Preoperative Preparation of Emergency Anaesthetic Drugs

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DECLARATION

I, Rima Husein, declare that this research report is my own work. It is being submitted for the degree of Master of Medicine in the branch of Anaesthesia and intensive care unit in the University of the Witwatersrand, Johannesburg. It has not been submitted before for any degree or examination at this or any other University.

Signature

Rima Husein

On this date 16October 2019

Abstract

Emergency anaesthetic drugs, are life-saving drugs routinely prepared by the anaesthetist before the start of the operating list. These drugs are discarded and a new batch of drugs is pre-prepared. Such pre-preparation has both advantages and disadvantages.

The aim of this study was to describe the practice of anaesthetists at the University of the Witwatersrand's academic training hospitals with regard to pre-preparation of emergency anaesthetic drugs, to describe the frequency of accidental drug administration and the degree of emergency drug contamination and wastage.

Methods

A questionnaire on the pre-preparation of emergency anaesthetic drugs was developed and distributed to members of the Department of Anaesthesiology at the three training hospitals of the University of the Witwatersrand.

Results

The total number of completed questionnaires was 194, giving a response rate of 88.5%. Eighty-four (43.30%) respondents always pre-prepare,101 (52.06%) only sometimes pre-prepare, and eight(4.12%) do not pre-prepare emergency anaesthetic drugs at the start of the list.

It has been observed that significantly fewer(34.82%) senior staff always pre-prepare emergency anaesthetic drugs compared to junior staff (58.11%) ($p<0.001$).Respondents with 0-2 years of experience pre-prepare emergency anaesthetic significantly more than respondents with six or more years of experience($p<0.001$).

The choice of emergency anaesthetic drugs routinely pre-prepared is dependent on the type of patient and the nature of surgery: elective or emergency surgery. The results showed a significant difference between practice for elective and emergency surgery: a significantly higher number of respondents prepare for succinylcholine, ephedrine, phenylephrine and adrenaline ($p=0.002$, $p=0.013$, $p=0.035$ and $p<0.001$ respectively) for emergency surgery. The result for atropine was non-significant ($p= 0.809$).

Conclusion

The practice of anaesthetists at three of the hospitals varies according to professional grade, nature of surgery and the type of patient. For the type and nature of surgery, the results show that senior staff tend to pre-prepare drugs less frequently than junior staff.

Departmental policy would assist to decrease the pre-preparation, and hence wasting of emergency anaesthetic drugs. It would also reduce the incidence of complications arising from their pre-preparation.

Introduction of pre-filled syringes for the most commonly used emergency anaesthetic drugs would be recommended to also decrease drug administration error and drug wastage.

Acknowledgements

I would like to say my warm thanks to a number of people who were involved in this project.

To all of my family: my mother, my husband and my children for all of their supporting and wishes.

To my hard worker supervisors, Dr Karin-Ann Ben-Israel for all her time, knowledge and effort.

To the following consultants from the Department of Anaesthesiology, University of the Witwatersrand for their invaluable input, guidance and assistance. In order to ensure content and face validity the questionnaire:

Prof Eddie Oosthuizen

Prof Analee Milner

Dr Alastair Moodley

To all of my colleagues: thank you for taking the time to complete questionnaires to succeed the study.

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List of Abbreviations

1. CMJAH	Charlotte Maxeke Johannesburg Academic Hospital
2. CHBAH	Chris Hani Baragwanath Academic Hospital
3. HJH	Helen Joseph Hospital
4. HPCSA	Health Professions Council of South Africa
5. WITS	Witwatersrand
6. CEO	Chief Operating Officers
7. UK	United Kingdom
8. MDV	Multiple-dose vial
9. SDV	Single-dose vial
10. ADX	Intravenous admixtures
11. NPSA	National Patient Safety Agency
12. APSF	Anaesthesia Patient Safety Foundation

Chapter One Overview of the research

1.1 Introduction

An assessment on the preoperative preparation of emergency anaesthetic drugs at three of the hospitals that comprise the University of the Witwatersrand's training hospitals, namely Charlotte Maxeke Johannesburg Academic Hospital (CMJAH), Chris Hani Baragwanath Academic Hospital (CHBAH)and Helen Joseph Hospital (HJH), was performed. This was done in order to describe the specific practices of anaesthetists, and their opinions regarding pre-preparation of emergency drugs as a source of drug administration error, contamination and wastage. This chapter provides an overview of the area that was studied and includes the background to the study; the problem statement: the aims and objectives: relevant definitions and a brief overview of methodology that was followed.

1.2 Background

Emergency anaesthetic drugs, such as adrenaline, ephedrine, succinylcholine, phenylephrine and atropine, are life-saving drugs routinely prepared by the anaesthetist before the start of the operating list. The most commonly pre-prepared anaesthetic emergency drugs are adrenaline, succinylcholine, atropine and phenylephrine(1, 2).

Guidelines for the pre-preparation of emergency anaesthetic drugs have been published by the Royal Collage of Anaesthetists(3).This guideline recommends the following emergency drugs be pre-prepared, labeled and ready to use before any case:

- Succinylcholine(100mg/2ml)
- Atropine (1mg/ml)

The European Board of Anaesthesiology guideline for safe medication practice was recently updated. The recommendations were to clearly label all medication pre-prepared for anaesthesia and to use pre-filled syringe wherever possible in order to reduce the risk of drug administration errors. It is also suggested that drugs should be stored in a way that assists with drug identification. (4)

Not many studies have surveyed the existence of guidelines for this purpose (1)and no South African protocol exists with regards to emergency anaesthetic drug pre-preparation**.**

Such pre-preparation has both advantages and disadvantages. The advantages of pre-preparation of these drugs are to save time in an emergency situation and are thus essential in certain theatres such as obstetric and paediatric theatres where physiological changes occur rapidly.

The disadvantages of pre-preparation of these drugs are the risk of drug administration errors. A national survey (1) of the attitudes and practices of New Zealand anaesthetists with regard to emergency drug pre-preparation showed that 26% of respondents reported drug administration errors with pre-drawn emergency drugs.

Another disadvantage of routine pre-preparation of emergency drugs is the risk of contamination, because pre-prepared drug solutions may be used for multi-dose administration and are no longer sterile once mixed. An Iranian study(5) conducted for the prevalence of multi-dose ampoule contamination by aerobic bacteria showed a contamination rate of 5.6%. The most frequently identified organisms were normal commensal flora. Unused drugs and wastage of these drugs is a further disadvantage of pre-preparation of emergency drugs and is especially relevant in underdeveloped countries

because of financial limitations. A 2016 study conducted in New York (6)showed that preventable waste was generated more frequently compared to unavoidable waste.

1.3 Problem statement

The pre-preparation of emergency drugs is associated with:

- the risk of accidental drug administration
- the risk of drug contamination
- drug and resource wastage.

Charlotte Maxeke Johannesburg Academic Hospital, Chris Hani Baragwanath Academic Hospital and Helen Joseph Hospital are academic hospitals in the greater Johannesburg area. Doctors join these hospitals having received training in many other facilities and so practice with regard to pre-preparation of emergency drugs is expected to vary. In addition, doctors may pre-prepare drugs based on the level of experience rather than a set protocol. Practice may also vary depending on whether the patient is booked for elective or emergency surgery, and the type of patient, that is an adult, paediatric or obstetrics patient.

1.4 Aims

The aim of this study was to describe the practice of anaesthetists at three Johannesburg academic hospitals with regard to pre-preparation of emergency anaesthetic drugs, to describe the frequency of accidental drug administration and to describe the degree of emergency drug contamination and wastage.

1.5 Objectives

The objectives of the study were to:

- To describe the practice of anaesthetists regarding pre-preparation of emergency drugs in elective and emergency theatres
- To describe which emergency anaesthetic drugs are pre-prepared
- To describe the opinions of anaesthetists regarding pre-preparation of emergency drugs as a source of drug administration error, contamination and wastage
- To compare demographics with emergency anaesthetic drug pre-preparation practices

1.6 Research definitions

Those subsequent definitions were used in the study

Medical officer: a qualified doctor who does not have a formal postgraduate specialisation in the discipline in which he or she is working.

Registrar: a doctor who is in the process of acquiring a specialist qualification endorsed by the Health Professions Council of South Africa (HPCSA).

Consultant: a doctor who has a specialist qualification endorsed by the HPCSA.

Anaesthetist: includes all staff administering anaesthesia.

Community service doctor: a doctor who is completing his/her community service as prescribed by the HPCSA prior to being granted full registration for independent practice. This doctor has completed two years internship, which is acknowledged as an extended period of training following graduation with a medical degree.

Preventable anaesthetic drug waste: the prepared drug which is drawn up for the case but was not used for the patient(6).

1.7 Study setting

The study was conducted at the Departments of Anaesthesiology at three of the hospitals that comprise the University of the Witwatersrand's training hospitals, namelyCMJAH, CHBAH and HJH.

1.8 Ethical consideration

The research protocol was submitted, and approval was obtained from the Human Research Ethics Committee (Medical), reference number: M160714 (Appendix 1) and permission to conduct the study was granted from the Graduate Studies Committee of the University of the Witwatersrand (WITS). Written consent from the Chief Operating Officers (CEO) of each of the academic hospitals was also given (Appendix 2, 3 and 4). The anaesthetic staff were invited to take part in the study. Completion of the questionnaire implied consent.

1.9 Research methodology

1.9.1 Study design

This was a prospective, descriptive study design entailed the distribution of questionnaires on pre-preparation of emergency anaesthetic drugs to members of the Department of Anaesthesiology at three of the hospitals that comprise the University of the Witwatersrand's training hospitals.

1.9.2 Study population

The study population consisted of all anaesthetic department staff affiliated with the University of the Witwatersrand. The total number of staff who were eligible to participate was 219anaesthetists. This included doctors from the professional levels of consultant, senior registrar, junior registrar, medical officer and community services doctor.

1.9.3 Study sample

All doctors in the anaesthetic department were identified and eligible to participate.

Inclusion and exclusion criteria

Inclusion criteria

All doctors working in the Department of Anaesthesiology affiliated to the University of the Witwatersrand are eligible to participate.

Exclusion criteria

Any member of the department who declined to participate was excluded.

Any respondents who answered questionnaires in a contradictory manner. This will be further explained in chapter three.

Interns were excluded as these doctors only rotate through the department for a two-month period, with the focus being on training them to administer a basic, safe anaesthetic therefore, they do not have the knowledge or experience to complete the questionnaire.

1.9.4 Data Collection

Data werecollected with the use of a self-administered questionnaire (Appendix 6).

Self-administered questionnaire (Appendix 6)

In order to develop a questionnaire that would accurately assess emergency anaesthetic drugs pre-preparation a review of the literature was done. The questionnaires from three studies served as foundations for the questionnaire. Permission to use the questionnaires was obtained from Dr Oswal (7). In order to ensure content and face validity the questionnaire was validated by three consultants from the Department of Anaesthesiology, University of the Witwatersrand. The questionnaire contains four categories, with a total of 19 questions. The four categories include demographics, departmental policies regarding emergency drug pre-preparation, emergency drug pre-preparation practices and frequency of use, and complications of emergency anaesthetic drug preparation. This included questions on drug administration errors, contamination and wastage.

Questionnaire distribution

Once approval to conduct the study was obtained from the Human Research Ethics Committee (Medical), the Graduate Studies Committee of the University of the Witwatersrand, and the respective hospital CEO's, consent was requested from the heads of the anaesthetic departments in the participating hospitals. An indication of appropriate times to approach these doctors was sought, e.g. departmental meetings and in departmental tea-rooms, where the questionnaires (Appendix 6) together with the information letter (Appendix 5) was distributed. Questionnaires were collected by the researcher at the end of these meetings and placed into a sealed box. The contact details of the researcher were available to participants should any queries arise.

1.9.5 Data Analysis

An electronic spread sheet (Microsoft Excel 2010 ®) was used to capture data collected from completed questionnaires. For statistical analysis data were analysed using IBM SPSS software package (version 20.0). Qualitative data were described using number and percent. Percentage and frequencies were computed for categorical variables. Comparisons between demographics and practice were made using Chi-squared tests. Monte Carlo correction test were used for correction for Chi-squared tests. A p-value of less than 0.05 was considered to be statistically significant.

1.10 Significance of the study

The study aims to describe the practices and opinions relating to pre-preparation of emergency anaesthetic drugs among anaesthetists working at the University of the Witwatersrand's training hospitals. With this information, protocols for the pre-preparation of emergency drugs can be developed with the view to reduce wastage but simultaneously ensure patient safety.

1.11 Validity and reliability

Validity and reliability were ensured and will be detailed in chapter three.

1.12 Project outline

The study is presented as follows:

In chapter one an overview of the study was provided. A review of the relevant literature is presented in chapter two. Chapter three describes the research methodology in detail. The

results and a discussion thereof are presented in chapter four. In chapter five a summary, limitations, recommendations and conclusions from the study is discussed.

1.13 Summary

In this chapter an overview of the study has been given. It has described the background; problem statement; aims and objectives; the research design and methodology; importance of the study and ethical considerations. In the next chapter a review of the literature related to the topic under research is presented.

Chapter Two Literature Review

1.14 Introduction

Emergency anaesthetic drugs, such as adrenaline, ephedrine, succinylcholine, phenylephrine and atropine are life-saving drugs and are considered necessary preparation before the start of the operating list. The purpose of the literature review is to explore the factors that influence anaesthetic practice and to examine published guidelines on pre-preparation of emergency anaesthetic drugs. In addition, both the advantages and disadvantages of emergency anaesthetic drug preparation will be discussed.

Anaesthetic practice with regards to pre-preparation of emergency anaesthetic drugs varies with years of experiences, the nature of the surgery, that is emergency or elective surgery, as well as the patient profile. These factors will be discussed. In addition, the location in which surgery occurs may influence the decision to pre-prepare emergency anaesthetic drugs and this will also be discussed.

Guidelines for the pre-preparation of emergency anaesthetic drugs have been published by the Royal Collage of Anaesthetists (3) and these will be reviewed. Local guidelines, however, have not been formulated.

The pre-preparation of emergency anaesthetic drugs comes with many advantages. The ability to save time in an emergency situation is one such advantage and is of particular value in specific situations where physiological changes occur rapidly. Another advantage

that will be discussed is the reduction in stress levels of the anaesthetist. This is because emergency drugs may be administered rapidly if pre-prepared.

The disadvantages are also important to consider as they affect both patient outcome and hospital costs. The risk of drug administration error and drug contamination with multi-dose administration will be discussed. Moreover, drug wastage and the impact on healthcare costs will be examined.

1.15 Drugs commonly pre-prepared

The most commonly pre-prepared anaesthetic emergency drugs are adrenaline, succinylcholine, atropine and phenylephrine. (2, 6)

Adrenaline is a sympathomimetic (adrenoreceptor agonist) drug acting directly on both alpha and beta-adrenergic receptors. Adrenalin dosage will vary according to the indication. These include anaphylactic shock, cardiac arrest, bronchospasm and as inotropic and vasopressor support in patients with cardiac instability. It is manufactured in amber coloured ampoules containing 1 mg/ml and may be diluted to concentrations of 5-100 µg/ml. (8)

Succinylcholine is a depolarising muscle relaxant which acts at the nicotinic acetylcholine receptor of the neuromuscular junction. The dose of succinylcholine is 1 mg/kg. It has a rapid onset of action of 30-60 seconds and a short duration of action of 11-15 minutes (9). For this reason it is used for rapid sequence induction but may also be used for the management of airway emergencies such as laryngospasm or an unanticipated difficult airway (9). It is also useful for cases in which a short duration of paralysis is required, such as electroconvulsive therapy (10). It is manufactured in amber coloured ampoules containing 2ml and a total of 100mg. For adult use no dilution is required but, in children, it is commonly diluted to concentrations of 1-10 mg/ml.

Atropine is an anticholinergic drug. In the peri-operative period it may be used to prevent or treat sinus bradycardia and can be used in combination with neostigmine to reduce the cholinergic side effects when reversing non-depolarising muscle relaxants. It is also used as a premedication and anti-sialagogue. Atropine is manufactured in transparent ampoules of either 0.5 mg/ml or 1mg/ml. It may be administered intramuscularly at doses of 0.015 mg/kg or intravenously at doses from 0.01-0.02 mg/kg. Due to this wide dose range it is commonly diluted to 0.1 mg/ml.(11)

Phenylephrine is an alpha$_1$ adrenergic receptor agonist. It causes direct vasoconstriction and is thus used to increase blood pressure when systemic vascular resistance is reduced (12). This is particularly useful to treat the sympathectomy that occurs with neuraxial blockade and so it is commonly pre-prepared for caesarean sections (12). It is also commonly used in emergency, cardiac and thoracic surgery (12). It is manufactured in transparent ampoules containing 10mg/ml. It may be diluted to concentrations between 50-200 µg/ml. Another factor to consider with this drug is its stability once diluted. The diluted solution is stable for at least 30 days when stored in polypropylene syringes at −20 °C, 3–5 °C, and 23–25 °C (13).

Factors influencing the pre-preparation of emergency anaesthetic drugs

1.15.1 Years of experience

It was postulated that anaesthetic practice with regards to pre-preparation of emergency anaesthetic drugs varies according to years of experience. A study done on peri-operative use of emergency anaesthetic drugs in New Zealand (1), however, showed this not to be the case. The study demonstrated a large degree of heterogeneity between years of experience and pre-preparation of emergency anaesthetic drugs. In addition, the study showed other factors to play a role in this practice namely departmental teaching and protocols, prior training and the frequency with which pre-prepared emergency anaesthetic drugs are used (1).

1.15.2 Nature of surgery: emergency or elective

The nature of surgery is another important factor to consider. Emergency surgery is associated with a high risk of a full stomach and consequent aspiration, haemodynamic instability and a rapidly changing physiological condition. This means that there is not much time for preparation of emergency anaesthetic drugs during the surgery (14).

The dilution and pre-preparation of emergency anaesthetic drugs is time consuming and the delay that this causes in administering these drugs to the patient may result in negative outcomes (15). For this reason, it has been suggested that these drugs should be available immediately in emergency theatres.

Such a situation is in direct contrast to elective surgery where the anaesthetist has performed a preoperative consultation and is thus afforded the opportunity to plan the anaesthetic. One of the reasons for a preoperative anaesthetic visit is to decide upon the most suitable anaesthetic plan for the patient and the surgery for which they are presenting (16). This allows the anaesthetist to pre-empt potential problems and plan accordingly, thereby reducing adverse events.

1.15.3 Patient profile

Both age and co-morbidity are important factors to consider when pre-preparing emergency anaesthetic drugs. For paediatric patients the dose of drug must be calculated and diluted according to the weight of the patient. Another factor to consider is when an emergency does occur a child's condition can deteriorate more rapidly due to reduced physiological reserve. The time taken to dilute drugs appropriately may result in an adverse outcome (17). Despite these considerations, a survey conducted in the United Kingdom

(UK)(18)showed that only 56% of participants, the majority of whom were consultants (82%), pre-prepare emergency anaesthetic drugs before the start of every paediatric case. The same survey reported that 12% of anaesthetists reported a critical event due to these drugs not being available in an emergency situation. It can thus be seen that pre-preparation of emergency drugs is advantageous during a critical event.

1.15.4 Location of surgery

The location in which surgery occurs may influence the decision to pre-prepare emergency anaesthetic drugs as the anaesthetist may be faced with an unfamiliar environment (7). Remote anaesthesia, such as in the intensive care unit (19),radiation oncology suite, magnetic resonance imaging suite and electroconvulsive therapy room, is an important factor to consider as these locations are often far from theatre. It may not be clear where the location of ampoules and syringes are. Also, one may be faced with working with an unskilled assistant. In addition, these procedures are often done as day cases meaning that the anaesthetist only sees the patient for the first time shortly before the procedure. Moreover, these suites are prepared for the procedure rather than for anaesthesia(20).

1.16 Guidelines for the pre-preparation of emergency anaesthetic drugs

Guidelines for the pre-preparation of emergency anaesthetic drugs have been published by the Royal Collage of Anaesthetists (3). This guideline recommends the following emergency drugs to be pre-prepared, labeled and ready to use before any case:

- Succinylcholine (100 mg/2ml)
- Atropine (1 mg/ml)

The European Board of Anaesthesiology guideline for safe medication practice was recently updated. The recommendations were to clearly label all medication pre-prepared for

anaesthesia and to use pre-filled syringe wherever possible in order to reduce the risk of drug administration errors. It is also suggested that drugs should be stored in a way that assists with drug identification. (4)

No South African protocol exists with regards to emergency anaesthetic drug pre-preparation**.** While not many studies have surveyed the existence of guidelines for this purpose, a national survey (1) of the attitudes and practices of New Zealand anaesthetists with regards to emergency anaesthetic drug pre-preparation showed that83.5% of participants reported that there was no protocol in their institution. The same survey done in New Zealand showed that 68.5% of participants reported that they also had no teaching program in their training. (1)

1.17 Advantages of pre-operative preparation of emergency anaesthetic drugs

A major advantage of routine pre-preparation of emergency anaesthetic drugs is the ability to save time in the case of an emergency. This is of particular value when the anaesthetist is working with an unskilled assistant or is working in an unfamiliar setting. In a published national survey of the attitudes and practices of New Zealand anaesthetists with regard to emergency drugs, 37% of anaesthetists reported having experienced delays in drawing up drugs in an emergency (1).

In addition, time-saving is of particular importance in theatres such as obstetric and paediatric theatres. In obstetric theatres, the time taken to prepare drugs at the time of an emergency may lead to major delays and consequently negatively affect the outcome of the mother as well as the baby. In a survey done in the United Kingdom on the preparation and storage of anaesthetic drugs for obstetric emergencies, as many as 87% of doctors routinely pre-prepare emergency drugs, most commonly succinylcholine (2).This may indicate that doctors appreciate the high risk nature of obstetric anaesthesia. The reason obstetric

anaesthesia is associated with higher risk is because certain life-threatening emergencies occur more commonly. Aspiration is one such example, where the incidence of aspiration is 1:400-500 obstetric patients in contrast to 1:2000 for all patients (21). Bleeding is another frequently encountered complication and is the most common cause of morbidity in obstetric patients (22).Also, a high or total spinal anaesthetic, with associated severe hypotension, is the most frequent complication of neuraxial anaesthesia (23).

Pre-preparation of emergency anaesthetic drugs may also assists to reduce the stress of the anaesthetist. A New Zealand based survey (1), however, showed that only seven of 44 respondents indicated that the absence of pre-prepared emergency anaesthetic drugs increased the anaesthetist's stress level even if the patient's morbidity and mortality was unaffected.

1.18 Disadvantages of pre-operative preparation of emergency anaesthetic drugs

1.18.1 Drug administration errors

Drug administration errors play an important role in patient morbidity and mortality(2, 14).The causal factors that have been recognized to contribute to drug administration errors include communication failure, haste, inattention, drug labelling errors, unclear drug labelling, and working in an unfamiliar environment, where the appearance and location of ampoules and syringes is not clear (24-27).

A national survey (1) of the attitudes and practices of New Zealand anaesthetists with regard to emergency drug pre-preparation showed that 26% of respondents reported drug administration errors with pre-drawn emergency drugs. The survey also found that 29.5% of respondents reported errors while drawing up a drug at the time of an emergency (1). It can thus be seen that both approaches may lead to drug administration errors.

Obstetrics theatre is a setting in which emergency anaesthetic drugs are routinely pre-prepared before the start of surgery (14). This may have the consequence of increasing the risk of drug administration errors. This is because ephedrine, ergometrine and adrenaline are all available in similar one millilitre ampoules and are therefore, easily misidentified (14). A 2003 postal survey (28)studying drug errors in obstetric anaesthesia showed that 39% of respondents reported at least one drug administration error in the last year that they knew about, and 40% of respondents experienced more than one drug administration error. The same study showed that drug administration errors occurred in 20 cases where drugs planned for spinal and epidural analgesia and anaesthesia were administered by other routes (28). Similarly, an Irish study (2) showed that the majority of anaesthetists (48 out of 59, 81.35%) found that pre-preparation of emergency drugs was a potential source of drug administration error.

Drug administration errors have been found to cause morbidity and mortality. A Canadian survey (26) among 687 anaesthesiologists reported that 85% of the respondents had experienced at least one drug administration error. Of these reported errors, 98% had a minor effect but there were four reported deaths. The most common error was the administration of muscle relaxants instead of a reversal agent (26).

The cause for these drug administration errors were syringe swap errors in 70.4% of cases and the misidentification of the ampoule labels in 46.8% of cases. Interestingly, 97.9% of anaesthetists reported that they usually read the ampoule label. Using the label colour was also an essential secondary sign of identification of the drug. Interestingly, only approximately half of respondents would report the error if a reporting program for medication errors existed (26), thereby suggesting an underestimate of the problem.

The Thai Anaesthesia Incidents Study (27),which was conducted over 18 months in 20 academic hospitals, also measured the incidence and adverse events related to drug administration errors. It reported 41 drug administration errors in 202 699 reported cases.

Almost half of all errors were due to incorrect drug administration (20 incidents; 48.8%). In addition, it was found that the incidents were not related to anaesthetic techniques unless a combined general and epidural technique was used. Induction of anaesthesia was the most common time for the error to occur, with an incidence of 63.4%. A total of 14 adverse events (34.1%), ranging from temporary mild to severe physiological changes, occurred. Thirteen of the patients made a full recovery but one died. (27)

The nature of the surgery also plays a role. An Australian incident monitoring study(29), part of which investigated drug administration errors, reported 896 incidents of a total of 8088 reports between 1988-2001. This finding was greater than the anticipated frequency. Fifty four percent of these errors were associated with emergency surgery, 40% were associated with elective surgery and 6% did not specify the type of surgery.

The nature of the errors included both syringe swap errors and drug ampoule misidentification

errors. In 169 (18.9%) incidents of syringe swap errors the drug was correctly labelled but given in error, and in 187 (20.8%) incidents ampoule labelling errors occurred. The study also reported the result of these errors, which included minor morbidity, such as prolonged hospital stay in 105 (11.7%) cases. Major morbidity occurred in 42 (4.7%) cases. These included unplanned high dependency care admission in 20 (2.2%) cases and death in 3 (0.3%) cases.(29)

The cost of drug administration errors is a further consideration and were found to contribute greatly to hospital costs. An American study done in 1993 (25) found that such errors were the cause for 7000 deaths in the United States and the cost associated with this was estimated to be about two billion dollars.

Factors that reduce the incidence of drug administration errors

Researchers have explored various options to reduce the rates of drug administration errors. Studies (25, 30) have developed and implemented a new multimodal record system by means of a multidimensional approach. Current practice involves writing an anaesthetic record as the case progresses. These studies used modified drug trays and principle designed drug trolley drawers to help to provide a well pre-prepared anaesthetic workstation and a sterile space in which to prepare drugs. Pre-filled syringes for the most commonly used anaesthetic drugs were used. These were prepared in clearly coloured and bar-coded syringes. A barcode reader was linked to a computer, together with speakers and touch screen in order to provide automatic visual and auditory confirmation of the syringe labels just before each drug was administered. A record of drugs administered, and a traditional anaesthetic chart were generated automatically (25, 30). The results showed a significant difference ($p=0.045$) between the new and conventional system. The mean rate of drug administration errors for the new system was 9.1 per 100 administrations (one in 11 administrations), and 11.6 per 100 administrations (one in 9 administrations) for the conventional system. In addition, the study showed that in prolonged, complicated and emergency procedures the anaesthetists favoured the new system (30).

Other factors also contribute to reducing the risk of drug administration errors. The Australian Incident Monitoring Study (29) reported the following factors to play a role in decreasing such errors: previous experience and training in the management of emergencies (23%), rechecking equipment (18%), having monitors capable of detecting adverse events (10%), supervision (8%), and skilled assistance (7%),the development of reporting programs for drug administration errors (29%), enhanced routines for eliminating fatigue (9%) and extra training for the anaesthetists (23%).Despite these findings the same study showed that in the majority of cases no factor was clearly identified that may have reduced the risk of a drug administration error. (29)

1.18.2 Drug contamination

The risk of drug contamination is another disadvantage of pre-preparation of emergency anaesthetic drugs. The reason for this is because some pre-prepared drug solutions may be used for multi-dose administration and would no longer be sterile once mixed. (2, 31)

A number of studies looking at drug contamination have been done. An Iranian study (5) was conducted for the prevalence of multi-dose ampoule contamination by aerobic bacteria. This study showed a contamination rate of 5.6%. The most frequently identified organisms were normal commensal flora. Gram positive bacteria accounted for 88.9%, where *Staphylococcus epidermidis* was the most common (44.4%) and *Actinomyces viscosus* the least common (2.8%). Potassium chloride, sodium chloride and saline were the most frequently contaminated solutions. Although the clinical consequences were beyond the scope of this study, the infection control department considered this as source of nosocomial infection(5).

A study conducted in Germany (32) on bacterial contamination of multiple-dose vials (MDV) reported that of the 227 opened vials found in the wards, *Staphylococcus epidermidis* was the organism found, with a contamination rate of 0.9%. In the same study, the opening dates were clearly indicated on the vial in only 50% of the MDV and 13% had already expired. Only 19% of the MDV had been stored in the refrigerator, despite 48% MDV containing medications without any preserving agent.

Factors that could increase the risk of drug contamination are: the number of withdrawals made from a vial, whether the withdrawal was as a sterile technique, the introduction of environmental air into a vial while aspirating, how often the drug is replaced, the storage technique (temperature), and whether a preservative is present or not (33). It has been

shown that drugs that do not contain a preservative or drugs that contain lipids have a higher level of bacterial contamination (5, 33)

Location of preparation is another factor to consider. An Iranian study (33) was done on bacterial contamination of single-dose vials (SDV), and MDV after multiple uses when prepared in the treatment room in the ward or a clean room in the pharmacy. Intravenous admixtures (ADX) are mixtures of two or more injected medications. Three different hospitals showed that *Bacillus subtilis* was the contaminant in one out of 92 (1.1%) ADX prepared by nursing staff in the treatment room, compared to none of the ADX prepared by the hospital pharmacist in aclean room in the pharmacy. In addition, no microbial contamination was found in MDV and SDV when prepared in the pharmacy clean room(33). Despite these findings, they do not demonstrate that location of drug pre-preparation makes a significant difference to rates of contamination.

Nevertheless, a study done in the United Kingdom in 1995 (31) reported that, due to the risk of drug contamination, one cannot advocate the pre-preparation of drugs at the beginning of a list for use later in the day. It looked at the rate of contamination at specific time intervals after drug pre-preparation. Contamination was detected in one syringe at the time of the drug being drawn; two more syringes had measurable contamination at the two-hour period; a further two syringes were contaminated at the four-hour period; and three more contaminated syringes were found at the eight-hour period. The isolated organism from the syringes were coagulase negative *Staphylococci* and an *Acinetobacter* species. (31)

In contrast, in a study conducted in Italy (34) on sterility and multiple withdrawals from SDV, no confirmations of microbial growth in the culture media plates of 7 200 samples and 14 400 cultures were found.

With these findings in mind, the National Patient Safety Agency (NPSA)(35) and the Anaesthesia Patient Safety Foundation (APSF) in the United States of America (14)have published recommendations for the preparation and administration of intravenous drugs to ensure patient safety. These guidelines state that intravenous drugs should not be stored for more than 24 hours (or less if pharmaceutically required or if stated by the manufacturer) (35). In the UK, obstetric units (80%) replace anaesthetic emergency drugs every 24 hours (14). In addition, in Ireland all emergency anaesthetic drugs must be replaced after 24 hours (2).

Numerous strategies to reduce the risk of contamination have been suggested. These include using alcohol hand sprays, disinfection of gums, observance of the pharmaceutical company's pre-preparation recommendations, adhering to the appropriate drug storage temperatures, marking of drug ampoule opening times, and avoiding the multiple use of medications not containing preserving agents. (31, 32)

Training of health care workers in their responsibility to prevent infection is also very important. This can be done via the application of guidelines for aseptic handling of intravenous solutions and aseptic preparation techniques. It has been shown that the best approach was using a clean room, specifically for the preparation of parenteral products to the reduce risk of microbial contamination. (33)

Similarly, the most recent guideline update by the European Board of Anaesthesiology for safe medication practice. In order to reduce the risk of infection between patient the use of multi-dose ampoules, saline bag for drug dilution and the flushing of intravenous lines are not recommended. The recommendation also advises the use of pre-filled drug syringes. (4)

1.18.3 Drug wastage

Unused drugs and wastage of these drugs is a further disadvantage of pre-preparation of emergency drugs and is especially relevant in underdeveloped countries because of economic implications.

A 2016 study conducted in New York (6) showed that preventable waste was generated more frequently compared to unavoidable waste. This study defined preventable drug waste as drugs drawn up in the operating room for use during a surgical case but was then not used. This is in contrast to routine drug waste, which is the amount of drug left over after the anaesthesia provider has administered the required dose to the patient. The preventable drugs most commonly wasted were ephedrine (59.5%), succinylcholine (33.7%) and phenylephrine (2.6%). In the same study, the cost of drug wastage over one year was calculated to be $18525 000.(6)

An Irish study (2), which also looked at drug wastage, showed that only 25% of anaesthetists actually perceived pre-preparation of emergency drugs as wasteful. In this study the total cost of emergency drug wastage for a 30-day period was €1361. Drug wastage in this case was defined as drugs prepared but not used, and drugs left in fridges. (2)

While no study on drug wastage, to the best of the researcher's knowledge, has been conducted in South Africa, Table 2.1 shows the unit price of commonly pre-prepared emergency anaesthetic drugs as well as the monthly cost if these drugs are pre-prepared daily for one month in one theatre. One can therefore appreciate that the cost of pre-preparation of emergency drugs is substantial.

Table 2.1: Cost of anaesthetic drugs, Charlotte Maxeke Johannesburg Academic Hospital, South Africa (August 2018)

Drug	Unit price (Rands)	Price(Rands per month)
Succinylcholine	10.04	301.20
Adrenaline	3.16	94.80
Atropine	1.80	54.00
Ephedrine	31.00	930.00
Phenylephrine	33.69	1 010.70
Total	79.69	2 390.70

A study done at the University of Washington Medical Centre (36) reported that anaesthesia waste is common. This study included 164 elective and emergency cases in a period of three weeks. In the study atropine, ephedrine and succinylcholine were drugs found in the waste ampoules, syringes and saline bags. The results of the study showed that the total waste in volume for atropine was 56ml, for ephedrine was 225ml, for phenylephrine was 201ml, for succinylcholine was 278ml and phenylephrine diluted in a saline bag was 4160ml. In addition, bags of phenylephrine accounted for major wastage of 25ml per case. There were, however, limitations to the study. Drugs that were discarded into sharps containers and rubbish containers at the end of the surgery in order to avoid the incorrect use of these drugs were not quantifiable. (36)

A number of studies have been done that demonstrate the cost associated with drug wastage (15, 37) . A study conducted at the University of California (38)found that phenylephrine and ephedrine were among the wasted ampoules and syringes, with reported wastage of 20.8% and 8.6% respectively (38).

Similarly, a study conducted at Rhode Island (39) on drug use inefficiency showed that the anaesthesia department used a considerable percentage of their operating budget on drugs. Drug wastage in this study was defined as the correct or incorrect discarding of unused or incompletely used ampoules or syringes of drugs. This study was conducted for a year and drugs were administered to 25 481 patients. Six drugs used in large volumes were chosen, including succinylcholine, Propofol and midazolam. The study reported the amount of drug not given as well as an efficiency index. This was defined as the amount of drug administered to patients divided by the cost for the pharmacy and is reported as a percentage.The results showed that 788 796 mg of succinylcholine,1 028 388 mg of Propofol and 28 235 mg of midazolam were not given despite being distributed by the pharmacy(efficiency index 33%, 49 %, 53% respectively). The cost of unused succinylcholine was $2953, Propofol $80 863 and midazolam was $25 511.(39)

One possible solution to reduce wastage would be the availability of prefilled syringes in order to decrease the need for pre-operative preparation of these drugs(37).The availability of pre-filled ephedrine syringes was investigated in a study inpatients coming for obstetric surgery. The study was conducted for a period of 14 days, and 130 cases were performed. The use of ampoules of ephedrine was compared to the use of prefilled syringes of ephedrine. The results showed that 155 ampoules were used in comparison to 45 prefilled syringes. The study thus showed that prefilled syringes could reduce anaesthesia costs and wastage (37). However, although the accessibility of prefilled syringes reduced the unnecessary wastage of drugs, this practice may involve a delay in the time taken to calculate and prepare dosages different to that of the prefilled syringes (9).This is particularly relevant in paediatric anaesthesia.

A second solution to reduce drug wastage would be the introduction of clean boxes in the anaesthesia workplace. These clean boxes are used to keep the unused syringes in a sterile environment until they are required. This would require a system to track the storage time

for each pre-prepared drug so that the recommended storage time for any drug is not exceeded. (36)

A third solution would be the education of anaesthetists regarding pre-operative drug preparation, drug use efficiency, drug costs and potential drug wastage to increase awareness about drug wastage. (39)

A fourth solution to reduce drug cost and wastage would be to change anaesthetists' behaviour in drug pre-preparation and drug administration by increasing awareness of drug costs (36, 38, 40). These methods, however, have been shown to only have a temporary impact as decreased drug wastage may not be the priority of some of anaesthetists (36). One final solution for an institution to save money would be that drugs supplied from the pharmacy are in quantities closer to those used by anaesthetists (6).

Chapter Three Research Methodology

2.1 Introduction

This chapter consists of the problem statement, aims and objectives, ethical considerations, research design and methodology.

2.2 Problem statement

The pre-preparation of emergency drugs is associated with:

- the risk of accidental drug administration
- the risk of drug contamination
- drug and resource wastage.

Charlotte Maxeke Johannesburg Academic Hospital, Chris Hani Baragwanath Academic Hospital and Helen Joseph Hospital are academic hospitals in the greater Johannesburg area. Doctors join these hospitals having received training in many other facilities and so practice with regard to pre-preparation of emergency drugs is expected to vary. In addition, doctors may pre-prepare drugs based on the level of experience rather than a set protocol. Practice may also vary depending on whether the patient is booked for elective or emergency surgery, and the type of patient, that is an adult, paediatric or obstetrics patient.

2.3 Aims

The aim of this study was to describe the practice of anaesthetists at the University of the Witwatersrand's academic training hospitals with regards to pre-preparation of emergency anaesthetic drugs, to describe the frequency of accidental drug administration and to describe the degree of emergency drug contamination and wastage.

2.4 Objectives

The objectives of the study were to:

- To describe the practice of anaesthetists regarding pre-preparation of emergency drugs in elective and emergency theatres
- To describe which emergency anaesthetic drugs are pre-prepared
- To describe the opinions of anaesthetists regarding pre-preparation of emergency drugs as a source of drug administration error, contamination and wastage
- To compare demographics with emergency anaesthetic drug pre-preparation practices

2.5 Ethical consideration

The research protocol was submitted and approval was obtained from the Human Research Ethics Committee (Medical), reference number: M160714 (Appendix 1) and permission to conduct the study was granted from the Graduate Studies Committee of the University of the Witwatersrand (WITS). Written consent from the Chief Operating Officers (CEO) of each of the academic hospitals was also given (Appendix 2, 3 and 4). The anaesthetic staff were invited to take part in the study. Completion of the questionnaire implied consent. Completed questionnaires were placed into a box. Anonymity of participants and questionnaires ensured by not recording participants' names on the questionnaires and once questionnaires were collected from the various departments, they were all placed together for data collection. Furthermore, confidentiality was ensured as the researcher and supervisors were the only people who had access to the raw data.

The study was conducted in adherence to the principles of the Declaration of Helsinki (41).

2.6 Research methodology

2.6.1 Study Design

This was a prospective, descriptive study design that entailed the distribution of questionnaires on the pre-preparation of emergency anaesthetic drugs to members of the Department of Anaesthesiology at three of the hospitals that comprise the University of the Witwatersrand's training hospitals.

A prospective study is defined as a study in which the variables will be measured at the time in which the study takes place(42). This study was prospective in that a group of doctors was identified for study and the data were collected from them during the course of the study.

A descriptive study aims to describe a situation or identify problems through observation, description or classification without manipulating variables(43). No treatment or intervention is tested(43). This study was descriptive in design in that it planned to provide new information on the study variables defined in the objectives.

2.6.2 Study Population

The study population consisted of all anaesthetic department staff affiliated with the University of Witwatersrand and all were eligible to participate. There were a total of 219anaesthetists. This included doctors from the professional levels of consultant, senior registrar, junior registrar, medical officer and community services doctor.

2.6.3 Study sample

All doctors in the anaesthetic department at the time of data collection were identified and eligible to participate.

Inclusion and exclusion criteria

Inclusion criteria

All doctors working in the Department of Anaesthesiology affiliated to the University of the Witwatersrand were eligible to participate.

Exclusion criteria

Any member of the department who declined to participate was excluded.

Any respondents who answered questionnaires in a contradictory manner. It was seen that for question 3.1 (Do you draw emergency drugs at start the list?) that seven respondents indicated that they did not pre-prepare emergency anaesthetic drugs before starting their list. Despite this they continued to answer the next questions which related to pre-preparation of emergency anaesthetic drugs. They were thus excluded from these questions.

Interns were excluded as these doctors only rotate through the department for a two-month period, with the focus being on training them to administer a basic, safe anaesthetic. Therefore, they do not have the knowledge or experience to complete the questionnaire.

2.6.4 Study Setting

The study was conducted at the Departments of Anaesthesiology at three of the hospitals that comprise the University of the Witwatersrand's training hospitals, namelyCMJAH, CHBAH and HJH.

2.6.5 Data Collection

Data were collected with the use of a self-administered questionnaire (Appendix 6).

Questionnaire development (Appendix 6)

In order to develop a questionnaire that would accurately assess emergency anaesthetic drugs pre-preparation a review of the literature was done. The search terms used were: emergency anaesthetic drugs, emergency anaesthetic drug preparation, emergency anaesthetic drug wastage, drug administration error and emergency anaesthetic drug contamination. The questionnaires from three studies served as foundations for the questionnaire. Permission to use one of the questionnaires was obtained from Dr Oswal (7), however, no response was received from the other two questionnaire authors. In order to ensure content and face validity the questionnaire was validated by three consultants from the Department of Anaesthesiology, University of the Witwatersrand. The questionnaire contains four categories, with a total of 19 questions. The four categories include demographics, departmental policies regarding emergency drug pre-preparation, emergency drug pre-preparation practices and frequency of use, and complications of emergency anaesthetic drug preparation. This included questions on drug administration errors, contamination and wastage.

Questionnaire distribution

Once approval to conduct the study was obtained from the Human Research Ethics Committee (Medical), the Graduate Studies Committee of the University of the Witwatersrand, and the respective hospital CEO's, consent was requested from the heads of the anaesthetic departments in the participating hospitals. An indication of appropriate times to approach these doctors was sought, e.g. departmental meetings and in departmental tea-rooms, where the questionnaires (Appendix 6)

together with the information letter (Appendix 5) was distributed. Questionnaires were collected by the researcher at the end of these meetings and placed into a sealed box. The contact details of the researcher were available to participants should any queries arise.

2.6.6 Data Analysis

An electronic spread sheet (Microsoft Excel 2010 ®) was used to capture data collected from completed questionnaires. For statistical analysis data was analysed using IBM SPSS software package version 20.0. Qualitative data were described using number and percent. Percentage and frequencies were computed for categorical variables. Comparisons between demographics and practice were made using Chi-square tests. Monte Carlo correction tests were used to correct for Chi-squared tests when more than 20% of the cells had an expected count of less than 5.A p-value of less than 0.05 was considered to be statistically significant.

2.7 Validity and reliability

Validity of the study is improved by:

- A representative sample size – all anaesthetists affiliated to the University of the Witwatersrand will be approached to participate thereby ensuring an adequate sample size.
- Selection bias will be minimised by approaching all doctors thereby ensuring representation across professional levels and years of experience
- Face and content validity. A panel of three consultants were involved in this process.

Reliability of the study was ensured by:

- Consistency has been ensured through a validation process by ensuring that items on the questionnaire measure the intended variables;
- The questionnaire was developed following a literature review. In addition, the questionnaire was assessed by three consultant anaesthetist, with a special interest in pain. This ensured the reliability of the questionnaire.

2.8 Summary

This chapter has described the research methodology employed in this study. This includes: the research question; the aims and objectives of this study; the ethical considerations encountered in the conduct of this study; detailed the research design; the description of the population and samples used; discussed the data collection methods; data analysis used and reliability and validity. In the next chapter, the results of this study are presented.

Chapter Four Results

3.1 Introduction

This chapter contains the results of the data collected and are presented according to the objectives stated in chapter one.

The objectives of the study were to:

- To describe the practice of anaesthetists regarding preparation of emergency drugs in elective and emergency theatres
- To describe which emergency anaesthetic drugs are pre-prepared
- To describe the opinions of anaesthetists regarding pre-preparation of emergency drugs as a source of drug administration error, contamination and wastage
- To compare demographics with emergency anaesthetic drug pre-preparation practices

3.2 Sample realisation

The anaesthetic department staff affiliated with three training hospitals of the University of the Witwatersrand were eligible to participate. This made the sample population219 doctors. This included doctors from the professional levels of consultant, registrar, medical officer and community services doctor. The total number of completed questionnaires was 194, giving a response rate of 88.5%.

3.3 Results

The first part of the questionnaire asked for demographic information. Tables 4.1, 4.2 and figures 4.1 and 4.2 show these demographic variables.

Table 4.1 Age of respondents

Age (years)	Number (%)
25 – 30	45 (23.20)
31 – 40	119 (61.34)
41 – 50	11 (5.67)
> 50	18 (9.28)
Blank	1 (0.51)

Table 4.2 Gender of respondents

Gender	Number (%)
Male	69 (35.57)
Female	124 (63.92)
Blank	1 (0.51)

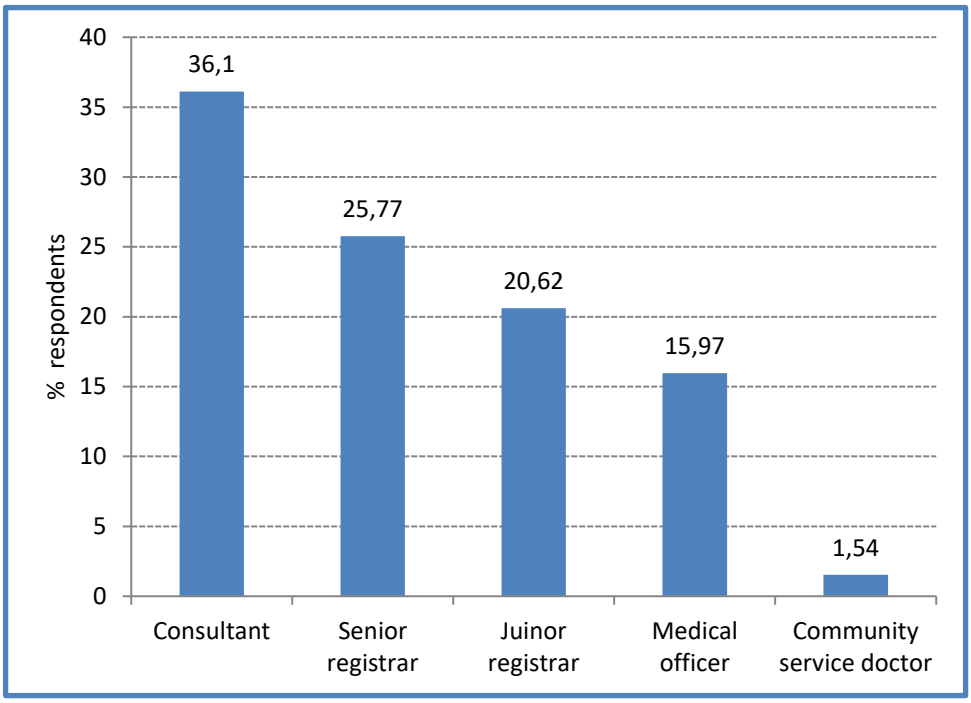

Figure 4.1 Professional grade of respondents

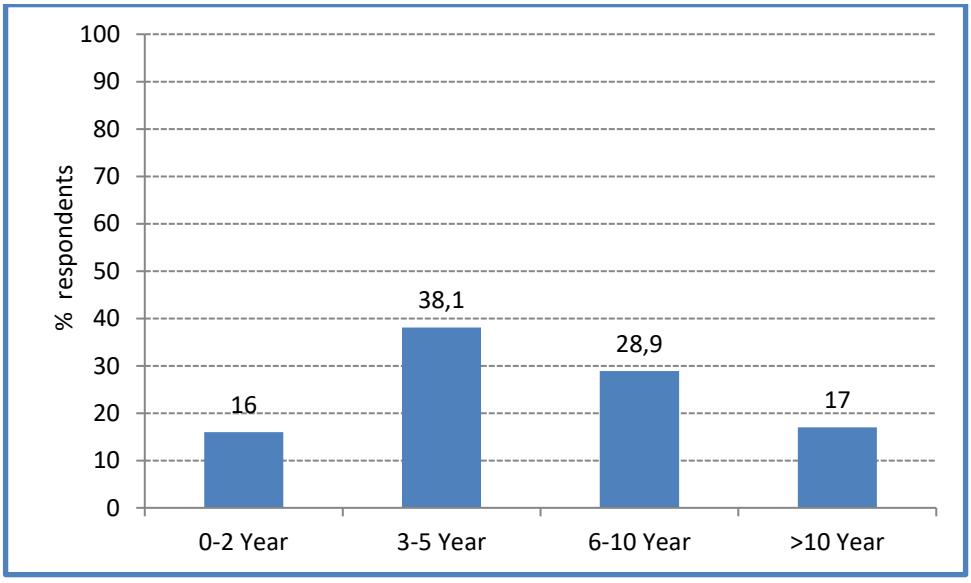

Figure 4.2 Years of experience

The first objective of the study was to describe the practice of anaesthetists regarding pre-preparation of emergency anaesthetic drugs in elective and emergency theatres. Departmental policy and teaching may influence practice and was thus, questioned. These results of appear in Tables 4.3 and 4.4 respectively.

Table 4. 3 Departmental policy regarding emergency drug pre-preparation

Response	Number (%)
Yes	48 (24.74)
No	101(52.06)
Do not know	45 (23.20)

Table 4.4 Teaching at university training hospitals regarding emergency drug pre-preparation

Response	Number (%)
Yes	100 (51.55)
No	48 (24.74)
Do not know	46 (23.71)

Respondents were questioned as to whether they pre-prepare emergency anaesthetic drugs at the start of a list. The results showed that 84 (43.30%) respondents always pre-prepare,101 (52.06%) only sometimes pre-prepare, and eight (4.12%) do not pre-prepare emergency anaesthetic drugs at the start of the list. One (0.52%) respondent did not answer this question.

Despite eight respondents indicating that they did not pre-prepare emergency anaesthetic drugs before starting their list, seven of them continued to answer the next questions which related to pre-preparation of emergency anaesthetic drugs. They were thus excluded from these questions.

Respondents were then asked to indicate their practice as it relates to the nature of surgery, that is emergency or elective surgery, as well as the type of patient, that is adult, paediatric and obstetric patients. These results can be seen in figures 4.3 and 4.4 respectively.

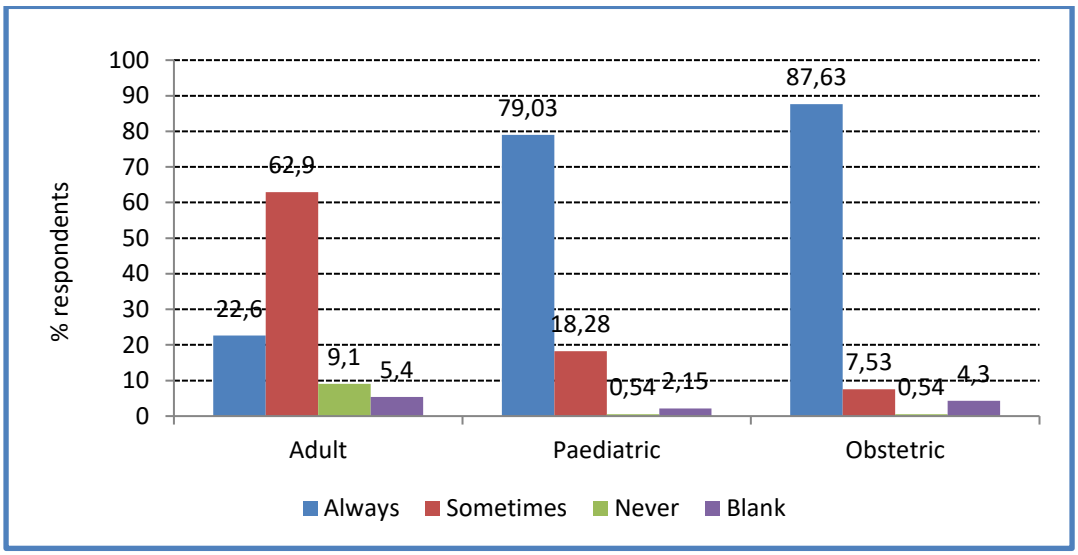

Figure 4.3 Frequency of emergency anaesthetic drug pre-preparation before the start of an elective list

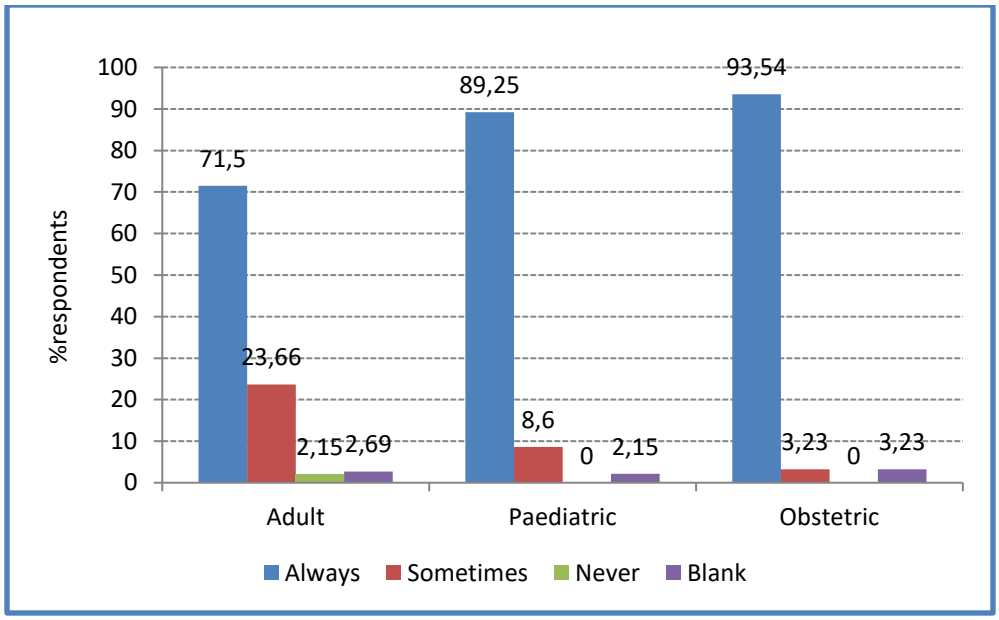

Figure 4.4 Frequency of emergency anaesthetic drug pre-preparation before the start of an emergency list

The second objective of the study was to describe which emergency anaesthetic drugs are pre-prepared. Figure 4.5 and figure 4.6 describe respondents' practices.

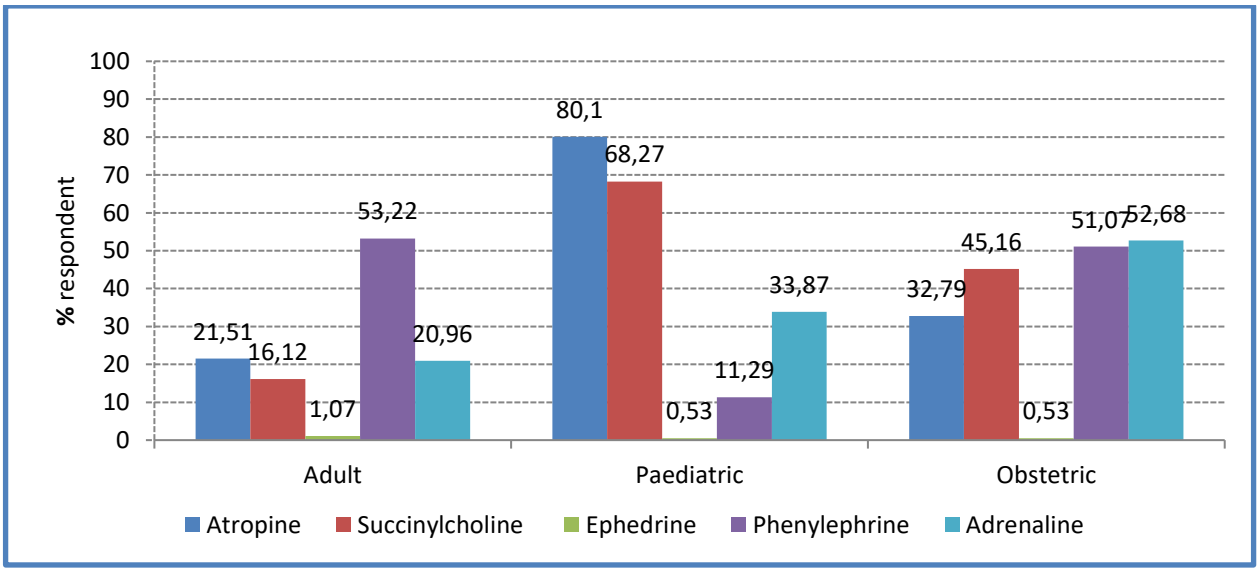

Figure 4.5 Emergency drugs pre-prepared routinely for elective lists

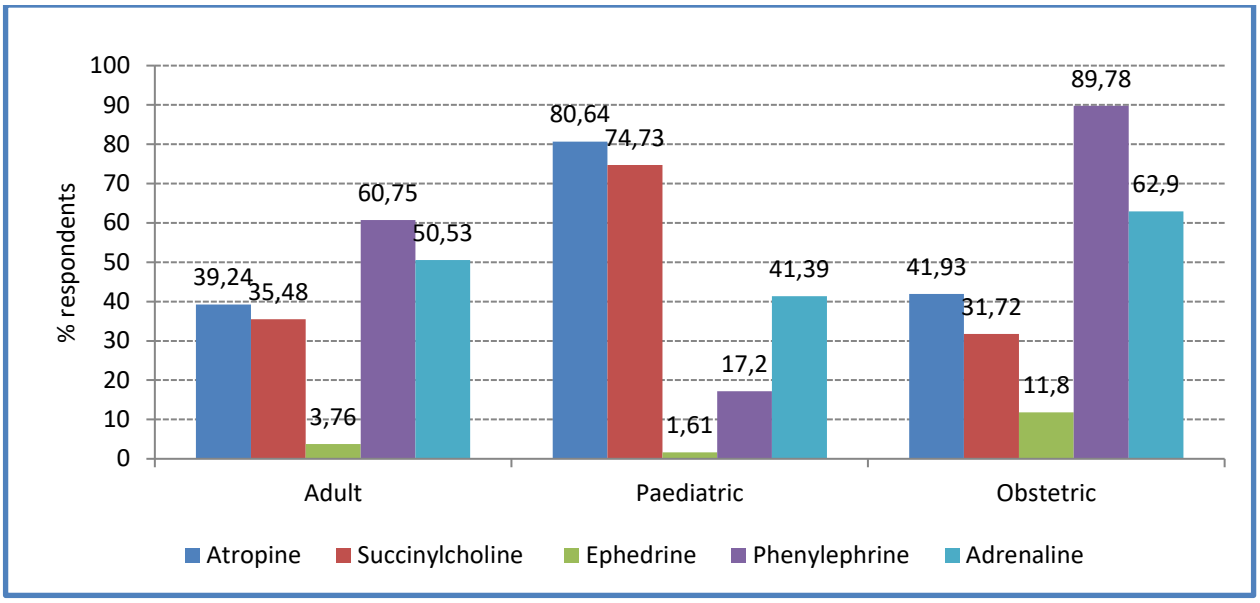

Figure 4.6 Emergency drugs pre-prepared routinely for emergency list

The choice of emergency anaesthetic drugs routinely pre-prepared is dependent on the type of patient and the nature of surgery: elective or emergency surgery. The results showed a significant difference between practice for elective and emergency surgery: a significantly higher number of respondents prepare succinylcholine, ephedrine, phenylephrine and adrenaline (p=0.002, p=0.013, p=0.035 and p=0.001 respectively) for emergency surgery. The result for atropine was non-significant (p= 0.809).

Eleven respondents answered “propofol” for other drugs that they pre-prepare. Nine indicated the theatre for which they pre-prepared propofol and two indicated the drug only. Six respondents pre-prepare propofol for emergency and elective paediatric theatres, one pre-prepares it for emergency and elective obstetric theatres and emergency paediatric theatre, one pre-prepares it for emergency paediatric theatre, and one pre-prepares it for emergency obstetrics theatre.

The actual use of pre-prepared emergency anaesthetic drugs was questioned. Respondents indicated frequency of use per month in elective theatres (figure4.7).

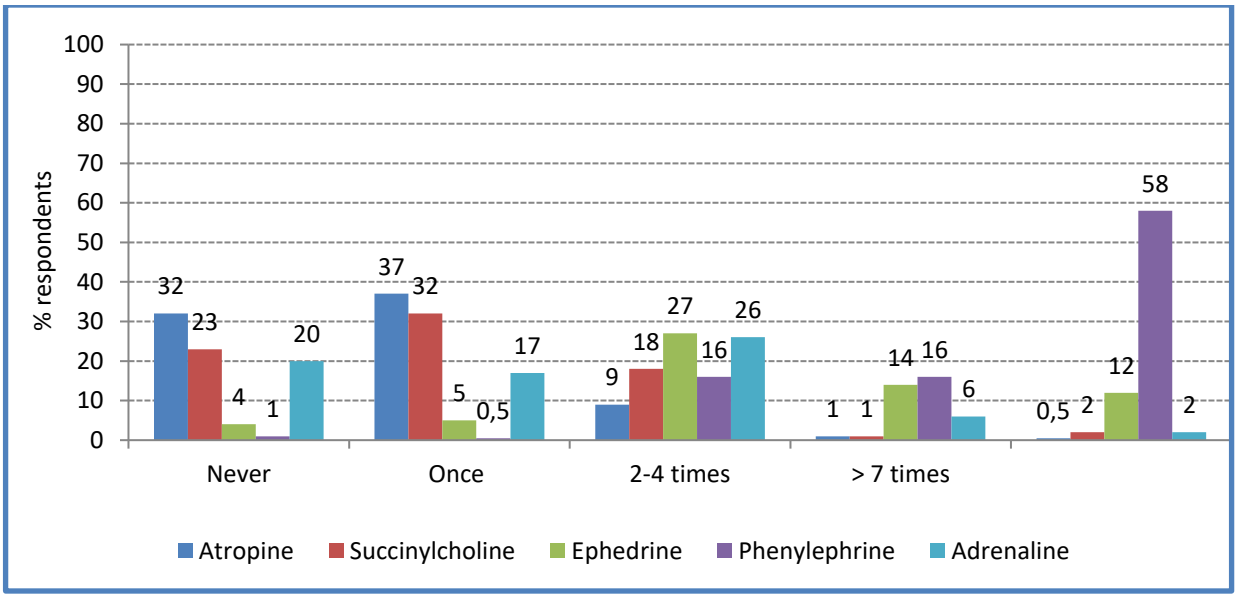

Figure 4.7Frequency of use of pre-prepared emergency anaesthetic drugs for elective surgery per month

The third objective in this study was to describe the opinions of anaesthetists regarding pre-preparation of emergency anaesthetic drugs as a source of drug administration errors, contamination and wastage.

Pre-preparation of emergency anaesthetic drugs may lead to syringe swap errors. Respondents were questioned about their syringe labelling practices (figure4.8) and then asked if they had experienced such errors (tables 4.5 and 4.6).

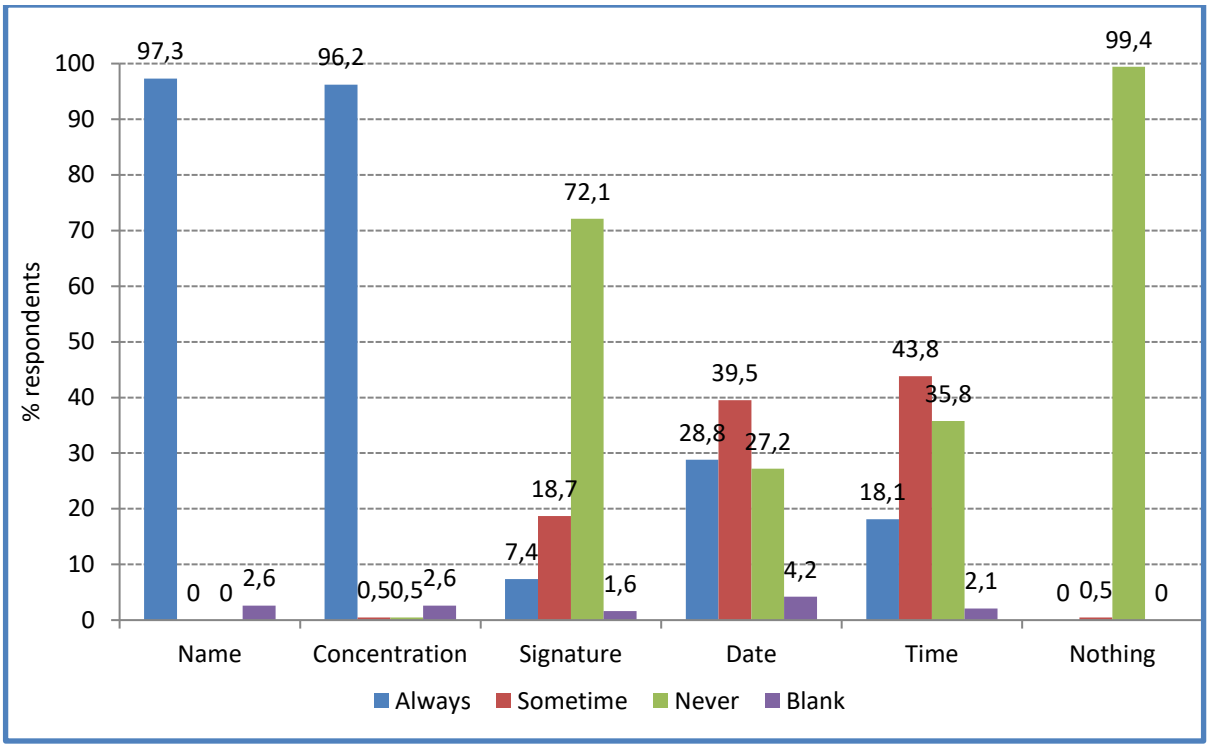

Figure 4.8 Syringe label information

Table 4.5 Respondents who have experienced syringe swap errors with pre-prepared emergency anaesthetic drugs

Response	Number (%)
Yes	47(25.26)
No	127(68.28)
Do not know	10(5.38)
Blank	2(1.08)

Table 4. 6 Frequency in the last year

Frequency	Number (%)
Once	32(68.09)
2-4 times	11(23.40)
5-7 times	0(0)
>7 times	0(0)

Four (8.51%) syringe swap errors were not in the last year.

Drug administration errors can occur if one has to draw emergency anaesthetic drugs at the time they are needed in an emergency. When questioned on this, 137 (73.66%) respondents indicated that this had not occurred in their practice, 33 (17.74%) indicated that it had occurred and 15 (8.06%) did not know. One (0.54%) did not answer the question; who only pre-prepare emergency drugs at the start of a list sometimes.

Respondents were then asked whether they had experienced a complication due to a delay in delivery of a required emergency anaesthetic drug to the patient at time of an emergency, the results of which appear in table 4.7.

Table 4.7 Respondents who have experienced a complication due to a delay in delivery of a required emergency anaesthetic drug at the time of an emergency

Response	Number (%)
Yes	66 (35)
No	104 (56)
Do not know	16 (9)

Of those respondents who indicated that they have experienced a delay in the delivery of a drug at the time of an emergency, 21 (31.82%) responded that this had had a negative

impact on the patient's outcome, 33 (50.00%) responded that it had not, and 12 (18.18%) did not know.

Some responses were not included in the results. Three of the respondents, who did not indicate that they have experienced a delay in delivery of a drug at the time of an emergency, answered the question concerning a delay that negatively affected the patient outcome. Two respondents indicated that they did not know if they had experienced a delay in delivery of a drug at the time of an emergency but answered the question where the delay negatively affected the patient's outcome.

Drugs that are pre-prepared and not immediately used may become a source of contamination. The frequency of replacement of emergency anaesthetic drugs in emergency theatre was thus examined (figure 4.9).

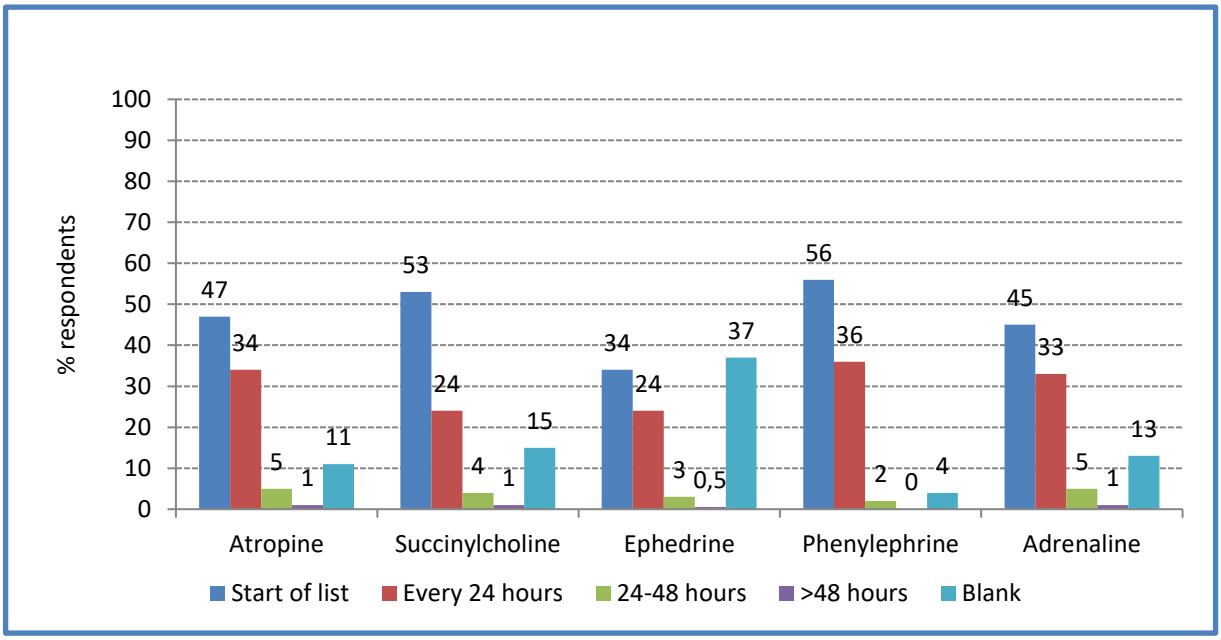

Figure 4. 9 Frequency of replacement of unused emergency anaesthetic drugs in emergency theatres

Respondents were then asked if they thought that pre-prepared emergency anaesthetic drugs are a potential source for drug contamination (table 4.8).

Table 4.8 Pre-preparation of emergency drugs as a potential source for drug contamination

Response	Number (%)
Yes	119(61.34)
No	54(27.84)
Do not know	20(10.30)
Blank	1(0.52)

Prefilled syringes may be a way of addressing both drug wastage and drug administration errors. The perception of respondents with regards to the availability of prefilled syringes to address these issues was assessed, the results of which appear in table 4.9 and 4.10

Table 4. 9 Perception of respondents with regards to availability of prefilled syringes as a way to reduce emergency drugs wastage

Response	**Number (%)**
Yes	156 (80.41)
No	22 (11.34)
Do not know	16 (8.25)

Table 4.10 Perception of respondents with regards to availability of prefilled syringe will decrease drug administration administration error

Response	**Number(%)**
Yes	153 (78.87)
No	17 (8.76)
Do not know	22 (11.34)
Blank	2 (1.03)

The fourth objective of the study was to compare demographics with emergency anaesthetic drug pre-preparation practices. The frequency of emergency anaesthetic drug pre-preparation according to professional grade and years of experience is shown in figure 4.10 and 4.11 respectively.

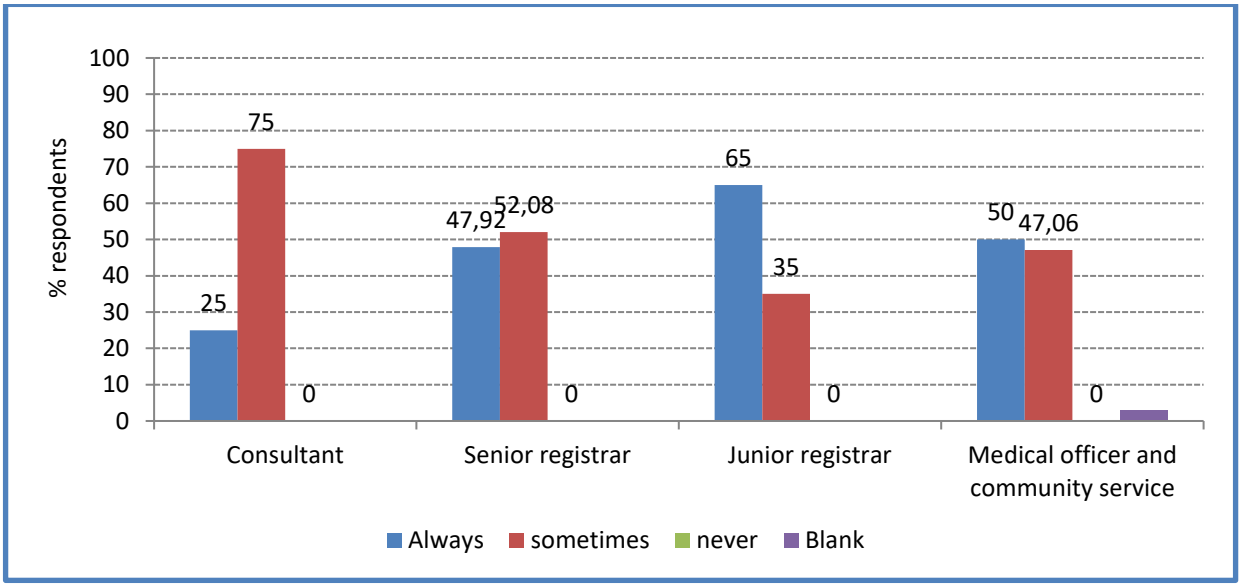

Figure 4.10 Frequency of emergency anaesthetic drug pre-preparation according to professional grade

It has been observed that significantly fewer(34.82%) senior staff (consultants and senior registrars)always pre-prepare emergency anaesthetic drugs compared to junior staff (58.11%) (junior registrars, medical officers and community service doctors) ($p<0.001$).These differences are further seen in detail below, when looking at practice according to the type of patient (adult, paediatric and obstetric) and nature of surgery: emergency or elective.

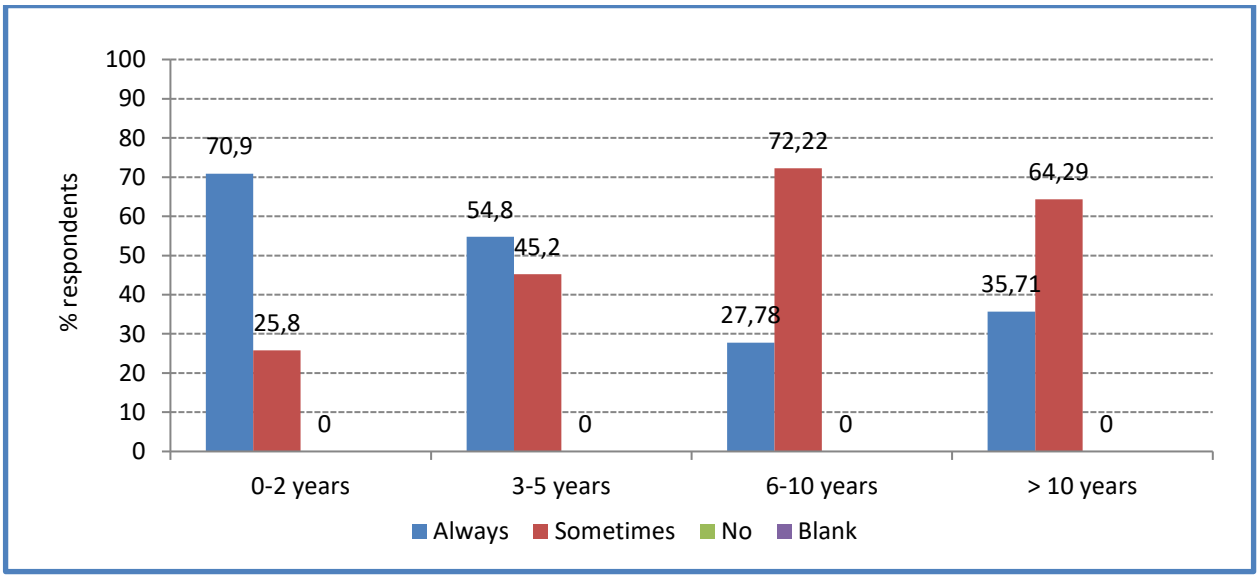

Figure 4.11 Frequency of emergency anaesthetic drug pre-preparation in relation to years of experience

Looking at years of experience in relation to emergency anaesthetic drug pre-preparation it has been observed that the results are similar to professional grade. Respondents with 0-2 years of experience pre-prepare emergency anaesthetic significantly more than respondents with six or more years of experience($p<0.001$). Respondents who have six years or more experience in practice tend to pre-prepare emergency anaesthetic drug only sometimes.

Respondents were questioned with regards to whether their practice should change according to the type of patient: adult, paediatrics and obstetrics patients and nature of surgery: elective versus emergency. The results were analysed as senior staff versus junior staff in order to investigate if these factors play a role. The results are shown in figures 4.12and 4.13.

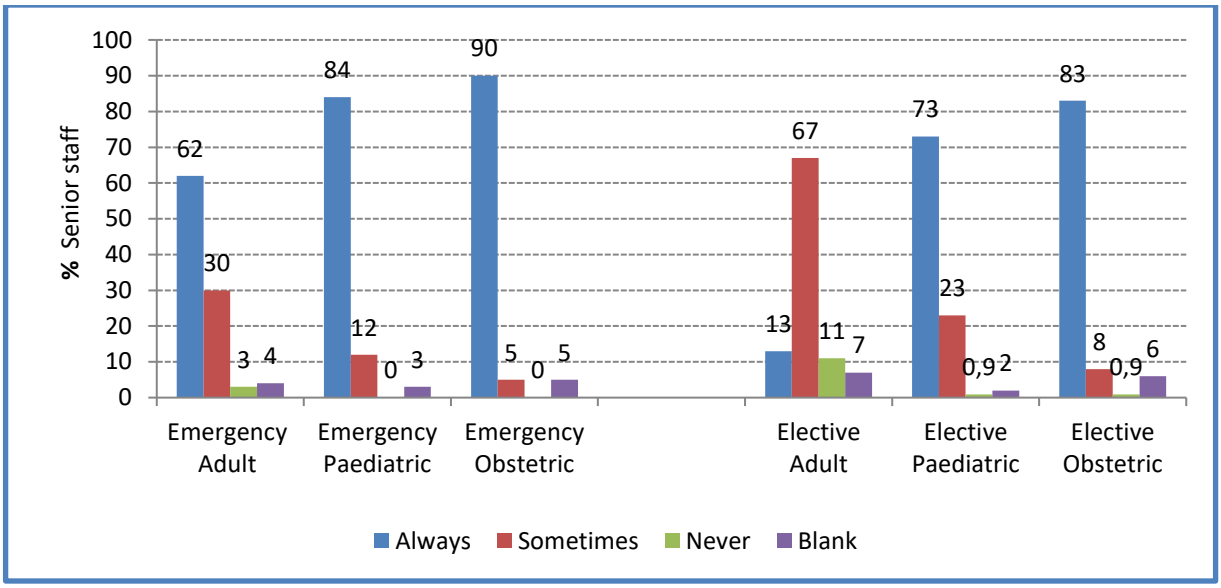

Figure 4.12 Frequency with which consultants and senior registrars pre-prepare emergency anaesthetic drugs according to type of patient for emergency and elective theatres

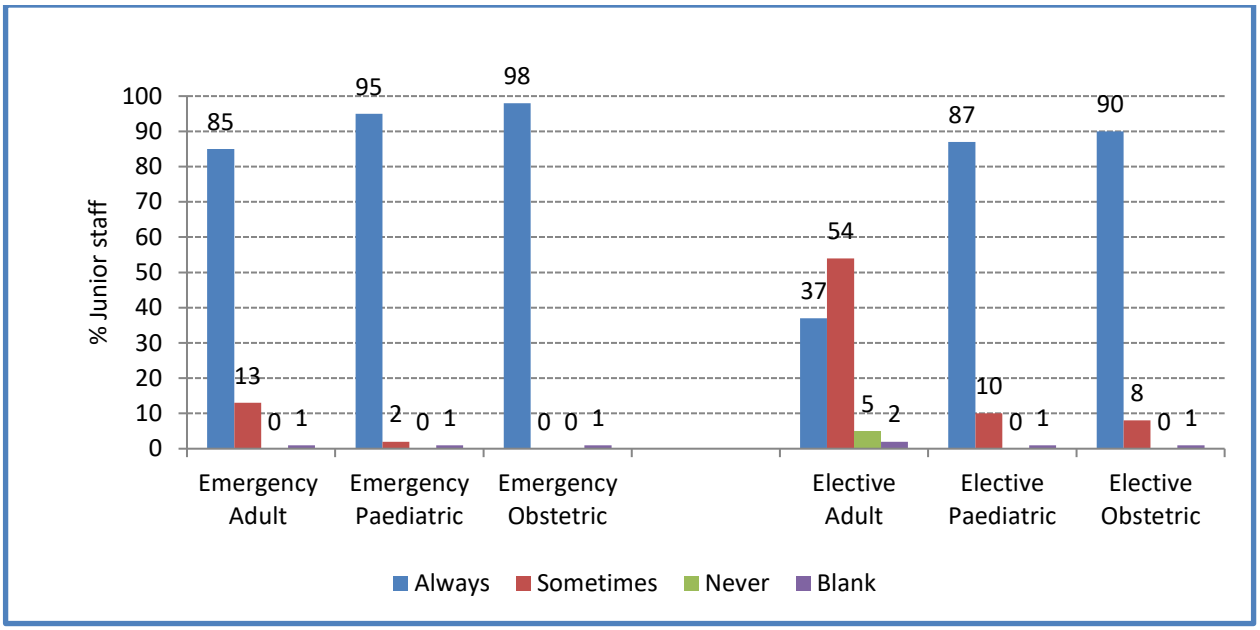

Figure 4.13 Frequency with which junior registrars, medical officers and community service doctors pre-prepare emergency anaesthetic drugs according to type of patient for emergency and elective theatres

From these two graphs, it can be seen that for emergency adult theatre, significantly fewer senior staff always pre-prepare these drugs compared to junior staff (61.95% versus 85.14%, p=0.004).

For emergency paediatric theatre, whilst a high proportion of both junior and senior staff always pre-prepare emergency anaesthetic drugs (95.90% and 84.1%, respectively), a significantly greater proportion of junior staff pre-prepare these drugs (p=0.034).Similarly, for emergency obstetric theatre almost all respondents (senior and junior staff), always pre-prepare emergency anaesthetic drugs, but once again, the highest proportion is amongst junior staff (p = 0.045).

The practice of all respondents in elective theatres compared to emergency theatres shows that there is a significant difference in practice only for elective adult theatres (p=0.001), with more respondents always pre-preparing emergency drugs for emergency adult theatre. The results show that61.95% of senior staff pre-prepare emergency anaesthetic drugs for emergency theatres but only 13.28% pre-prepare for elective adult theatres. This is similar to the junior staff, where 85.14% pre-prepare drugs for emergency theatre but only 37.84% pre-prepare for elective adult theatre. There is a non-significant difference in practice for obstetric and paediatric theatres (p=0.144 and p=0.057 respectively).

The choice of emergency anaesthetic drugs to pre-prepare varies with professional grade. The results show that junior staff pre-prepare succinylcholine(p=0.012) and phenylephrine(p=0.023) significant more than senior staff for all elective theatres.

In addition, junior staff pre-prepare adrenaline significantly more that senior staff for all elective theatres (adult, paediatric and obstetric) ($p<0.001$) and all emergency theatres (adult, paediatric and obstetric) ($p<0.001$).

The results showed non-significant differences between senior and junior staff, for pre-preparation of atropine and ephedrine, at different types of theatres.

It can thus be seen from these results that practice regarding pre-preparation of emergency anaesthetic drugs varies according to professional grade, nature of surgery and the type of patient. For the type and nature of surgery, the results show that senior staff tend to pre-prepare drugs less frequently than junior staff.

3.4 Discussion

Departmental policy and teaching is one factor that may influence practice of anaesthetists regarding pre-preparation of emergency anaesthetic drugs. In this study 52.06% of respondents reported that there was no departmental policy regarding emergency anaesthetic drug pre-preparation. In comparison to a New Zealand study (1), 83.5% of respondents reported that no departmental policy in this regard existed. It is thus evident that such policies need to be developed in order to help guide individual anaesthetists in this area.

With regards to training, the results showed almost equal responses for receiving and not receiving training. This may be accounted for by the fact that there are three training facilities and training may differ between the hospitals. Other reasons may be that there is no departmental policy, differing of opinions with regards of emergency anaesthetic drug pre-preparation. When compared to a New Zealand study (1), where only 27.5% of respondents had received training, these results reflect an improvement

The practice of pre-preparing emergency anaesthetic drugs varies greatly. In this study most respondents either always pre-prepare (43.30%) or sometimes pre-prepare (52.06%) emergency anaesthetic drugs at the start of the list, with only 4.12% indicating that they never pre-prepare emergency anaesthetic drugs. The same New Zealand study (1) showed a much smaller percentage of respondents (26%) who routinely pre-prepare emergency anaesthetic drugs but a similar number (41%) who pre-prepare them sometimes. This is because the circumstances of the case influence practice. Once again, only a small proportion(8.5%)never pre-prepare emergency anaesthetic drugs at start list.

Other factors that may influence the decision to pre-prepare emergency anaesthetic drugs include the nature of surgery, that is elective or emergency lists, and the type of patient, that is adult, paediatric and obstetric patients.

In this study most respondents always pre-prepare emergency anaesthetic drugs before the start of elective paediatric with (78.60%) and obstetric with (87.16%) lists but only sometimes (62.56%) before the start of an elective adult list. This is in contrast to emergency cases, where most respondents always pre-prepare emergency anaesthetic drugs.

In obstetrics theatre,87.1% of respondents pre-prepare emergency anaesthetic drugs. This is the similar to a survey of UK practice (14)where 87% of respondents routinely pre-prepare these drugs for obstetric cases. Reasons for this are the higher risk associated with obstetrics patients and the unpredictable nature of such surgery, hence the need to have emergency anaesthetic drugs readily available for use.

Elective paediatric cases is another theatre where most respondents (78.6%) pre-prepare emergency anaesthetic drugs. This is different to the survey conducted by the Association of Paediatric Anaesthesia(APA)(18), where a lower figure of 56%was reported to always pre-prepare emergency anaesthetic drugs prior to elective paediatric anaesthesia. This difference may be due to the majority of respondents in the APA survey (82%) being consultants (18), and hence, having completed specialist training together with having a greater number of years of experience than registrars. This is in contrast to this study where only 36% of respondents were consultants.

The nature of surgery will affect the choice of emergency anaesthetic drugs pre-prepared routinely. In both elective and emergency obstetrics theatres the most commonly pre-prepared drugs were phenylephrine and adrenaline. This is different to a survey of UK practices (14) where the most commonly pre-prepared emergency anaesthetic drugs were thiopental and succinylcholine. This may be accounted for by the fact that, once again, most respondents in the UK survey were consultants.

Looking at elective and emergency adult theatres, including obstetrics theatre, the most commonly pre-prepared vasopressor was phenylephrine. The vasopressor of choice in another study describing practice in elective and emergency adult theatres was ephedrine (7). The reason for this difference is not clear as the literature has shown that phenylephrine is the vasopressor of choice for caesarean section due to the lower incidence of foetal acidosis when compared to ephedrine (7).

Elective paediatric theatres showed a difference in the choice of drugs pre-prepared. The most commonly pre-prepared drugs were atropine (79.6%) and succinylcholine (67.9%). This is similar to the APA survey which also reported that atropine(92%) and succinylcholine (83%) were the most common drugs pre-prepared(18).This highlights the common experience of complications such as laryngospasm being the reason for the choice of drug pre-preparation.

Actual use of pre-prepared drugs

Pre-preparation of emergency anaesthetic drugs for elective surgery showed similar results to those obtained in another study (7). In both studies, most respondents pre-prepare atropine and succinylcholine.

In this study, the overwhelming majority of respondents pre-prepare both these drugs before the start of an elective list. Actual use of these drugs is infrequent though: for atropine results showed that of the 81.28% of respondents who pre-prepare this drug, 59.86% actually used it; 76.92%only gave it once and less than a fifth (18.68%) gave it 2-4 times per month. For succinylcholine results showed that of the 73.26% of respondents who pre-prepare this drug, 75.18% actually used it; 59.22% only gave it once per month. Similar frequency of use has been by Oswal et al (7).These finding show that despite atropine and succinylcholine commonly being pre-prepared before the start of the elective list, they are infrequently used and were thus a potential source of drug wastage(7).

For ephedrine the results showed that only 8.55% pre-prepare this drug, but two thirds (60.42%) of respondents actually use it. In addition, just less than half (46.01%) of them gave it 2-4 times. This is different to the study on peri-operative use of emergency anaesthetic drugs showed that almost all respondents (93.2%)actually used of ephedrine. (7)

Of the drugs pre-prepared, the one most frequently used (95%) was phenylephrine, with 63.74% of respondents indicating they gave it >7 times in a month. The use of phenylephrine in the study on peri-operative use of emergency anaesthetic drugs showed that just over half (55.9%) of respondents actually used phenylephrine, and 42.4%of them gave it 2-4 times per month(7).

It can thus be seen that phenylephrine is the vasopressor of choice in this study whereas ephedrine was preferred in the study conducted by Oswal et al (7).

Labelling syringes correctly is necessary to reduce drug administration errors. In this study almost all the respondents put the drug name and drug concentration on the syringe. A far smaller proportion (28.8%) of respondents put the date of preparation, the time of preparation (18.1%) and only 7.4% signed their names on the drugs. Such information is more important for multi-dose vials that would be handed over a colleague at the change of a shift.

A survey of UK (14) practice, which looked at the preparation and storage of anaesthetic drugs for obstetric emergencies recommended that syringe information be clear, with at least the drug name and concentration labelled, in order to reduce the risk of drug administration errors (4, 14). It is encouraging that almost all respondents in the South African study adhere to this practice.

Syringe swap errors were the commonest factor leading to drug administration errors (26), with similar incidence (25-29%) occurring in this study and those done in other centers(1, 7, 29). These errors are important to consider as they may impact patient outcome.

Although this study did not specifically look at drug administration errors and impact patient outcome, the Thai Anaesthesia Incidents Study(27)measured the incidence and adverse events related to drug administration errors. The result showed a total of 14 adverse events (34.1%), ranging from temporary mild to severe physiological changes. Thirteen of the patients made a full recovery but one died.(27)

Another factor to consider is the occurrence of drug administration errors related to drawing up emergency drugs at time they were needed in an emergency. In this study 17.55% of respondents have experienced this but a greater proportion has been reported in the literature (29.5%)(1).This may be related to the anaesthetist being unaware of the error or not feeling comfortable to report it. Ducat et al (1) found that the reason for this difference was that assistants were slow or ineffective in drawing up emergency drugs at the time of emergency.

The consequence of such delays is the potential risk of complications occurring to the patient. In this study 35.29% of respondents experienced a complication due to a delay in delivery of a required emergency drug to the patient. This finding is similar to a New Zealand study(1), which showed that which showed that37% of respondents have had such complications. In addition, the APA survey (18) of emergency drug preparation prior to elective paediatric anaesthesia showed that 12% of respondents experienced critical event related to non-availability of these drugs. It can thus be seen that pre-preparation of emergency anaesthetic drugs has the advantage of saving time when an emergency does occur (1) but caution should still be taken to avoid syringe swap errors.

The National Patient Safety Agency (NPSA)(35) in the UK and the Anaesthesia Patient Safety Foundation (APSF) in the USA(14) have published recommendations for the preparation and administration of intravenous drugs to ensure patient safety. These guidelines state that intravenous drugs should not be stored for more than 24 hours (or less if pharmaceutically required or by the manufacturer)(35). The results of this study showed that approximately half of respondents do replace emergency anaesthetic drugs at the start of a list, as recommended. This is in line with UK practice (14), which showed that replaced of emergency anaesthetic drugs was done every 24 hour.

Pre-preparation of emergency drugs as a potential source of drug contamination. In this study 61.34% of respondents perceived that pre-preparation of emergency drugs is a potential source for drug contamination. This is similar to an Irish study(2)that showed that 62.7% of respondents also perceive this.

The availability of prefilled syringesis one solution to help reduce emergency drug wastage and cost. Most respondents (80.41%) indicated that the availability of prefilled syringes will help to reduce emergency drug wastage. Other studies(2, 7, 37) have also demonstrated such perceptions regarding the use of prefilled syringes.

With a reduction in waste comes the reduction in cost. There is evidence to show that the use of prefilled syringes is able to reduce cost(6, 37). Despite the advantages of prefilled syringes, the concern about the time it takes to dilute a drug further at time of emergency particularly for paediatric theatre, remains (17).

Prefilled syringes offer a number of other benefits, namely drug administration errors, syringe swap errors as well as labelling errors (24). In this study 78.87% of respondents perceive that the availability of prefilled syringes will decrease drug administration errors. Prefilled syringes are further supported by the recently updated European Board of

Anaesthesiology guidelines for safe medication practice. These guidelines advocate the use of pre-filled syringe wherever order to reduce the risk of drug administration errors(4).

A comparison between demographics emergency anaesthetic drug pre-preparation practices was also done. In this study more than half the respondents (60.42%) were either consultants or senior registrars. The results showed that they draw emergency anaesthetic drugs before the start of a list only sometimes. This is different to the study on peri-operative use of emergency anaesthetic drugs, where approximately 60% of respondents were consultants. More than half the senior members of staff including consultants and staff grade anaesthetists (South African equivalent is career medical officer) always draw these emergency drugs at the beginning of every list.(7)

This is in comparison to junior staff, which includes junior registrars (with one to two years of experience), medical officers and community service doctors, who always pre-prepare emergency anaesthetic drugs. This is similar to the results found by the Oswal et al. (7)

When examining practice according to years of experience, it was found in this study that the greater the number of years of experience the less frequently one pre-prepares emergency anaesthetic drugs. This is similar to a New Zealand study (1), where respondents also indicated the circumstances for which the pre-prepare these drugs. The specific circumstances, such as individual patient characteristics, elderly or high risk patients, paediatric patients, obstetric patients, major regional procedures (for which a vasopressor may be required) and when alone with poor assistance, or when in a remote location. (1)

Indeed, respondents who have 6 years or more experience pre-prepare emergency anaesthetic drugs only sometimes. This result mirrors those relating to professional grade.

In conclusion, pre-preparation of emergency anaesthetic drugs at the University of the Witwatersrand academic training hospitals varies according to patient and anaesthetist

related factors. There is no protocol and so these decisions are according to individual preference. Anaesthetist related factors are professional grade and this is related to years of experience. Patient related factors, such as paediatric or obstetric, and emergent surgery also impact practice.

It is suggested that pre-preparation of emergency anaesthetic drugs at the start of list for either elective or emergency theatres be under the supervision of senior staff, as they have more experience. This may guide trainees as to what complications to anticipate for certain cases and hence inform the choice of drugs pre-prepared. This guided pre-preparation will help to reduce the complications associated with pre-preparing multiple drugs, such as drug administration error. In addition, it will help to reduce waste and theater operating costs.

3.5 Summary

This chapter discusses the research results asper the research objectives. This includes the introduction of study objectives, sample realisation, results and discussion. The final chapter will present a summary of the study as well as the limitations, recommendations and conclusion of this study.

Chapter Five Summary, limitations, recommendations and conclusions

4.1 Introduction

In this chapter a summary of the objectives, study design and results of the study are presented. The limitations of the study will be addressed, recommendations for clinical practice and research made and a conclusion presented.

4.2 Summary of the study

4.2.1 Aim of the study

The aim of this study was to describe the practice of anaesthetists at three Johannesburg academic hospitals with regards to pre-preparation of emergency anaesthetic drugs, to describe the advantages and disadvantages of pre-preparation of these drugs.

4.2.2 Objectives of the study

The objectives of the study were to:

- To describe the practice of anaesthetists regarding pre-preparation of emergency drugs in elective and emergency theatres
- To describe which emergency anaesthetic drugs are pre-prepared
- To describe the opinions of anaesthetists regarding pre-preparation of emergency drugs as a source of drug administration error, contamination and wastage

- To compare demographics with emergency anaesthetic drug pre-preparation practices

4.2.3 Summary of the methodology used in the study

This was a prospective, descriptive study design that entailed the distribution of questionnaires on the pre-preparation of emergency anaesthetic drugs to members of the Department of Anaesthesiology at three of the hospitals that comprise the University of the Witwatersrand's training hospitals.

All anaesthetic department staff affiliated with the University of Witwatersrand were eligible to participate. There were a total of 219 anaesthetists. This included doctors from the professional levels of consultant, senior registrar, junior registrar, medical officer and community services doctor.

Data were collected with the use of a self-administered questionnaire (Appendix 6). Approval from the Human Research Ethics Committee (Medical) of the University of the Witwatersrand and the respective hospital CEO's was obtained, consent was requested from the heads of the anaesthetic departments in the participating hospitals. Questionnaires were distributed and collected by the researcher at departmental meetings and placed into a sealed box. The contact details of the researcher were available to participants should any queries arise.

4.2.4 Results

Pre-preparation of emergency anaesthetic drugs at the University of the Witwatersrand academic training hospitals varies according to patient and anaesthetist related factors. There is no protocol and so these decisions are according to individual preference.

Anaesthetist related factors are professional grade and this is related to years of experience. Patient related factors, such as paediatric or obstetric, and emergent surgery also impact practice.

4.3 Limitations of the study

Limitations of this study include the use of a self-administered questionnaire and the contextual nature of the study. Self-administered questionnaires have a number of limitations including incomplete answering of all questions, the inability to provide clarification on any of the questions should a query arise and a desire amongst participants to provide the perceived accepted responses. (42)

The study was contextual in nature. Only those anaesthetists at the three training hospitals of the University of the Witwatersrand were involved and thus the findings may not be generalised to other academic hospitals in the province or country.

4.4 Recommendations

4.4.1 Recommendations for clinical practice

The research showed the varied practice among anaesthetists with regards to pre-preparation of emergency anaesthetic drugs. Recommendations are to develop departmental guidelines in order to ensure patient safety by having appropriate drugs readily available should the need arise. It is also important to bare the disadvantages of pre-preparation of emergency anaesthetic drugs when developing such guidelines. These include the reduction of drug administration errors, contamination, waste and cost. The availability of pre-filled syringes can also be investigated as a means to address these issues.

4.4.2 Recommendations for further research

There may be a difference between what respondents indicate in a questionnaire compared to what they actually do in theatre. Therefore, possible future research would entail the researcher being present in theatre. This would allow direct observation of the drugs pre-prepared, used and wasted. It would also provide more accurate information on how drugs are pre-prepared and stored. The stability and sterility of these drugs could also be investigated.

4.5 Conclusion

The practice of anaesthetists at three of the hospitals that comprise the University of the Witwatersrand's academic training hospitals has been described. Practice varies according to professional grade, nature of surgery and the type of patient. For the type and nature of surgery, the results show that senior staff tend to pre-prepare drugs less frequently than junior staff.

Departmental policy would be helpful for the decrease the pre-prepared of emergency complication and for guidance with regarding pre-preparation of emergency anaesthetic drugs.

Introduction of pre-filled syringes for most common used emergency anaesthetic drugs would be recommended for decrease drugs administration error and drug wastage.

References

1. Ducat CM, Merry AF, Webster CS. Attitudes and practices of New Zealand Anaesthetists with Regard to Emergency Drugs. Anaesth Intens Care. 2000;28(6):692-7.

2. Kulcsar Z, Bredin S, Seigne D, Lohom G. Anaeshetic emergecy drug preparation and storage. Eur J Anaesth. 2010;27(47):234.

3. Getting Started - Preparing Your Theatre 2016 [cited 2017 19/01/2017]. Available from: http://www.e-lfh.org.uk/e-learning-sessions/rcoa-novice/content/started/theatre.html.

4. Whitaker D, Brattebo G, Trenkler S, Vanags I, Petrini F, Aykac Z, et al. The European Board of Anaesthesiology recommendations for safe medication practice: First update. Eur J Anaesthesiol. 2017;34(1):4-7.

5. Motamedifar M. the prevalence of multidose vial contamination by aerobic bacteria. Am J Infect Control. 2009;37(9).

6. Atcheson M, Spivack J, Williams B, Ethan O. Preventable drug waste among anesthesia providers: opportunities for efficiency. J Clin Anesth. 2016;30:24-32.

7. Oswal S, Kyriakides k. Audit: Peri-operative use of Emergency Anaesthetic Drugs 2008 [cited 2016 01/06/2016]. Available from: http://www.aagbi.org/sites/default/files/OSWAL%2C%20Smita%20-%20SAS%20Prize2008.pdf.

8. Milner A. Autonomic nervous system In: Milner A, editor. Applied Pharmacology in Anaesthesiology and Critical Care. South Africa: Medpharm Publication; 1st edition; 2012. p. 163-4.

9. Gurung AM, Tomlinson AA. Pre-preparation of succinylcholine: significant waste for questionable benefit. Anaesth. 2004;59(3):211-2.

10. Milner A. Neuromuscular blocking agent. In: Milner A, editor. Applied Pharmacology in Anaesthesiology and Critical Care. South Africa: Medpharm Publication; 1st edition; 2012. p. 491, 513.

11. Morgan G, Mikhail M, Murray S. Anticholinergic drugs. In: John F. Butterworth IV, David C. Mackey, JohnD. Wasnick, editors. Clinical Anesthesiology. fourth ed. New York: McGraw-Hill Companies; 2006. p. 239.

12. Ertmer C, Morelli A, Westphal M. The Role of Phenylephrine in Perioperative Medicine. In: Vincent J-L, editor. Yearbook of Intensive Care and Emergency Medicine. Berlin, Heidelberg: Springer Berlin Heidelberg; 2009. p. 483-97.

13. Kiser T, Oldland A, Fish D. Stability of phenylephrine hydrochloride injection in polypropylene syringes. Am J health syst pharm. 2007;64(10):1092-5.

14. Stone JP, Fenner LB, Christmas TR. The preparation and storage of anaesthetic drugs for obstetric emergencies: a survey of UK practice. Int J Obstet Anesth. 2009;18(3):242-8.

15. Lejus C, Blanloeil Y, Oudot M, Le Teurnier Y, Lepage JY, Loutrel O, et al. Atropine and ephedrine: a significant waste in the operating theatre. Anaesth. 2012;67(3):300-1.

16. Nightingale JJ, Lack JA, Stubbing JF, Reed J. The pre-operative anaesthetic visit. Anaesth. 1992;47(9):801-3.

17. Morgan G, Mikhail M, Murray S. Pediatric Anaesthesia. In: John F. Butterworth IV, David C. Mackey, JohnD. Wasnick, editors. Clinical Anesthesiology. Fourth ed. New York: McGraw-Hill Companies; 2006. p. 922.

18. Nakhjavani S, Rohan D, Brendan O. Association of Paediatric Anaesthetists of Great Britain and Ireland survey of attitude to Emergency Drug Preparation prior to routine Paediatric Anaesthesia. 2011 [cited 2017 8/03/2017]. Available from: http://www.apagbi.org.uk/sites/default/files/images/Emergency%20Drugs%20Survey%20Report%20O%27Hare%20%202011_0.pdf.

19. Kruger H. Anaesthesia for ICU-based procedures: the advantages of and options available for inhalational anaesthesia. South Afr J Anaesth Analg. 2010;16(3):63-9.

20. Nevin M, Brennan L. Anaesthetic services in remote sites the royal college of anesthetists2014 [updated 2017; cited 2017 26/03/2017]. Available from: http://www.rcoa.ac.uk/system/files/REMOTE-SITES-2014_3.pdf.

21. Morgan G, Mikhail M, Murray S. General Anesthesia. In: John F. Butterworth IV, David C. Mackey, JohnD. Wasnick, editors. clinical anesthesiology. fourth ed. New York: McGraw-Hill Companies; 2006.

22. Morgan G, Mikhail M, Murray S. Pregnancy -Related Mortality. In: John F. Butterworth IV, David C. Mackey, JohnD. Wasnick, editors. Clinical Anesthesiology. fourth ed. New York: McGraw-Hill Companies; 2006.

23. Morgan G, Mikhail M, Murray S. Obstertric Anesthesia. In: John F. Butterworth IV, David C. Mackey, JohnD. Wasnick, editors. Clinical Anesthesiology. fourth ed. New York: McGraw-Hill Companies; 2006. p. 1.

24. Webster CS, Merry AF, Ducat CM. Safety, cost and predrawn emergency drugs. Anaesth. 2001;56(8):799-820.

25. Merry AF, Webster CS, Mathew DJ. A New, Safety-Oriented, Integrated Drug Administration and Automated Anesthesia Record System. Anesth Analg. 2001;93(2):385-90.

26. Orser BA, Chen RJ, Yee DA. Medication errors in anesthetic practice: a survey of 687 practitioners. Canadian journal of anaesthesia = Journal canadien d'anesthesie. 2001;48(2):139.

27. Hintong T CIW, Thienthong s, Nakcharoewaree s. An analysis of the drug error problem in the Thai Anesthesia Incidents Study. J Med Assoc Thai. 2005;88.

28. Yentis SM, Randall K. Drug errors in obstetric anaesthesia: a national survey. Int J Obstet Anesth. 2003 12(4):246-9.

29. Abeysekera A, Bergman IJ, Kluger MT, Short TG. Drug error in anaesthetic practice: a review of 896 reports from the Australian Incident Monitoring Study database. Anaesth. 2005;60(3):220-7.

30. Merry AF, Webster CS, Hannam J, Mitchell SJ, Henderson R, Reid P, et al. Multimodal system designed to reduce errors in recording and administration of drugs in anaesthesia: prospective randomised clinical evaluation. BMJ. 2011;343.

31. Magee L, Godsiff L, Matthews I, Farrington M, Park GR. Anaesthetic drugs and bacterial contamination. European journal of anaesthesiology Supplement. 1995;12:41-3.

32. Mattner F, Gastmeier P. Bacterial contamination of multiple-dose vials: a prevalence study. Am J Infect Control. 2004;32(1):12-6.

33. Khalili H, Sheikhbabayi M, Samadi N, Jamalifar H, Dalili D, Samadi N. Bacterial contamination of single- and multiple-dose vials after multiple use and intravenous admixtures

in three different hospitals in iran. Iranian journal of pharmaceutical research : IJPR. 2013;12(1):205-9.

34. Ripoll Gallardo A, Meneghetti G, Ragazzoni L, Kroumova V, Ferrante D, Ingrassia PL, et al. Multiple withdrawals from single-use vials: a study on sterility. International journal of pharmaceutics. 2015;485(1-2):160-3.

35. National-patient-safety-agency. Promoting safer use of injectable medicines 2007 [cited 2016 2 June]. Available from: http://www.nrls.npsa.nhs.uk/resources/?entryid45=59812.

36. Hannah D. Drug-and-Material-Wastage-in-Anesthesia-Care. GUJHS. 2012;6(2):4-8.

37. Bellefleur JP, Milhaud Y, Beconcini G, Zieleskiewicz L, Ortega D, Martin C, et al. [Use of ephedrine prefilled syringes reduces anesthesia costs]. Annales francaises d'anesthesie et de reanimation. 2009;28(3):211-4.

38. Weinger MB. Drug wastage contributes significantly to the cost of routine anesthesia care¹. Journal of clinical anesthesia.13(7):491-7.

39. Gillerman RG, Browning RA. Drug Use Inefficiency: A Hidden Source of Wasted Health Care Dollars. Anesth Analg. 2000;91(4):921-4.

40. Hawkes C, Miller D, Martineau R, Hull K, Hopkins H, Tierney M. Evaluation of cost minimization strategies of anaesthetic drugs in a tertiary care hospital. Canadian journal of anaesthesia = Journal canadien d'anesthesie. 1994;41(10):894-901.

41. Declaration of Helsinki 2013 [cited 2018 12-09-2018]. Available from: https://www.wma.net/what-we-do/medical-ethics/declaration-of-helsinki/.

42. Brink H, Van der Walt C, Van Rensburg GH. Fundamentals of research methodology for health care professionals. Cape Town, South Africa: Juta; 2012.

43. Burns N, Grove S. Understanding quatitative research design. In: Henderson L, editor. The Practice of Nursing Research. 6 ed. United States of America: Saunders Elsevier; 2009. p. 218-35.

Appendices:

Apendix1 Permission from the Human Research Ethics Committee (Medical

R14/49 Dr Rima Husein

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)

CLEARANCE CERTIFICATE NO. M160714

NAME: (Principal Investigator)	Dr Rima Husein
DEPARTMENT:	Anaesthesia Charlotte Maxeke Maxeke Johannesburg Academic Hospital Chris Hani Baragwanath Academic Hospital Helen Joseph Hospital
PROJECT TITLE:	Preoperative Preparation of Anaesthetic Emergency Drugs
DATE CONSIDERED:	29/07/2016
DECISION:	Approved unconditionally
CONDITIONS:	
SUPERVISOR:	Karin-Ann Ben-Israel
APPROVED BY:	Professor P Cleaton-Jones, Chairperson, HREC (Medical)
DATE OF APPROVAL:	23/11/2016

This clearance certificate is valid for 5 years from date of approval. Extension may be applied for.

DECLARATION OF INVESTIGATORS

To be completed in duplicate and **ONE COPY** returned to the Research Office Secretary in Room 301, Third Floor, Faculty of Health Sciences, Phillip Tobias Building, 29 Princess of Wales Terrace, Parktown, 2193, University of the Witwatersrand. I/we fully understand the conditions under which I am/we are authorized to carry out the above-mentioned research and I/we undertake to ensure compliance with these conditions. Should any departure be contemplated, from the research protocol as approved, I/we undertake to resubmit the application to the Committee. **I agree to submit a yearly progress report**. The date for annual re-certification will be one year after the date of convened meeting where the study was initially reviewed. In this case, the study was initially reviewed in July and will therefore be due in the month of July each year. Unreported changes to the application may invalidate the clearance given by the HREC (Medical).

Principal Investigator Signature _____ Date _____

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES

Apendix2 : permission from CHBH COE.

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

MEDICAL ADVISORY COMMITTEE

CHRIS HANI BARAGWANATH ACADEMIC HOSPITAL

PERMISSION TO CONDUCT RESEARCH

Date: 29th September 2016

TITLE OF PROJECT:

Preoperative Preparation of Anaesthetic Emergency Drugs

UNIVERSITY: Witwatersrand

Principal Investigator: Dr R Husein

Department: Department of Anaesthesiology

Supervisor : Karin-Ann Ben-Israel

Permission Head Department (where research conducted): Yes

The Medical Advisory Committee recommends that the said research be conducted at Chris Hani Baragwanath Academic Hospital. The CEO / management of Chris Hani Baragwanath Academic Hospital is accordingly informed and the study is subject to:-

- **Permission having been granted by the Committee for Research on Human Subjects of the University of the Witwatersrand.**
- The Hospital will not incur extra costs as a result of the research being conducted on its patients within the hospital
- The MAC will be informed of any serious adverse events as soon as they occur
- Permission is granted for the duration of the Ethics Committee Approval.

.....
Recommended
(On behalf of the MAC)
Date: 29/09/2016

.....
Approved/Not Approved
Hospital Management
Date: 04/10/16

Apendix3 : permission from CMJAH.

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

CHARLOTTE MAXEKE JOHANNESBURG ACADEMIC HOSPITAL

Enquiries:
Mr. J. Maepa
Office of the Clinical Director
Tell: (011) 488-3365
Email:johannes.maepa@gauteng.gov.za
22 September 2016

Dear Rima Husein

STUDY TITLE: Preoperative preparation of Anaesthetic Emergency Drugs.

Permission to conduct the above mentioned study is provisionally approved. Your study can only commence once Ethics approval is obtained. Please forward a copy of your ethics clearance as soon as the study is approved by the Ethics committee for the CEO's to give you the final approval to conduct the study.

Supported/~~not supported~~

Dr M.I. Mofokeng
Clinical Director
DATE: 22/9/2016

~~Approved~~/not approved

Ms G. Bogoshi
Chief Executive Officer
Date: 23.09.2016

Apendix4 : permission from HJH COE

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

Gauteng Department of Health
Helen Joseph Hospital
Enquiries: Dr. M.R. Billa
Chief Executive Officer
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Date: 19 September 2016

Dr.M.R.Billa
Chief Executive Officer
Helen Joseph Hospital

Dear Dr.Billa

STUDY: Preoperative Preparation of Anaesthetic Emergency Drugs

RESEARCHER: Dr. Rima Husein

The above was discussed at the Research Committee Meeting. We recommend that permission be granted for Helen Joseph Hospital to be used as a site for the above research. However, since this is a research project involving voluntary participation.

Upon completion of the study, a copy thereof should be submitted to Helen Joseph Hospital.

Thank you

Dr. Murimisi Mukansi
CHAIRPERSON
DATE:

Approved

DR. M.R. BILLA
CHIEF EXECUTIVE OFFICER
DATE: 19.54.2016

Apendix5 : Information letter

Dear colleague,

Hello, my name is Rima Husein and I am an anaesthesiology registrar at the University of the Witwatersrand.

I would like to invite you to participate in a research study entitled: Preoperative preparation of emergency anaesthetic drugs. This will be handed in to the Wits University Department of Health Sciences as part of my MMED degree.

The aim of this study is to describe the practice of doctors administering anaesthesia at Johannesburg academic hospitals(Charlotte Maxeke Johannesburg Academic Hospital, Chris Hani Baragwanath Academic Hospital, Helen Joseph Hospital and RahimaMoosa Mother and Child Hospital)with regard to pre-preparation of emergency anaesthetic drugs, with the specific objectives being:

- To describe which emergency anaesthetic drugs that are pre-prepared
- To describe the perception of anaesthetistsregarding pre-preparation of emergency drugs as a source of drug administration error, wastage and contamination
- To describe the opinion of anaesthetistsregarding preparation of emergency drugs in elective and emergency theatres.

The study has been approved by the Human Research Ethics Committee (HREC) (Medical) (Number R14/49) and the Graduate Studies Committee of the University of the Witwatersrand. Furthermore, permission to conduct the study has been obtained from the CHBAH Research Committee and the heads of departments involved.

Consent will be implied by agreeing to complete the questionnaire and is entirely voluntary. Questionnaires are not marked in any way for identification and no identifying data will be

collected. The questionnaire should only take approximately 15 minutes to complete. Once completed questionnaires will be placed into a sealed box. The content of the completed questionnaires will only be viewed by myself and my research supervisors.

Results published will have no identifying data and will be made available to participants.

The study offers no benefit to participants but may result in positive changes for the future.

Thank you for taking the time to read this letter. If you have any questions or concerns with regard to the study, you may contact the following people with your queries:

- Professor Cleaton-Jones (chairperson of the HREC): 011 717 1234
- Rima Husein: 079 346 9246

Please know that you are free to withdraw from the study at any time without having to provide a reason. The study is entirely voluntary and not taking part in it or withdrawing from it carries no penalty or repercussion of any sort.

Yours sincerely

Rima Husein

Apendix6 : Self-administered questionnaire

I would like to thank you for taking the time to complete the following questionnaire. The questionnaire consists of four sections, and has a total of 19 questions. It should take approximately 15 minutes to complete.

Instructions: Please will you complete the following questionnaire by marking the appropriate box with an "x".

Please note: All respondents will be kept anonymous and the information kept confidential.

1. Introduction

1.1 What is your age?

25-30	
31-40	
41-50	
> 50	

1.2 What is your gender?

Male		Female	

1.3 What is your anaesthetic grade?

Consultant (specialist or career medical officer with greater than 10 years of experience)	
Senior registrar (year 3 & 4)	
Junior registrar (year 1 & 2)	
Medical officer	
Community service doctor	

1.4 How many years of experience in anaesthesia do you have?

0-2	
2-5	
5-10	
>10	

Emergency anaesthetic drugs, such as adrenaline, ephedrine, succinylcholine, phenylephrine and atropine, are life-saving drugs routinely prepared by the anaesthetist before the start of the operating list.

2. Departmental policies regarding emergency drug pre-preparation.

2.1 Is there a departmental policy in Wits training hospitals regarding emergency anaesthetic drug pre-preparation?

Yes	
No	
Do not know	

2.2 Is there any teaching at Wits training hospitals regarding emergency drug pre-preparation?

Yes	
No	
Do not know	

3. Emergency drug pre-preparation, frequency of use and drug wastage

3.1 Do you draw emergency drugs at start of the list ?

Yes	
No	
Sometimes	

If your answer is " yes" or "sometimes" please answer the follow questions (3.2, 3.3, 3.4)

3.2 How often do you draw emergency drugs at start of the list?

Type of theatre		Always	Sometimes	Never
Elective	Adult			
	Paediatric			
	Obstetric			
Emergency	Adult			
	Paediatric			
	Obstetric			

3.3 Which of the following emergency anaesthetic drugs do you prepare routinely ?

Type of case		Atropine	Succiny l-choline	Ephedrin e	Phenyl-ephrine	Adrenalin e	Other
Elective	Adult						
	Paediatri c						
	Obstetric						
Emergenc y	Adult						
	Paediatri c						
	Obstetric						

If you marked "other", please specify which drug.....

3.4 When you prepare emergency anaesthetic drugs before elective surgery, how often do you actually use them on average per month?

Time/month	Atropine	Succinyl-choline	Ephedrine	Phenyl-ephrine	Adrenaline
Never					
Once					
2 to 4times					
5to 7 times					
> 7times					

4. Complications of emergency anaesthetic drug preparation

If you pre-prepare anaestheticemergency drugs please answer the following questions.

4.1 What information do you put on the individual syringe when you prepare emergency anaesthetic drugs?

	Always	Sometimes	Never
Nothing			
Drug name			

Concentration			
Operator's signature			
Date of preparation			
Time of preparation			

4.2 Have you ever experienced syringe swap errors with prepared emergency anaesthetic drugs?

Yes	
No	
Do not know	

- If you answered "yes" to the above question, please indicate how many times in last year have you experienced syringe swap errors with prepared emergency anaesthetic drugs?

Once	
2-4	
5-7	
> 7	

4.3 Have you ever experienced drug administration errors related to drawing up emergency drugs at the time they were needed in an emergency?

Yes	
No	

Do not know	

4.4 Have you ever experienced complications due to delay in delivery of a required emergency drug to the patient at time of an emergency?

Yes	
No	
Do not know	

- If you answered “yes” to the above question, do you think that a delay in delivery of the requiredemergency drug at the time of the emergency negatively impacted the patient’s outcome?

Yes	
No	
Do not know	

4.5 How often do you replace pre-prepared emergency anaesthetic drugs in emergency theatre if still un used ?

	When I start my shift	Every 24 hours	24 - 48 hours	>48hours
Atropine				

Succinylcholine				
Ephedrine				
Phenylephrine				
Adrenaline				

4.6 Do you think that pre-preparation of emergency anaesthetic drugs is a potential source of drug contamination?

Yes	
No	
Do not know	

5. A prefilled syringe is a medication delivery method, which involves the pharmaceutical manufacturer providing syringes with medication that are diluted to commonly used concentrations. This reduces the need to draw up medication into a syringe, thereby increasing the rate of delivery of medication and reducing the risk of drug wastage and drug administration errors.

5.1 Do you think that the availability of prefilled syringes will help to reduce emergency anaesthetic drug wastage?

Yes	
No	
Do not know	

5.2 Do you think that the availability of prefilled syringes will help to reduce drug administration errors?

Yes	
No	
Do not know	