supply OK
Theatre list produced and displayed	**OP 3**	
Changing in list or delays	*Equipment and provisions*	*Communication*
PRE 2	Supplying requested drains	A command to move
Patient	Swab & instrument count	
Correct patient verified		**POST 2**
Surgical site and laterality verified		*Patient*
Surgical procedure verified		Ensure notes and X-rays are with patient
Notes and X-rays present for patient		Adequate fluids and post-op instructions
Communication		Adequate analgesia written up / pca set up
Sn and Cn confirm instruments check		
Critical incidents		*Communication*
Critical incident		Ensure op-notes are written and filed
Critical incidents reported		
PRE 3		
Patient		
Pressure points protected		
Correct position for procedure		
Equipment and provisions		
Diathermy pad applied		
Diathermy checked and ready		
Suction prepared and ready		

Table 8.3: Tasks that all interviewees decided should be retained in the list

There were 55 tasks that 8 out of the 9 participants agreed on including in the final task list. (Tasks that 8/9 respondents agreed on including in the list (count = 55)). See table 8.4 for details.

PRE 1	**OP 1**	**POST 1**
Communication	*Patient*	*Patient*
Patient consents to the surgery	Betadine painting	Check for diathermy burns
A-ODA (patient specific requirements)	Draping	Check pressure areas
PRE 2		Cleaning up patient
Patient	*Equipment & provisions*	Oxygen mask attached
Patient condition monitored by A	Connection of leads and suction	*Equipment and provisions*
Equipments and provisions	Diathermy settings	Bringing in the trolley
A equipment checked and working	Sterile handles for spotlight	Sharps safely disposed of
Team composition in theatre (at incision / access of patient)	**OP 2**	Suction for A
Surgeon	*Communication*	Sats probe
Assistant	S informs of bleeding	Dressing
Sn		
Cn	**OP 3**	*Communication*
A	*Patient*	Airway instructions to ODA
Assistant	Blood loss analysis	A OK for patient removal
Supervised	Blood / fluids monitored	Verbal communication to patient to waken
ODA		**POST 2**
Ancillary staff	*Equipment and provisions*	*Patient*
Surplus staff kept to minimum	Supplying suture material	Patient made comfortable
PRE 3		*Communication*
Patient	*Communication*	Drug chart and instructions hand-over
Safe transfer to operating table	S states closure start	Ensure notes and X-rays are with patient
Td stockings	A acknowledgment	Sn hands over to Rn
A-ODA airway check	S instructs Sn on sutures for closure	A informs recovery of patient condition
S-ODA patient position		A informs recovery on drugs used
Equipment and provisions		Recovery staff acknowledge information
Arm boards		
Warming blanket		
Catheter		

Table 8.4: Tasks that 8 /9 interviewees decided should be retained in the list

8.4.3: Integration of the Data from the Interviews & Experts' Judgement

Once the data from the interviews were collected, analysed and summarised, agreement across the interview participants was used as an index to guide the task elimination / reorganisation. No perfect agreement was reached for task exclusion. Therefore focus was laid on tasks that 6-7/9 interviewees agreed to exclude from the list. A tentative list was prepared excluding the tasks that the interviewees mostly agreed should be excluded or re-grouped them into broader task categories. Likewise, for task inclusion, the starting point was the tasks that participants mostly agreed (9/9 & 8/9) should be included. Working in parallel, a senior surgeon involved in the teams research and the author, prepared a revised version of the list. On the basis of both the interviews and the versions of the senior surgeon plus the author an integrated draft was prepared.

From the various options available to us we carried out the following inclusions and exclusions from the lists.

1. Tasks where 9/9 respondents agreed should be included (31) were included
2. Tasks where 8/9 respondents agreed should be included (55) were included
3. Tasks where 6-7/9 respondents agreed should be excluded (15) were excluded
4. Tasks where 4-5/9 respondents agreed should be excluded (25) were mostly excluded based on the judgement of the research group and from the experts list.

The critical incidents tasks were felt to be important and hence were recorded just once at the end of each phase. Furthermore it was decided that the team composition along with supervision should also be recorded during the key stages of the procedure. Following this task revision we had a task list where several issues had been addressed as we had set out to do. Some issues however still need to be addressed in future refinement and research.

Following the revision we had resolved some important issues. The first was that the original structure of the list was maintained (pre 1-3, op 1-3 & post 1-2). Secondly virtually all of the tasks that the senior surgeon plus author created in parallel were included in the list (either individually or within a sub-group). Most importantly the list was now shorter and easier to use. There were some issues which still need addressing for futures studies and the main one was whether the scoring of the task list should continue the in the current format i.e. the "yes / no" system or should have a rating scale format. The rating scale format would include whether the task was done and how well it was done on a scale of 0-6 (e.g. 0, not done at all – 6, done very well) for certain tasks. Having discussed the options the teams research group decided that the current format should be continued and that the rating scale with the task lists could be tested in a future study. This left us with the new definitive task list which consisted of 115 tasks. Further team composition, supervision and critical incidents were included as discussed earlier.

8.5: Development of Surgery Specific Behavioural Scales

Following the refinement of the task lists we attempted to simplify the behavioural data collection with a view of ease of trainability. We also aimed to develop demonstrative scenarios and examples of what each score may appear like in a surgical context. The scales and scenarios were developed by collaboration between two surgeons and three psychologists and refined by one surgeon and one psychologist. Scales, demonstrative scenarios and exemplars were developed individually for each of the 5 constructs.

8.5.1: Exemplar Behaviours

Exemplar behaviours are items that serve to guide the observer in 'looking for behaviours' that indicate effective teamwork. Exemplar behaviours may be checked for their occurrence, in support of overall behaviour ratings. This method was used in the development of OTAS. Exemplar behaviours were constructed for each of the five behavioural constructs and were constructed specifically in a surgical context. For example during the Intra Operative Phase the surgeons asks the team if they are ready and asks the anaesthetist if it is ok to start the procedure.

8.5.2: Demonstrative Scenarios

Scenarios are particularly useful for calibrating the rating of behaviour to a standardised ordinal scale. Scenarios provide a context in which behaviours are related to levels of teamwork effectiveness. They demonstrate that certain patterns of team behaviour are associated with certain levels of team effectiveness. These scenarios again were created with specific surgical scenarios in mind to enable ease of marking even if the observer is not very familiar with surgery. For example the

Anaesthetists give clear and audible instructions to the team about the latest blood results and that he/she will be transfusing the patient with two units of blood. The details of the summary scales, demonstrative scenarios and exemplars are available in the appendix at the end of the OTAS user manual (Appendix O).

8.5.3: Sub Team Assessment

Initially, the psychologist observer allocated a rating to each one of these behaviours across all members of the surgical team. However it was noted that discrepancies existed at times between the sub-teams that make up the operating theatre team – namely, the nursing, the surgical and the anaesthetic sub-teams and rating the whole team did not give an accurate assessment for the whole teams "teamwork". For example there were times when one sub group showed poor communication and another sub group had excellent communication but the score would be average for the whole team. The rating scheme was, therefore, revised to provide separate ratings for each one of the five behaviours to each one of the three theatre sub-teams (nurses, surgeons and anaesthetists). The scoring was further aided by the use of specifically designed demonstrative scenarios and exemplar behaviours. It was felt that adding the sub team scores to the behavioural ratings would greatly enhance our understanding of team work in theatre. The sub team analysis included a separate score per behavioural construct, per stage for the surgical team (surgeons and their trainees/assistants), the nursing team (scrub and circulating nurses) and the anaesthetic team (anaesthetist, trainees and ODP's).

8.6: Development of Training for Observers

8.6.1: Training of Observer 1

Alongside the changes and refinement of OTAS an observer was trained in the task list aspects and data was collected during 20 laparoscopic cholecystectomy operations. This observer was a surgeon at the same level of training as the author. The task list and its marking criteria were explained in great detail to the trainee along with examples and evidence from the first 50 cases. The conclusion from this training was that at this stage it is difficult for a non clinician or someone without practical experience of theatre and surgical procedures to be able to satisfactorily mark the task list. However we found that as few as 5 cases were adequate for a surgical observer to be able to reliably assess the tasks from the OTAS checklist.

8.6.2: Training of Observer 2

Regarding the formal training of Observer 2, we recommend that Observer 2 should have training in behavioural sciences or ergonomics. Ideally, Observer 2 should be at post-doctoral level of training or, at least, having completed postgraduate training in a behavioural science or ergonomics discipline. In general terms we feel that if the aim is to use the present version of OTAS to assess operating theatre teams, we recommend that Observer 2 be trained in human factors measurement or in psychological assessment. During the years of OTAS development, we have found that a non-clinician is better suited to be an "external observer" of events and interactions that take place in the operating theatre. In addition, we have found that it is easier for clinicians to understand and believe that they are not assessed individually if a non-clinician is involved in the observations. Moreover, from a practical point of view, a non-clinician is less likely to be distracted by requests for assistance coming from OT staff – such requests are harder to avoid in the case of a clinician observer.

We trained a psychologist in the behaviour ratings. The initial part of the training consisted of familiarisation of theatre and observation techniques. This observer was also involved in a project conducting observations in theatre on distractions. Having completed this project which exposed the observer to over 25 surgical procedures the training for the OTAS behavioural ratings were commenced. The scales were discussed and the exemplars and demonstrative scenarios were also utilised. The use of exemplars and demonstrative scenarios were encouraged prior to actual observations so the trainee would not use various sheets of information at the expense of missing actual observations. The initial 10 cases consisted of observations by both observers followed by post hoc comparison of scores and discussions on the scores after each case. Following this the two observers independently assessed a number of cases. Reliability studies were also carried out but not as part of the initial training process and have been discussed later in this chapter.

It is important for the trainee observer to assess a range of different operations within the same speciality to be exposed to the range of behaviours. However, too much variability may obscure the behavioural patterns. Hence the training should be restricted to one speciality at a time. If the aim is to use OTAS in a variety of surgical specialties (e.g., for cross-specialty comparisons), we recommend an initial exposure of Observer 2 to procedures in a single specialty, followed by exposure to procedures in the second specialty of interest and so on. Since we have found that, after the initial familiarisation with procedures in a single surgical specialty, it is easier for Observer 2 to familiarise with procedures in a different specialty, we recommend a minimum of 10 procedures as initial exposure to every specialty following the first one.

Furthermore to ensure that a person is ready to observe the behavioural scales and had a general understanding of theatre procedures a brief questionnaire has been designed. This is available in the appendix (Appendix H)

8.7: Reliability Studies

Preliminary reliability studies for the behavioural aspect of OTAS have been conducted. One of the observers has collected data on the initial 50 cases and has been part of the development of the OTAS prototype and further teams research. The 2nd observer was also a post doctoral psychologist involved in the teams research and had prior experience of collecting data in theatre to look at the effect of distractions in theatre. This observer was trained in the use of the behavioural scales.

8.7.1: Inter-Observer Reliability in the Rating of Behaviours

Preliminary reliability results were as follows:

Two psychologists with a background in behavioural research and with adequate exposure to the operating theatre environment (NS > 40 procedures; AH > 80 procedures at the time of the study) observed jointly six urology operations and provided a total of 45 ratings each per procedure (5 behaviours x 3 specialties x 3 operating phases). Table 8.5 presents Pearson r correlation coefficients between the behaviour ratings of the two observers. We obtained correlations (i.e., rs > 0.50) for all behaviours which were positive except Communication, for which the obtained correlation was positive but lower (r = 0.35). These findings indicate overall adequate agreement between the two observers in the assessment of the behaviours.

		Obs 2				
		Comm	Co ord	Co op	Lead	Mon
	Communication	**.35***	.29*	.43**	.39**	.42**
	Coordination	.72***	**.72*****	.82***	.75***	.81***
Obs 1	Cooperation	.57***	.49***	**.64*****	.52***	.55***
	Leadership	.59***	.53***	.69***	**.62*****	.58***
	Monitoring	.43**	.42**	.56***	.46**	**.53*****

Table 8.5: Inter-correlation matrix of the psychologist observers' behaviour ratings
Note: The significance levels for the tabulated correlations are as follows: $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$. All Ns = 51 (Observing 3 sub-teams in 3 stages in 6 procedures gives N = 54. However, one procedure was done with local anaesthesia; hence there was no anaesthetic team to observe in any of the three stages.)

8.8: Summary and Conclusions

The process of refining the tool affected both the task checklist and the behavioural assessment. The task checklist was shortened, as a result of a structured review by operating theatre experts. The behavioural scoring was sharpened by the allocation of separate behavioural ratings to the three sub-teams of professional that make up a full operating theatre team (surgeons, anaesthetists, and nurses). In addition, the behavioural scoring was facilitated by the development of demonstrative scenarios and exemplar behaviours for the psychologist observer.

Regarding the reliability of the assessment, the two psychologist observers were adequately consistent in their ratings of all five behaviours – although the correlation between their ratings was somewhat lower for communication than for the other four behaviours. Less clear anchors and exemplars in communication than in the other behaviours may have caused this greater discrepancy. The communication scale is currently being revisited. On the whole, however, these findings suggest that two non-surgeon observers can be trained to achieve a reasonable standard of agreement between them in assessing operating theatre teamwork. Though the reliability scores were not as high as we would have liked them to be (>.7) at the end of this phase of the research we felt we had a reasonably reliable rating scale which was ready for further testing in another setting. The possible reasons for the correlations scores being what they were may be that further training may be required or that the scales and the scoring system may need to be reassessed in future studies. However we have shown that people can learn how to use OTAS relatively quickly, which is essential if the measures are to be circulated for broader use. We then set out to conduct further testing in the urology theatres using the new tool OTAS II.

9: Chapter Nine: Testing the Refined OTAS II in the Urology Theatre:

9.1: Introduction:

Following the refinement of the OTAS tool and the training and reliability studies as described in the previous study we chose to test it in the urology theatres. Urology was chosen as it is a specialty that poses a number of challenges to operating theatre professionals' team-working skills. In addition to the usual interactions between surgeons, nurses, and anaesthetists, urological procedures often require input from radiologists, radiographers and other technicians. Thus, urology surgical teams tend to be fluid, encompassing different members and different input from them over time. This adds a layer of complexity to the task of coordinating the team, leading it effectively and efficiently in the different phases of the procedure, and communicating adequately with other team-members. Secondly the author has considerable experience in urology and it would be easy to understand the procedures that were carried out in these theatres. Thirdly but very importantly, urology as a speciality is particularly vulnerable to medical errors such as wrong side surgery on the kidney or testis. Both these scenarios carry devastating consequences. Urology ranks high in terms of wrong site surgery and every effort must be taken to prevent it in the future with the use of standard protocols (Rao *et al.* 2005). In recent publications urologists have recognised the need to learn from these mistakes. Coxon et al suggested training similar to that used in aviation would help to minimise errors in urology (Coxon *et al.* 2003). Training and standard protocols are just some of the ways on which safety can be improved in the urology operating theatre.

We used the refined OTAS II tool for this study. This assessment tool was designed to be a two person assessment tool. Observer 1, a clinician, would assess the team tasks. Observer 2, a human factors expert or a suitably trained psychologist, would assess the behavioural aspects of the team. The refined tool OTAS II was employed to observe 50 cases in urology theatres.

9.2: Aims

The aim of this study was to

- Assess the feasibility of the assessment instrument.
- Gain sub team measures on the behavioural scores
- Compare the differences between urology and general surgery.

9.3: Method

9.3.1: Design

An observational study of surgical team performance using the modified OTAS II tool. This included the revised task list and behavioural scales along with use of demonstrative scenarios, exemplars and specifically developed sub team measures of surgical performance.

9.3.2: Sample

Data was collected 50 urological surgery operations in two operating theatres, one in a teaching hospital and the other at a specially designed treatment centre. For the purpose of this study detailed analysis of the various different patient and operation type was not carried out.

Twenty (40%) operations were the first operation of the day and the remaining thirty (60%) operations were either the second or subsequent operation of the day. The typical mix of operations contained Cystoscopy, Ureteroscopy, Ureterorenoscopy, TURP and procedures such as Orchidectomy, vasectomy and circumcisions.

Since surgeons tend to operate in a fixed operating theatre every week they tend to work with the same pool of nurses. The anaesthetists are also allocated to the same theatre on a weekly basis and hence there was reasonable consistency of personnel in the sample. The duration of the operation used for the purposes of data collection from 30 minutes to 240 minutes.

9.3.3: Measures

OTAS II has two elements similar to the OTAS prototype: A task checklist, completed by a surgical observer, and an assessment of team and sub team behaviours, completed by a post doctoral psychologist. The surgical process, as in our previous study, was divided into the same number of phases and stages.

9.3.3.1: Task checklist

The refined task list as described in the previous chapter was used. The revised tasks for the urology project were placed into three categories: namely, patient, equipment and communications tasks. Patient tasks related to actions or information associated directly with the patient. Equipment tasks included items such as checking and counting of surgical instruments. Communication tasks included transfer of information such as confirming of consent, patient details and operative site. The criteria for items on the checklist were marked yes or no depending on the nature of the task. The criteria for scoring the tasks were as in the previous study but there were fewer tasks in this task list (152 vs 115)

9.3.3.2: Team behaviours

Team performance was also assessed on the same set of teamwork behaviours and comprised of shared-monitoring, communication, co-operation, co-ordination and leadership. Furthermore unlike our previous studies which only assessed the whole team in this study sub team assessments were carried out. The surgical sub team comprised of the surgeon and the surgical assistants. The nursing sub team consisted of the scrub nurses and the circulating nurses and the anaesthetic sub team consisted of the anaesthetists, their assistants and the ODPs. Behavioural summary scales on a 7 point Likert scale were used, with each scale-point relating to a certain level of quality and quantity of a given teamwork component. Scoring was further aided by the use of the specifically designed demonstrative scenarios and exemplar behaviours. Notes were also taken on effective and ineffective behavioural exemplars/markers during each case, which provided support for behavioural ratings given.

9.3.4: Procedure

A surgeon of registrar level (observer 1) and post-doctoral psychologist (observer 2) collected data on tasks and behaviours, respectively. Other measures taken during observation included operative stage times, team composition in theatre and a record of any critical incidents and the end of each phase of the operation.

9.3.5: Data Analysis

A mix of parametric and non-parametric tests was employed to analyse the data. We carried out ANOVAs to assess the differences of task completion and behaviour ratings across the operative stages. In addition, we calculated Spearman's Rho rank order correlation coefficients (r_S) for rates of task completion and behaviour rating across stages.

9.4: Results

The Results section is divided into three sub-sections; completion of teamwork-related tasks, behavioural dimensions of teamwork and correlations between the teams' scores on the behavioural dimensions and rates of task completion.

9.4.1: Task Completion

Table 9.1 summarises the findings from the task checklist. Table 9.1 also summarises data on the monitoring of the Patient's condition which was also recorded by Observer 1. The overall rate of task completion in the three categories (equipment, communication and patient) was high: 83% of the tasks were completed. However there were large variations between types of task and phases of the procedures.

A chi-square test revealed significant differences in rates of task completion across the different types of task. The observed rates of task completion were 93% for patient-related tasks, 92% for the monitoring of the patient's condition, 80% for task relating to the equipment and the provisions of the operating theatre, and 71% for communication-related tasks. Moreover, in the tasks relating to the equipment and the provisions of the operating theatre and in the communication tasks we observed variation in task completion across the three operating phases. Specifically, in tasks relating to equipment and provisions, we found that a significantly lower number of them was completed in the pre-op phase (61%) than in the intra-op (91%) or in the post-op phases (95%; χ^2 (2) = 204.20, $p < 0.001$). In communication tasks, there were higher completion rates in the pre-operative (71%) and post-operative phase (84%) and lower in the intra-operative phase (57%; χ^2 (2) = 81.61, $p < 0.001$). There were no differences in task completion across the three phases in the patient-related tasks (χ^2 (2) = 5.51, $p > 0.05$) or in the monitoring of the patient's condition (χ^2 (2) = 1.84, $p > 0.05$).

Table 9.1: *Rates of task completion across phases and task types in the categories of patient, equipment and provisions, communication and patient condition*

		Task Type									
		Patient		Equip and Provisions		Communication		Patient Condition		Totals	
		Task Completion									
		Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Phase	Pre Op	667	44	329	213	377	156	183	14	1556	427
	Intra Op	389	29	458	43	266	199	270	29	1383	300
	Post Op	554	51	269	14	386	72	94	6	1303	143
Totals		1610	124	1056	270	1029	427	547	49	4242	870

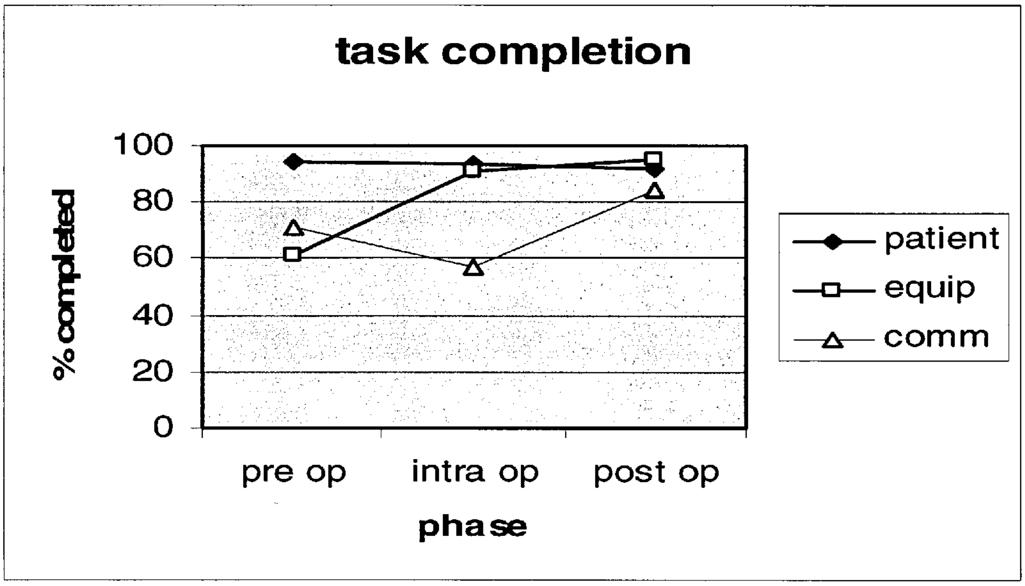

Figure 9.1: The mean percentage of task completed per phase in the three categories of Patient tasks, communication tasks and equipment and provisions. The graph bears a striking resemblance to the task completion rates in the general surgery data see figure 7.1 on page 130

9.4.2: Comparison between General Surgery and Urology for Task Completion:

Table 9.2 juxtaposes the checklist results that we obtained in the urology theatres to those we obtained in general surgery theatres. Although the rates of task completion that we observed were somewhat higher in urology, the overall pattern of task completion was strikingly similar. This was despite the fact that the refined check list was utilised in the urology study

Task	Pre-op		Op		Post-op	
	Surg	Urol	Surg	Urol	Surg	Urol
Equip	56%	61%	82%	91%	89%	95%
Comm	61%	71%	55%	57%	90%	84%
Patient	90%	94%	93%	93%	97%	92%
Overall	69%	77%	77%	80%	92%	90%

Table 9.2: This table outlines the comparison of the percentage of task completion in general surgery versus urology across the phases in the different task categories.

In summary, task completion was highest for patient tasks and lowest for communication tasks, with equipment/provisions tasks somewhere in between. In addition, the urology data showed a higher % rate of task completion than that found in general surgery. The pattern, however, of task completion across task types was very similar across the two specialties.

9.4.3: Behavioural Measures

The five teamwork-related behaviours assessed in the OTAS assessment are communication, coordination, leadership, monitoring, and cooperation. Each of these dimensions was scored on a seven-point scale (0 – 6), in which higher scores indicate higher observed performance of the behaviour.

In terms of overall behaviours the analysis showed that there are differences across the behaviours with lowest scores on communication and leadership. This was similar to the data in the general surgery where communication rated the lowest [4.53], followed by leadership [5.12], shared-monitoring [5.41], co-ordination [5.48] and co-operation [5.77] rated highest.

Further to the overall team behaviours analyses were carried out on the sub-teams through the different stages and phases. Table 9.3 summarises the scores of all sub-teams (i.e., anaesthetic, nursing, and surgical) across all phases of the observed procedures (i.e., pre-operative, intra-operative, and post-operative). We submitted these scores to a 3x3x5 mixed model ANOVA, with Sub-team (Anaesthetists vs. Nurses vs. Surgeons) as a between-subjects factor and Phase (Pre-op vs. Intra-op vs. Post-op) and Behaviour (Communication vs. Coordination vs. Leadership vs. Monitoring vs. Cooperation) as within-subjects factors. The analysis yielded a main effect of Phase ($F(2, 256) = 3.37$, $p < 0.05$) and a main effect of Behaviour ($F(4, 512) = 110.41$, $p < 0.001$).

In what follows, we report findings from the analyses separately for Anaesthetists, Nurses, and Surgeons with regards to the behaviours only.

In Anaesthetists, the analysis revealed an effect of Behaviour ($F(4, 160) = 32.35$, $p < 0.001$). Post-hoc pair-wise comparisons of the five behavioural dimensions within this group revealed, most notably, that Anaesthetists scored highest on Cooperation and lowest on Communication. (See Table 9.3 for a full description of the findings of the pair-wise comparisons in all sub-teams.)

In Nurses, the analysis revealed a very similar pattern. In this group too we obtained a significant effect of Behaviour ($F(4, 176) = 56.55$, $p < 0.001$). The Nurses' scores were highest on Cooperation, followed by Monitoring and Coordination. Finally, the Nurses scored lowest on Communication (as did the Anaesthetists) and on Leadership.

In the Surgical sub-team the analysis yielded a main effect of Behaviour ($F(4, 176) = 28.87$, $p < 0.001$), such that Communication scores were the lowest and Cooperation scores were consistently high. These findings replicate those in the Anaesthetic and Nursing groups.

		Anaesthetists									
		Communication		Coordination		Leadership		Monitoring		Cooperation	
		M	SD	M	SD	M	SD	M	SD	M	SD
	Pre Op	4.73^{a}	0.81	5.42^{b}	0.87	4.93^{a}	0.79	5.42^{b}	0.92	5.76^{c}	0.54
Phase	Intra Op	4.81^{a}	0.84	5.49^{b}	0.84	4.95^{a}	0.95	5.42^{b}	1.11	5.76^{c}	0.49
	Post Op	4.76^{a}	0.94	5.29^{b}	1.21	4.89^{a}	1.00	5.42^{b}	1.19	5.59^{c}	0.77
		Nurses									
		Communication		Coordination		Leadership		Monitoring		Cooperation	
		M	SD	M	SD	M	SD	M	SD	M	SD
	Pre Op	4.73^{a}	0.81	5.22^{b}	1.06	4.69^{a}	0.90	5.42^{b}	1.14	5.60^{c}	0.78
Phase	Intra Op	4.40^{a}	0.94	4.86^{b}	1.28	4.47^{a}	1.06	5.42^{b}	1.22	5.49^{c}	0.90
	Post Op	4.56^{a}	0.94	5.07^{b}	1.37	4.57^{a}	1.14	5.42^{b}	1.33	5.47^{c}	0.87
		Surgeons									
		Communication		Coordination		Leadership		Monitoring		Cooperation	
		M	SD	M	SD	M	SD	M	SD	M	SD
	Pre Op	4.89^{a}	0.94	5.42^{b}	1.01	5.18^{c}	0.81	5.42^{b}	0.92	5.53^{d}	0.89
Phase	Intra Op	4.87^{a}	0.92	5.58^{b}	0.78	5.16^{c}	0.71	5.42^{b}	0.69	5.71^{d}	0.63
	Post Op	4.58^{a}	0.92	5.22^{b}	1.22	4.61^{c}	1.05	5.42^{b}	1.33	5.36^{d}	1.03

Table 9.3: *Mean ratings of teamwork-related behaviours across phases and staff specialties.* Note: means not sharing the same superscript *within a row* differ at $p < 0.05$. For Anaesthetists and Nurses, the table summarises all the significant differences across behaviours and phases. For Surgeons, these findings are supplemented by those described on page XX.

In addition to these analyses it was important to know how well the team scored above the average scores. The individual scores were submitted to a one sample *t*-test against the score of 3. Scores lower than 3 represent behaviours that hindered team performance. A score of 3 represents a behaviour that did not hinder or enhance team performance. Finally, scores of 4 and above represent behaviours that enhanced team performance. The score of 3, therefore, functions as a conceptual and also behavioural cut-off criterion. Hence, scores that are significantly higher than 3 indicate behaviour of acceptable standard and, in contrast, scores that are significantly lower than 3 to indicate behaviour in need of improvement. In this set of data, all the one-sample *t*-tests performed were significantly higher than 3 (all *p*s < 0.001), thereby indicating that, regardless of the differences across teams, phases, and individual behaviours, the teams observed exhibited teamwork-related behaviours of acceptable level.

In summary, the behaviours were acceptable for all the specialities across the phases. The behavioural findings were reasonably consistent across teams, phases, and behaviours. All sub-groups exhibited their lowest scores in Communication and their highest in Cooperation. The overall scores for behaviours were the lowest for communication and these findings were similar to those found in the general surgery study. The analyses that we report above demonstrate the presence of variability in teamwork-related behaviours as assessed by the OTAS tool across phases of the operation and across professional teams.

9.4.4: Correlations between Behavioural Measures and Task Completion by Phase

Pre-operative phase: We found no significant correlations between task completion rates and behaviours.

Intra-operative phase: We did not find any correlations between task completion rates and overall behavioural ratings (i.e., ratings across the three sub-teams).

In the Post-operative phase, we did not find any correlation between the task completion and the behavioural scores (other than the overall Leadership score which correlated with the rates of task completion of communication tasks: $r = -0.32$, $p < 0.05$, $N = 43$)

In summary there were no significant correlations between the tasks completion rates and the overall behavioural scores across the phases other than leadership which had a correlation with the completion of communication tasks in the post operative phase.

9.5: Discussion:

We conducted the observational study of teamwork in urology with an aim to test the feasibility of this application in a new speciality. We further compared the results with those done in the general surgery theatre to assess the differences and identify training requirements in this group. We found that assessing the team work in urology was feasible and practical. Interestingly the results were quite similar in many ways to the study conducted in the general surgery theatres and highlighted key areas for targeted training. The refined OTAS II was easy to use and the reduction in tasks was a clear benefit for scoring. There are still some further refinements which may be required but in general it was easy for people other than the developers to use with help from the instruction manual. The behavioural scores for sub teams also enabled detailed analysis which can be used for targeted training.

The results showed that, overall, team-working was of adequate standards. The majority of the teamwork-related tasks were performed. Likewise, the behaviours were scored relatively high. More detailed examination of the findings, however, reveals some reasons for concern. A number of communication and equipment/provisions tasks were not routinely performed. Simply put, this means that at times, equipment was left unchecked or that there was minimal communication between surgeons and anaesthetists. These findings were complemented by the sub team behavioural ratings. Anaesthetists obtained their lowest scores on communication behaviours. Likewise, nurses scored low on both communication and leadership. Surgeons, as a group, demonstrated a more complex pattern in their behaviours. Although surgeons also obtained their lowest scores on communications (just as the other two sub-teams did), their scores also deteriorated as the procedures were approaching their end. This pattern affected all of the surgeons' behaviours; except coordination with other team-members.

In the task completions we found that there was a relatively high rate of task completion and that the urology data showed a higher % rate of completion than that found in the general surgery theatre. However in some instances even though it seems that overall tasks completion is high there may still be safety issues if certain tasks are not completed to a set standard e.g. anaesthetic machines or other high tech equipment. In addition despite the various studies showing the importance of communication, communications tasks scored the lowest across the phases with the sole exception of the equipment tasks in the pre op phase. Equipment failures have been documented in many safety reports and are often the cause of delays and problems in theatre. Yet in the pre op phase when ideally there is enough time to be checking the equipment while the patient is being anaesthetised this is not consistently done. Perhaps the introduction of clear guidelines and protocols similar to those mandating the checking of name bands and anaesthetic machine by the anaesthetists are required to avoid these problems. Another excellent method of addressing this problem would be to introduce a checklist similar to those used in aviation to ensure that all the equipment is in theatre and in working order before each case. A pre operative checklist has been piloted by Lingard et al to try and get operating theatre teams to have systematic communications (Lingard *et al.* 2005). A similar method has been piloted by our group in the simulated operating theatre and will be described briefly in the next chapter.

The low scores that were found in the communication tasks again mirror those of general surgery and it would be interesting to conduct a study in centres where pre operative briefing is being carried out to assess whether this form of intervention actually improves the communication scores. A new study underway pre and post briefing / check-listing in a urology department of a teaching hospital will explore this further.

9.6: Conclusions:

The team assessment tool is easy to use and with some modification can be easily applied to any surgical speciality. The similar low scores in communication tasks and behaviours highlight the need for specifically designed training programs to tackle these issues. These findings were also common to the previous study in general surgery. The next chapter will discuss aspects of training and interventions that may be applied to surgical teams to improve communication and enhance team work. There is definitely a place for studying the effect of team interventions such as briefing and check listing and perhaps these should be introduced early on in the medical and nursing curriculum. Only then can we influence and change attitudes and culture. A similar situation which existed in aviation required training for several years before any effects of this was seen. Similarly it may be a few years before the impact of this kind of training is seen however any steps to improve the quality of communication will be an added advantage towards improving patient safety and improving surgical outcome. Furthermore this team work assessment tool may be used in some cases simply as an audit tool for surgeons and theatre teams to study the impact of any team training interventions such as development of guidelines and check-listing procedures for equipment or indeed communication.

10. Chapter Ten: Team Training using Simulations

10.1: Introduction

As discussed in the introductory chapters high-risk organizations such as aviation, nuclear industries and the military have applied human factors research to develop safety training programs through simulation, ensuring each member of the team has the capacity to perform a defined role (Flin *et al.* 2002). These include training in technical and non-technical skills or team skills which was developed as Cockpit resource management and later Crew Resource Management in aviation (Helmreich *et al.* 1999). In medicine, little attention has so far been paid to the potential of such training despite the fact that communication failures have been uncovered at the root of accidents in various settings (Donchin *et al.* 2003).

It seems that the skills required for effective performance in complex high risk environments including health care go beyond the correct execution of technical tasks at the level of the individual clinician (Vincent *et al.* 2004). Increasingly with the changes in hospital practice and for efficient functioning, doctors must interact with patients and work effectively with several members of their own and other teams and other specialities. Other aspects of team communication include speaking up against an authority gradient, clarity in assuring a sequence of messages sent-messages received, and attentiveness to roles and relationships, monitoring and back up (Duffy *et al.* 2004).

In addition doctors also need to acquire other non-technical skills as part of their training (Baldwin *et al.* 1999). These include skills on teamwork, leadership, situation awareness, decision making, and co-ordination. Unfortunately for the most part of surgical careers, these skills are learned on an ad hoc basis or "on the job". There is no specific training given and there are currently no assessment methods to test that a doctor has all the necessary skills to become a successful practitioner in that respect.

Simulations have been used in the aviation industry for over twenty years as part of the Crew Resource Management (CRM) training (Salas *et al.* 2001). While surgery and aviation are different in many ways, lessons may be transferable between the disciplines. Both surgeons and pilots have to learn how to manage stressful and potentially life-threatening situations that are unpredictable and subject to change without warning. Anaesthesia and emergency medicine have also taken on forms of CRM as part of their training and have been able to demonstrate the benefits of simulations in the form of anaesthetic crisis resource management where technical skills and crisis management skills were assessed (Gaba *et al.* 1998;Morey *et al.* 2002). The results showed that there were significant improvements in quality of teamwork for the experimental group following training.

The interventional aspects and team training section of this thesis was developed simultaneously while the team measures were being developed for main theatres. Secondly the team assessment measures used in the earlier studies were primarily designed for routine processes and needed further development before they could be used in a crisis environment. Hence, following on from previous work in our unit which assessed surgeons non technical skills using crisis simulations (Moorthy *et al.* 2005), we piloted a method of training the entire theatre team in a simulated operating theatre. Standardized tasks along with crisis scenarios to train and assess entire operating theatre teams were employed.

10.2: Aims:

The aims of this study were:

1. To develop a multidisciplinary team training module for crisis management for entire surgical teams in a simulated operating theatre;
2. To evaluate the feasibility and value of such training;
3. To explore potential differences in:
    a. Non-technical skills across the different professions making up theatre teams;
    b. Trainee and trainers ratings of performance on technical and non-technical skills.

10.3: Methods:

10.3.1: Study Design:

An observational cross-sectional study using simulated operations in a specially designed operating theatre. Following development of the assessment tools for team training and two pilot crisis simulations, 20 half day team training simulations were conducted.

10.3.2: Participants

An entire surgical team consisting of a trainee surgeon, trainee anaesthetist, trainee ODP and scrub nurse were recruited. Two medical students were trained to play the part of surgical assistant and circulating nurse when real members of staff were unavailable for these roles, which were not individually assessed. The trainee surgeons were either senior house officers (SHO) or registrars (equivalent to residents of year 2 or above) who had prior experience of performing the procedure in the real operating theatre. The anaesthetic trainees were also senior house officers or registrars and the crisis was tailored appropriate to their level of expertise. The nurses varied from newly qualified nurses to senior scrub nurses. The ODPs also consisted of newly qualified staff or students' still undergoing training.

10.3.3: The Assessors

The assessors consisted of a consultant surgeon, consultant anaesthetist, senior theatre nurse, ODP trainer, project coordinator and two Psychologists. The trained medical students also provided feedback during the debriefing session of the trainers.

10.3.4: The Training Environment

A virtual operating theatre environment was used (Moorthy *et al.* 2004). This theatre is a fully equipped functional operating theatre separated from a control room by a one way glass and containing a standard operating table operating lights, suction apparatus, anaesthetic machine, and other equipment required for standard open or laparoscopic surgery together with a moderate fidelity anaesthetic simulator mannequin (SimMan, Laerdl, UK). The mannequin is connected to a compressor and controlled by a computer from the viewing room, with software which enables the controller to create various anaesthetic crises for training and feedback. A previously validated surgical scenario was used to simulate a surgical crisis (Moorthy *et al.*

2004). The model consists of a synthetic High Tie Sapheno-femoral vein bench model which has been modified to incorporate bleeding through a pre-sited 1 cm laceration in the femoral vein. The scrub nurse trolley was modified by removing instruments or swabs to ensure that counting procedures were correctly followed. Further challenges such as missing valves, unsterile sets, faulty retractors, blocked connectors or air in the intra venous drip giving set were created for the ODP and Nurses to ensure that machines and equipment were checked correctly.

Figure 10.1: Depicts a simulation in progress.

10.3.5: The Measures

A team of experts consisting of a consultant surgeon, consultant anaesthetist, ODP trainer, senior scrub nurse, nurse trainer, research fellow and two psychologists developed specially modified assessment tools for the assessment of team skills of the anaesthetists, ODPs and Nurses based on a template from a modified Line Operated Safety Audit (LOSA) Non Technical Skills for Pilots (NOTECHS) checklist. An assessment tool for the technical skills of nurses was also developed. These assessment tools were piloted in 2 cases to ensure that the model and the equipment worked appropriately. The pilot cases were also needed to ensure that the assessment was feasible and that the measures were appropriately constructed according to each speciality. Further refinement and modification was carried out with input form the participants of the pilot simulations. Once the team of trainers was satisfied with the scenario and the measures 20 simulations were carried out.

The non technical or team skills were evaluated by specifically modified versions of the NOTECHS checklist for each group (Helmreich *et al.* 1999). These were the human factors rating scale- modified for surgeons (HFRS-MS (used in previous simulations))(Moorthy *et al.* 2006), human factors rating scale- modified for nurses (HFRS-MN), human factors rating scale- modified for anaesthetists (HFRS-MA) and human factors rating scale- modified for ODPs (HFRS-MO)). The checklists were modified with discussion between the domain specific trainers and the human factors experts and were based on pilot simulation data. The HFRS and the technical skills assessment forms are available in the appendix (Appendix K).

Surgical technical skills were measured using a modified OSATS (objective structured assessment of technical skills) scoring sheet developed by Reznick et al in Toronto (Martin *et al.* 1997). This scale consists of a 5 point Likert scale on various aspects of generic skill assessment such as handling of tissues, handling of instruments, time etc. It was modified to exclude the team work component which was being assessed separately in this scenario. Technical skills for nurses were assessed using specially developed Imperial College assessment of technical skills for nurses forms (ICATS-N). This assessment was developed through expert advice based on current best practice and operating theatre guidelines. For the current study, we did not assess the technical skills of anaesthetists or ODPs but instead detailed notes on their technical performance were recorded to provide feedback at the end of the scenario. The technical skills assessment forms are available in Appendix I

For the team skills, behavioural components of the OTAS tool were used but only as a template to facilitate team feedback rather than a formal team assessment score.

10.3.6: The Scenario

The participants were briefed by the trainers prior to the scenario and instructed to perform the procedure as close to reality as possible. They were also briefed about which equipment could or could not be used (e.g., diathermy machine). The team was instructed to ask out loud if they had any questions or required drugs or equipment which was not present in theatre during the scenario. The assessors would respond appropriately to them via a loud speaker in the virtual theatre.

The scenario consisted of a day surgery unit patient for a routine high tie ligation of a Sapheno-femoral junction for varicose veins. The simulated patient had been marked and consented prior to entering the theatre and his notes and investigations were available. A full set of notes were prepared and included patients history of well controlled angina, a recent ECG report, blood investigations and a drug chart. The anaesthetic trainee and ODP commenced set up of anaesthesia while the scrub nurse set up the surgical trolley. During the anaesthesia phase, the anaesthetic team were presented with an anaesthetic crisis which was tailored according to the level of experience of the trainee. These included rapid sequence anaesthesia and difficult intubation. Once the patient had been stabilised, surgery commenced. The surgical crisis consisted of bleeding from the femoral vein. The team crises consisted of haemorrhage or cardiac changes leading to a cardiac arrest. Throughout the routine and the crisis phases the assessors rated the technical and non technical skills of their trainees. In addition, the two psychologists rated the team behaviours using OTAS

10.3.7: Evaluation and Feedback

Following the scenario, the participants were asked by to evaluate their own performance both in technical and non-technical skills using the relevant rating scales. Participants were then given individual technical and non technical feedback. Following the individual feedback, the participants all met in a room with the two psychologists. The psychologists facilitated discussions about how they did as a team, discussed their perceptions of team performance and the importance of teamwork. They then completed an evaluation questionnaire and were given a completion certificate and written materials about reflective learning practices and dimensions of teamwork.

10.3.8: Data Analyses

We used parametric tests to analyse the data. When we were comparing more than two groups of observations, we submitted the data to mixed-model Analyses of Variance (ANOVAs). When we were comparing two groups of observations, we analysed the data using independent sample *t*-tests when the observations were independent and paired sample *t*-tests when they were related. Finally, we assessed the internal consistency of our evaluation scale using reliability analysis, which results in a Cronbach alpha (α) statistic.

10.4: Results

We conducted 20 team training crisis simulations. The results section has been split into four sub-sections. Firstly, the results report the trainees' evaluations of the training. Secondly, the results report the trainee surgeons' and nurses' technical skills. Thirdly findings on all trainees' non-technical skills (i.e., their skills in communication, vigilance, teamwork, leadership, and decision-making) are reported. Finally the results report on the variation of skills between the different professions and the relationship between the trainer and trainee ratings.

10.4.1: Evaluation of the Training

The trainees evaluated the training using a 13-item scale. The scale achieved good internal consistency across all four professional groups as revealed by acceptable Cronbach alpha coefficients (between 0.84 and 0.94 across specialties). An evaluation score was computed for each professional group by averaging the items. These scores (range 1-6) can be seen in Table 10.1.

	Surgeon	Nurse	Anaesthetist	ODP
	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Training Evaluation	4.47 (0.72)	4.49 (1.04)	4.26 (0.83)	4.25 (0.75)

Table 10.1: *Mean training evaluation scores by trainees in all specialties*

Overall the scores were positive. These scores were the submitted to a one-way ANOVA with Specialty (Surgeon vs. Nurse vs. Anaesthetist vs. ODP) as a between-subjects factor. The analysis did not reveal any significant differences across the four professional groups ($F(3, 61) < 1$). Next, the evaluation scores were submitted to a one-sample t-test against the midpoint of the evaluation scale (i.e., 3.50). As above, the aim of this analysis was to reveal whether the trainees' evaluations were above the midpoint of the scale (i.e., positive) or below it (i.e. negative). All four t-tests yielded significant results (all $ps < 0.01$). All trainee groups' evaluations were significantly above the scale midpoint, thereby indicating that the trainees assessed the training favourably.

10.4.2: Technical Skills during Simulation

Data on technical skills were only available for surgeons and scrub nurses. Trainee surgeons and nurses assessed their own technical skills. These skills were also assessed by the trainers (via direct observation). The trainees' self-assessment of these skills and the assessment of the trainers' can be seen in Table 2. Overall the scores for nurses and surgeons were within the acceptable range.

Assessor	Surgeons	Nurse	Nurse	Nurse	Nurse
	OSATS	Gown & Glove	Instrument handling	Draping	Sterility
	M (SD)	M (SD)	M (SD)	M (SD)	M (SD)
Trainee	27.39 (6.10)	5.35 (1.01)	5.27 (1.00)	5.26 (1.06)	5.27 (0.93)
Trainer	26.33 (6.11)	4.50 (1.07)	4.81 (0.70)	4.19 (1.48)	4.57 (0.97)

Table 10.2: *Mean ratings of technical skills by trainees and trainers in the surgical and nursing specialties*

For the surgeons (column 1), surgical skills were assessed using modified OSATS scores. OSATS scores can range between a minimum of 8 and a maximum of 40. An independent samples *t*-test failed to reveal a significant difference between the trainees' and the trainers' assessments ($t(36) = 0.54$, $p > 0.05$). This finding indicates that the trainees' self-assessment of their skill matched that of the trainers.

Next, the technical skill scores for the nurses were analysed (columns 2-5). Trainee nurses were assessed on four different skills, namely gowning and gloving, handling of instruments, draping, and maintenance of sterility of their working space using the imperial college assessment of technical skills for nurses form (ICATS-N). These were scored on a 6 point Likert scale where 1 represented not done and 6 represented done very well. We submitted these scores to a 2x4 mixed-model ANOVA, with Assessor (Trainee vs. Trainer) as a between-subjects factor and Skill (Gowning/Gloving vs. Instrumentation vs. Draping vs. Sterility) as a within-subjects factor. The analysis yielded only a main effect of Assessor ($F(1, 36) = 7.43$, $p <$

0.05), such that, across all four skills, trainee nurses rated their technical skills significantly higher than their trainers.

In summary, the trainee surgeons scored within the acceptable range of scores and their self assessment matched that of the trainers. On the other hand, the trainee nurses appeared to overrate their technical skills – although, like the surgeons, they were within the acceptable range.

10.4.3: Non-Technical Skills during Simulation

Scores of the trainees on the different non-technical skill scales were analysed and differences between the skills were examined. The differences between the trainees' self-assessment of these skills and the assessment of their trainers (which was done via observation, as in the technical skills) were also analysed. Non-technical or team skills were measured using modified NOTECHS for surgeons, nurses, anaesthetists and ODPs (HFRS-MS, HFRS-MN, HFRS-MA and HFRS-MO). The skills assessed were leadership, decision making, vigilance, team working and communication. For each skill, the assessment was done on a number of 6-point Likert scales, on which 1 represented "not done" and 6 represented "done very well".

Speciality	Assessor	Non technical or Team Skills				
		Communication	Vigilance	Teamwork	Leadership	Dec Making
		Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)	Mean (SD)
Surgeons	Trainer	4.00 (0.97)	4.11 (1.17)	3.96 (1.15)	3.78 (1.01)	3.95 (1.10)
	Trainee	3.69 (1.03)	3.67 (1.15)	3.76 (0.91	3.73 (0.90)	3.74 (0.94)
Nurses	Trainer	4.83 (1.05)	4.93 (0.94)	4.76 (0.98)	4.51 (1.06)	4.47 (1.11)
	Trainee	4.29 (0.86)	4.47 (0.88)	4.18 (0.93)	3.84 (0.92)	3.99 (0.94)
Anaesthetist	Trainer	4.00 (0.62)	4.29 (0.79)	3.99 (0.65)	3.50 (0.91)	3.83 (0.89)
	Trainee	4.37 (0.76)	4.33 (0.67)	4.13 (0.63)	3.72 (0.62)	3.88 (0.75)
ODP	Trainer	4.21 (0.98)	4.27 (0.65)	4.21 (0.52)	3.84 (0.98)	3.92 (0.90)
	Trainee	4.95 (0.52)	4.88 (0.53)	4.53 (0.47)	4.17 (0.63)	3.95 (0.77)

Table 10.3: *Mean ratings of non-technical skills by trainees and trainers in all specialties*

Data on the sub-score results for the five dimensions of non-technical skills assessed are shown in table 10.3. These scores were submitted to a 2x4x5 mixed-model ANOVA, with Assessor (Trainee vs. Trainer) and Specialty (Surgeon vs. Nurse vs. Anaesthetist vs. ODP) as between-subjects factors and Skill (Communication vs. Vigilance vs. Teamwork vs. Leadership vs. Dec-making) as a within-subjects factor. Overall most of the team skills were scored above 4 – in other words, the trainees appeared to be within acceptable standards in these skills. Results showed that there was a main effect of Skill ($F(4, 568) = 24.04$, $p < 0.001$), such that leadership and decision-making were scored lower than the other three skills. In addition, the analysis yielded a main effect of Specialty ($F(3, 142) = 4.85$, $p < 0.01$), such that nurses scored overall higher than surgeons ($p < 0.01$) and anaesthetists ($p < 0.05$). These effects, however, were qualified by a significant Skill x Specialty interaction that the analysis also revealed ($F(12, 568) = 2.36$, $p < 0.01$). Further analysis of this interaction is described in the section that follows. In summary, overall the skills leadership and decision-making were scored lower than the other three skills

10.4.4: Variation in Non-Technical Skills between Professions

To evaluate the difference in skills per speciality the interaction was split into five one-way ANOVAs, one for each non-technical skill, with Specialty (Surgeon vs. Nurse vs. Anaesthetist vs. ODP) as a between-subjects factor. In what follows, findings from these additional analyses separately for each skill are reported. In Communication, the analysis revealed a significant effect of Specialty ($F(3, 148) = 5.64$, $p < 0.01$). Post-hoc tests further revealed that surgeons scored lower in communication than nurses ($p < 0.01$) and ODPs ($p < 0.01$). An identical pattern of findings in Teamwork were obtained ($F(3, 149) = 4.42$, $p < 0.01$), in which the surgeons again scored lower than nurses ($p < 0.01$) and ODPs ($p < 0.05$). In Vigilance, the findings were similar ($F(3, 149) = 6.34$, $p < 0.001$), with surgeons scoring lower than all the other specialties (all $ps < 0.05$). However, somewhat different results in Leadership were obtained ($F(3, 147) = 3.02$, $p < 0.05$), in which both surgeons ($p < 0.05$) and anaesthetists ($p < 0.01$) scored significantly lower than the nurses. Finally, in Decision-making skill the analysis failed to reveal any significant effect ($F(3, 148) = 1.57$, $p > 0.05$).

In summary the surgeons scored lower than nurses on communication. Surgeons scored lower than nurses and ODPs on teamwork skills. The surgeons scored lower than all other specialities on vigilance. Surgeons and anaesthetists scored lower than nurses on leadership.

10.4.5: Relationship between Trainer and Trainee Ratings

For the surgeons technical skills there were no significant difference between the trainees' and the trainers' assessments. For the nurses technical skills the analysis showed trainee nurses rated their technical skills significantly higher than their trainers.

In addition to the effects described above in the team skills section, the analysis for the non technical skills also yielded a significant Specialty x Assessor interaction ($F(3, 142) = 2.88$, $p < 0.05$). This interaction suggests that across the different subgroups of theatre professionals that we examined (i.e., surgeons, anaesthetists, nurses and ODPs), there were discrepancies between the trainees' ratings of their own skills and the ratings of the same skills by the trainers.

To evaluate the differences in the trainer versus trainee scores we split the interaction into four independent sample *t*-tests, one for each specialty, examining the differences in the assessment of non-technical skill between trainees and trainers. There were no significant differences between the trainees' and the trainers' assessments in the surgeons group ($t(37) = 0.88$, $p > 0.05$) or in the anaesthetists group ($t(36) = -0.79$, $p > 0.05$). There were, however, such differences in the other two groups. Trainee nurses significantly overrated their non-technical skills ($t(38) = 2.01$, $p = 0.052$), whereas, in contrast, trainee ODPs tended to underrate these skills ($t(31) = -1.96$, $p = 0.059$).

10.5: Discussion

This study aimed to develop a team training module in crisis management using simulations for the entire surgical team. It assessed the feasibility and value of such training and explored possible differences in: a) ratings of technical skills between trainees and trainers for surgeons and nurses; and b) team skills between the different professions. Overall, the results showed that the simulated operating theatre represents a useful training environment where participants can get immersed in the scenario. Team training using crisis simulations is feasible and participants across professions found the simulations helpful as evidenced by their evaluation. There were one of two participants, however, who found the simulations intimidating and unhelpful and their views will be taken into consideration when designing future studies.

Technical Skills

For the technical skills, the trainee surgeons' scores matched those of their trainers indicating similar perceptions of performance. This has important implications for training as some aspects of the training could be self assessed if these results can be replicated in other studies. Yet trainee nurses, seemed to overestimate their performance. There may be differences between professions, and between grades within professions on perceptions of performance on technical skills, which is a subject for further research. In this case, it is unclear whether the nurse trainers had higher standards or the findings reflect a lack of insight from the trainee nurses on their technical performance due to limited opportunities for training and guidance during their everyday work.

Non Technical Skills

For non technical skills, the scores across skills and professions were at moderate level with leadership and decision making getting lower scores, indicating potential for improvement with relevant training. The lower scores on leadership and decision making were surprising in the anaesthetic and surgical groups especially, since they have to lead during various parts of the procedure. The anaesthetists are the presumed leaders during the anaesthesia phase and if a cardiac event should occur. During the crucial parts of the operating, the surgeon would be assumed to be the leader. Similarly decision making skills must be high among these groups, but was lower than for other team members, reflecting perhaps the lack of formal training on such subjects in the current medical curriculum. Surgeons scored lower than nurses on communication and lower than nurses and ODPs on teamwork skills, despite communication being highlighted as one of the most important factors in patient care and safety. The lower scores obtained by surgeons on non technical skills replicate findings from another study on training surgical teams to use briefings in simulations and suggest that this may be a robust difference and an area to be targeted for further improvement. There were no difference between the trainee and trainers scores for anaesthetists and surgeons in terms of non technical skills.

Although the findings are preliminary, there were differences in teamwork skills across the professions which may signify specific needs for improvement. Findings about the variations in scores between sub-teams and across dimensions need to be interpreted with caution, given the small study size, the absence of cross-validation between observers and the developmental nature of the measures used. Assessment measures need to be validated and results need replication, to determine the value of this form of training. If further studies support it, simulation-based training for the whole team may be useful to address deficient areas in team performance. Further work will also include assessment of the impact of team training on actual performance in theatre especially during a crisis by direct observations and self report measures. Regular integrated and efficient training in such crises should enable the team to handle the situation in an automated manner and prevent errors.

Setting up of simulations for team training following this study's methods is a challenging task and requires resources and time along with the necessity of at least five experienced trainers to conduct online ratings, which can be difficult to organise and coordinate. Further refinements on this training model could be made. Different scenarios (procedures, problems) for crisis management with specific learning objectives for each team member need to be developed alongside with the technology to implement them. Systematic training for the trainers need to be developed further and standardised.

In terms of the process of assessment, future studies will evaluate the benefit of assessing video recordings of the simulations for team scores and assessing the relationship between online ratings and video ratings. Furthermore preliminary studies have been carried out following the development of the Team Training version of our measure, "The Observational Teamwork Assessment for Surgery- Team Training Version" (OTAS TT). An overview and pilot data will be reported in next chapter.

10.6: Conclusions

Multi-disciplinary simulation-based team training is feasible and well received by surgical teams. Although the findings are preliminary, the results showed moderate levels of performance in teamwork skills overall, and differences across the professions which may signify specific needs for improvement through systematic training. If further studies support it, simulation-based training for the whole team may be a realistic and useful way to address deficient areas in technical skills and aspects of team performance and could form part of comprehensive training on such skills for entire surgical teams. Further work should include assessment of the impact of team training on actual performance in theatre especially during a crisis by direct observations and self report measures. Regular integrated and efficient training in such crises should enable surgical teams to handle crises in an automated manner, and improve safety and quality of operations.

11. Chapter Eleven: Summary of Results, Conclusions & Future Direction

11.1: Introduction

This thesis aimed to develop methods of team assessment and training for the operating theatre. Through a systems approach a team assessment tool was developed for the measurement of team tasks and behaviours in the operating theatre. Ultimately it was hoped that this would provide a framework for developing team training and other interventions which could enhance the team working in the operating theatre and improve the quality and safety in surgery.

The introductory chapters drew on research to help understand the nature of teams in surgery. It also explored the team measurement and team performance models along with CRM and other interventions. The literature review and the preliminary interview study provided an understanding of the different components and quality of teamwork and created a framework on which our assessment tool was modelled. The interview study additionally revealed that currently there is no agreement on teamwork in the operating theatre or indeed what the ideal team should be. It however confirmed the findings from other studies that communication is an important aspect and one which may be taught in order to enhance teamwork in theatre.

The main aim of the thesis was to develop measures of team performance. Our model was specifically designed with the input-process-output model structure and used the principles of systems approaches to guide the development. The team assessment tool, developed through a combination of task analysis and behavioural constructs, was initially designed to capture the essentials of the surgical process during routine procedures. It was developed using a systems approach and was practical to use. We assessed its feasibility and reliability successfully. In this chapter I will outline the key results from the empirical studies, methodological issues and future studies that will emerge form this line of work.

11.2: Summary of Findings

11.2.1: Key Findings of Interview Study

Using semi-structured interviews OT professionals' perceptions of teamwork were assessed. The results showed that participants did not agree on the current structure of their teams and that most team members indicated a desire for change from the current structure. Team members overestimated their understanding of their team-mates' roles and the surgeons did so to a considerable degree. In ratings of communication, team members allocated similar ratings for both the quality and also the importance of the communication between the pairs of team members. The sole exception to this pattern was the communication between the surgeon and the anaesthetist. Team members judged the communication between this pair of highest importance yet it fell short in the actual current ratings of communication. This study provided valuable insight into how teams are currently perceived by the team members. It further helped in developing a frame work for team work assessment for surgery.

11.2.2: Key Findings of Observational Studies using the OTAS Prototype

Based on pilot observations and task analysis and the results of the interview study along with various sources we developed and assessed the feasibility of the observational assessment tool in general surgery. Fifty operations in general surgery in a single London teaching hospital were assessed. Task completion and rated teamwork behaviours were generally above average. Yet there was considerable variation in the tasks being completed and the behaviours across the phases. In addition there was a lot of inefficient use of time and delays and changes to the lists happened almost in over 70% of the cases.

Communication was rated lower than other behaviours, particularly in the pre-operative and post-operative phases. The fact that the results did not consistently find correlations between the task completions and the behaviours signifies that the two different aspects may be measuring different aspects of teamwork and neither element can be eliminated until further detailed studies have been carried out.

The results also suggest that since deviation from recommended practice often occurs and there is a lack of clear teamwork protocols, then interventions such as briefing and checklists in theatre and team training may improve teamwork. The key findings from that study were that observational assessment in operating theatres is feasible, purposeful and informative.

11.2.3: Key findings from Training of Observers and Reliability Studies:

The OTAS prototype tool was refined using a combination of interviews and expert judgement to come up with a shortened task list which was more relevant and easier to use. The behaviours were also modified to include exemplars and demonstrative scenarios to enable ease of trainability.

Following refinement of the assessment tool an attempt was made to develop a training program for other observers for the definitive study. It is recommended that for a psychological observer to be trained in the measures reliably they should observe a minimum of 25 cases before they can observe these behaviours. Hence the reliability studies were carried out between two psychologists one of whom had been part of the initial development and data collection and the second also who had prior exposure of theatre observations for a distraction study that was developed during the initial phase of this research. The results showed that the two psychologist observers were adequately consistent in their ratings of all five behaviours – although the correlation between their ratings was somewhat lower for communication than for the other four behaviours. On the whole the findings suggest that two non-surgeon observers can be trained to achieve a reasonable standard of agreement between them in assessing operating theatre teamwork.

Simultaneously a second observer was trained in the task list aspects with. I feel at this stage it will be difficult for a non clinician or someone without practical experience of theatre and surgical procedures to be able to satisfactorily mark the task list. With that in mind, and based on the training experience, I feel that as few as 5 cases are adequate for a surgical observer to be able to reliably assess the tasks from the OTAS checklist.

11.2.4: Key Findings of Observational Studies using the Refined OTAS II in Urology

Following the refinement of the OTAS 50 cases were observed in the urology theatre.

In the urology study the overall team-working was of adequate standards and majority of the teamwork-related tasks were performed. The pattern was similar to that observed in general surgery. For example in the urology data the same safety concerns over checking of equipment such as the anaesthetic equipment seemed to recur. The results once again showed a higher rate of task completion in the category of patient tasks. This was similar in pattern to the study conducted in general surgery theatre. It can be speculated that the patient tasks are higher due to set protocols and guidelines in this area. A lot of the tasks in that category for example checking of the patients name, consent and operative site are mandatory theatre protocol in most hospitals. It may be that more stringent guidelines about equipment checking are necessary to see improvement in this category.

The behaviours were scored relatively high. However Communication scores were low. Anaesthetists obtained their lowest scores on communication behaviours. Likewise, nurses scored low on both communication and leadership. Surgeons, as a group, demonstrated a more complex pattern in their behaviours. Although surgeons also obtained their lowest scores on communications and their scores deteriorated as the procedures were approaching their end. This pattern affected all of the surgeons' behavioural scores, except coordination.

The findings were somewhat unsettling. Although it might be claimed that little leadership or perhaps overt communication should be expected in routine procedures such as those that we observed, this argument is not convincing. Communication and leadership behaviours are certainly needed when a crisis arises, but in current practice an expectation seems to exist that these behaviours will somehow 'occur' when needed. These findings are exacerbated in the surgical sub-team. Surgeons received lower scores towards the end of the procedures simply because they often left immediately after suturing the patient. More senior surgeons sometimes left the operating theatre when a critical step in the procedure had been performed and their junior colleagues were left with the task of finishing off. As a result of this practice, the nurses were the sole group that was coordinating the flow of cases during the day and, to both the surgeon and the psychologist observer's eyes, operating theatres often appeared chaotic. It is not unreasonable to explain the nurses' comparatively low leadership scores as a result of their increased preoccupation with the state of the operating theatre.

11.2.5: Key Findings from Team Training Studies using Simulations

Simulations have been shown to be beneficial in the training of technical skills for laparoscopic surgery and for non technical skills training in aviation, anaesthesia and emergency medicine. A similar training program has been developed for human factors and team training in surgery. In the primary simulation study we developed a team training module and assessed the feasibility of team training using simulated crisis scenarios. These simulations were different from a lot of other simulations studies used in anaesthesia and emergency medicine in that the whole team was present and each person performed their own role as they would in real theatres. The results showed that the simulated operating theatre represents a useful training environment where participants can get immersed in the scenario.

For the technical skills, the trainee surgeons' scores matched those of their trainers but trainee nurses, seemed to overestimate their performance. For non technical skills, the scores across skills and professions were at moderate level with leadership and decision making getting lower scores. The lower scores on leadership and decision making were surprising in the anaesthetic and surgical groups especially, since they have to lead during various parts of the procedure. Similarly decision making skills must be high among these groups, but was lower than for other team members, reflecting perhaps the lack of formal training on such subjects in the current medical curriculum. Surgeons scored lower than nurses on communication and lower than nurses and ODPs on teamwork skills. The lower scores obtained by surgeons on non technical skills replicate findings from our other simulation study on training surgical teams to use briefings in simulations described later in the chapter. There was no difference between the trainee and trainers scores for anaesthetists and surgeons in terms of non technical skills.

Although the findings are preliminary, there were differences in teamwork skills across the professions. Assessment measures need to be validated and results need replication, to determine the value of this form of training. If further studies support it, simulation-based training for the whole team may be useful to address deficient areas in team performance.

11.3: Methodological and Ethical Issues

While most of the staff members in theatres were quite comfortable with observers being present in theatre, some (approximately 5-10%) put up a lot of resistance during data collection. There are several reasons for this. The study of teams in healthcare/surgery has only started recently and people naturally have a fear of the unknown and the ultimate outcome of such research. People fear surveillance or checking up on personal skills and the possibility of disciplinary action if errors occur. The most difficult issue was associated with the use of our 'operating theatre black box' which consists of video and audio equipment in theatre and the anaesthetic room. Some members of the anaesthetic team were entirely opposed to this to the point that we had to abandon the research in one particular theatre altogether. This may be due to the fact that they felt that video recordings would make people nervous and may promote litigation. However, if staff can be reassured and if they overcome their anxiety, this would be an excellent and non intrusive way of collecting team data and as Xiao et al and Guerlain et al pointed out may even provide added information which may have been lost at the time due to the observers being pre occupied with the actual scoring process (Guerlain *et al.* 2002;Xiao *et al.* 1996). There would however be the issue of encrypting and anonymously storing the data. The other point to consider would be that during the research phase should an error or patient death occur how these data then would be dealt with in terms of litigation and requirements as evidence. In this current climate where openness and honesty are being advocated and encouraged we feel that such recordings may actually speed up the legal process and may even work to the benefit of the medical personnel involved especially if everything has been done correctly. In the longer term such research and training should help improve attitudes and safety and ultimately reduce the incidence of errors.

11.4: Training of Observers

With regards to observer 1, it will be fairly easy to train someone who has experience in surgery. However if researchers who are no clinicians wish to be trained for the checklist observations then they will not only have to learn the scoring system but will have to gain in depth knowledge of surgical procedures especially to understand the stages and phases of each procedure. It will be possible however to train any member of the theatre team for example a nurse or anaesthetic assistant or indeed a medical student to perform this aspect of the assessment. The training of observer 2 it is a bit more complicated. They need be able to understand the psychological measures and also understand it in a surgical context. Furthermore the observer will have to be exposed to a number of operations for familiarisation of the surgical process. This initial training process is time consuming and requires multiple observers in theatres at a time. A solution to this problem may be an intensive training session using videos of real operations and familiarisation of the tool outside the theatre environment.

11.4.1: Important Issues to Consider during Training:

Additionally during our training period there were a number of questions which were raised by the observers that were being trained to use the scales. These will be important issues to consider for anyone that plans to use these measures in the future.

Measurement Issues:

While training the observer 2 some interesting questions were raised such as:

1. "How would behaviour x be considered in the rating scales?" (for example some behaviours such as shouting, repeating instructions and unresponsive silence)?
2. "How do I measure overall teamwork if the team hands over to different people and their performance is completely different?" (this may happen in cases where the member of the team goes on a break and the replacement displays different behaviours even though it may be the same phase and stage of the operation)?
3. "How do I rate the team if I see someone from one team doing the work that another team should do?"
4. "How do I differentiate "Within team communication" from "Between team communications"?

Clear instructions during the training phase and post hoc discussions after every training observation should resolve most of the issues. Regarding the difficulty in differentiating "Within team communication" from "Between team communications", and team members doing the work of other members the sub team analysis has solved that problem as the scores per group would reflect this discrepancy. For example, if an anaesthetist communicates with the surgeons and the ODP communicates with the nurses, as a team they are communicating with the other teams so between-team communication is satisfied. However, if then they do not communicate with each other, this caused problems for scoring. This problem has been addressed by keeping detailed notes in addition to simply the scores so that these issues can be highlighted and taken into account and scores justified. Furthermore the refined OTAS II addresses this by assessing sub teams so there is a score for each professional group. It makes it easier to then see which sub group needs targeted training unlike having team scores averaged across the whole team. The addition of sub team observation and analysis was a step forward in team research.

11.5: Challenges with Team Training Interventions

Setting up of simulations for team training is a challenging task and requires resources and time along with the necessity of at least 5 trainers for online rating along with one person to coordinate the activities. The large numbers required makes it difficult to organise and coordinate. Trainees may feel under pressure and may actually perform differently in the simulated environments. It will be important to develop training interventions such as simulations as part on an on going training program and one which incorporate assessment of the same skills in real performances.

In our primary study since we did not have ready measures, and we felt that the OTAS tool was not sufficiently ready for a training intervention, we developed measures based on previous research in our department looking at non technical skills for surgeons. This was developed for all the theatre professions and was adapted from the assessment of non technical skills for pilots. The overall team measures used was the behavioural aspect of an initial version of OTAS behaviours and consisted of the same 5 behaviour scales as in OTAS (Appendix L). The scoring was only used for providing team feedback and facilitating discussion and not to formally score the teams as such. Following the full development and testing of OTAS we conducted a study in which a medical student was trained by the author to use the task list measures and assess the observer 1 aspect of the team measures. This specially designed version of OTAS (OTAS TT) was developed in with the current scenarios in mind. Further studies are now needed using the OTAS TT scales along with the behavioural components along with the demonstrative scenarios and exemplars which may need modification for the crisis simulations. This study has been briefly discussed in the next section.

The other important issue to consider is that if this is to be a truly team training exercise do we really need so many raters who are currently present during the simulations? If the team assessment methods prove reliable and valid it may eliminate the need for a large group of trainers giving up their time for online ratings. There could simply be two raters similar to the real theatre environment assessing teamwork. However this may mean that the trainees will not have technical feedback which was found to be valuable during our initial study. One way to combat this problem is for the technical assessments to be carried out by post hoc video rating by both the trainers and trainees and they would get valuable insight into their performance.

To ensure the success of any training intervention or training program an essential aspect is training the trainers. Training is needed on how to assess different aspects of performance. Training will also be required in communication skills, specifically relating to education of colleagues and how to impart advice and provide performance feedback.

11.6: Future Direction for Research and Team Assessment

11.6.1: Future Direction for Observational teamwork Assessment

While this research provided some exciting results it also uncovered a number of studies which can still be done using the same observational method. I have outlined a few of the important ones and how they might be done.

11.6.1.1: Comparison of Live versus Video Recorded Observations

One important study is the assessment of team work using the operating room black box which has been installed at our hospital. This specially designed system consists of cameras and voice recorders with several data feeds. The cameras and microphones are capable of capturing all the activity in theatre and the anaesthetic room as well as the actual operation through a camera in the operating light. This system will enable team scores to be generated without having the observers in theatre. Further evaluation will be necessary to establish which method provides more comprehensive results. One advantage will be the observers will not miss any data since they can always view sections which have been missed out. In addition further reliability and validity studies can be carried out by comparing the video ratings with live observations. These should ideally be done by the same observers so as to avoid inter rater differences and just assess the reliability of the measures.

11.6.1.2: Use of OTAS in Non Routine Surgery (such as emergency aneurysm repairs or trauma surgery)

Most of the observations using OTAS have been during routine surgery. There are yet several instances when non routine situations or crises arise. We have still to explore the use of OTAS in non-routine or crisis scenarios. We feel that in its current form it may not capture the differences between routine and non routine behaviours and further development in that aspect will be necessary. This has been to some extent been explored in a preliminary way in the simulated crisis study using OTAS TT but needs further work.

11.6.1.3: Validity Studies using OTAS

The next stage of OTAS development involves testing of validity and further reliability studies. While observational assessment does have limitations, such as perhaps unavoidable subjective elements, it does provide the most effective method to assess performance in real-time. Validity studies would include linking OTAS measures to other process measures such as operative duration or post operative self report measures.

11.6.1.4: Assessing links to surgical outcome

In the studies outlined in this thesis it was not possible to make any direct inferences to surgical outcome due to the number of variables described by the operation profile by Vincent et al (Vincent *et al.* 2004). However a separate study has been conducted which was called the integrated study which included most of the other aspects of the operation profile such as technical skills, distractions, review of medical records and patients post operative course. It was also hoped that enhancing the input and process factors in our model, perhaps by improving team structure, attitudes and behaviour may help improve patient outcome, and OTAS (observational teamwork assessment for surgery) provides the framework for measurement. This line of research has not yet reached the level of refinement needed to confidently associate outcome with team scores. However we hope that in the future, teamwork may predict certain aspects of surgical outcome.

11.6.2: Development of OTAS TT (Team Training Version)

The primary simulation study was commenced prior to the completion of the development and testing of OTAS in the general surgery theatre. Hence for the preliminary study we chose to work from a framework which had been developed previously for assessment of non technical skills in surgeons using crisis simulations. The author had been involved in the previous study and felt that it was natural progression to conduct team studies on an existing framework with further development of rating scales for the other three specialities. The ultimate aim was to link the OTAS tool with the simulation studies the preliminary step of which was the development of the OTAS TT (Team Training version) and the studies done to test it using video recordings of the simulations from the primary study. The aim was to test the feasibility of the OTAS TT measures and assess rates for routine and crisis task completion.

This study was conducted by a medical student following development of the measures by the author. The author also trained the medical student in the use of the measures. OTAS was modified to include assessment of crisis scenarios which allow teams to train and be assessed in the simulated operating theatre. OTAS TT assesses team performance by using a checklist for routine and crisis tasks and behavioural rating scale to assess team behaviours; however the focus of this study was to develop the task checklist for team training. OTAS TT as applied in the current set of simulations only assesses the PRE2 stage to the OP2 stage. This is due to the simulations starting from the patient already being in the theatre and ready to be anaesthetised and the scenario ends after the main crisis but not necessarily at the end of the operation. The behavioural scales to assess crisis simulations will need further modifications and will need to be tested in future studies.

The preliminary findings showed that OTAS TT was a feasible method of assessing teams in training in the simulated operating theatre. Task completion was high (69%) but was variable between phases and types of tasks performed. Routine task completion was higher at 74% than that of crisis task completion at 64%. Similar to the observations in general surgery and urology the results showed that there was frequent failure to check surgical and anaesthetic equipment. Lack of verbal communication and lack of briefing were also prominent in these results. Routine task completion rates were similar to that found in our other observational studies. This signifies that there is a similar level of team work and that the simulated environment reflects routine team work.

The results also showed that teams scoring higher on non-technical skills ratings were more likely to complete tasks related to routine equipment and provisions. This result suggests that there is, albeit minimal, some relation between broad based assessment of team behaviours and task completion.

The reason that the relationship between assessment of team behaviours and task completion was so minimal might have something to do with the current content of the OTAS TT task checklist. At present the OTAS TT task checklist scores whether the tasks are 'not done' or 'done' with no evaluation of the quality of the tasks being performed. Perhaps in the future assessments there should be a scale of how well the task is done rather than a simple yes or no. Further studies also need to be carried out to assess the current behavioural scores using the same video recordings of the simulations.

11.7: Team Training: Future developments for training and evaluation

11.7.1: Cross role team training

From the interview study one of the important points which emerged was the lack of understanding of other team members' roles. Other industries where teamwork is important for smooth performance and safety (e.g. aviation) have described the effects of cross role training in the enhancement of role understanding (Salas *et al.* 2001). In surgery it may be possible that if cross role training were appropriately modified, its incorporation within surgical team training could enhance role understanding across the different specialties. For example during simulated training if surgeons had to play the role of the scrub nurse it may give them insight into what the role actually entails and enhance team working. Further the interview study suggested that the design of teamwork training programmes should start with an assessment of how the team members conceptualise their team and what they think of their teamwork. It would be an added advantage if prior to training we could assess participants understanding and approach to teamwork. Consequently training could also be focused in how to incorporate new team-members without breaking an effective routine. Team training could provide guidance on how to establish the minimum requirements for efficient and conflict-free teamwork by standardisation of procedures.

Hence future studies should commence with assessment of the teams perceives their teamwork. Further training should also assess the impact of cross training in enhancing team work.

Further work is required regarding development and preparation of a range of standardized training scenarios for OT team training simulations. In terms of content of training, experienced health care professionals from all OT disciplines should contribute to the development of relevant scenarios that can provide learning opportunities for all members of the team for both technical and teamwork skills. Educational principles specific to multidisciplinary team training (Salas and Cannon-Bowers 1999) and the use of simulations in clinical settings (Kneebone 2005) should be used in the design and delivery of such programmes. Scenarios should be tailored to the experience and level of training for participants aimed for, so trainees can derive maximum benefit.

Further work will also evaluate the value of teams assessing themselves. This will make the simulations a much more practical tool for training in team work skills. More scenarios will be developed including complex cases and operations from different specialities such as Urology. Further simulation work will also include assessment of the impact of team training on actual performance in theatre especially during a crisis by direct observations and self report measures. We hope that regular integrated and efficient training in such crises should enable the team to handle the situation in an automated manner and prevent errors in real life.

11.7.2: Development of Briefing and Check Listing in Surgery

Several studies highlighted the importance of communication in improving safety in surgery. Team communication is important in reducing errors in complex workplace environments, but has not been studied in any depth in operating theatres. The observational studies and the simulations studies also confirmed the findings that communication could be improved in surgery. One of the ways that this has been achieved in other industries is by the use of specific protocols and communication tasks such as briefing and checklists. Future work from this thesis also hopes to assess the benefit of briefing and check lists in the operating theatre. As a first step to that a line of work has been developed, which focuses on formalising and improving team communication in theatre. We developed and piloted a briefing survey to assess the extent of briefing and the content of briefing in surgery at present.

11.7.2.1: Development of a briefing questionnaire

Following a literature review a Psychologist, a Commercial Airline Pilot and the author developed a briefing questionnaire. This was further modified based on previous experience, observational studies, team interviews and expert consultation. The long version of this questionnaire is available in the appendix (Appendix N). Using this questionnaire, we conducted a detailed survey of surgical staff (N = 182) from 3 UK hospitals to explore their views on the application of team briefings in the operating theatre. Overall, theatre staff were positive about the potential of briefings to improve communication and team performance in surgery. The full results of this study will not be included in this thesis but is the process of being written up for a peer reviewed publication.

11.7.2.2: Briefing and check-listing in the simulated operating theatre

Alongside the development of the briefing survey and the simulation studies further simulations were developed. The author was part of the development process and helped conduct some of those simulations. The full methods and results of the briefing and checklist simulations do not form a part of this thesis but will be described very briefly.

Ten theatre teams participated in a half day training programme which included a pre- training simulation, an interactive workshop on using briefing and checklists and a post-training simulation, followed by feedback on technical and non-technical skills and teamwork. Each team as in the previous simulation study, consisted of a trainee surgeon, anaesthetist, operating department practitioner (ODP) and scrub nurse. The environment and the measures were exactly the same as those used and described in the previous study. Further surgical crises had been developed for this study and consisted of laparoscopic surgery as well as open procedures. Individual technical and non-technical (communication, vigilance, team skills, leadership, & decision-making) skills were assessed on line by domain experts and a psychologist using relevant rating scales as described in the previous study. Participants' attitudes to briefing before and after training and their evaluation of the training were assessed via self-report questionnaires using a short version of the previously developed briefing questionnaire.

Results showed that staff attitudes to training were positive. Improvements were observed post-training as to the value of briefings in improving quality of care, enhancing communication and teamwork. Participants' evaluations of the training were positive with no differences observed across professions.
These preliminary findings indicate that training in systematic communication is feasible and well received by OT teams and that there is potential for improvement on non-technical skills for all professions.

The OTAS data suggested that equipment were not checked consistently. Perhaps the introduction of clear guidelines and protocols similar to those mandating the checking of name bands and anaesthetic machine by the anaesthetists are required to avoid these problems. An excellent method of addressing this problem would be to introduce a checklist similar to those used in aviation to ensure that all the equipment is in theatre and in working order before each case. A pre operative checklist has already been piloted by Lingard et al to try and get operating theatre teams to have systematic communications (Lingard *et al.* 2005).

We still need to assess if it would positively influence performance and surgical outcome. Further we need to assess whether we would face resistance to the introduction of such interventions and whether it would be perceived to be beneficial.

It may be some while till the culture shift occurs in surgery and these interventions would be seen as routine part of day to day team work and training.

The eventual aim of these pilot studies is to develop and conduct a study to evaluate the impact of training and the use of briefings and checklists in routine clinical practice on team performance (especially on communication ratings of OTAS) and surgical outcomes in the operating theatre. We will use a within subjects design, with pre and post training in the use of briefings evaluation of surgical teams within a specific specialty. Outcome measures will include the OTAS, staff's attitudes to briefings and self-reported perceptions of teamwork. A pilot study has been designed and will be conducted shortly in the urology theatre of a teaching hospital.

The various pilot studies on team interventions have added to our insight into how improvements can be made to team work and communication both in the real operating theatre and in simulated environments. These interventions will have to be tested in practice to evaluate their impact in surgery. Further the team observational tool could be used to assess the benefit of such interventions. If the benefits of such studies can be demonstrated and translated to real practice, it makes a case for curriculum change in surgery so that these aspects are included routinely.

11.8: Conclusion

This thesis has reviewed all the team literature and presented them in a context that is relevant to surgery. It summarised the relevant literature from the theory of teams and also from the training aspects such as CRM and other training interventions which may be applied to surgery. Following this and based on a theoretical rationale the team assessment tool was developed which was one of the main aims for this research. This body of research added to the surgical and the team literature by providing a model for assessing surgical teamwork that was grounded in theory but had a practical approach based on the systems principle. The input-process-outcome model seems to be an effective model for studying teamwork in surgery and this thesis has confirmed this application. There are still questions to be answered regarding the best form of assessment for teams and while the behaviours chosen for the purpose of this research seemed to be adequate it still remains to be seen whether assessment of other methods such as non technical skills for each member of the team may give a more accurate assessment of team work.

The next aim for this observational team work assessment tool for surgery (OTAS) was to test this tool and refine it. Further testing was also carried out in the two observational studies in different branches of surgery. This was assessed in the prototype form for general surgery and its refined form for urology. Further we developed and tested several team training interventions in the form of simulation studies, surveys and other interventions such as briefing in theatre. This thesis provides an initial platform for the development of team training interventions in surgery including briefing and simulations. The difficulties and low scores in the reliability ratings raise questions which all need to be addressed in future studies.

We have found the OTAS tool to be extremely helpful in assessing surgical teams although still for research in its current form. In the future I hope that it will have a place both in research on surgical teams and in real theatre for identifying training needs so specific team based training can be tailored according to the needs. By gaining valuable information about successful, smooth running and efficient teams we hope that further interventions can be developed to enhance poorly functioning teams in theatre. Different groups may wish to use the OTAS instrument either after modification or to help develop their own assessment tools. The team training interventions such as briefing can be easily applied to routine surgery to enhance communication and team working in theatre. Above all I hope that this thesis provides a first step towards developing successful team training programs based on a systems theory to improve safety and efficiency in surgery.

Overview of literature review

Extensive searches were carried out through Medline (1966-2006), Psychinfo (1966-2006) and ISI web of science (1970-2006) using the search terms outlined below. Further sources such as conference proceedings (healthcare, psychology and human factor related), bibliography from relevant articles and book chapters were used.

In any field: Teams or teamwork

The searches yielded a vast number of references most of which were not relevant to our field of research. The searches were further refined and modified to include the following search terms.

In all fields: Developing + measures + team + performance, Group + dynamics, Teams + theory, Teams + high risk + environment, Teams + aviation, Teams + healthcare, Teams + surgery, Teams + validation, CRM, Simulations, Safety + surgery, surgical + outcomes, adverse events + surgery, errors + surgery, communication + operating + theatre, communication + surgery, communication + medicine, surgical + competence, surgery + attitudes + safety, attitudes + safety, anaesthesia + simulations, simulations + surgery

In title: Teamwork, Team + performance, Group + dynamics, Team + dynamics, Team + Assessment, Team + measurement, Team + inventory, Teams + theory, Teams + healthcare, Teams + surgery, Observational + assessment, Shared + mental + models, CRM or crew resource management,

In title: Teamwork or communication, + surgery or clinical or anaesthesia or emergency medicine, Non-technical + skills + high risk, Non-technical + skills + medicine, non-technical + skills + surgery, Human + factors + surgery, observational studies + surgery, or observations and healthcare, teams and observations,

In title: Safety + surgery, surgical + outcomes, adverse events + surgery, errors + surgery, communication + operating + theatre, communication + surgery, communication + medicine, surgical + competence, surgery + attitudes + safety, attitudes + safety, anaesthesia + simulations, simulations + surgery

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List of figures and tables

Figures by chapter

Chapter two: Understanding Surgical Outcome

Tables by chapter

Appendix A

Standards and recommendations for general surgical procedures

Functioning as a Team. The 2002 Report of the National Confidential Enquiry into Peri-operative Deaths (CEPOD) http://www.ncepod.org.uk

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Appendix B

Patient tasks

Recommended Standard Practice for Surgical Site Verification (AORN)
Pre-op (RN) • Verify that the patient's informed consent describes the operative site and laterality as appropriate. • Verbally confirm the surgical site and laterality with the patient and/or family members/significant others. • Review the medical record for consistency in identifying the correct surgical site. • Have patient (or other as designated in facility policy) mark the surgical site with an indelible marking pen over, or as close as possible to, the surgical incision site. **OP-room (RN)** • Confirm patient identity, consent, operative procedure, and laterality before transfer to the operative bed. (RN circulator.) • Review the medical record for consistency in identifying the correct surgical site. • Review imaging studies and confirm surgical site. • Require surgical team timeout immediately before the incision or start of the procedure for final confirmation of the surgical site.

Patient Monitoring

RECOMMENDATIONS FOR STANDARDS OF MONITORING DURING ANAESTHESIA AND RECOVERY

SECTION I: SUMMARY

The Association of Anaesthetists of Great Britain and Ireland regards it as essential that certain core standards of monitoring must be used whenever a patient is anaesthetised. These standards should be uniform irrespective of duration or location of anaesthesia.

1. The anaesthetist must be present throughout the conduct of an anaesthetic.
2. Monitoring devices must be attached before induction of anaesthesia and their use continued until the patient has recovered from the effects of anaesthesia.
3. The same standards of monitoring apply when the anaesthetist is responsible for a local anaesthetic or sedative technique for an operative procedure.
4. All information provided by monitoring devices should be recorded in the patient's notes. Trend display and printing devices are recommended as they allow the anaesthetist to concentrate on managing the patient in emergency situations.
5. The anaesthetist must check all equipment before use. All alarm limits must be set appropriately. Infusion devices and their alarm settings must be checked before use. Audible alarms must be enabled when anaesthesia commences.
6. The recommendations state the monitoring devices which are essential and those which must be immediately available during anaesthesia. If a monitoring device deemed essential is not available and anaesthesia continues without it, the anaesthetist must clearly state in the notes the reasons for proceeding without the device.
7. Additional monitoring may be necessary as adjudged by the anaesthetist.
8. Only a brief interruption of monitoring is acceptable if the recovery area is immediately adjacent to the operating theatre. Otherwise monitoring should be continued during transfer to the same degree as any other intra or inter hospital transfer.

AORN's Recommended practices for environmental cleaning in the Surgical practice setting. www.aorn.org/proposed/clean.htm

The following draft is being published for review and comment by AORN members and others in the health care arena. The AORN Recommended Practices Committee (RPC) is interested in receiving comments on this proposal from members and others.

These recommended practices are intended as achievable recommendations representing what is believed to be an optimal level of practice. Policies and procedures will reflect variations in practice settings and/or clinical situations that determine the degree to which the recommended practices can be implemented. AORN recognizes the numerous types of settings in which perioperative nurses practice.

These recommended practices are intended as guidelines to be adopted in various practice settings. These practice settings include traditional operating rooms (Ors), ambulatory surgery units, physicians' offices, cardiac catheterization suites, endoscopy suites, radiology departments, and all other areas where surgery may be performed.

Purpose

These recommended practices provide guidelines for environmental cleaning in the surgical practice setting. Conscientious application of these recommended practices should result in a clean environment for surgical patients. These recommended practices should be carried out in a manner that minimizes health care workers' and patients' exposures to potentially infectious microorganisms. All patients are potentially infected with bloodborne pathogens. All surgical procedures, therefore, must be considered potentially infectious and the same environmental cleaning protocols be implemented for all procedures.

RECOMMENDED PRACTICE I

Patients should be provided a safe, clean environment.

RECOMMENDED PRACTICE II

During surgical procedures, contamination should be confined and contained within the immediate vicinity of the surgical field to the degree possible.

RECOMMENDED PRACTICE III

After each surgical procedure, a safe, clean environment should be reestablished. Disposable items should be disposed of according to local, state, and federal regulations and in accordance with the AORN recommended practices for environmental responsibility in the practice setting.13 Reusable items should be processed according to the policies and procedures in the surgical practice setting.

RECOMMENDED PRACTICE IV

Surgical procedure rooms and scrub/utility areas should be terminally cleaned daily.

RECOMMENDED PRACTICE V

All areas and equipment in the surgical practice setting should be cleaned according to an established schedule.

RECOMMENDED PRACTICE VI

Policies and procedures for environmental cleaning should be written, reviewed annually, and be readily available within surgical practice settings.

Environmental controls in operating theatres

S. Dharan and D. Pittet

Infection Control Programme, Department of Internal Medicine, University of Geneva Hospitals, 1211 Geneva 14, Switzerland

Summary: Surgical-site infection is the leading complication of surgery. Normal skin flora of patients or healthcare workers causes more than half all infections following clean surgery, but the importance of airborne bacteria in this setting remains controversial. Modem operating theatres have conventional plenum ventilation with filtered air where particles _5 mm are removed. For orthopaedic and other implant surgery, laminar-flow systems are used with high-efficiency particulate air (HEPA) filters where particles _0.3 mm are removed. The use of ultra-clean air has been shown to reduce infection rates significantly in orthopaedic implant surgery. Few countries have set bacterial threshold limits for conventionally ventilated operating rooms, although most recommend 20 air changes per hour to obtain 50±150 colony forming units/m3 of air. There are no standardized methods for bacterial air sampling or its frequency. With the use of HEPA filters in operating theatre ventilation, there is a tendency to apply clean room technology standards used in industry for hospitals. These are based on measuring the presence of particles of varying sizes and numbers, and are better suited than bacterial sampling. Environmental bacterial sampling in operating theatres should be limited to investigation of epidemics, validation of protocols, or changes made in materials which could influence the microbial content.

Effectiveness of the hands-free technique in reducing operating theatre injuries

B Stringer, C Infante-Rivard, J A Hanley

....
....

Occup Environ Med2002;59:703–707

Background: Operating theatre personnel are at increased risk for transmission of blood borne pathogens
when passing sharp instruments. The hands-free technique, whereby a tray or other means are
used to eliminate simultaneous handling of sharp instruments, has been recommended.
Aims: To prospectively evaluate the effectiveness of the hands-free technique in reducing the incidence of percutaneous injuries, contaminations, and glove tears arising from handling sharp instruments.
Methods: For each of 3765 operations carried out in main and surgical day care operating theatres
in a large urban hospital, over six months, circulating nurses recorded the proportion of use of the
hands-free technique during each operation, as well as other features of the operation. The hands-free
technique, considered to be used when 75% or more of the passes in an operation were done in this
way, was used in 42% of operations. The relative rate of incidents (percutaneous injuries, contaminations,
and glove tears) in operations where the hands-free technique was used and not used, with
adjustment via multiple logistic regression for the different risk profiles of the two sets of operations, was
calculated.
Results: A total of 143 incidents (40 percutaneous injuries, 51 contaminations, and 52 glove tears)
were reported. In operations with greater than 100 ml blood loss, the incident rate was 4% (18/486)
when the hands-free technique was used and 10% (90/880) when it was not, approximately 60% less.
When adjusted for differences in type and duration of surgery, emergency status, noisiness, time of
day, and number present for 75% of the operation, the reduction in the rate was 59% (95% CI 23% to
72%). In operations with less than 100 ml blood loss, the corresponding rates were 1.4% (15/1051)
when the hands-free technique was used and 1.5% (19/1259) when it was not used. Adjustment for
differences in risk factors did not alter the difference.
Conclusions: Although not effective in all operations, use of the hands-free technique was effective in
operations with more substantial blood loss.

See end of article for
authors' affiliations

Appendix C

Interview instructions

The interviewer/s aim is to administer the interview to all interviewees in the same way, without prejudice or bias for outcome and without 'leading' the interviewee to particular answers. The sample of interviewees should be randomised, if not, the interviewer should describe and record recruitment. Each interview section has an approximate time limit serving as a guide; the aim is 30-minute maximum.

Firstly express to interviewee that their responses will be kept confidential and anonymous.

Opening section (4 minutes)

Q2

The interviewer must say explicitly that 'Staff' includes Surgeons, ODAs, Scrub Nurses, Anaesthetists and assistants.

Team Structure section 10 minutes)

Q3 & Q4

The interviewer must firstly define A, B & C components. When asking the interviewee to choose their diagram/s the interviewer must not provide any visual cues such as pen or finger pointing to an area of the answer sheet. The interviewer must obtain answers to both Qs: "Which diagram"? And "Where do you think A, B & C components should be positioned / configured", before recording any response.

Role Comprehension (4 minutes)

Q5 & Q6

Define 'role' as the usual function or part played in theatre

Communication (4 minutes)

Q7 Define communication as the exchange of information between staff

Q8

Quality refers to the scale from poor to good communication, which the interviewee would have described in answering Q7.

Knowledge & Experience of teamwork (8 minutes)

Q9

Define 'characteristics' as qualities, attributes and traits

Q10

Request for 'scenarios' is a request for description of the where, when, what and how things happened during their experience of good and poor teams.

Ask each interviewee not to divulge much about the questionnaire to colleagues.

Appendix D

Interview Questionnaire
Opening Section

1 In your experience, how well do theatre staff* work together?
2 Do you think theatre staff work together as a single team or as multiple teams?

Team Structure

3 Which of the structures on Page 3 best represent the structure of theatre staff and insert* A, B & C into the diagram's cells to show where you think staff are positioned in the structure; where A = Surgeons and assistants, B = Anaesthetists and assistants, C = Scrub Nurses and assistants.
3a Please explain your choice and provide 4 words to define the team structure.

4 Which of the structures on Page 4 best represent the ideal for theatre staff to accomplish their objectives in theatre? Please insert* A, B & C into the diagram's cells to show where you think staff would be best positioned in that structure.
4a Please explain your choice and provide 4 words to define the team structure.

Role Comprehension

5 Please rate your understanding of the role of the: a) anaesthetist b) surgeon c) scrub-nurse d) ODA e) circulating nurse

6 Please rate how much the following understand your role in theatre: a) anaesthetist b) surgeon c) scrub-nurse d) ODA e) circulating nurse

---

Communication

7 Please give six examples of a) good and b) poor communication in theatre

8 Please rate the 'typical' quality of communication between the following?

a) surgeons-ODAs
b) circulating nurses-ODAs
c) anaesthetists-surgeon
d) anaesthetists-ODAs
e) anaesthetists-scrub-nurses
f) scrub nurses-circulating nurses
g) scrub nurses-ODAs
h) surgeons-scrub nurses

8a Place a-h in their order of importance in relation to the overall success of surgery

---

Knowledge & Experience of teamwork

9 Please give six characteristics of both: a) a good and b) poor team

10 Describe a scenario when you worked in: a) a good and b) poor team in theatre

11 Which aspects of teamwork, if any, make a difference to surgical outcome?

Appendix E

Interview Answer Sheet

Opening Section

Q1

Q2

Role Comprehension

Q5

a	0	1	2	3	4	5
b	0	1	2	3	4	5
c	0	1	2	3	4	5
d	0	1	2	3	4	5
e	0	1	2	3	4	5

Q6

a	0	1	2	3	4	5
b	0	1	2	3	4	5
c	0	1	2	3	4	5
d	0	1	2	3	4	5
e	0	1	2	3	4	5

Communication

Q7a. Good

A1	
A2	
A3	
A4	
A5	
A6	

Q7b. Poor

A1	
A2	
A3	
A4	
A5	
A6	

Q8 Communication rating **Q8a**

a	0	1	2	3	4	5	
b	0	1	2	3	4	5	
c	0	1	2	3	4	5	
d	0	1	2	3	4	5	
e	0	1	2	3	4	5	
f	0	1	2	3	4	5	
g	0	1	2	3	4	5	
h	0	1	2	3	4	5	

Knowledge & Experience of teams

Q9a Good team characteristics

A1	
A2	
A3	
A4	
A5	
A6	

Q9b Poor team characteristics

A1	
A2	
A3	
A4	
A5	
A6	

Q10a Scenario Good team

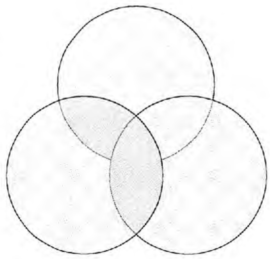
Q10b Scenario Poor team

Q11 Aspects of teawork

<u>**Team Structure**</u>

Question 3 – Current Structure

1



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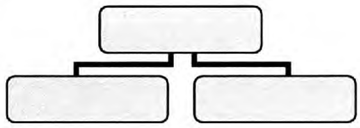

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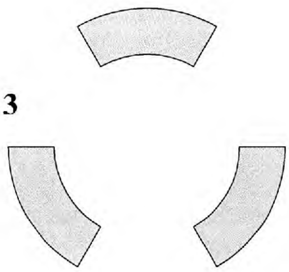


4

5

A = Surgeons **B = Anaesthetists** **C = Scrub Nurses**

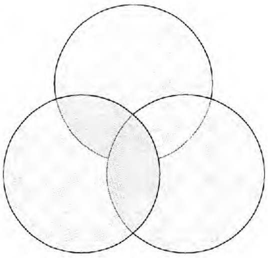
Q3a Explanation

Word 1	**2**	**3**	**4**

Team Structure

Question 4 – Ideal Structure

1



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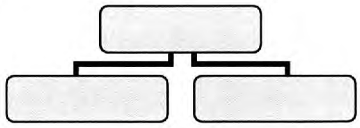

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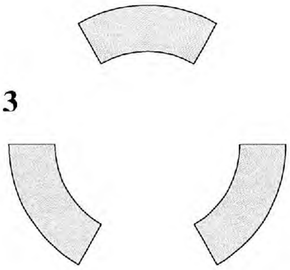


5

4

A = Surgeons **B = Anaesthetists** **C = Scrub Nurses**

Q4a Explanation

Word 1	**2**	**3**	**4**

Appendix F

OTAS prototype: task list prior to refinement

Pre1

Pre-Op planning and prep before pt sent for (before pt sent for)	**yes**	no	comment

Team Tasks

patient

Bed allocated

Patient notes prepared

equipment

sets autoclaved & available

specific equipment available

specific instruments available

Anaes. logbook for maintenance available

Anaes. logbook for maintenance up to date

communication

surgeon agrees appropriate surgery

patient consents to the surgery

surgeon informs of co morbidities

surgeon informs of special equipment

Anae-ODA (pt spec requirements)

Anae informs of special needs

theatre list produced & displayed

staff rota list produced & displayed

changes in list or delays

environment

op env prepared to hygiene requirements

OPERATION NAME

OPEN=1; CLOSED=2

Pre2

Pt sent for (PS) - to Anaesthesia (AS)	**yes**	no	comments

Sent for time

Arrival time

Anaesthesia start

Observer 1

Team Tasks

patient

patient sent for

correct patient verified

surgical site & laterality verified

surgical procedure verified

notes & x-rays present for patient

patient details entered to pc

booked operation time

patient condition monitored by Anaesthetist

equipment & provisions
Anae. Equip. checked and working
Surg. Instruments checked and working
Surg. Instruments covered till op
op-specific equip. checked working
gowns & gloves prepared
Anae. Drugs prepared

communication
surgeon briefs team on procedure
Anae-ODA discuss pt requirements
Sn & Cn confirm instruments check
correct patient confirmed verbally
procedure confirmed verbally
surgical site laterality verbally confirmed

Condition of patient
anaesthetised
temperature within range
urine output within range
cardiac output in range
Anae-ODA (pt spec requirements)

Critical incidents
critical incident
critical incidents reported
hazards to pt

Team Composition in theatre
(at incision/access of pt)
surgeon
assistant
supervised
sn
assistant
supervised
cn
anes
assistant
supervised
oda
assistant
supervised
ancillary staff
surplus staff kept to minimum
staff leave room
staff enter room

	Pre3	yes	no	comments
Set-up (PIR) to op readiness (PC)				
Set-up time				

Observer 1
Team Tasks

patient
safe transfer to operating table
pressure points protected
td stockings
anti embolism measures
Anae-ODA airway check
oda-anaes drug requirements
correct position for procedure
surg-oda patient position

equipment & provisions
Surg. Instruments covered till op
diathermy pad applied
barriers
arm boards
Anti-pressure devices prepared
diathermy checked and ready
suction prepared and ready
DVT device
inappropriate use of equipment
warming blanket
catheter

communication
OP readiness stated verbally to team
team ackknowledges readiness statement
Antibiotics noted verbally

Condition of patient
anaesthetised
temperature within range
urine output within range
cardiac output in range
Anae-ODA (pt spec requirements)

Critical incidents
critical incident
critical incidents reported
hazards to pt

Team Composition in theatre
(at incision/access of pt)

Op1	yes	no	comments
Opening - from access (PCT) to contact of target organ			
Time of Incision			

Observer 1
Team Tasks
patient
betadine painting
draping
Anaes. monitoring maintained
blood/fluids monitored

staff aligned to patient for procedure

equipment & provisions
pedals to surgeon
adjusting light
connection of leads and suction
diathermy settings
final op-specific equipment prep.
hand-free instrument transfer if bleeding
swabs organised
sharps organised
staff aligned to equipment for procedure
sterile handles for spotlight
inappropriate use of equipment

communication
OK to start
OK to start acknowedgement
SGN clearly instructs SN on instruments

Condition of patient
anaesthetised
temperature within range
urine output within range
cardiac output in range
Anae-ODA (pt spec requirements)

Critical incidents
critical incident
critical incidents reported
hazards to pt

Team Composition in theatre
(at incision/access of pt)

Op2	yes	no	comments
Op-specific procedure to PCB			
Time at target			

Observer 1
Team Tasks
patient
anaes checking pt condition
surgeon performing procedure
Anaes. monitoring maintained
blood/fluids monitored

equipment & provisions
hand-free sharps handling
correct instruments for operation
spot light directed to site adequately
sufficient and appropriate swabs
sufficient and appropriate sharps
diathermy

suction attached
inappropriate use of equipment

communication
Anaes. updating on pt condition
Anaes. - maintenance of Anaess
surg. Informs of bleeding etc

Condition of patient
anaesthetised
temperature within range
urine output within range
cardiac output in range
Anae-ODA (pt spec requirements)

Critical incidents
critical incident
critical incidents reported
hazards to pt

Team Composition in theatre
(at incision/access of pt)

Op3	yes	no	comments

Prep to close (PCB) to close (PF)
Time - ready to close

Observer 1
Team Tasks
patient
blood loss analysis
correct suture
correct dressing
Anaes. monitoring maintained
blood/fluids monitored

equipment & provisions
supplying requested drains
swab and instrument count
supplying suture material
hand-free instrument transfer if bleeding
dressings
inappropriate use of equipment

communication
surgeon states closure start
Anaesthetist acknowledgement
SG instructs SN on sutures for closure
Anaes instructs ODA on reversal

Condition of patient
anaesthetised
temperature within range

urine output within range
cardiac output in range
Anae-ODA (pt spec requirements)

Critical incidents
critical incident
critical incidents reported
hazards to pt

Team Composition in theatre
(at incision/access of pt)
including supervision level

Post1	**yes**	no	comments

Anae Reversal to exit (POR)
Time at reversal start
Observer 1

Team Tasks
patient
check for diathermy burns
check pressure areas
drains catheter safely positioned and working
ensure airway is maintained
safe transfer to trolley
cleaning up the patient
removal of diathermy pad
ensuring no injury to the patient
drapes removed
extubation
pt protected on trolley for transport
oxygen mask attached

equipment & provisions
bringing in the trolley
disconnect suction etc
sharps safely disposed of
dismantling of equipment
suction for Anaesthesia
oxygen supply OK
Sats probe
dressing
inappropriate use of equipment

communication
airway instructions to oda
Anaes. Oks pt removal
anaes command to move
SN states final counts
Staff verbal comm to pt to waken

Condition of patient
anaesthetised
temperature within range

urine output within range
cardiac output in range
Anae-ODA (pt spec requirements)

Critical incidents
critical incident
critical incidents reported
hazards to pt

Team Composition in theatre
(at incision/access of pt)
and supervisionlevels

Post 2	**yes**	no	comments

Recovery and transfer
Exit Time

Team Tasks
patient
ensure notes & x rays with pt
adequate fluids and post op instructions
adequate analgesia written up/pca set up
Patient made comfortable

communication
ensure op note written and filed
drug chart & instructions hand-over
ensure notes and x rays are with pt
SN hand-over to RN
anesthetist informs recovery of op
anaes. informs rec. of pt condition
anes. Informs rec. of drugs used
recovery staff acknowledge information

Condition of patient
temperature within range
urine output within range
cardiac output in range
Anae-ODA (pt spec requirements)

Critical incidents
Critical incident
Critical incidents reported
hazards to pt

Equipment condition
recovery equipment prepared for pt

COMMUNICATION SCALE

6

The team carried out essential communication tasks at the correct stage with positive attitude and polite manner. Task-related communication was clearly audible and well articulated. The team made a concerted and consistent effort to maintain open communication in order to fulfil roles and enhance team function.

- Team communication was extremely effective.

5

4

3

The team carried out essential tasks but not all at the correct stages. Task-related communication was acceptable, though members did sometimes seek clarification. The manner and effort of communication was acceptable but could be improved. Team communication probably did not enhance nor hinder team function.

- Team communication was generally effective

2

1

0

The team did not carry out many communication tasks. Task-related comm. was unclear and members consistently sought clarification and repeats. The manner of communication was negative and unacceptable. This team had a problem communicating openly. Overall the function of this team was hindered by poor communications.

- Team communication was often ineffective.

LEADERSHIP SCALE

6

Members provided direction, instruction and explanation to the team. They fully asserted themselves in drawing attention to team process and changing events. They were proactive in their effort to direct the team to relevant stimuli and process.

- Their leadership enhanced team function.

5

4

3

They provided some evidence of leading the team. They made some suggestions but were not assertive enough to direct the team's attention to process or events.

- Their leadership did not enhance nor hinder team function.

2

1

0

They did not provide any leadership when they should have. They made no attempt to instruct the team when it was their responsibility to do so. They made no effort in directing the team when events dictated they should have.

- Their lack of leadership hindered team function

COORDINATION SCALE

6

Within and between stages the team co-ordinated among individual tasks and within shared tasks. Members were present when required at each stage to co-ordinate activities. They made a concerted and consistent effort to ensure team tasks co-ordinated.

- Co-ordination was highly effective and enhanced team function.

5

4

3

Within and between stages they co-ordinated most of their tasks with those of other members. Not all members were always present when required at each stage. They did make some effort to ensure team tasks co-ordinated.

- Co-ordination was reasonable but did not enhance nor hinder team function.

2

1

0

Within and between stages they did not co-ordinate tasks and events. The lack of coordination disrupted team process. The team made little effort to ensure team tasks co-ordinated.

- Co-ordination was ineffective and hindered team function.

AWARENESS/ MONITORING SCALE

6

The team showed clear evidence of awareness and monitoring of their own tasks and those of other members and of process. They were attentive, vigilant to process and changing events. They made a concerted and consistent effort in monitoring.

- Awareness was highly effective in enhancing team function.

5

4

3

They showed some evidence of awareness and monitoring of team process and tasks. They were responsive to changing events, but could have been more vigilant. They were reasonably attentive and made some effort in monitoring.

- Awareness did not enhance nor hinder team function.

2

1

0

They showed little evidence of awareness and monitoring of process and events. Their anticipation was poor and response to events delayed and unacceptable. They made little effort in monitoring.

- Lack of awareness hindered team function.

COOPERATION SCALE

6

Team members acknowledged and acted upon suggestions and requests from each other immediately and fully. Members offered and gave assistance to each other and compensated for weaknesses and difficulties. They made a concerted and consistent effort to co-operate with each other.

- Their co-operation enhanced team function.

5

4

3

They acted on requests but often did not acknowledge them. They gave some assistance to others but did not compensate fully for weakness or difficulties. Team members co-operated with each other but did not make much effort.

- Their co-operation did not enhance nor hinder team function.

2

1

0

They did not meet all requests from other members and were clearly uncooperative. They made little or no effort to help or compensate for others' weaknesses or difficulties. Members were uncooperative to one another.

- Their lack of co-operation hindered team function.

Appendix G

Refinement Interviews for OTAS prototype task list

Interview with scrub nurses, anaesthetists and surgeons for the modification of OTAS I task list.

The aim of this exercise is to determine if these tasks fall into the following categories for the team performance in surgery model.
Please scale all the tasks as yes, no or probably according to the below criteria. If you answer "probably" please give further explanation.

Inclusion Criteria (Any of the Below)

1) contributes to patient safety or quality of care
2) contributes to surgical outcome positively or its omission would contribute adversely to surgical outcome
3) essential for team work or enhances team working
4) makes an important contribution to the whole system

Exclusion criteria

Please omit any tasks which are duplicated or covered by another task
Please omit any tasks which are irrelevant to any of the above categories
Please omit any tasks which are inherent to the procedure (or obvious)

Additional Information

Please also add any tasks which you feel are important for any of the above criteria and have been omitted from the list.

Please comment on the various stages and if they are appropriate as per the definitions. Would you have altered the categorising of stages and phases? If yes, how would you define them?

Comments

Speciality

Years in the Speciality

Appendix H

OTAS Observer 2 training questionnaire

- **The purpose of this questionnaire is to partially determine whether someone training to use OTAS is qualified to begin assessing the performance of surgical teams.**

- **Scan the questionnaire before beginning and attempt to answer succinctly all of the following five sections (1-5):**

1. The surgical team,
2. The surgical process
3. The teamwork model
4. The measures
5. The method

1. The surgical team

1. Name the three main disciplinary groups in surgery

a)	b)	c)

2. Briefly, describe the different roles within each of the three main disciplinary groups

a)

b)

c)

2. The surgical process

1. State the key-events that mark the start of each of the three OTAS phases:

a) The pre-operative phase

b) The intra-operative phase

c) The post-operative phase

2. At which point in surgical process should the lead members of each discipline begin their work in the operating theatre?

3. The teamwork model

1. Name the five teamwork behaviours (constructs) that comprises OTAS

1	2
3	4
5	

2. Provide description of each behavioural construct. For each, supply two behavioural exemplars/markers that reflect a highly performing team, use any stages of process.

Construct 1

Construct 2

Construct 3

Construct 4

Construct 5

3. Which behavioural construct is the following text describing?

'Members provided direction, instruction and explanation to the team. They fully asserted themselves in drawing attention to team process and changing events. They were proactive in their effort to direct the team to relevant stimuli and process.'

4. Which operative stage (a) and construct (b) do the following exemplars mainly apply?

A	N	S
• Updates theatre manager on any changes to case list • Confirms pt details and condition with N • Verbal communication to theatre team on patient transfer and set-up	• TM mediates progress of case through proactive communication • Confirms patient specific requirements with A & S • Communicate any problems regarding set-up or provisions to team	• Changes to operation or case list communicated to all concerned • Establishes open atmosphere for communication from sub-teams • Verbal confirmation of procedure and intra-op requirements
a)		
b)		

5. Deduce from the following scenario where the five behaviours are demonstrated

'All members of the team were present in Theatre 1 as the patient was brought into the operating theatre, having just been anaesthetised. While all of the surgeons were scrubbing, the patient was transferred to the operating theatre very smoothly and set-up was completed with care. Everyone seemed to know what needed to be done without asking questions or being given explicit instructions. The patient had been draped and painted, and everyone appeared to be ready; the surgeon began the incision immediately.' However, after incision, the ODA was unable to answer the surgeon's question about anaesthetics when asked.

For instance, *co-ordination* is demonstrated by the fact that all team members were present in Theatre 1 as the patient was brought in, but no surgeons were present in the operating theatre area!

4. The measures

1. When observing team process we use a general scale for each behaviour to be rated,

a) Define the mid-point on the scale in general terms of team performance

b) Describe the direction of performance above the mid-point to the extreme of the scale.

c) Describe the direction of performance below the mid-point to the extreme of the scale.

2. Which scale point does the following refer?

'Within and between stages they did not co-ordinate tasks and events. The lack of co-ordination disrupted team process. The team made little effort to ensure team tasks co-ordinated.'

3) Referring back to question 4 of section 3, extrapolate from the scenario, providing scores on each construct for the team performance described.

1	2
3	4
5	

5. The method

1. What is the intended purpose of OTAS?

2. Describe the overall method of OTAS

3. What problems might occur in the use of OTAS that threaten its measurement validity?

4. What should an observer do if they are confronted aggressively by a team member?

5. What measures must an observer take to ensure their safety?

6. Name four health-hazards in the operating theatre that observers are vulnerable to

Appendix I

CONSENT FORM

AGREEMENT TO PARTICIPATE IN RESEARCH AND TRAINING PROJECT

Name:

Speciality and grade:

Department:

Number of years of experience in the operating theatre:

I the undersigned agree to take part in the research and training project entitled

"Simulations and Team Training in the Virtual Operating Theatre"

I understand that I may withdraw from the project at any time for whatever reason.

Signed: .... Print Name: ....

Witness: .... Print Name: ....

Date: ....

I agree not to divulge the content and scenario of this simulation to any other colleagues.

Appendix J

GLOBAL RATING SCALE OF OPERATIVE PERFORMANCE

PROCEDURE________________________ CANDIDATE NO.____________ ASSESSOR_________

Please circle the number corresponding to the candidate's performance regardless of their level of training

Respect for tissue

1	2	3	4	5
Frequently used unnecessary force on tissue or cause damage by inappropriate instrument use		Careful handling of tissue but occasionally caused inadvertent damage		Consistently handled appropriately with minimal damage to tissue

Time and motion

1	2	3	4	5
Many unnecessary moves		Efficient time & motion but some unnecessary moves		Clear economy of movement and maximum efficiency

Instrument handling

1	2	3	4	5
Repeatedly makes awkward or tentative moves with instruments through inappropriate use		Competent use of instruments but occasionally appeared stiff or awkward		Fluid movements with instruments and no stiffness or awkwardness

Suture handling

1	2	3	4	5
Awkward and unsure with repeated entanglement, poor knot tying and inability to maintain tension		Careful and slow with majority of knots placed correctly with appropriate tension		Excellent suture control with correct placement of knots and correct tension

Flow of operation

1	2	3	4	5
Frequently stopped operating and seemed unsure of next move		Demonstrated some forward planning and reasonable progression of procedure		Obviously planned operation with efficiency from one move to another

Knowledge of procedure

1	2	3	4	5
Insufficient knowledge Looked unsure and hesitant		Knew all important steps of operation		Demonstrated familiarity with all steps of operation

Overall performance

1	2	3	4	5
Very poor		Competent		Clearly superior

Quality of final product

1	2	3	4	5
Very poor		Competent		Clearly superior

TOTAL SCORE__________

Scrub Nurse Identifier (initials) Assessor (EXPERT)

VIRTUAL OPERATING THEATRE **TECHNICAL** SKILLS RATING SCALE

Please follow the key given below and circle the number corresponding to the scrub nurse's performance

NA-not applicable

1 Not done	2 Not done well	3	4	5	6 Done very well

CATEGORY	ELEMENT							
Preparation & Planning	(a) Ensure that the environment meets the needs of the patient.	NA	1	2	3	4	5	6
	(b) Equipment is selected, checked and prepared to protect and meet the needs of patients undergoing surgery.	NA	1	2	3	4	5	6
	(c) The electro-surgical pad has been safely attached to the patient.	NA	1	2	3	4	5	6
	(d) Endoscopic equipment (Including videos & monitors has been safely checked.	NA	1	2	3	4	5	6
	(e) Operating lighting checked for cleanliness and functionality.	NA	1	2	3	4	5	6
	(f) Instrument sets and supplementary instruments are selected, checked and prepared.	NA	1	2	3	4	5	6
	(g) Equipment that is no functional or unsafe is removed from use, replaced and correct procedures are explained or demonstrated for its repair and maintenance.	NA	1	2	3	4	5	6
	(h) Suction apparatus is checked	NA	1	2	3	4	5	6
Gowning & Gloving	(a) Gowned and gloving using close method	NA	1	2	3	4	5	6
	(b) Placement of gloved hands – Clasped mid- chest	NA	1	2	3	4	5	6
	(c) Back of gown tied using appropriate aseptic technique.	NA	1	2	3	4	5	6
Creating The Surgical Field	(a) Once opened tray is checked sterilised, and for any debris	NA	1	2	3	4	5	6
	(b) Instruments and items are counted, named, and recorded prior to the procedure.	NA	1	2	3	4	5	6
	(c) Instruments are checked as safe and functional.	NA	1	2	3	4	5	6
	(d) Items are passed into and from the surgical field in a way, which avoids risk of contamination and protects patients and staff.	NA	1	2	3	4	5	6
	(e) The location of items is monitored throughout the procedure.	NA	1	2	3	4	5	6
	(f) Correct accounting procedures are performed as the surgical procedure comes to an end.	NA	1	2	3	4	5	6
Managing The Surgical Field	(a) The operative site is safely and correctly prepared.	NA	1	2	3	4	5	6
	(b) Count swabs in 5's showing raytex and ties	NA	1	2	3	4	5	6
	(c) Prepare swabs for cleaning	NA	1	2	3	4	5	6
	(d) Mount blades safely.	NA	1	2	3	4	5	6
	(e) Placement of sharps in kidney dish							
Prepping And Draping	(a) Ensure two team members drape together	NA	1	2	3	4	5	6
	(b) Hand drape over right-side up and without dragging (supporting drape)	NA	1	2	3	4	5	6
	(c) First drape both sides then bottom and top as recommended by manufactures	NA	1	2	3	4	5	6
	(d) Ensure operating site is fully and correctly draped	NA	1	2	3	4	5	6
	(e) Anticipate surgeon's needs.	NA	1	2	3	4	5	6
	(f) Have control of instrumentation and soiled swabs i.e. no instruments lying on top of patient	NA	1	2	3	4	5	6
	(g) Maintaining contact with surgeon and procedure	NA	1	2	3	4	5	6
Posture & Movement	(a) Eye contact on procedure maintained (Did not turn their back to the surgeon)& Maintained good posture throughout.	NA	1	2	3	4	5	6
	(b) Universal precautions are used throughout	NA	1	2	3	4	5	6

Appendix K

Surgeon Identifier (initials) Assessor (HF expert)

VIRTUAL OPERATING THEATRE HUMAN FACTORS RATING SCALE -MS

Please follow the key given below and circle the number corresponding to the surgeon's performance

NA-not applicable

1 Not done	2 Not done well	3	4	5	6 Done very well

CATEGORY	ELEMENT							
COMMUNICATION AND INTERACTION	(a) Instructions to assistant- clear and polite	NA	1	2	3	4	5	6
	(b) Waited for acknowledgment from the assistant	NA	1	2	3	4	5	6
	(c) Instructions to scrub nurse- clear and polite	NA	1	2	3	4	5	6
	(d) Waited for acknowledgement from the scrub nurse	NA	1	2	3	4	5	6
VIGILANCE/ SITUATION AWARENESS	(a) Monitored patient's parameters throughout the procedure	NA	1	2	3	4	5	6
	(b) Awareness of anaesthetist	NA	1	2	3	4	5	6
	(c) Actively initiates communication with anaesthetist during crisis periods	NA	1	2	3	4	5	6
TEAM SKILLS	(a) Maintains a positive rapport with the whole team	NA	1	2	3	4	5	6
	(b)Open to opinions from other team members	NA	1	2	3	4	5	6
	(c) Acknowledges the contribution made by other team members	NA	1	2	3	4	5	6
	(d) Supportive of other team members	NA	1	2	3	4	5	6
	(e) Conflict handling eg. concentrates on what is right rather than who is right	NA	1	2	3	4	5	6
Leadership And Management Skills	(a) Adherence to best practise during the procedure eg. does not permit corner cutting by self or team	NA	1	2	3	4	5	6
	(b) Time management eg. appropriate time allocation without being too slow or rushing team members	NA	1	2	3	4	5	6
	(c) Resource utilisation i.e. appropriate task-load distribution and delegation of responsibilities	NA	1	2	3	4	5	6
	(d) Debriefing the team i.e. provides details and feedback to the entire team about the procedure	NA	1	2	3	4	5	6
	(e) Authority/ assertiveness	NA	1	2	3	4	5	6
DECISION MAKING- CRISIS	(a) Prompt identification of the problem	NA	1	2	3	4	5	6
	(b) Informed team members- promptly, clearly and to all team members	NA	1	2	3	4	5	6
	(c) Outlines strategy/ institutes a plan i.e. asks scrub nurse for suction, instruments, suture material	NA	1	2	3	4	5	6
	(d) Anticipates potential problems and prepares a contingency plan eg. asks anaesthetist to order blood, calls for help	NA	1	2	3	4	5	6
	(e) Option generation- takes the help of the team (seeks team opinion)	NA	1	2	3	4	5	6

Anaesthetist Identifier (initials) Assessor (HF expert)

VIRTUAL OPERATING THEATRE HUMAN FACTORS RATING SCALE-MA

Please follow the key given below and circle the number corresponding to the Anaesthetist's performance

NA-not applicable

1 Not done/	2 Not done well	3	4	5	6 Done very well

CATEGORY	ELEMENT							
Communication And Interaction	(a) Instructions to ODP clear	NA	1	2	3	4	5	6
	(b) Waited for acknowledgment from the ODP	NA	1	2	3	4	5	6
	(c) Instructions to Surgeon clear and polite	NA	1	2	3	4	5	6
	(d) Waited for acknowledgement from the surgeon	NA	1	2	3	4	5	6
Vigilance/ Situation Awareness	(a) Monitored patient's parameters throughout the procedure	NA	1	2	3	4	5	6
	(b) Awareness of Surgeon							
	(b) Awareness of ODP	NA	1	2	3	4	5	6
	(c) Actively initiates communication with Surgeon during crisis periods	NA	1	2	3	4	5	6
Team Skills	(a) Maintains a positive rapport with the whole team	NA	1	2	3	4	5	6
	(b)Open to opinions from other team members	NA	1	2	3	4	5	6
	(c) Acknowledges the contribution made by other team members	NA	1	2	3	4	5	6
	(d) Supportive of other team members	NA	1	2	3	4	5	6
	(e) Conflict handling eg. concentrates on what is right rather than who is right	NA	1	2	3	4	5	6
Leadership And Management Skills	(a) Adherence to best practise during the procedure eg. does not permit corner cutting by self or team	NA	1	2	3	4	5	6
	(b) Time management eg. Appropriate time allocation without being too slow or rushing team members	NA	1	2	3	4	5	6
	(c) Resource utilisation i.e. appropriate task-load distribution and delegation of responsibilities	NA	1	2	3	4	5	6
	(d) Debriefing the team i.e. provides details and feedback to the entire team about the pre op problem with patient	NA	1	2	3	4	5	6
	(e) Authority/ assertiveness	NA	1	2	3	4	5	6
Decision Making-Anaesthetic Crisis	(a) Prompt identification of the problem	NA	1	2	3	4	5	6
	(b) Informed ODP promptly and clearly	NA	1	2	3	4	5	6
	(c) Outlines strategy/ institutes a plan i.e. asks ODP for suction, instruments, airway	NA	1	2	3	4	5	6
	(d) Anticipates potential problems and prepares a contingency plan eg. asks Surgeon of availability/ asks ODP to order blood	NA	1	2	3	4	5	6
	(e) Option generation- takes the help of the team (seeks team opinion)	NA	1	2	3	4	5	6

Scrub Nurse Identifier (initials) Assessor (HF expert)

VIRTUAL OPERATING THEATRE HUMAN FACTORS RATING SCALE-MN

Please follow the key given below and circle the number corresponding to the scrub nurse's performance

NA-not applicable

1	2	3	4	5	6
Not done/	**Not done well**				**Done very well**

CATEGORY	ELEMENT							
COMMUNICATION AND INTERACTION	(a) Instructions to runner clear	NA	1	2	3	4	5	6
	(b) Waited for acknowledgment from the runner	NA	1	2	3	4	5	6
	(c) Instructions to Surgeon clear and polite	NA	1	2	3	4	5	6
	(d) Waited for acknowledgement from the surgeon	NA	1	2	3	4	5	6
VIGILANCE/ SITUATION AWARENESS	(a) Monitored steps of the procedure	NA	1	2	3	4	5	6
	(b) Awareness of Surgeon							
	(b) Awareness of runner	NA	1	2	3	4	5	6
	(c) Anticipates equipment needs during the crisis periods	NA	1	2	3	4	5	6
TEAM SKILLS	(a) Maintains a positive rapport with the whole team	NA	1	2	3	4	5	6
	(b)Open to opinions from other team members	NA	1	2	3	4	5	6
	(c) Acknowledges the contribution made by other team members	NA	1	2	3	4	5	6
	(d) Supportive of other team members	NA	1	2	3	4	5	6
	(e) Conflict handling eg. concentrates on what is right rather than who is right	NA	1	2	3	4	5	6
LEADERSHIP AND MANAGEMENT SKILLS	(a) Adherence to best practise during the procedure eg. does not permit corner cutting by self or team	NA	1	2	3	4	5	6
	(b) Time management eg. Appropriate time allocation without being too slow or rushing team members	NA	1	2	3	4	5	6
	(c) Resource utilisation i.e. appropriate task-load distribution and delegation of responsibilities	NA	1	2	3	4	5	6
	?							
	(e) Authority/ assertiveness	NA	1	2	3	4	5	6
DECISION MAKING-CRISIS	(a) Prompt identification of the problem	NA	1	2	3	4	5	6
	(b) Informed runner promptly and clearly	NA	1	2	3	4	5	6
	(c) Outlines strategy/ institutes a plan i.e. asks runner for suction, vascular tray	NA	1	2	3	4	5	6
	(d) Anticipates potential problems and prepares a contingency plan eg. informs Surgeon of availability of suction or vascular clamps	NA	1	2	3	4	5	6
	(e) Option generation- takes the help of the team (seeks team opinion)	NA	1	2	3	4	5	6

ODP (initials) Assessor (hf expert)

VIRTUAL OPERATING THEATRE HUMAN FACTORS RATING SCALE-MO

Please follow the key given below and circle the number corresponding to the ODP's performance

NA-not applicable

1 Not done/	2 Not done well	3	4	5	6 Done very well

CATEGORY	ELEMENT							
COMMUNICATION AND INTERACTION	(a) Communication with Anaesthetist clear	NA	1	2	3	4	5	6
	(b) Waited for acknowledgment from the Anaesthetist	NA	1	2	3	4	5	6
	(c) Instructions to Surgeon clear and polite	NA	1	2	3	4	5	6
	(d) Waited for acknowledgement from the surgeon	NA	1	2	3	4	5	6
VIGILANCE/ SITUATION AWARENESS	(a) Monitored steps of the Anaesthesia	NA	1	2	3	4	5	6
	(b) Awareness of Anaesthetist							
	(b) Awareness of team	NA	1	2	3	4	5	6
	(c) Anticipates equipment needs during the crisis periods	NA	1	2	3	4	5	6
TEAM SKILLS	(a) Maintains a positive rapport with the whole team	NA	1	2	3	4	5	6
	(b)Open to opinions from other team members	NA	1	2	3	4	5	6
	(c) Acknowledges the contribution made by other team members	NA	1	2	3	4	5	6
	(d) Supportive of other team members	NA	1	2	3	4	5	6
	(e) Conflict handling eg. concentrates on what is right rather than who is right	NA	1	2	3	4	5	6
LEADERSHIP AND MANAGEMENT SKILLS	(a) Adherence to best practise during the procedure eg. does not permit corner cutting by self or team	NA	1	2	3	4	5	6
	(b) Time management eg. Appropriate time allocation without being too slow or rushing team members	NA	1	2	3	4	5	6
	(c) Resource utilisation i.e. appropriate task-load distribution and delegation of responsibilities	NA	1	2	3	4	5	6
	(e) Authority/ assertiveness	NA	1	2	3	4	5	6
DECISION MAKING- Anaesthetic CRISIS	(a) Prompt identification of the problem	NA	1	2	3	4	5	6
	(b) Informed anaesthetist promptly and clearly	NA	1	2	3	4	5	6
	(c) Outlines strategy/ institutes a plan i.e. prepares suction, airway etc	NA	1	2	3	4	5	6
	(d) Anticipates potential problems and prepares a contingency plan eg. informs anaesthetist availability of suction or blood	NA	1	2	3	4	5	6
	(e) Option generation- takes the help of the team (seeks team opinion)	NA	1	2	3	4	5	6

Appendix L

Communication

	Team	
Communication tasks completed at correct stage		Example (+):
Provision of information within team		
Manner of communication of team		Example (-):
Articulation and audibility		
Open and receptive to communication team-members		
Acknowledgements to communication provided		

Co-ordination

	Team	
Present when required in team process		Example (+):
Tasks completed at correct stage		
Sequenced own tasks with those of others		Example (-):
Contribution to shared tasks		
Prioritised action to coincide with changing events		

Leadership

	Team	
Inquiry and evaluation of team process		Example (+):
Direction provided to team		
Instruction provided to team		Example (-):
Suggestions provided to team		
Encourages and involves team members		

Co-operation

	Team	
Responsive to others' leads and requests		Example (+):
Assisting other members		
Compensating for others' weaknesses or difficulties encountered		Example (-):
Back-up offered and provided to others		

Awareness

	Team	
Anticipating events		Example (+):
Monitoring of team process and condition		
Vigilant of process and changing events		Example (-):
Questions asked to enhance team awareness		
Attention & focus on own work and on team process		

Scale: Little (mark "L") / Adequate (mark "A") / Very Good (mark "VG")

Exemplar behaviours

		Statement of exemplar behaviour					
From	to		Com	Coor	Coop	Awar	Lead

Score:
0……1……2……3……4……5……6
(L)……………..(A)………..………(VG)

Appendix M

Speciality Surgeon Scrub Nurse ODP Anaesthetist

Evaluation of the Simulation as a training event

We are interested in your own views of the simulation as a training event. There are no right or wrong answers to these questions. Anonymity of your responses is guaranteed. Please indicate (circle, tick or write) your answer to the following questions as appropriate.

Level of agreement

1 Do not agree at all	**2**	**3**	**4**	**5**	**6 Completely agree**

The synthetic model is a realistic representation of the operation	1	2	3	4	5	6
The simulated environment is a realistic representation of an operating theatre eg communication, interaction between team	1	2	3	4	5	6
The bleeding scenario is a realistic representation of real situation	1	2	3	4	5	6
The simulated environment is a good training opportunity in technical skills eg how to deal with bleeding for trainees	1	2	3	4	5	6
The simulated environment is a good training opportunity in technical skills eg how to deal with bleeding for consultants	1	2	3	4	5	6
The simulated environment is a good training environment in the team skills (communication, leadership etc) required to successfully manage the bleeding for trainees	1	2	3	4	5	6
The simulated environment is a good training environment in the team skills (communication, leadership etc) required to successfully manage the bleeding for consultants	1	2	3	4	5	6
The simulation is a good method for assessing my technical skills	1	2	3	4	5	6
The simulation is a good method for assessing my team skills	1	2	3	4	5	6
I would behave in the same way in real procedures	1	2	3	4	5	6
I would benefit by practicing this scenario again	1	2	3	4	5	6
I found the feedback at the end of the simulation of benefit in terms of technical skills	1	2	3	4	5	6
I found the feedback at the end of the simulation of benefit in terms of team skills	1	2	3	4	5	6

Please tell us here any comments you may have about the simulation (e.g., on content, process, any suggestions on how it can be improved)

____

____

____

____

____

Appendix N

OTAS TT(Team Training Version)

	Pre2 Pt sent for (PS) - to Anaesthesia (AS)	Opt	Act	Effect on team function or source of deviation
	simulation start time			
	anaes start time			
	Observer 1			
	Team Tasks			
	patient tasks			
1	**Patient notes checked**			
2	By Nurse	1		
3	By ODA	1		
4	By Anaes	1		
5	By Surgeon	1		
1	**surgical site & laterality verified**	1		
2	By Nurse	1		
3	By ODA	1		
4	By Anaes	1		
5	By Surgeon	1		
1	**Consent Form checked**	1		
2	By scrub nurse	1		
3	By ODA	1		
4	By Surgeon	1		
5	By Anaes	1		
1	**surgical procedure verified**	1		
2	By scrub nurse	1		
3	By ODA	1		
4	By Surgeon	1		
5	By Anaes	1		
	equipment & provisions	1		
1	sets checked	1		
2	specific equipment requested	1		
3	sharps handling	1		
1	**Anaes. Equipment checked**	1		
2	By ODA	1		
3	By Anaesthetist	1		
4	Anae. Drugs prepared	1		
5	Has odp found valve missing	1		
6	Air in drip set found	1		
7	anaes suction checked	1		
8	laryngoscope battery checked	1		
9	found empty oxygen cylinder	1		
10	has sn found set unsterile			
11	has sn found faulty retractor			
12	has sn found swabs without tag			
	Communication Tasks			
1	surgeon briefs team on procedure	1		

2	Anae-ODA discuss pt requirements	1		
3	Sn & Cn confirm instruments check	1		
1	Patient asked about allergies	1		
2	By ODA	1		
3	By Anaes	1		
4	By Surgeon	1		
1	Patient asked about co morbidities, sob	1		
2	By ODA	1		
3	By Anaes	1		
4	By Surgeon	1		
1	Patient asked about medication	1		
2	By ODA	1		
3	By Anaes	1		
4	By Surgeon	1		
1	Patient asked about metal work and false teeth			
2	By ODA	1		
3	By Anaes	1		
1	Anae informs of special needs	1		example rapid sequence
1	procedure confirmed verbally	1		by whom
2	By ODA	1		
3	By Anaes	1		
4	By Surgeon	1		
1	surgical site laterality verbally confirmed	1		by whom
2	By ODA	1		
3	By Anaes	1		
4	By Surgeon	1		
1	Patient asked about fasting	1		
2	By ODA	1		
3	By Anaes	1		
4	By Surgeon	1		
1	anaes- odp about (anaes) crisis	1		example diff intubation, reflux
2	anas-surg about crisis	1		
	Pre3			**Effect on team function**
	Set-up (PIR) to op readiness (PC)	**Opt**	Act	**or source of deviation**
T4	***set up time***	**?**		
	Observer 1			
A	***Team Tasks***			
	Patient			
1	Anae-ODA airway check	1		
2	oda-anaes drug requirements	1		
3	correct position for procedure	1		
4	surg-oda patient position	1		
	betadine painting	1		
	Draping	1		

	equipment & provisions			
1	Surg. Instruments covered till op or in prep room	1		
2	diathermy pad applied	1		
3	arm boards or sheets	1		
4	suction ready	1		
5	suction checked	1		
6	inappropriate use of equipment	0		
	Communication			
1	OP readiness stated verbally to team	1		
2	team ackknowledges readiness statement	1		
3	Antibiotics noted verbally	1		
6	surgeon briefs team on procedure	1		
	communication during anaes crisis			
	anaes- odp about (anaes) crisis	1		

	Op1 **Opening - from access (PCT) to contact of target organ**	**Opt**	Act	**Effect on team function** **or source of deviation**
T5	***Time of incision***	**?**		
	Observer 1			
A	***Team Tasks***			
	Patient			
3	Anaes. monitoring maintained	1		
4	staff aligned to patient for procedure	1		
	equipment & provisions			
1	adjusting light	1		
2	connection of suction			
3	final op-specific equipment prep.	1		
4	hand-free sharps transfer	1		
5	swabs organised	1		
6	sharps organised	1		
7	staff aligned to equipment for procedure	1		
8	inappropriate use of equipment	0		
	Communication			
1	OK to start	1		
2	OK to start acknowedgement	1		
3	SGN clearly instructs SN on instruments	1		
4	SGN clearly instructs asst	1		
	anaes to team about pt condition	1		eg sats dropping
	if procedure stopped ok to restart	1		

	Op2 **Op-specific procedure to PCB**	**Opt**	Act	**Effect on team function** **or source of deviation**
T6	***Time at target***	**?**		
	Observer 1			
A	***Team Tasks***			
	Patient			
1	anaes checking pt condition	1		

2	surgeon performing procedure	1	
3	Anaes. monitoring maintained	1	
	patient tasks once crisis starts		
	approprite control of bleeding	1	
	pressure applied to wound	1	by whom?
	approprite cpr	1	
	insertion of new iv line	1	
	fluids put up/ sped up	1	
	equipment & provisions		
1	hand-free sharps handling	1	
2	correct instruments for operation	1	
3	spot light directed to site adequately	1	
4	sufficient and appropriate swabs	1	
5	sufficient and appropriate sharps	1	
6	suction attached	1	
7	inappropriate use of equipment	0	
	equipment & provisions once crisis starts		
	vascular set or clamps	1	
	Prolene	1	
	blood ordered	1	
	defib	1	
	resus trolley	1	
	pressure bag for fluids	1	
	Communication		
	Anaes. updating on pt condition	1	
	sgn updating about progress	1	
	com once crisis starts		
1	Anaes. updating on pt condition	1	
2	Anaes. - maintenance of Anaess	1	
	anaes asks if blood x matched	1	
	anaes asks ODP to request units	1	
3	surg. Informs of bleeding immediately	1	how many seconds from blood appearing?
4	surg comm with assistant	1	
5	surg comm with scrub nurse	1	
6	sn comm with cn	1	
7	sgn asks for help from senior	1	
	nurse asks for suction	1	
	sgn asks for vascular clamps or set	1	
	anaes asks for atropine	1	
	com once arrest scenario starts		
	Anaes. -informs team of arrest	1	
	Anaes. Takes the lead and instructs on cpr	1	
	anaes asks for help from senior	1	
	team asks for resus trolley and defib	1	
	anaes asks for adrenalin	1	how many seconds from arrest

Appendix O

Staff Survey
Briefings in Surgery

A few words about team briefings:

Team briefing

Team briefing is a process of face to face communication using a simple synchronised formula that takes place on a regular basis and usually lasts about 5 minutes.

Its purpose is to pass factual information about relevant local work issues, provide explanation, clarification and feedback. It includes and involves everyone in the teams with questions asked and answered, and it is chaired by the team briefer who usually is the team leader or a dedicated professional.

Team briefings have been used routinely in industry and aviation enabling ongoing focus on quality and safety. Both sectors have benefited immensely from the drive for ever higher quality standards and safety improvements.

Team briefings in health care

Because medication errors are common in patient care, team briefings have been developed in recent years by healthcare organizations to address medication safety issues. Relevant research on adverse events in healthcare has also shown that most adverse events occur in the operating theatre, with general surgery presenting the highest rate. In a related survey, over 80% of 1033 medical staff felt that briefings defined as preoperative discussions, are an important part of safety teamwork, yet reported that they very rarely happen in practice. These findings were also reflected on preliminary discussions with staff from our hospital.

Debriefing

In areas where briefing takes place in a systematic way, debriefing also occurs. In this context debriefing is an opportunity for reflection and feedback on the operating session's work. The team members can discuss what went well and what went badly and how things can be done differently the next time if necessary. It also gives people a chance to air any misgivings. The staff can also discuss any untoward events or any events which did not go as planned (e.g., why more blood/ less blood was given). It will also give people an opportunity to add into the future briefings things which may have been important but missed out.

****

On the basis of the above, we would like you to consider team briefings for surgery and their potential impact on quality of surgical care. We would be very grateful if you could spare a few minutes of your time giving us your views on the subject by answering the following questions:

Questionnaire on Briefings in Surgery

We are interested in your views on the subject of surgical briefings. There are no right or wrong answers to these questions. Anonymity of your responses is guaranteed. Please indicate (circle, tick or write) your answer to the following questions as appropriate.

1. Please tell us in your own words what you think the role of briefings can be, if any, on clinical practice in surgery

2. On the basis of your work experience in the operating theatre (OT), to what extent do you think that some form of surgical briefing already takes place? (please circle your answer)
Do not know Not at all Sometimes Often Very often Routinely

3. In your opinion, how useful would it be to formalise surgical briefings?
Do not know Not useful A little bit useful Moderately useful Very useful

4. In your opinion, how useful would it be to have surgical briefings on a regular basis?
Do not know Not useful A little bit useful Moderately useful Very useful

5. In your opinion, how useful do you think the surgical briefing will be in helping to reduce the risk of surgical errors?
Do not know Not useful A little bit useful Moderately useful Very useful

6. On a scale of 1 to 10, how valuable do you think briefings will be in improving quality of care?
Please tick the box if you do not know ☐

1 2 3 4 5 6 7 8 9 10
Not valuable Neutral Very valuable

7. To what extent do you think that briefings can enhance team working in the OT?
Please tick the box if you do not know ☐

1 2 3 4 5 6 7 8 9 10
Not at all Moderately Very much

8. To what extent do you think that briefings can enhance communication of team members working in the OT?
Please tick the box if you do not know ☐

1 2 3 4 5 6 7 8 9 10
Not at all Moderately Very much so

9. Will the briefing contribute in other ways (not mentioned in questions above) to the teamwork in OT?

10. Do you perceive any problems in implementing surgical briefings in clinical practice? (please tick)
Do not know ☐ Yes ☐ No ☐

If yes, please specify:

____

____

____

Briefer

11. Who do you think should chair/lead the briefing? (*please, rank professional roles in order of relevance from 1= most relevant role, - 9 least relevant role*)

	Ranking 1 = most relevant – 9 = least relevant role to be the briefer
Surgeon	
Anaesthetist	
Scrub nurse	
ODA	
Circulating nurse	
Theatre manager	
Recovery nurse	
Ancillary Staff	
A dedicated person (please specify professional role)	

12. Why do you think your first choice of professional role should be the briefer?

____

____

____

____

Time and Place

13. When do you think should the briefing happen?
(*please tick more than one answer if appropriate*)

☐At the start of the day ☐At the start of each session ☐At the start of each case

☐At some other point during the working day? (please specify)________________

☐The evening before

14. How long should the briefing last? 5-10 min ☐, 11-15 min ☐, other (please specify) _______

Participants

15. Who do you think should be present/participate in the briefing?

	Present (please tick as appropriate)
Surgeon	
Anaesthetist	
Scrub nurse	
ODA	
Circulating nurse	
Theatre manager	
Recovery nurse	
Ancillary Staff	
Other (please specify professional role)	

Briefing Content

16. What should be included in the briefing generally?

____
____
____
____
____
____
____
____

17. Please state what each professional role should report in the briefing:

Surgeon	*Please circle as appropriate*	If **YES**, how **important** do you think it is for the **surgeon** to report on each item on a scale from 1 = not important to 5 = very important?
Order of list	Yes – No	1 2 3 4 5 Not important Very important
Special requirements for each case	Yes – No	1 2 3 4 5 Not important Very important
Anticipated difficulties and contingency plans for each case	Yes – No	1 2 3 4 5 Not important Very important
Specific equipment	Yes – No	1 2 3 4 5 Not important Very important
Estimated length of procedure	Yes – No	1 2 3 4 5 Not important Very important
Expectations from assistants	Yes – No	1 2 3 4 5 Not important Very important
Expectations from scrub nurses	Yes – No	1 2 3 4 5 Not important Very important
Who is the primary surgeon	Yes – No	1 2 3 4 5 Not important Very important
Arrangements for ancillary staff to be present	Yes – No	1 2 3 4 5 Not important Very important
Anything else *(please specify)*	Yes – No	1 2 3 4 5 Not important Very important

Anaesthetist	*Please circle as appropriate*	If **<u>YES</u>**, how **important** do you think it is for the **anaesthetist** to report on each item on a scale from 1 = not important to 5 = very important?
Special requirements for anaesthesia	Yes – No	1 2 3 4 5 Not important Very important
Patient co-morbidities which may affect procedure	Yes – No	1 2 3 4 5 Not important Very important
Length of anaesthesia induction	Yes – No	1 2 3 4 5 Not important Very important
Requirements for ITU	Yes – No	1 2 3 4 5 Not important Very important
Special instructions for recovery staff	Yes – No	1 2 3 4 5 Not important Very important
Type of anaesthesia to be given and why	Yes – No	1 2 3 4 5 Not important Very important
Who is the primary anaesthetist	Yes – No	1 2 3 4 5 Not important Very important
Anything else *(please specify)*	Yes – No	1 2 3 4 5 Not important Very important

Nursing staff: Scrub Nurse, Circulating Nurse, Theatre Manager	*Please circle as appropriate*	If **<u>YES</u>**, how **important** do you think it is for the **nursing staff** to report on each item on a scale from 1 = not important to 5 = very important?
Availability of equipment	Yes – No	1 2 3 4 5 Not important Very important
Back up instruments/ stacks etc	Yes – No	1 2 3 4 5 Not important Very important
Which scrub nurse is scrubbing for which case	Yes – No	1 2 3 4 5 Not important Very important
Level of experience for each scrub nurse	Yes – No	1 2 3 4 5 Not important Very important
Shortages of staff	Yes – No	1 2 3 4 5 Not important Very important
Availability of instruments	Yes – No	1 2 3 4 5 Not important Very important
Availability of equipment	Yes – No	1 2 3 4 5 Not important Very important
Anything else *(please specify)*	Yes – No	1 2 3 4 5 Not important Very important

Operating Departmental Assistant (ODA)	*Please circle as appropriate*	If **YES**, how **important** do you think it is for the **ODA** to report on each item on a scale from 1 = not important to 5 = very important ?
Machines checked	Yes – No	1 2 3 4 5 Not important Very important
Any shortages of drugs	Yes – No	1 2 3 4 5 Not important Very important
Emergency equipment	Yes – No	1 2 3 4 5 Not important Very important
Anything else *(please specify)*	Yes – No	1 2 3 4 5 Not important Very important

18. How willing will you be to participate in briefings in surgery?

1 2 3 4 5 6 7 8 9 10
Not at all A little Moderately Very much

19. How willing will you be to participate in training on how to conduct briefings in surgery?

1 2 3 4 5 6 7 8 9 10
Not at all A little Moderately Very much

Debriefing

20. In your opinion, how useful would it be to debrief and feedback after surgery?

Do not know Not useful A little bit useful Moderately useful Very useful

21. In your opinion, how useful do you think will debriefing be in helping to reduce the risk of surgical errors?

Do not know Not useful A little bit useful Moderately useful Very useful

22. On a scale of 1 to 10, how valuable do you think debriefings will be in improving quality of care in surgery?

1 2 3 4 5 6 7 8 9 10
Not valuable Neutral Very valuable

De-Briefer

23. Who do you think should chair/lead the debriefing? (*please, rank professional roles in order of relevance from 1= most relevant role, - 9 least relevant role*)

	Ranking 1 = most relevant – 9 = least relevant role to be the briefer
Surgeon	
Anaesthetist	
Scrub nurse	
ODA	
Circulating nurse	
Theatre manager	
Recovery nurse	
Ancillary Staff	
A dedicated person (please specify professional role)	

24. Why do you think your first choice of professional role should be the de-briefer?

____
____
____
____
____

Time and Place
25. When do you think should the de-briefing happen?
(please tick more than one answer if appropriate)
☐At the end of the day ☐At the end of each session

☐At some other point during the working day? (please specify)______________________

☐Once a week ☐Other interval (please specify) ___________________________

26. How long should the de-briefing last?: 5-10 min ☐, 11-15 min ☐, other (please specify) _______

Participants
27. Who do you think should be present/participate in the de briefing?

	Present (please tick as appropriate)
Surgeon	
Anaesthetist	
Scrub nurse	
ODA	
Circulating nurse	
Theatre manager	
Recovery nurse	
Ancillary Staff	
Other (please specify professional role)	

De-Briefing Content
28. What should be included in the debriefing generally?

____
____
____
____

29. Any other suggestions or comments (please continue overleaf if required)

____
____
____
____
____

30. Please tell us here any suggestions/comments you may have about this questionnaire (e.g., on content, suggestions on how it can be improved)

____
____
____
____
____

Background Information

Profession:________________ **Specialism:** ________________ **Grade:** ____________

Gender: ❑ Male ❑ Female

How many years (or months if less than 1 year) of experience do you have in OT? _____ years/months (delete one)

How many years (or months if less than 1 year) have you worked in ***this*** dept? _____ years/months (delete one)

Job status

- ❑ full-time
- ❑ Part-time
- ❑ Locum
- ❑ Agency
- ❑ other (specify) __________

Ethnic group

- ❑ White British
- ❑ White Irish
- ❑ White (all other)
- ❑ Mixed (White & Black Caribbean)
- ❑ Mixed (White & Black African)
- ❑ Mixed (White & Asian)
- ❑ Mixed (all other)
- ❑ Asian/Asian British (Indian)
- ❑ Asian/Asian British (Pakistani)
- ❑ Asian/Asian British (Bangladeshi)
- ❑ Asian/Asian British (all other)
- ❑ Black/Black British (Caribbean)
- ❑ Black/Black British (African)
- ❑ Black/Black British (all other)
- ❑ Chinese
- ❑ All other ethnic groups
- ❑ Not Given

Current age ______ years

Usual shift

- ❑ days
- ❑ evenings
- ❑ nights
- ❑ variable shifts

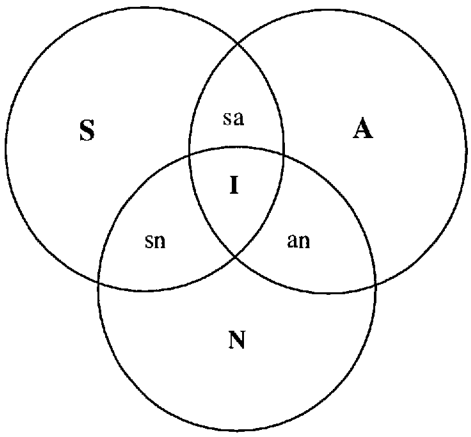
On average how many patients do you treat/manage/operate on each day _________

Thank you for completing the questionnaire – your time and participation are greatly appreciated

Imperial College London

Clinical Safety Research Unit

Observational Teamwork Assessment in Surgery (OTAS) User Manual



The Clinical Safety Research Unit

Imperial College

London

Shabnam Undre & Andrew Healey

This manual provides a guide for using the OTAS research instrument and a background to the development of the measures comprised within. The manual provides practical information about the use of a task checklist and a set of behavioural measurement scales. This manual and publications associated with OTAS are available on the CSRU OTAS webpage

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15 - 19 Bloomsbury Way

London

WC1A 2BA

http://www.bupafoundation.com

Patient Safety Research Programme

The Department of Health

Richmond House

79 Whitehall

London

SW1A 2NL

http://www.dh.gsi.gov.uk

Smith and Nephew Foundation

15 Adam Street,

London

WC2N 6LA

http://www.snfoundation.org.uk/

The teams research group

Shabnam Undre, Andrew N. Healey, Nick Sevdalis, Maria Koutantji, Avril Chang, Sanjay Gautama, Peter McCulloch, and Charles A. Vincent

LIST OF ABBREVIATIONS	
A	Anaesthetist
ANOVA	Analysis of variance
CN	Circulating nurse
CSRU	Clinical Safety Research Unit
Intra-op	Intra-operative phase of surgery
N	Nurse
ODP	Operating department practitioner
OT	Operating theatre/room
OTAS	Observational teamwork assessment for surgery
Post-op	Post-operative phase of surgery
Pre-op	Pre-operative phase of surgery
S	Surgeon
SN	Scrub/sterile nurse

OTAS (Observational Teamwork Assessment for Surgery) user manual

This manual provides a step by step guide to understand the practical issues for using the instrument along with some background about the development of the measures.

Introduction

Teamwork is fundamental to effective surgery yet there are currently no measures to;

1. Assess the impact of teamwork on outcomes
2. Evaluate teamwork for training
3. Evaluate the effect of team interventions

The development of measures of team performance in other high risk environments has proved to be a complex undertaking. There are several methods for assessing teams and team work such as interviews, questionnaires and observation. After developing an interview to assess the current perceptions of teamwork (Undre et al 2006), we set out to develop an observational assessment for teamwork. Observational research has been used in many other high risk domains effectively and more recently for assessing communication and errors in the operating theatre. Team assessment measures in aviation, military and naval settings provided important guidelines, however none of the measurement tools were directly applicable to surgery. Therefore, we attempted to derive our own measures from guidelines of best surgical practice, combining broader dimensions of behaviour relevant to the surgical context and the assessment of specific surgical, anaesthetic and nursing tasks. We have, in the first instance, focused on assessing the team skills required for relatively routine surgery, while recognising that more complex team skills may need to be incorporated at a later date.

Overview

OTAS was developed by a team of surgeons and psychologists and was initially designed to be used by two observers in theatre. Though the initial pilot and series of data collected so far has been collected by a surgeon and psychologist each measuring different aspects of teamwork. However we envisage that different researchers may utilise the instrument in various ways tailoring it to the needs of their respective teams. For example some researchers may not have the luxury of having observers from both psychology and surgery. These groups may modify the instrument to incorporate tasks and may wish to apply behavioural scales to some extent that would be practically possible by a surgeon or nurse in theatre. Other groups may purely use the behavioural aspects of the instrument to suit their own purposes.

The aim of this work was to develop a practical method of assessing teamwork in theatre able to capture the most important behavioural dimensions of surgical teamwork and task completion. We aimed to test the feasibility and practicality of systematic observations in the operating theatre. OTAS is a preliminary step toward assessing that safe practice; it addresses concurrently *what* surgical teams do and *how* they do it. It provides a framework for an evolving assessment and a useful reference for anyone attempting to develop their own team work assessment instrument. The full conceptual background, research findings and the development of OTAS are described in a series of papers (see appendix). This short guide or user manual is designed with an aim to provide straightforward practical information about the use of the task list and behavioural scales for anyone wishing to undertake team observations in the operating theatre.

The structure of OTAS

OTAS has two elements, each completed in the current format by separate observers addressing different aspects of teamwork: a task checklist, completed by a surgical observer (observer 1), and an assessment of team behaviour on five dimensions, completed by a psychologist (observer 2).

The surgical observer may be a surgeon or any member with sufficient knowledge of the theatre practices and the stages of the operation to a level that they may score the check list accurately. The second observer, who was a psychologist in our study, could be a researcher with experience in human factors or a clinician familiar with the psychological approach to teamwork. All observers need to be trained to a consistent level before they observe independently.

Other measures recorded during observation included operative stage times, team composition in theatre and a record of any critical incidents.

Surgical process

The general surgical process is divided into phases and stages (Table 1). Each phase consists of distinct stages. We use the abbreviations PRE, OP and POST to refer to pre-operative, intra-operative and post-operative stages respectively.

Phase	Stage 1	Stage 2	Stage 3
1 PRE-OP	pre-op planning and preparation	patient sent for to anaesthesia	patient set-up to op-readiness
2 INTRA-OP	opening/ access to contact of target organ	op-specific procedure	from prepare to close to closure complete
3 POST-OP	anaesthetic reversal to exit	recovery & transfer	Feedback -self-assessment (under development)

The measures

The measures are divided into the task or checklists and the behaviours which a are recorded by two separate observers. These are measured across the entire surgical process using the stages and phases to guide transition and ease of recording data. A description of the measures and the requirements for the observers are given below. This is not by any means exhaustive and we appreciate that researchers wishing to use the instrument may modify various aspects of this assessment to suit institutional needs or research requirements. We have separated the two separate types of measures to allow a more thorough understanding of the process of data collection.

Task checklist

The Observer (observer 1)

Observer 1 ideally should be a domain expert or at least have sufficient surgical knowledge to understand the phases and stages of the operation. They should also be familiar with all the equipment in theatre so they have sufficient knowledge for marking the task list. In our experience any doctor or scrub nurse who has spent at least 2 years in surgery or the operating theatre after a period of initial training could perform adequately as observer 1. The training period may vary from person to person but our own initial experience is that if the person has sufficient domain knowledge the training period may be as short as 10 operations before the observer is ready to evaluate the tasks on their own.

The Tasks (checklist measures)

The task list was constructed for each stage and phase of the operation with the help of experts using the various theatre protocols and guidelines available. Tasks were divided into three categories: patient, equipment and communications tasks. Patient-centred tasks comprised either actions or information associated directly with the patient such as safe transfer to operating table and patient notes present. Equipment-centred checks included checking and counting of surgical instruments. Communication-centred tasks included information such as confirmation of the patient details, consent and side of the operation.

Criteria for scoring the task list

Items on the task checklist are marked yes or no depending on whether the task has been properly carried out. For example, under the category of equipment preparation, diathermy machine preparation was scored positive if it was switched on and tested prior the operation. Likewise, the anaesthetic machines were deemed checked if the anaesthetist on duty was observed running through standard testing. In some instances the anaesthetic machines may have been checked prior to the observers entering the theatre suite. This information can be obtained by asking the operating department practitioner or anaesthetic nurse (ODP/ Anaes nurse) or by checking the anaesthetic chart which may have a specific section on checking of anaesthetic machines. In our hospital the chart has to be signed and dated along with the time the machine was checked by the anaesthetist. If the operation is the second or subsequent case of the day, all the machines are scored as checked on the presumption that they had been working correctly in the previous case. If however the particular instrument or equipment had not been used then the same criteria as the first case would apply. Some cases may not require some of the machines or indeed may not be performed under anaesthesia. In these cases the check list scores should be marked N/A as they can be omitted from the analysis for that particular case. Similarly with cases that do not require the different team members (e.g. anaesthetist in local anaesthetic procedures) the scores will have to be altered accordingly.

The procedure

Pre-operative phase:

Observer 1 should enter the operating room before the patient arrives. The observer begins checking pre-operative planning tasks the PRE 1 stage, namely whether the patient has been allocated a bed and whether patient notes are prepared. Such information is gained by asking the relevant personnel and by examining the patient notes in detail. Observer 1 also checks whether appropriate equipment and instruments are available and whether the anaesthetic equipment logbook is up-to-date. Communications, among staff, concerning patient-consent, co-morbidity and special requirements, such as allergy to latex are also checked. Additional information about any changes to the list or requests for special equipment or last minute change in procedures may be gained from the theatre staff.

In stage Pre2, Observer 1 must observe the anaesthetic procedure in the anaesthetic room and at the same time carry on checking tasks which may be occurring in the nursing prep room and the main operating suite. This may be sometimes difficult and observer 1 may have to move from room to room to gather all the information required for that stage.

In Pre 3, Observer 1 will perform checks for specific tasks that must be carried out during patient set-up ready for incision, such as Ted-stockings, use of warming blanket and appropriate pressure point protectors. In addition, the positioning of the patient, readiness of the equipment such as diathermy and suction apparatus is also checked. Essential communication such as request for antibiotics and announcing the start of the procedure is also noted at this point.

Intra-Operative:

Intra-op1 is a crucial stage, where the whole team must be fully prepared for incision. This phase is the time when the main operative procedure is underway from the incision right up to the point of closure. Observer 1 continues with recording task list checks during the intra-operative phase, checking that the patient has been draped correctly and whether equipment settings and placement are correct and organised appropriately. Observer 1 also checks that the surgeon and anaesthetist confirm verbally that the incision can be made. In addition, the team composition is noted during this stage and whether all the members of the surgical team are adequately supervised or not.

During Intra-op 2, the operation proper, Observer 1 checks for correct handling of sharps, appropriate use of equipment and instruments, whether there are sufficient swabs and sharps and whether patient condition is monitored adequately. Observer 1 also checks for essential communication tasks between surgeon and anaesthetist. The team composition is noted during this stage and whether all the members of the surgical team are adequately supervised or not.

During Intra-op 3 Observer 1 checks for blood-loss analysis, swab and instrument checks, correct dressing and suturing and essential communications between surgeon and anaesthetist. As in the other operative stages the team composition is noted during this stage and whether all the members of the surgical team are adequately supervised or not.

Post-Operative:

This phase lasts from closure and anaesthetic reversal to after the transfer of the patient to the recovery room, Observer 1 records patient transfer form the operating table onto the transfer trolley or bed and notes specifically whether the patient's airway is maintained, pressure and diathermy areas checked and oxygen-mask fitted and patient cleaned. Safe transfer to trolley is also recorded by Observer 1.

Post op 2 is the final observation stage where the patient is transferred from the OR to recovery. Observer 1 follows the anaesthetist and accompanying nurse along with the patient to the recovery room where transfer is observed. Observer 1 checks that patient notes and x-rays accompany the patient, that adequate fluids and analgesia has been administered to the patient and whether the recovery staff were ready to receive the patient. Observer 1 also checks that the patient is made comfortable and that essential information is transferred from the anaesthetist, scrub-nurse to the recovery nurse, namely, information regarding the operation carried out, drugs administered and any other patient specific requirements.

Team behaviours (behavioural measures)

The Observer (observer 2)

For the purposes of our research observer 2 was a post doctoral psychologist and had considerable experience of observing theatre teams. Ideally Observer 2 should have had some training in behavioural sciences or ergonomics and be familiar with psychological approaches to teamwork. However a clinician with an interest and knowledge of teamwork could be a very effective Observer 2.

We believe that, it is preferable that, unlike Observer 1, Observer 2 is *not* a clinician or at least be able to put aside their clinical perspective on events. During the years of OTAS development, we have found that a non-clinician is better suited to be an "external observer" of events and interactions that take place in the operating theatre. In addition, we have found that it is easier for clinicians to understand and believe that they are not assessed individually if a non-clinician is involved in the observations. Moreover, from a practical point of view, a non-clinician is less likely to be distracted by requests for assistance coming from OT staff – such requests are harder to avoid in the case of a clinician observer.

Although Observer 2 need not have formal clinical training, it is essential that he/she has had adequate exposure to the operating theatre environment before starting using the OTAS to assess operating theatre teams. In our experience this could vary but should be approximately 10-25 procedures. Ideally, the procedures will not be identical to each other, but they will be from the same surgical specialty (e.g., vascular, urological, cardiothoracic, etc.). For reasons that relate to the sampling of observed behaviours, a degree of variability in the procedures is necessary for Observer 2, as it allows him/her (i) to observe a range of behaviours and (ii) to understand what the observable behavioural cues are that he/she should be recording and using as inputs for the ratings. Too much variability, however, is likely to obscure the patterns of observable behaviours that a non-clinician observer would otherwise be able to extract from procedures in the same specialty – hence our recommendation for procedures within a single surgical specialty. If the aim is to use OTAS in a variety of surgical specialties (e.g., for cross-specialty comparisons), we recommend an initial exposure of Observer 2 to procedures in a single specialty, followed by exposure to procedures in the second specialty of interest and so on.

Since we have found that, after the initial familiarisation with procedures in a single surgical specialty, it is easier for Observer 2 to familiarise with procedures in a different specialty, we recommend a minimum of 10 procedures as initial exposure to every specialty following the first one (i.e., a familiarisation process shortened by 60%).

Teamwork behaviour scales

OTAS uses five broad behavioural dimensions or constructs which have been adapted from Dickinson and McIntyre 1997, who used 7 constructs to rate team work. The five we chose to use which we felt were most appropriate for observing theatre teams were as follows.

- Communication
- Leadership
- Co-ordination
- Monitoring
- Co-operation

The five teamwork behaviours are rated with the following scales, guided by exemplar behaviours and demonstrative scenarios that help indicate levels of behaviour typical of effective or ineffective performance. Behavioural summary scales are used to rate performance with broad summary statements of behaviour. The summary scales are ordinal: each scale-point relating to a certain level of quality and perhaps quantity of a given teamwork component, determined by various descriptive elements of a component; the scales were designed with certain rules:

4. Behaviour rating scales are for assessing routine interdisciplinary teamwork in general surgery.

5. Each behavioural rating scale relates to a single *interdisciplinary* 'team function'.

6. The scales should not be too specific to scenario, group or event. They should be equally applicable to all disciplinary groups in any operative phase. (See appendix)

7. Together, the behaviours rated should discriminate varying levels of interdisciplinary team performance, providing some objective indication of why one team is more effective than another team

Exemplar behaviours - Exemplar behaviours are items that serve to guide the observer in 'looking for behaviours' that indicate effective teamwork behaviour. Exemplar behaviours may be checked for their occurrence, in support of overall behaviour ratings (see appendix).

Demonstrative scenarios - Scenarios provide a context in which behaviours are related to levels of effectiveness (see appendix). They demonstrate that certain patterns of team behaviour are associated with certain levels of team effectiveness. Scenarios are particularly useful for calibrating the rating of behaviour to a standardised ordinal scale.

The Procedure

An important issue is to consider the balance between actual observation and performance scoring. Scoring should be as simple as possible, so that notation can be carried out without disrupting the process of observing the team. Inevitably, during observation and notation, observers of fast-paced work must rely on their short-term memory to some extent; however, the reliance on memory should be minimised to preserve accuracy.

Pre-operative phase:

Observer 2 needs to enter the operating room before the patient arrives. Observer 2 then begins observing and noting teamwork behaviours as they occur using a form with the abbreviation key and headings below it (see appendix). Observer 2 may also record exemplar behaviours, together with actors' role-identity the event or incident and their corresponding behaviours.

During PRE 2, Observer 2 continues recording behaviours, which are usually related to the anaesthesia and preparation for operation. In Pre3, the final preoperative phase, Observer 2 uses the behaviour summary scales to provide ratings for his/her overall impression of each behaviour that is displayed by the team, supported by a record of exemplar behaviours related to events observed.

Intra-Operative:

Intra-op1 is a crucial stage, where the whole team must be fully prepared for incision. Observer 2 continues with checking behaviours during the intra-operative phase. During Intra-op 2, the operation proper, Observer 2 continues recording behaviours, which are usually somewhat stable as the surgeon operates with assistance from the scrub-nurse, supported by surgical assistants and circulating nurses. During Intra-op 3 Observer 2 continues as before and toward closure rates team behaviours with the behavioural summary scale.

Post-Operative:

From closure and anaesthetic reversal, Observer 2 continues with behaviour recording, noting particularly the availability of team members to assist in safe patient transfer to trolley.

Post 2 is the final observation stage where the patient is transferred from the OR to recovery. Observer 1 and Observer 2 follow the anaesthetist and accompanying nurse to the recovery room where transfer is observed. Observer 2 enters the recovery room before the patient to observe the action and communication provided by the recovery team upon patient and OR staff entry. Observer 2 records the observed behaviour among the relevant team members and rates team behaviours for the post-operative phase accordingly.

Validity and Reliability

For the purpose of audit or simple initial survey of theatre teams it may be possible to use the measures as they are. However for a more robust research program then issues of validity and reliability will have to be considered and the training tailored accordingly.

Technical and practical difficulties

We encountered a number of difficulties and practical problems during the course of our research. We have outlined these and provide suggestions on how to tackle them.

- The researchers may find that on the morning of the operation some team member may object to the presence of the researchers in theatre. In these cases a full explanation of the project should be offered stressing the fact that individuals are not being assessed in any way. If this still does not appease the team then observations may not be possible for that case. Attempts should be made to discuss the project again at length at another time especially if the team member is likely to be present in a large number of cases in the future.
- There may be too many people in theatre which may affect the team behaviour and hinder team observations too. In these cases the two observers may choose to stay for part of the case and if it is felt that indeed the data collection is hampered by the number of surplus people then they should abandon the data collection for that procedure.
- Some teams especially in the early stages may be behaving differently when observers are in theatre. This problem becomes less obvious when observing the same team on numerous occasions and they "let down their guard" after the observers have built a rapport with the team.
- A lot of the information may have been exchanged prior to the observers coming to theatre and unless a rapport has been built with the theatre staff a lot of the information may be lost. The way to combat this problem is to ask the team members immediately after the case about any information which may have been missed such as the delays in patient arriving, changes to the list.

Consent from the staff

Consent, either verbal or written, must be obtained from all the staff members present during the procedure. It is important however that the obtaining of consent does not hinder the data collection. We found that some members of staff resist observers in theatre and some may be unnecessarily alarmed or anxious and may actually affect the team behaviour. The best way to solve this is to build up a rapport with the theatre staff well in advance and obtain consent after a thorough explanation of the research exercise. Consent may be obtained for a series of cases instead of per case if the members are likely to remain constant to that theatre suite.

Conclusions

We have found this tool to be extremely helpful in assessing surgical teams. We hope that it will have a place both in research on surgical teams and in identifying training needs so specific team based training can be tailored according to the needs. By gaining valuable information about successful, smooth running and efficient teams we hope that further interventions can be developed to enhance poorly functioning teams in theatre. Different groups may wish to use this instrument either to modify or help develop their own assessment tools. This guide has aimed to provide a complete understanding of our experience and hopes to simplify team assessment in theatre for a variety of purposes.

Appendix

Task list for Observer 1

	Pre1	
1	**Pre-Op planning and prep before pt sent for**	**Opt**
	(before pt sent for)	
A	***Team Tasks***	
	patient	
1	Patient notes prepared	1
	equipment	
1	specific equipment available	1
2	specific instruments available	1
3	Anaes. logbook for maintenance available and uptodate	1
	communication	
1	patient consents to the surgery	1
2	surgeon informs of co morbidities	1
3	surgeon informs of special equipment	1
4	Anae-ODA (pt spec requirements)	1
5	Anae informs of special needs	1
6	theatre list produced & displayed	1
7	changes in list or delays	0
	OPERATION NAME	?
	OPEN=1; CLOSED=2	?
	Pre2	
	Pt sent for (PS) - to Anaesthesia (AS)	**Opt**
T1	***Sent for time***	**?**
T2	***Arrival time***	**?**
T3	***Anaesthesia start***	**?**
A	***Team Tasks***	
	patient	
1	patient sent for	1

2	correct patient verified	1
3	surgical site & laterality verified	1
4	surgical procedure verified	1
5	notes & x-rays present for patient	1
6	patient condition monitored by Anaesthetist	1
	equipment & provisions	
1	Anae. Equip. checked and working	1
2	Surg. Instruments and equipment checked and working	1
3	op-specific equip. checked working	1
4	Anae. Drugs prepared	1
	communication	
1	surgeon briefs team on procedure	1
2	Anae-ODA discuss pt requirements	1
3	Sn & Cn confirm instruments check	1
4	correct patient confirmed verbally	1
5	procedure confirmed verbally	1
6	surgical site laterality verbally confirmed	1
B	***Condition of patient***	
1	anaesthetised	1
	Pre3	
	Set-up (PIR) to op readiness (PC)	**Opt**
T4	***Set-up time***	**?**
A	***Team Tasks***	
	patient	
1	safe transfer to operating table	1
2	pressure points protected	1
3	td stockings	1
4	Anae-ODA airway check	1
5	correct position for procedure	1
6	surg-oda patient position	1
7	betadine painting	
8	Draping	
	equipment & provisions	
1	diathermy pad applied	1

2	arm boards	1
3	diathermy checked and ready	1
4	suction prepared and ready	1
5	warming blanket	1
6	catheter	1
	communication	
1	Antibiotics noted verbally	1
B	***Condition of patient***	
1	anaesthetised	1
2	Physiology within range	
C	***Critical incidents***	
1	critical incident hazards to pt or staff	0
2	critical incidents reported	1
D	***Team Composition in theatre (at incision/access of pt)***	
1	surgeon	1
	assistant	1
	supervised	1
2	sn	1
	assistant	?
	supervised	1
3	cn	1
4	anes	1
	assistant	?
	supervised	
5	oda	1
	assistant	?
	supervised	1
6	ancillary staff	?
7	surplus staff kept to minimum	≤4
	Op1	
	Opening - from access (PCT) to contact of target organ	**Opt**
T5	***Time of Incision***	**?**

A	***Team Tasks***	
	patient	
1	Anaes. monitoring maintained	1
2	blood/fluids monitored	1
	equipment & provisions	
1	pedals to surgeon	1
2	adjusting light	1
3	connection of leads and suction	1
4	diathermy settings	1
5	hand-free instrument transfer	1
6	swabs and sharps organised	1
7	sterile handles for spotlight	1
	communication	
1	OK to start	1
2	OK to start acknowedgement	1
3	SGN clearly instructs SN on instruments	1
B	***Condition of patient***	
1	anaesthetised	1
2	physiology within range	
D	***Team Composition in theatre***	
	(at incision/access of pt)	
1	surgeon	1
	assistant	1
	supervised	1
2	sn	1
	assistant	?
	supervised	1
3	cn	1
4	anes	1
	assistant	?
	supervised	
5	oda	1
	assistant	?
	supervised	1
6	ancillary staff	?
7	surplus staff kept to minimum	≤4

	Op2	
	Op-specific procedure to PCB	**Opt**
T6	***Time at target***	**?**
A	***Team Tasks***	
	patient	
1	anaes checking pt condition	1
2	surgeon performing procedure	1
3	Anaes. monitoring maintained	1
4	blood/fluids monitored	1
	equipment & provisions	
1	hand-free sharps handling	1
2	sufficient and appropriate swabs and sharps	1
	communication	
1	Anaes. updating on pt condition	1
2	Anaes. - maintenance of Anaess	
3	surg. Informs of bleeding etc	1
B	***Condition of patient***	
1	anaesthetised	1
2	physiology within range	
D	***Team Composition in theatre***	
	(at incision/access of pt)	
1	surgeon	1
	assistant	1
	supervised	1
2	sn	1
	assistant	?
	supervised	1
3	cn	1
4	anes	1
	assistant	?
	supervised	
5	oda	1
	assistant	?
	supervised	1

6	ancillary staff	?
7	surplus staff kept to minimum	≤4
	Op3	
	Prep to close (PCB) to close (PF)	**Opt**
T7	***Time - ready to close***	**?**
A	***Team Tasks***	
	patient	
1	blood loss analysis	1
2	correct suture	1
3	correct dressing	1
4	Anaes. monitoring maintained	1
5	blood/fluids monitored	1
	equipment & provisions	
1	supplying requested drains	1
2	swab and instrument count	1
3	supplying suture material	1
4	hand-free instrument transfer	1
	communication	
1	surgeon states closure start	1
2	Anaesthetist acknowledgement	1
3	SG instructs SN on sutures for closure	1
4	Anaes instructs ODA on reversal	1
	SN states final count	
B	***Condition of patient***	
1	anaesthetised	1
2	physiology within range	
C	***Critical incidents***	
1	critical incident/ hazards to pt or staff	0
2	critical incidents reported	1
D	***Team Composition in theatre (at incision/access of pt)***	
1	surgeon	1
	assistant	1

	supervised	1
2	sn	1
	assistant	?
	supervised	1
3	cn	1
4	anes	1
	assistant	?
	supervised	
5	oda	1
	assistant	?
	supervised	1
6	ancillary staff	?
7	surplus staff kept to minimum	≤4

	Post1	
	Anae Reversal to exit (POR)	**Opt**
T8	***Time at reversal start***	**?**
A	***Team Tasks***	
	patient	
1	check for diathermy burns	1
2	check pressure areas	1
3	drains catheter safely positioned and working	1
4	ensure airway is maintained	1
5	safe transfer to trolley	1
6	cleaning up the patient	1
7	removal of diathermy pad	1
8	drapes removed	1
9	extubation	1
10	oxygen mask attached	1
	equipment & provisions	
1	sharps safely disposed of	1
2	dismantling of equipment	1
3	suction for Anaesthesia	1
4	oxygen supply OK	1
5	Sats probe	1
6	dressing	1
7	theatre cleaned up	
	communication	
1	airway instructions to oda	1
2	Anaes. Oks pt removal	1

3	Staff verbal comm to pt to waken	1
B	***Condition of patient***	
1	physiology within range	1
D	***Team Composition in theatre***	
	(at incision/access of pt)	
1	surgeon	1
	assistant	1
	supervised	1
2	sn	1
	assistant	?
	supervised	1
3	cn	1
4	anes	1
	assistant	?
	supervised	
5	oda	1
	assistant	?
	supervised	1
6	ancillary staff	?
7	surplus staff kept to minimum	≤4
	Post 2	
	Recovery and transfer	**Opt**
T9	***Exit Time***	?
A	***Team Tasks***	
	patient	
1	ensure notes & x rays with pt	1
2	adequate fluids and post op instructions	1
3	adequate analgesia written up/pca set up	1
4	Patient made comfortable	1
	communication	
1	ensure op note written and filed	1
2	drug chart & instructions hand-over	1
3	ensure notes and x rays are with pt	1
4	SN hand-over to RN	1
5	anaes. informs rec. of pt condition	1

6	anes. Informs rec. of drugs used	1
7	recovery staff acknowledge information	1
C	***Condition of patient***	
1	physiology within range	
D	***Critical incidents***	
1	Critical incident/ hazards to pt or staff	0
2	Critical incidents reported	1
F	***Equipment condition***	
1	recovery equipment prepared for pt	1

Communication SUMMARY SCALE

6	The team exchanged information proactively and politely. Case specific communication was clearly audible and well articulated. The team made a concerted and consistent effort to maintain open communication in order to fulfil teamwork. • Team communication was highly effective in enhancing team work.

5	• High level of enhancement to team work through communication

4	• Moderate enhancement to team work through communication

3	Case specific communication was acceptable, though members did sometimes seek clarification. The manner and effort of communication was reasonable. Team communication neither hindered nor enhanced team work. Team communication neither enhanced nor hindered teamwork

2	• Slight detriment to team work through communication

1	• Team work compromised through poor communication

0	The team did not communicate appropriately. Case specific communication was unclear and members consistently sought clarification, and repeats, or did not ask for clarification. The manner of communication was negative and unacceptable. This team had a problem communicating openly. Overall, the function of this team was hindered by poor communication. • Team communication severely hindered team work

EXEMPLAR BEHAVIOURS for Communication

PREOP

A	N	S
• Updates theatre manager on any changes to case list • Confirms pt details and condition with patient and informs N • Verbal communication to theatre team on patient transfer and set-up	• Scrub nurse mediates progress of case through proactive communication • Confirms patient specific requirements with A & S • Communicate any problems regarding set-up, provisions and staffing to team	• Changes to operation or case list communicated to all concerned • S talks to team and encourages communication from sub-teams • Verbal confirmation of procedure and intra-op requirements

INTRAOP

A	N	S
• Asks surgeons if patient positioning is OK • Provides update on patient condition and anything administered to patient • A enquires about operation and patient progress	• SN repeats surgeon's requests, confirming requirements • SN provides clear and audible requests for provisions to CN • Swabs needles and instrument s count confirmed verbally between CN and SN	• Asks team if all are prepared to begin the operation • Asks A if ready to start the operation • Requests and instructions to team communicated clearly and effectively • Provides information to whole team on progress • S informs the team of technical difficulties and/or changes of plan • S informs A of bleeding

POSTOP

A	N	S
• A instructs team on patient transfer to trolley • Asks team if ready to transfer patient and instructs on process • Information on patient condition and drugs provided to recovery nurse • A informs Surgeon about special needs for analgesia	• Provides information concerning surgical procedure and patient condition to recovery nurses • Recovery nurse confirms information transferred from theatre team • Ensures that patient documents are with patient in recovery	• Informs and instructs team on any new patient requirements. • Comments on work done in this case

DEMONSTRATIVE SCENARIOS for communication scales

6	Surgeon explains clearly and audibly the steps of the operation to assistant and team throughout the procedure. Clear and audible instructions of A to the team regarding the latest blood gas report and that he will be giving to patient 2 units of blood. Scrub nurse is aware and informs the team the circulating nurse is new and provides clear instructions about the location and type of instruments required.

3	Surgeon mostly busy operating but communicates effectively with scrub nurse when asked about progress explaining that he will be resecting the bowel and that he will need a staple gun. Anaesthetist not volunteering patient management information but she is polite and clear when asked by the surgeon and explains that she has given muscle relaxant that will last for 20 minutes. When A reminds surgeon about requirements for local infiltration of anaesthetic to the wound, scrub nurse communicates with Anaesthetist about amount of local anaesthetic to be infiltrated before closure.

0	Enquiry by surgeon about cardiovascular status of patient met with hostile comments from anaesthetist about inadequacy of patient preparation. Surgeon entirely uncommunicative, simply holding out hand when instrument required and dropping it if scrub nurse guesses incorrectly. Scrub nurse chatting loudly to circulating nurse about unrelated matters to the operation whilst surgeon and assistant request instruments from her.

SUMMARY SCALE for Cooperation

6	Team members acknowledged and acted upon suggestions and requests from each other immediately and fully. Members offered and gave assistance and support to each other and compensated for weaknesses and difficulties. They made a concerted and consistent effort to co-operate with each other. • Their co-operation enhanced team function.

5	• High level of enhancement to team teamwork through co-operation

4	• Moderate enhancement to team teamwork through co-operation

3	They acted on requests but did not always acknowledge them. They gave some assistance to others but did not compensate fully for weakness or difficulties. Team members co-operated with each other but without making an extra effort. • Their co-operation did not hinder or enhance team work.

2	• Slight detriment to team work through lack of co-operation

1	• Team work compromised through lack of co-operation

0	They did not meet all requests from other members and were clearly uncooperative. They made little or no effort to help or compensate for others' weaknesses or difficulties. Members were uncooperative to one another. • The lack of co-operation severely hindered team function.

EXEMPLAR BEHAVIOURS for Cooperation

PREOPERATION

A	N	S
• ODP provides assistance to A • A team provide timely information on request from N team • Respond to requests from S concerning results or condition of patient	• Co-operate with any last minute requests from S • Provide support and assistance to A if needed • Help surgeons with gowns and dress patient in preparation for operation	• Respond to questions and requests from N • Respond to questions and requests from A • Provide assistance in patient set-up

INTRAOPERATION

A	N	S
• A responds to S requests immediately • A provides team with information requested • ODP acts on requests and inquiry from team • ODP being proactive and provide support when needed	• SN responds well to requests from S and provides smooth exchange of instruments • CN responds to instructions and requests from SN • SN supports and compensates for inexperience of CN or unfamiliarity with the environment of agency staff	• Reacts positively to questions and requests from N • Responds to requests or questions from A • Ensures smooth instrument exchange with SN • S supports the AS and compensates for lack of experience of AS or SN

POSTOPERATION

A	N	S
• ODP provides support and responds to A requests during anaesthetic reversal • ODP responds well to requests from the team • A respond well to questions from team	• CN and SN co-operate in dismantling equipment and clearing theatre • Acknowledge requests from S • Recovery N responds to patient entry and to theatre team instructions	• S assistants remain to help with safe patient transfer to trolley • S ensures documentation is up-to-date and transferred with the patient

DEMONSTRATIVE SCENARIOS for Cooperation

6	Scrub nurse volunteers to act as extra assistant and retract during difficult phase of procedure; Surgeon offers to help in transferring patient on/off table. Anaesthetist responds immediately to surgeon's request (e.g., to alter the table's position). ODP helping SN if CN not in the room without being asked to do so.

3	Surgeon responds with correct information only when asked by inexperienced scrub nurse to explain what specific equipment is needed for joint replacement; Anaesthetist gives more relaxant on request, but only after asked to do so; Scrub nurse provides correct sutures for dealing with haemorrhage but only in response to exact instructions.

0	Scrub nurse refuses to hold retractor for surgeon in difficulty as this is not her role. Surgeon stops work altogether because of difficulty from partial failure of lung collapse by anaesthetist during thoracotomy, and makes unhelpful comments about anaesthetist's competence. Assistant upset by an earlier reprimand behaves in entirely passive fashion and makes no active attempt to help surgeon see operative field by using the suction poorly.

SUMMARY SCALE for Coordiantion

6	Within and between stages they co-ordinated among individual tasks and within shared tasks. Members were present when required at each stage to co-ordinate activities. They made a concerted and consistent effort to ensure team tasks co-ordinated. • Co-ordination was highly effective and enhanced team function.
5	High level of enhancement to team work through co-ordination
4	Moderate enhancement to team work through co-ordination
3	Within and between stages they co-ordinated most of their tasks with those of other members. Not all members were always present when required at each stage. They made some effort to ensure team tasks co-ordinated. • Co-ordination was reasonable and did not hinder or enhance team work
2	Slight detriment to team teamwork through lack of co-ordination
1	Team function compromised through lack of co-ordination
0	Within and between stages they did not co-ordinate tasks and events. The lack of co-ordination disrupted team process. The team made little effort to ensure team tasks co-ordinated. • Co-ordination was ineffective and severely hindered team function (or teamwork).

EXEMPLAR BEHAVIOURS for Coordination

PREOPERATION

A	N	S
• cA present to supervise A trainee during anaesthetic process • ODA and A present when patient enters • The ODA prepares the drugs and hands the equipment to the A in a timely fashion for anaesthesia to progress in a smoothly and co-ordinated manner	• Nursing team preparing trolley and theatre in readiness for operation • SN prepared for operation waiting in prep room to maintain sterility • Nursing team arrange stack appropriately for laparoscopic operation • Final arrangements of equipment and provisions as surgeons finish set-up	• Surgeons arrive in preparation for patient entry to theatre and set-up • Final assessments of patient and equipment made before scrubbing • Surgeons scrub while nurses and A complete set-up

INTRAOPERATION

A	N	S
• Ready for operation when surgeons are ready to operate • A ensures all provisions at hand • Information provided about changes in patient condition as they occur	• CNs proactive in checking SN provisions prepared and ready during operation • SN anticipates S requirements for instruments • A CN is always present to provide backup to SN	• Gives prior notification of requirements to SN to enhance timing of instrument exchange • Surgeons co-ordinate use of equipment, such as camera in MAS providing adequate view of operating filed • Contributes to smooth exchange of instruments and provisions with SN

POSTOPERATION

A	N	S
• Lines and patient set-up on trolley checked before transport • ODP available to assist A in transfer of patient to trolley	• Immediate dismantle and removal of instruments and equipment before patient exit • Recovery Nurse prepared for patient transfer and set-up in recovery	• S assistants remain to help on patient transfer to trolley

DEMONSTRATIVE SCENARIOS for Coordination

6	SN paying attention and is ready with instruments before being asked by S. Passing of mounted ties and release of artery forceps appropriately on request when operating deep in the abdomen of chest by AS or SN. Drains and suture ready by CN. ODP ready with reversal drugs and helps A with extubation.

3	Scrub nurse warns anaesthetist that surgeon is about to release aortic clamp because surgeon forgets to do so. Assistant attempts to provide perfect retraction and "following" of suture during abdominal closure, but surgeon concentrating on the procedure does not facilitate this. Team moves patient to trolley, with minimal discussion or planning.

0	Surgeon begins incision without checking if anaesthetist is ready. Assistant releases artery forceps when he thinks surgeon is ready though he is not and the patient starts to bleed. Scrub nurse begins swab and instrument count with circulating nurse whilst surgeon is in urgent need of instruments. Team moves patient to trolley without planning and just misses dropping the patient.

SUMMARY SCALE for Leadership

6	Members provided direction, instruction and explanation to the team. They fully asserted themselves in drawing attention to team process and changing events. They were proactive in their effort to direct the team to relevant events and process. • Excellent leadership which enhanced team work.

5	• High level of enhancement to team work through shared leadership

4	• Moderate enhancement to team work through shared leadership

3	They provided some evidence of leading the team. They made some suggestions to direct the team's attention to process or events. • Their leadership did not hinder or enhance team work.

2	• Slight detriment to team work through lack of shared leadership and by not being assertive enough to direct teamwork

1	• Team work compromised through lack of shared leadership

0	They did not provide any leadership when they should have. They made no attempt to instruct the team when it was their responsibility to do so. They made no effort in directing the team when events dictated they should have. • Their lack of leadership severely hindered team work.

EXEMPLAR BEHAVIOURS for Leadership

PREOPERATION

A	N	S
• Take lead on transfer of patient to operating table and set-up • Questions asked about drugs and antibiotics to Surgeon • cA provides instruction and explanation to staff about drug requirements	• Take lead in response to case list changes • N team provides instruction and explanation to staff	• Take lead to instruct team on consequences of change to operation • Enquiry into any problems encountered by N and A sub-teams • Provide confirmation with N for specific surgical requirements

INTRAOPERATION

A	N	S
• Advises team on best management for patient • cA instructs A and ODP and team on crisis contingency plans • Supervision provided for staff lacking familiarity with tasks or equipment	• Informs S and/or A of any concerns in procedure and or equipment • Assertive in controlling noise and distractions in theatre • Supervision provided for staff lacking familiarity with tasks or equipment	• Instructions and explanations provided to assistants • Advises A if unfamiliar with operative technique (e.g., tube insertion) to call for senior help • Supervision provided for staff lacking familiarity with tasks or equipment

POSTOPERATION

A	N	S
• A takes lead on anaes. reversal and manoeuvring of patient • A ensures sufficient staff remain to help transfer pt safely • ODA proactive in supporting A	• Questions asked of surgeons with regard to any special requirements for patient • Summarises plans for next case	• Instructions provided to team on any post-operative requirements for patient • Provides explanation regarding the next case

DEMONSTRATIVE SCENARIOS for Leadership

6	Anaesthetist directs team activity during appropriate anaesthetic events. Scrub nurse takes control of counting procedure. Surgeon on opening anticipates extended procedure time and after discussion with team arranges to cancel a few cases on the list.

3	The surgeon and anaesthetist discuss whether the patient should go to ITU at the end of a very complex case although both were aware of patient's condition beforehand. Surgeon is hesitant to decide whether to perform Hartmann's procedure or subtotal colectomy for obstructing rectosigmoid tumour but formulates plan after suggestions from assistant and scrub nurse. SN advises and assists trainee surgeon in using correct procedure for wearing gown and gloves after being asked to do so.

0	Inexperienced surgeon instructs team to carry out ambitious procedure when not able to do it. Senior anaesthetist does not advise trainee surgeon to call for help although trainee surgeon clearly faces technical difficulties. Surgeon insists on sending for the next patient and the scrub nurse sends although she knows that she does not have adequate staff for the case.

SUMMARY SCALE for Awareness

6	The team showed clear evidence of monitoring and awareness of their individual tasks and those of other members. They were attentive, vigilant to process and changing events. They made a concerted and consistent effort in monitoring. • Awareness and monitoring were highly effective in enhancing team work.

5	• High level of enhancement to team work through effective monitoring and awareness

4	• Moderate enhancement to team work through effective monitoring

3	They showed some evidence of awareness and monitoring of team work and tasks. They were responsive to changing events, but could have been more vigilant. They were reasonably attentive and made some effort in monitoring teamwork. • Awareness did neither hinder nor enhance team work.

2	• Slight detriment to team work through lack of monitoring

1	• Team work compromised through lack of monitoring and lack of awareness of the work of other team members

0	They showed no evidence of awareness and monitoring of the work of the other team members and events. Their anticipation was poor and response to events delayed and unacceptable. • Lack of monitoring and awareness severely hindered team work.

EXEMPLAR BEHAVIOURS for Awareness

PREOPERATION

A	N	S
• Check correct patient and procedure • Monitor any changes to operation and drug requirements • Check condition of equipment, gases and provisions • Check patient is comfortable and stable on set-up	• Monitor changes to case-list • Monitor progress of anaesthesia • Check that patient is comfortable and heating blanket etc fitted • Monitor surgeon's availability	• Monitor final stages of patient and equipment set-up • Reassess set-up and intra-op requirements in advance • Monitor progress of anaesthesia

INTRAOPERATION

A	N	S
• Checks and refines set-up • Maintains monitoring of patient condition, blood loss and of surgical progress • ODP monitors requirements of drugs for anaesthetist	• Final checks on equipment and diathermy connections • SN observes procedure closely • CN observes procedure and monitors the needs of the SN	• Check table positioning and positions of team members • Assistants monitor direction of light • Checks team condition • Aware of patient condition including anaesthesia

POSTOPERATION

A	N	S
• Monitors patient condition upon transfer to trolley • Check that lines and patient set-up are correct for transport	• Monitor patient's positioning on transfer to trolley • Monitor handling of specimens and their labelling	• Monitors patient transfer to trolley and exit • Monitor labelling of specimens

DEMONSTRATIVE SCENARIOS for Awareness

6	Anaesthetist checks with surgeon about duration of procedure before giving more muscle relaxant. Scrub nurse asks circulating nurse to get staple gun tray out when anastomosis is imminent. Assistant asks surgeon if it is time to send for x-ray team for operative cholangiogram. Scrub nurse points out area of haemorrhage not seen by surgeon. Surgeon notices change in patient parameters and discusses plan with anaesthetist

3	Surgeon asks inexperienced assistant to hold clamp on major vein without checking whether the assistant is aware of when and how to release the instrument; Anaesthetist machine is alarming and the anaesthetist doesn't notice immediately. Surgeon has to ask twice for an instrument before the scrub nurse gives it to him.

0	Scrub-nurse constantly talking to circulating nurse and repeatedly needs to have attention attracted by surgeon. Assistant tired or pre-occupied and constantly needs to be asked to re-position retractors, which have been allowed to slip. Surgeon begins procedure without checking availability of special retractor, which has been used by another team. Anaesthetist engaged in conversation and unaware of bleeding in the surgical field.

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