A RETROSPECTIVE DESCRIPTIVE ANALYSIS OF CRITICAL CARE TRANSFERS IN THE PRIVATE SECTOR OF SOUTH AFRICA

By

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VNTMON004

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DECLARATION

I, Monique Venter, hereby declare that the work on which this thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university. I authorise the University to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever. I further declare the following:

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Contents

List of Tables & Figures:

ABBREVIATIONS

CCT – Critical Care Transfers

ALS – Advanced Life Support

MICU – Medical Intensive Care Unit

PART A: Background and Literature Review

Background:

Critical Care Transfers

Critical Care Transfers (CCT) are necessitated by the growing prevalence of high acuity patients who require upgrade of care to multidisciplinary teams from less equipped referring facilities.(1) Due to the high acuity of the critical care transfer patient, specialised teams with advanced training and equipment are called upon to undertake these transfers.(2–4) The specialised and dedicated teams are utilized to mitigate and treat adverse events at referring facilities, as well as during transfers, which is found in the especially vulnerable, high acuity patients.(5–7)

Additional demand for CCTs have also been found to be due to a lack of access to appropriate health care facilities (especially in rural geographical locations), a growing patient population versus an insufficient number of medical specialists, along with an outgrowing demand for Intensive Care Unit and High Care beds.(5,8)

Previous correlation studies have found a link between patient morbidity and mortality, and number of adverse events during CCTs, and level of training of the transferring practitioners, as well as resource availability.(5–7,9,10)

A study in the Netherlands discuss a different approach to CCTs. Wiegersma et al. performed a prospective audit on a specialised Mobile Intensive Care Unit (MICU) and compared their findings to a previous study completed in 2005 on standard ambulance transport of critically ill patients.(11) This study. had the main aim of establishing the safety of transfer protocols for critically ill patients.(11) The study looked at several components, including diagnosis upon transfer, adverse event type and frequency, as well as required interventions during and after the transfers.(11) Using the Paired Sample T-test and McNemar test on predefined “critical thresholds”, 74 transfers undertaken by the MICU were compared to the 100 transfers completed by standard ambulance transport in the previous study.(11)

Technical failure incidents (such as equipment failures or mechanical breakdown of vehicles) were comparable in both groups, as well as no statistically significant difference in vital variables between both groups.(11) Statistically significant differences were however found in the deterioration with pulmonary status of patients, as 5 patients from the standard ambulance transport group required imminent mechanical ventilation upon arrival at the referring facilities, as compared to 0 patients in the MICU group.(11)

The study furthermore found that the number of adverse events, along with number of required interventions during transfer, were reduced within the MICU group in comparison to the

standard ambulance transport group.(11) The study ultimately concluded that specialised units for the transport of critically ill patients set a major improvement in quality of patient care for the critically ill.(11)

Causes of adverse events during CCTs have been shown to be multifactorial, however, a substantial correlation has been identified between the levels of training of practitioners undertaking the transfers, as well as equipment available during the transfer.(7,9,10,12,13) The rate and frequency of adverse events during CCTs that were reported, differ. This is largely due to the inconsistencies in the definition assigned to the term ‘adverse event’. The range of frequency of adverse events during CCTs have been reported to be between 13.7% and up to 79.8%.(7,9,10,12,13) Literature supports the need for higher levels of training and equipment to reduce adverse events during CCTs.(9,10,14,15)

As such, internationally, CCTs are undertaken by specialised and dedicated teams. These teams either consist of specialist physicians and nurses, or paramedics that have undergone further training and hold qualifications in the field of critical care transport.(2–4)

In contrast, CCTs in South Africa are performed by Advanced Life Support (ALS) paramedics whom have not undergone any specific additional training and hold variant forms of scopes of practice.(16,17) Furthermore, the Health Professions Council of South Africa has released new practice guidelines which has brought changes that will see the scope of practice of certain ALS paramedics, who are currently involved in CCTs, being limited further.(18)

Internationally, the insufficient data relating to CCTs has been repeatedly reported as a concern due to the increased number of critical care transfers being undertaken and the high acuity of the patients, along with the reported high number of adverse events that occur during such transfers. The inherent understanding of the potential effects, and therefore needs of the critical care transfer patient, are affected due to the paucity of international, but more specifically, local data relating to CCTs.

The South African CCT setting

The increasing need for Critical Care Transfers (CCTs) within the South African setting due to a shortage in intensive care units as well as specialist physicians, especially in the more rural settings in South Africa, has been well documented.(5,8) Furthermore, it has been estimated that circa 30% - 50% of local medical graduates emigrate annually.(8) This translates to an evident need for CCTs to be undertaken to more urbanised areas where multidisciplinary teams are accessible.

The *2nd triennial report of the committee on morbidity and mortality in children under 5 (COMMIC),* which was published in 2014, found that a high proportion of deaths within the paediatric population locally was attributed to preventable causes.(19) It was stated that approximately 70% of these modifiable factors occurred within the health care system, and of the 70%, 80% of those factors were attributed to health care personnel. (19)

A study completed by P Ashokcoomar et al found that the majority of neonatal inter-healthcare facility transfers were undertaken by paramedics within the eThekwini district in Kwazulu-Natal within South Africa.(20) The study also found that the majority (77.5%) of these patients were referred from hospitals and the remaining patients were referred from primary health care clinics.(20) The study noted that there was a significantly higher rate of transfers within the district compared to other countries such as Ireland and Slovenia and was related to the lack of neonatal specialist facilities and trained staff.(20) It was also noted that the equipment required for the transfer was unavailable for over 30% of the transfers for various reasons and further concluded that dedicated and specialised transfer units are required for the safe transfer of the neonatal populous.(20)

Two previous studies completed by S Cheddie et al. and T.C. Hardcastle et al. respectively, found that trauma is still a significant cause of morbidity and mortality in the young population within South Africa, and that furthermore, there was a clear shortage of appropriate trauma facilities locally.(21,22) This was found to impact the frequency of CCT within the South African setting and also that the CCT undertaken in the South African setting required better equipment, more advanced trained staff and significantly more resources in general.(21,22) Another retrospective observational study conducted in South Africa found that the incidence of hypoxaemia in patients arriving from transferring facilities, to specialized ICU facilities, was high.(21,22) This was found to potentially be prevented by appropriate transfer monitoring equipment.(21,22)

Further compounding the complexity of the CCT patients within the South African context is the level of training and availability of appropriately trained and experienced staff at referring facilities. A retrospective observation study, undertaken within the Western Cape region of South Africa, found that times spent on scene by crews undertaking inter-facility transfers of higher acuity patients were prolonged, especially when comparing flight crews to road ambulance crews.(23) The study also found that the transferring flight crews perhaps spent more time stabilizing patients prior to transport as a result of insufficient interventions completed by the referring facility teams.(23)

Finally, a study completed over 5 years that explored the use of air transportation of patients within the Kwazulu-Natal area in South Africa found that 88.4% of calls completed by the

service were inter-facility transfers.(24) This is a significantly higher number than what has been found internationally and could relate to inaccessibility of multidisciplinary teams (more prominent in rural areas), lack of resources and specialised road crews.(24)

For the CCT environment and quality of care to improve within the South African context, one would seek to develop a curriculum to improve the training and potentially extend the scope of practice of local practitioners undertaking these transfers. Harden R. M. speaks about ten questions that need to be addressed when developing curricula within medical education, one of which is identifying the needs in relation to the product of the training program.(25) This question specifically focuses on addressing the needs of the local populous when developing curricula. An improved understanding towards the specific demographics and disease pathology, along with required interventions present in the South African critical care populous, is important to be able to establish the needs regarding required training and level of care in the CCT setting. This is particularly important when exploring the potential development of a curriculum for practitioners undertaking CCTs within South Africa as data relating to the field has long been an area deficient of research. No studies which explore the specific case mix within the South African CCT populous nationwide could be found and as such, designing a curriculum to improve quality of care in this patient populous would be based on little to no evidence. Such data is therefore significant and required before one is able to explore potential developments of specific curricula in an attempt to improve quality of care within this populous.

Failing the establishment of further training in the near future, a minimum aim of a benchmark assessment would want to be proposed as an interim solution as a measure to assist in setting standards for CCTs locally.(16) However, as mentioned previously, in order to establish either an extended training program or benchmark exam, a need exists to gain a more advance understanding of the local CCT patient group. The aim of this study was therefore to describe a sample of patients who underwent CCT transfer by dedicated CCT services in the private sector of South Africa. However, first the literature related to CCT and patient case mix will be described.

Search Strategy:
A search in the NCBI PubMed database was conducted using Medical Subject Headings (MeSH) on January 3rdth and January 4th, 2020. The search was filtered to English only texts, not older than 10 years (year 2010).

Exclusion Criteria –

- Published before 2010- Deemed not relevant to current demographics and environment
- Publications with no relevance to current study (Does not involve Critical Care Transfers OR does not evaluate inter-facility transfers)
- Non-English Studies

Inclusion Criteria –

- Relevant to Critical Care Transfers OR inter-facility transfers
- Published since 2010
- English Language Studies

The following search strings were used under the "Advanced" search option, yielding acceptable results:

Search string 1:

("Patient transfer" [MeSH] OR "Air Ambulance" [MeSH]) AND ("Emergency Medical Services" [MeSH] OR "Emergency Medical Technician" [MeSH])– 1200 hits produced.

219 studies were chosen for abstract text review (based on title relevance) and 24 studies were ultimately included for full text review based on relevance from abstract as per inclusion criteria.

Search string 2:

South Africa [MeSH] AND (Patient transfer [MeSH] OR Air Ambulance [MeSH]) – 38 hits produced.

8 studies chosen for review of abstract (included on title relevance)

1 study was chosen for full text review (included on abstract relevance as per inclusion criteria)

A second search using the first two search strings was performed on the 10th of December 2021 to ensure no recent studies have been excluded from the literature review. The first search string presented 23 results, 2 of which underwent abstract review, whereafter neither were included for full review due to lack of relevance. The 2nd search string resulted in 59 new results, 3 of which underwent abstract review, whereafter none were included for full review.

All the search string results were scanned for relevance and either excluded or included for abstract review as per the set-out criteria. The articles found relevant for abstract review were further reviewed and were either included or excluded for full text review as per set out criteria. The remainder of the text were once again reviewed under full text review and once again included or excluded based upon the set out criteria. The full text articles' references were screened for relevance and a further 2 articles were added for full review. A total of 15 out of 1240 publications (Figure 1) were found to meet the inclusion criteria and were included for the complete literature review. Table 1 presents the articles included for review along with the various demographics of the studies. The aim of the literature search was to find both local and international research that addresses the following in respect to Critical Care Transfers, both locally and internationally, in order to compare current local practices, training, and patient population:

- Epidemiology
- Adverse Events
- Level of Training.

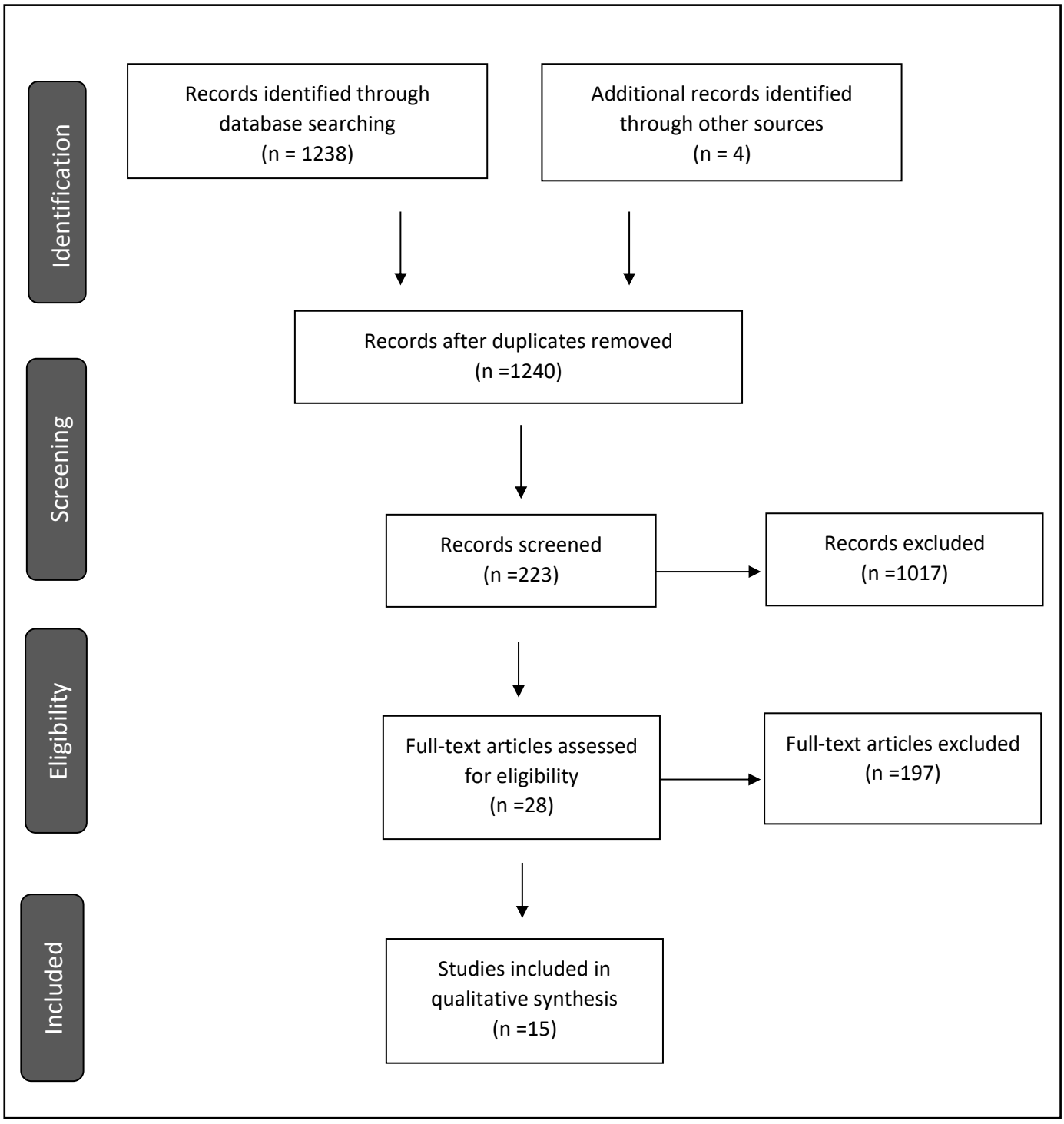

Figure 1- PRISMA Flow Diagram

Each study included was reviewed to extract 1.) Epidemiology of CCTs 2.) Incidence and types of adverse events encountered during CCTs and 3.) Level of training of practitioners / teams undertaking CCTs. The studies reviewed were predominantly prospective or retrospective observational studies, with the exception of 1 randomized control trial and 2 systematic reviews.

Literature Review:

Epidemiology:

CCTs have increased in demand due to an increase in transfer needs of higher acuity patients requiring multidisciplinary teams and upgrade of care. The increase in need for transfers can relate back to a disproportionate increase in population versus number of physicians and number of available multidisciplinary teams locally. Several epidemiological studies have been conducted to determine the patient populous making use of CCT services, however the paucity of research within the South African context is still a concern.

A retrospective observational study conducted on air ambulance transport in KZN, South Africa, found that majority of CCTs performed by the service constituted the transfer of obstetric patients (34.5%).(26) Second to obstetric patients, the paediatric populous accounted for 27.9% of CCTs undertaken, followed by trauma patients at 15.9%.(26) The study collected data from a single centre of a single service and, as such, has limitations regarding true representation of the South African population requiring CCT.(26) A total of 1253 CCT flights were conducted within the KZN area in the 5-year period analysed.(26)

Another study conducted in Greece analysed the patient presentation and patient group differences between patients presenting directly to a facility and patients referred and transported to a receiving facility in a setting without a formal trauma referral system. Burn injuries (27.5%) were the most common injuries sustained and transferred, followed by blunt (13.6%) and penetrating trauma (11.6%). Industrial injuries (16.95), motor vehicle collisions (16.4%), and falls (10.9%) were the most prevalent mechanisms of injury reported. (27) The study found that patients that were transferred presented with a significantly higher Injury Severity Score (ISS) than when compared to non-transferred patients. (27) The study further found that improved co-ordination could result in less transfers and improved patient outcome, if facilities were used appropriately.(27) One noted limitation for this study was that most of the cases only had a single respondent (either referring or receiving facility) for data collection and as such, some parameters may be skewed regarding Injury Severity Score post-transfer, along with outcomes regarding morbidity and mortality rates prior to and post-transfers.

A Scottish study found that CCTs were undertaken predominantly for need of specialised care or investigations at another facility.(28) Furthermore, the study found that a total of 19 747 inter-hospital transfers of acutely ill patients were undertaken during the audit period and as such the researchers estimated a total of 51 342 transfers are undertaken annually within the United Kingdom (UK).(28) The most significant limitation for the study was that they did not establish the proportion of high acuity patients within the sample size represented, and

secondly, no outcomes were recorded during the audit.(28) Lastly, another notable limitation of the study was that no study duration period was specified.(28) The study does however boast a large sample size and as such can be commended for producing data that should be a good representation and close to a true reflection of the CCT patient group in the UK area.(28)

A retrospective observational study found that there were higher incidences of burns and head injury, multi-trauma patients transported by a specialised CCT adult retrieval unit in Victoria, Australia, than when compared to unplanned emergent transfer patients. (29) The study further found that the patients transported by the specialist CCT unit presented with higher ISS and ultimately longer stays in hospital.(29) A larger proportion of patients transferred by the dedicated CCT unit were also found to be living independently at 6 months post injury, however no correlation was found between transport source and functional recovery.(29) The main age groups found to be transported by the unit was 16-24 years of age and second to this group, 25-45 years of age.(29) Limitations to consider with the Victorian adult retrieval study is the obvious exclusion of the paediatric and infant population requiring CCT.(29) Confidence intervals were set at 95% and statistics was said to be significant at a p-value of less than 0.002. (29) A Bonferroni correction was used due to the multivariable nature of data, which could produce results that are perhaps too conservative and as such not give a true reflection of the significance of the data.(29) External validity of the study is limited as the study analysed data from a single service, single center patient group within a mature adult trauma system, which is not aligned with populations found in low- to middle-income countries without developed trauma transfer systems.(29)

A retrospective observational study, conducted in Wales, focusing on the paediatric ICU patient populous, established that majority of the patients transferred were for admission to ICU at the receiving facility (35%).(30) A significant percentage of transferred patients carried respiratory and cardiovascular system diagnoses with further significant PICU requirements of invasive mechanical ventilation (82%) and vasoactive drugs (32%).(30) Limitations to this study were that the researchers used Paediatric Index of Mortality for comparison of the two groups of transferred and non-transferred patients, however co-morbidities and underlying disease pathologies were not accounted for in the non-transferred patient group potentially skewing outcomes due to selection-bias.(30) Additionally, individual variables were used rather than calculating log odds from the original coefficients.(30) Lastly, distances calculated for transferred patients were based on distance from the patients' residential postal codes and

receiving facility, rather than that of the distance between the actual referring facility and receiving facility.(30)

The majority of studies reviewed here were of a retrospective observational nature, and as such, do present with limitations given this study design. Although the studies provide insight to the patient population undergoing CCTs, only one study addressed the South African population specifically. Furthermore, majority of the studies only looked at populations within a small specific geographical location or a single centre or service, influencing the external validity of the data as it relates to the CCT populous within South Africa.

Adverse Events

An outcome that has frequently been measured in previous studies relating to CCTs is that of the prevalence of adverse events, often citing higher rates in instances where patients are being transferred by non-dedicated services. The ability to relate adverse events to morbidity and mortality, and some of their causes, allows for a better understanding of the requirements of the high acuity patients. Ultimately, to avoid adverse events from occurring in the first place.. Adverse events during Critical Care Transfers (CCT) have been categorized in several different manners.

A systematic review done in 2017 broadly categorized complications and adverse events during transfers in either cardiac specific or mixed groupings.(14) The researchers reviewed 7 different publications around adverse events during CCT undertaken specifically by paramedic crews. The study found that the frequency of adverse events during these transfers ranged between 5.1% and 18%.(14) The study noted that the paramedics undertaking these CCT all had advanced training in inter-facility transfers and furthermore that the heterogeneous nature of the varying methodologies and definitions for adverse events used in the studies that were reviewed, did not allow for generalization within the CCT environment.(14)

A retrospective chart review of adult, intra-hospital transfer patients was completed using data from Johns Hopkins Hospital over a 6 month period.(31) Of 3383 charts reviewed, a total of 59 charts were identified as having clinically significant adverse events during transport, thus the clinically significant adverse event rate was found to be 1.7%.(31) Overall, 67 adverse events occurred during the 59 transfers, 65 interventions were performed in total, with 6 patients having 2 or more interventions performed.(31) 75% of the adverse events recorded were related to hypoxic or hypotensive events, with 83% of all adverse events occurring during transfers of higher acuity patients.(31) At time of transport, 71% (42/59) of patients in this group were intubated, 41% (24/59) patients had both arterial and central venous lines in-situ,

and 63% (37/59) patients had at least 1 infusion running at time of transfer.(31) Whilst the study speaks to the level of acuity of patients and the rate of adverse events during CCTs, the researches have no comparison of data between specialised transfer teams and non-specialised transfer teams. Furthermore, the researchers reported adverse events they deemed clinically significant in-line with the specific setting of the institution.(31) Another limitation of the study, noted by the authors, was that the data was reviewed only by a single reviewer, which compromises inter-rater reliability.(31)

The IMPACT trial, conducted using an air ambulance transport service in the United States, reviewed how improved blood pressure monitoring during CCTs of the paediatric patient, affected number of interventions during transportation.(32) The researchers performed a randomised control trial between May 2006 and June 2007, within their specialised paediatric retrieval service.(32) The primary objective of the trial was to measure length of stay in hospital (from day of admission to day of discharge) stratified using the Paediatric Mortality Index II scoring system.(32) However, due to several technical difficulties encountered during the trial, the researchers were unable to obtain their targeted enrolment. As such, fluid administration during transportation was used as the primary outcome measure.(32) Patients between the ages of 1 – 17 years were eligible for enrolment into the study.(32) Furthermore, it is understood that only Traumatic Brain Injury (TBI) and Systematic Inflammatory Response Syndrome (SIRS) patients were found eligible to partake in the study.(32) A total of 1995 cases were screened, with a total of 94 patients enrolled (48 controlled, 46 intervention).(32) The study found that patients in the improved monitoring group received more intravenous fluids (19.81 vs 9.91mL/kg), had a decrease in hospital stay, and presented with less organ dysfunction.(32) It has been noted however, that no goal-directed treatment approach to fluid administration was used during the study, and as such one is unsure of what the transporting practitioners were aiming to achieve during treatment.(32) Ultimately, improved blood pressure monitoring during transportation of the paediatric patient populous was deemed to improve patient outcome, however, early termination and final sample size were significant limiting factors for the researchers and the study outcomes.(32)

A retrospective observational study, completed in the Netherlands, reviewed transfers undertaken by a specialized CCT service for the number of technical adverse events during transfers.(15) Within a 30-month period, 353 patients were transferred, and a total of 55 technical adverse events were recorded.(15) Although no significant changes in patient stability was noted, the study concluded that practitioners

undertaking CCT with specialised equipment required an improved understanding and knowledge of the specialised equipment in order to resolve any potential complications.(15) It is noted that due to no standardised definition or criteria for adverse events amongst different studies, inconsistencies do exist in reporting. The technical adverse events referred to in this study address adverse events relating to equipment and resource failures.

Another study conducted in the Netherlands, using a prospective observational methodology, compared adverse event rates experienced during CCTs undertaken by a specialised transport unit, to that of a previous study that looked at adverse event rates of CCTs undertaken by standard ambulances.(11) Data, from a total of 74 ICU patients that were transferred over a 9-month period, was collected.(11) Patient status was measured using 14 different parameters, including but not limited to vital signs and arterial blood gases.(11) The previous study used as comparison, reported technical adverse event rates of 30% (of a 34% total adverse event rate), whereas this study found technical adverse event rates to be 12.5%.(11) Transfer organization and staff management accounted for 70% (of a total of 34% total adverse event rate) in the previous study, whereas no adverse events could be found in this study relating to these factors.(11) Limitations noted were the Acute Physiology and Chronic Health Evaluation II (APACHE II) scoring system used, as this was secondary scores performed as patients were being transferred from other ICU facilities.(11) Prior stabilisation efforts at the referring ICU facilities may have caused underestimation of the Standard Mortality Ratio (SMR) predicted by the study's APACHE II scores.(11) This may have resulted in underestimation of the acuity of patients transferred. Despite the potential skewing of this data set, the study still found significant improvement in the rate of adverse events recorded by the specialised CCT teams, in comparison to the standard ambulance teams.(11)

A literature review done by Droogh et al. on adverse event rates during critical care transfers, also found significant correlation between rates of adverse events and level of training, equipment, and mode of transport.(6) Literature reviewed, did however, also highlight the inconsistencies regarding research performed within the CCT environment. No standardisation regarding clinical parameters, as well as standard definitions for adverse events, exist.(6) As a result, outcomes of studies vary significantly, and ability to reproduce results have been difficult. The literature review also presented several limitations as there were no specified search strings or databases used to perform the review, consequently subjecting the study to selection bias. Furthermore, due to no set parameters in the methodology and setting, reliability of the study was compromised.

The current literature found on adverse event rates during CCTs show significant correlation between adverse event rates and resource availability, mode of transport, and level of training. Reiteration of patient safety improving significantly with CCTs undertaken by practitioners with advanced and specialised training, advanced monitoring equipment, and dedicated training teams is noted. However, the apparent inconsistencies in parameters used, methodologies employed, and overall standardisation of defining adverse events, result in an inability to draw comparisons across different studies. Although there is still a need for further research, this is made arduous by the lack of standardisation. Standardisation of protocols, methodologies, and set parameters are recommended in order to obtain more reliable, reproducible results.

Levels of Training

Internationally, many services use dedicated and specialised teams of practitioners to undertake the transfers of critically ill patients. The reason for the use of specialised or multidisciplinary teams to undertake these transfers is that, as stated before, correlation has been made between level of training and patient morbidity, mortality and number of adverse events during transportation.

Although no standardized approach is found regarding practitioner level of training and critical care transfers internationally, consensus exists regarding the high acuity, critically ill patients requiring more advanced prehospital care and equipment.

As reviewed earlier, Alabdali et al performed a systematic review on the prevalence of adverse events during CCTs and their correlation to level of training of the practitioners undertaking the transfers.(14) Two articles reviewed in the study were found to be level 4 Oxford Centre for Evidence-Based Medicine 2011 levels of evidence, which meant that the studies were unable to draw a definitive conclusion between level of training and patient outcome.(14) Several causes for the inability to draw a definitive conclusion were found to be related to varying study designs, focus on a single service sampling, lack of longitudinal follow-up of patient outcomes, and lastly, potential underreporting of adverse events by medical personnel.(14) Although no definitive conclusion was drawn regarding level of training of treating practitioners and patient outcome during CCTs, it must be noted that all studies transfers undertaken in the studies reviewed, were undertaken by paramedics with “advanced” training.(14)

Ramnarayan et al. completed a multivariable analysis through which it was found there was a significantly lower risk of death (0.58 vs 0.39-0.87) in the paediatric patient group transferred by specialist retrieval teams in comparison to that of the paediatric patient group transferred by non-specialist teams.(30) Although the study had a multitude of limitations, previously

mentioned under adverse events, the significance of risk of death difference in the different groups is noticeable.(30)

A study completed in the United States, which used a web-based survey, described the neonatal transfer teams' level of training of 335 teams respectively.(33) Out of the 335 teams that completed the online survey, 229 (68.4%) were unit-based, and the remainder 106 (31.6%) teams were dedicated transfer units.(33) The median transport volumes recorded are suggestive of an average of number of transfers annually were as high as 68 797.(33) A total of 26 different team compositions were identified, with only 1 team notably not including either a registered nurse or neonatal nurse specialist.(33) The most common composition of the neonatal teams identified, were a combination of Registered Nurses, along with Respiratory Therapists.(33) Although certification requirements varied across the different teams, the most commonly required certificate was found to be a certification course in neonatal resuscitation (98.7% unit-based vs 99.1% dedicated).(33) Notably, the majority of the services did not assess mortality related to transport (43.7% unit-based vs 34.9% dedicated).(33) This contributes to the current difficulty in assessing whether level of training within the CCT environment affects morbidity and mortality rates. The use of a self-reported survey methodology should be noted as it does limit the validity of the study. As this study was completed in the United States (a high-income country) the results are not transferable to the South African context.

A national consensus statement released by various leaders within the CCT realm stated that current evidence shows correlation between decreased morbidity and mortality rates during high acuity transfers, and the level of training of the personnel undertaking the transfers.(34) The national consensus meeting, from which the consensus statement is based, included 75 attendees whom of which were either executive committee members, section members, or invited guests viewed as topic specialists.(34) Although it is noted by the authors that research pertaining to CCTs is sparse and largely retrospective in nature, it is also noted that there has been a drive and as such an increase in quality assurance programs within the CCT environment.(34) It is further noted, by the authors, that there is no standardisation in team compositions, level of training pre-requisites, and transport and treatment protocols.(34) Although the paucity of level of training and CCTs is low, the current available research does show that there is a statistically significant decrease in not only morbidity and mortality during transfers, but furthermore, a decrease in adverse events and the need for invasive interventions when such transfers are undertaken by dedicated and specialised teams.(34)

The most significant limitation to this publication is the low level of evidence as a consensus statement.

A literature review was completed by Droogh et al analysing the correlation between rate of adverse events during critical care transfers and level of training.(6) The authors found that there were no studies that investigated any direct correlation between level of training and rates of adverse events or overall patient outcome.(6) The authors mainly drew the conclusion that higher level of training could potentially decrease adverse events during transfers as there is existing evidence that illustrates that training leads to quality improvement.(6) The greatest limitation noted regarding this study is that the authors did not show any methodology regarding the literature review or any statistical analyses performed.(6) This raises the concern of several biases such as selection bias and decreases the overall validity and reliability of the study.

A retrospective observational study performed using the National Trauma Registry of the American College of surgeons to analyse and compare mortality rates between patients transported by HEMS operations and road operations crewed by ALS paramedics.(35) The study found that the two cohorts were well-matched in regards to injury severity scores, demographics, and physiology.(35) No significant differences in length of stay in hospital, complications, or overall patient mortality were found.(35) Although there was a significant decrease in time to hospital between the two cohorts, the researchers concluded that road transportation was equally as affective as long as the practitioner/s undertaking the road operations were of a similar level of training as that of the HEMS operations.(35) The researchers used multivariate logistic regression to determine the potential differences between the two cohorts.(35) It was found that an increase in age and injury severity score was associated with an increase in overall mortality, along with a notable decrease in temperature and revised trauma score.(35) The most significant limitations noted of this study was the retrospective nature of the methodology, alongside the fact that the data was collected from a single-centre, which potentially skews the outcomes found due to lack of standardisation of level of training within the CCT environment.(35)

Currently, due to the lack of evidence and standardisation of research regarding the correlation of level of training and averse events, morbidity, and patient mortality, it is not possible to definitively state that increased level of training of practitioners undertaking critical care

transfers improve overall patient outcome. It has however become more common practice internationally for only specialised, dedicated CCT teams to undertake such transfers. Overall standardisation of protocols, definitions of adverse events, as well as quality assurance is required to more concretely conclude that higher acuity patients would benefit from more highly trained practitioners undertaking CCTs.

Conclusion

Out of the fifteen studies that were identified during the literature review, majority were descriptive and retrospective in nature, as well as conducted in middle to high-income countries, with only a single study specific to the South African context. The paucity of research pertaining to the high acuity patient undergoing CCTs has been noted as a significant limitation. Further to this is the even more significant lack of research pertaining to the high acuity patient undergoing CCTs within the South African environment specifically.

Although there is a paucity in research relating to CCTs, the existing studies have shown evidence linking increased morbidity and mortality rates to level of training of transferring practitioners and resource availability. Furthermore, it has been identified that there is no standardised level of training for CCT practitioners globally, and in comparison to international standards, the level of training within the South African context leaves much to be desired. This could potentially be due to several factors: Lack of further training opportunities for pre-hospital providers, lack of epidemiological data relating to the CCT population within the South African context, as well as lack of specialist resources and equipment.

Given the scope of this dissertation, it is acknowledged that some publications may have been omitted from this review as only the Pubmed database was searched, including searches of the references of each of the relevant studies identified.

Table 1 - Literature Review

Author, N	Setting	Study Focus	Study Duration	Comments	Results
D'andrea et al. N = 1429 South Africa, Retrospective review	Air Ambulance	Epidemiology	1 January 2006 – 31 December 2010	Descriptive statistics reported	1429 Flights of which 88.4% were IFTs with case mix of 34.5% obstetrics, 27.9% paediatrics, and 15.9% trauma
Kue et al. N = 3383 United States, Retrospective review	CCT, Road Ambulance	Clinical Adverse events	November 2017 – April 2008	Descriptive and frequency statistics reported	3383 Charts reviewed 1.7% AE Rate
Alabdali et al. N = 7 UK, Systematic review	MEDLINE, Web of science, Embase, and CINAHL databases	Level of training and adverse events	1990 – February 2016	Descriptive statistics reported	7 Observational Studies All Paramedic led transfers AE rates of between 5.1% - 18%
***Ramnarayan et al. N = 57997* Wales and** England**, prospective review**	PICUs In-Hospital	Level of training and patient outcome	1 January 2005 – 31 December 2008	Descriptive, case mix statistics reported	29 PICUs 57997 admissions Specialised retrieval teams showed improved survival rates (0.58, 0.39 – 0.87)
Stroud et al. N = 1995 United states, Randomized control trial	CCT, Air Ambulance	Resource availability and patient outcome	May 2006 – June 2007	Descriptive and non-parametric statistics reported	Improved blood pressure monitoring in paediatric CCTs resulted in increased interventions and improved clinical patient outcomes
Kennedy et al N = 3009 Australia, Retrospective observational	CCT, Road Ambulance	Patient outcome	2009 - 2013	Descriptive and non-parametric statistics reported	3009 major trauma CCTs Adult Retrieval Victoria (ARV) transferred 1174 (39%) Decrease in median time spent by ARV at referring facility.

Author, N	Setting	Study Focus	Study Duration	Comments	Results
					Co-ordinated transfer units potentially decrease morbidity and mortality of major trauma patients.
Katsaragakis et al **N = 8524** **Greece,** **Retrospective review**	In-Hospital and CCT	Epidemiology	October 2005 – October 2006	Descriptive statistics reported	8524 patients, 86.3% not transferred, 13.7% transferred. Improved co-ordination could lead to improved outcomes and less cost (less transfers undertaken).
Fried et al. **N = 3048** **Scotland,** **Prospective review**	CCTs, Road Ambulance	Epidemiology	Unspecified	Descriptive statistics reported No timeline for study reported	2396 transfers included, 1580 (66%) for specialist management, 550 (23%) for specialist investigation. Increase in medical equipment failure in ventilated patient transfers undertaken by non-dedicated teams (0.6% vs 9.8%).
Droogh et al. **N = 353** **Netherlands,** **Retrospective observational**	CCTs, Road Ambulance	Technical Adverse Events	March 2009 – August 2011	Descriptive statistics reported	353 patients transported, 55 technical adverse events recorded.
Karlsen et al. **N = 345** **United States,** **Exploratory prospective observational**	Neonatal Transfer Teams, Air and Road Ambulance	Level of training	August 2006 – April 2007	Descriptive statistics reported	335 team surveys, 106 (31.6) dedicated teams, 229 (68.4%) unit-based teams. Registered nurse – respiratory therapist team composition was found to be most prevalent (44.3% dedicated teams, 40.2% unit-based teams).
Stroud et al. **N/a** **United States,** **Consensus statement**	Paediatric and Neonatal Transfers	Level of training	2012	N/A	Specialised transport teams are associated with improved outcomes and safety in comparison to non-specialised teams.

Author, N	Setting	Study Focus	Study Duration	Comments	Results
Wiegersma et al N = 74 Netherlands, Prospective observational	CCTs, Road Ambulance	Epidemiology Adverse events	March 2009 – December 2009	Parametric and descriptive statistics reported	74 Inter-hospital transfers, less adverse events in specialised transfer team (12.5%) vs non-specialised transfer teams (34%).
Droogh et al N = 81 Netherlands, literature review		Epidemiology Adverse Events Level of training	2015	Descriptive statistics reported	Specialised retrieval teams decrease adverse events during transfers due to several factors; equipment, mode of transport, and level of training.
Borst et al N = 3901 United States, retrospective observational	CCTs, Road and Air Ambulance	Epidemiology Level of training	1 January 2008 – 1 November 2012	Descriptive statistics reported	No mortality benefit in helicopter vs road CCTs (9.0% vs 8.1%).
Nawrocki et al. N = 1223 United States, Retrospective observational	Obstetric CCTs	Epidemiology	1 January 2012 – 31 December 2016	Descriptive statistics reported	1101 patients, 693 (62.9%) transported by road, 408 (37.1%) transported by rotary wing

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PART B: Manuscript in Article Format

The manuscript that follows will only be reporting on the non-neonatal transfer undertaken during the study period. The reason for this is that this MPhil project has already delivered a published output on the neonatal cohort of this project.

The publication can be found here: Venter M, Theron E, Williams W, Khan W, Stassen W. A national retrospective review of neonatal critical care transfers in dedicated critical care transport services in the private sector. South African Med J. 2021;111(10):981–4.

A RETROSPECTIVE DESCRIPTIVE ANALYSIS OF NON-NEONATAL CRITICAL CARE TRANSFERS IN THE PRIVATE SECTOR OF SOUTH AFRICA

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Abstract

Background: Critical Care Transfers (CCTs) are necessitated by the growing prevalence of high acuity patients who require upgrade of care to multidisciplinary teams from less equipped referring facilities.(1,2) Due to the high acuity of the critical care transfer patient, specialised teams with advanced training and equipment are called upon to undertake these transfers. The specialised and dedicated teams are utilised to mitigate and treat adverse events during transfers, which is found in the especially vulnerable, high acuity patients. Internationally, the insufficient data relating to CCTs has been repeatedly reported as a concern due to the increased number of critical care transfers being undertaken and the high acuity of the patients, along with the reported high number of adverse events that occur during such transfers. The inherent understanding of the potential effects, and therefore needs of the critical care transfer patient, are affected due to the paucity of international, but more specifically, local data relating to CCTs. The aim of this study was to describe a non-neonatal cohort of patients who underwent CCT transfer by dedicated CCT services in the private sector in South Africa.

Methods: This observational cohort study with a retrospective descriptive design, sampled all non-neonatal, critical care transfers completed for a one-year period (1 January 2017 – 31 December 2017) from the dedicated CCT of the two largest national emergency medical services in South Africa. Data were extracted from patient report forms by trained data extractors and subjected to descriptive analysis.

Results: A total of 1839 patients were transferred between the two services (excluding the neonatal cohort). A total of 3143 diagnoses were recorded, yielding an average of ~2 diagnoses per patient. The most prevalent primary diagnosis was cardiovascular disease (n=457, 25%), followed by infection (n=180, 10%) and head injury (n=133, 7%). Patients had an average of ~3 attachments, with the most prevalent being patient monitoring (n=2856, 155%). The second most prevalent attachment was peripheral intravenous access (n=794, 43%), followed by mechanical ventilation (n=445, 24%). A total of 2152 instances of medication infusion or administration were required during transport, yielding an average of ~1 medication or infusion per patient transported. The most common medications recorded were central nervous system depressants (n=588; 32%), followed by analgesics (n=482, 26%), and a further 17% of patients required inotropic or vasoactive agents (n=320, 17%).

Conclusion: This study provides insight into the demographics, most prevalent diagnoses and interfacility transfer monitoring needs of patients being transported in South Africa by two private dedicated critical care transport services. The results of this study may be used to inform future specialised critical care transport courses and qualifications, as well as the scopes of practice of providers undertaking critical care transfers.

Introduction:

The growing need for Critical Care Transfers (CCTs) have been necessitated by the growing population of high acuity patients requiring upgrade of care from resource limited facilities, to facilities with multidisciplinary teams. Internationally, specialised CCT teams have been set to undertake these transfers, due to the high acuity of the patients leading to the need of specialised training and equipment.(1,3,4)

Additional demand for CCT have also been found to be due to a lack of access to appropriate health care facilities, a growing patient population, versus an insufficient number of medical specialists, along with an outgrowing demand for intensive care unit and high care beds.(1,2)

Several international studies have shown that dedicated and specialised CCT teams decrease the potential for adverse events during transfers, due to the increased capabilities in training and equipment of such teams.(5–7) Locally, within the Southern Africa context, limited regulations and additional training opportunities have been presented in relation to the CCT environment and the practitioners that undertake them. Furthermore, very little data has been published to show the specific population and the needs of said population within the South African CCT environment.(1,4,8,9)

The South African Emergency Medical Services' qualifications have undergone several restructures over the past decade. The scope of practices of all prehospital practitioners have also been updated during 2018. All Advanced Life Support (ALS) practitioners, are eligible to undertake and work in the CCT environment, transferring high acuity patients, with some exceptions.(10) The notable exceptions are that only degree ALS practitioners can perform neonatal mechanically ventilated transfers, perform RSI (endotracheal and nasotracheal intubation) and perform transfers of patients who are deemed haemodynamically unstable or are on inotropic support.

Internationally, in higher-income countries, specialised physicians, nurses, and paramedics undertake these high acuity transfers.(5–7,11) Locally, Emergency Medical Services (EMS) are responsible for all interfacility (IFT) and CCTs, regardless of patient acuity. This is unlikely to change as South Africa has a severe shortage in physicians, and furthermore, offers no opportunities for specialisation for prehospital providers currently undertaking these transfers.(2,12) Consequently, a number of high acuity critical care patients may undergo CCTs by non-dedicated services that do not have specialised training, and/or required specialised equipment and resources. Numerous previous international studies have shown correlation in increased adverse events to level of training and resource availability.(4,8,9,12,13)

In an effort to mitigate such an increase in risk to the high acuity patient requiring transfer, South Africa has initiated the process of developing specialised and dedicated CCT services and teams.(14) This process has been done however with little standardised protocols or guidelines relating to specifics in resource availability and the need for increased levels of training.(14) Furthermore, the scarcity of such specialised teams at this time, means that many high acuity patients requiring transfers for upgrade of care, may not have access to such dedicated teams but rather services without specialised training and equipment.

As stated previously, there are currently no opportunities or standardisation in existence for practitioners undertaking CCTs, to specialise in, to be able to undertake such transfers safely and confidently.(14) Very little data has been published to describe the critical care, high acuity, transfer patient within the South African setting. The ability to describe this population would allow for the establishment of further training opportunities lead by population specific needs and requirements in relation to training, scope of practice, and equipment requirements. The aim of this study was therefore to describe a sample of patients who underwent CCT transfer by dedicated CCT services in the private sector of South Africa.

Methodology

This observational cohort study with a retrospective descriptive design sampled all non-neonatal, critical care transfers completed for a one-year period (1 January 2017 – 31 December 2017) from the dedicated CCT of the two largest national emergency medical services in South Africa. Data were extracted from patient report forms by trained data extractors and subjected to descriptive analysis.

Study Setting

In South Africa, non-specialised, non-physician emergency personnel undertake CCTs. Currently, only ALS practitioners may undertake CCTs.(10) There are several factions of ALS qualifications however, from a vocational one year certificate course, to higher education (two or three year diploma, or four year university honours degree) training.(10)

There are very few dedicated CCT services in South Africa, especially in the public sector.(15) To our knowledge, only the Western Cape and Gauteng Departments of Health operate such. Although both services sampled in this study are from the private EMS, each does serve a certain percentage of government patients either funded through the patient themselves, or through dedicated funding agreements between the Department of Health and the service. Both services have dedicated patient critical care transfer services that operate in various geographic locations within South Africa, including the Western Cape, Gauteng, and Kwazulu-Natal.

Services are typically crewed by one ALS and one intermediate life support provider. Combined, these transfer services perform an estimate of over 2000 patient transfers per annum.

Sample and Sampling:
Critical care transfers were identified in two ways, corresponding with the patient report form archiving systems of the EMS. For the first EMS, who utilises electronic patient report forms (PRFs), all cases performed by the aeromedical (helicopter and fixed wing) and ground critical care transfer services were identified and extracted into a Microsoft Excel (Microsoft Corporation, Redmond, Washington, United States) spreadsheet. Data were anonymised upon extraction. Only transfers of patients undertaken by the dedicated services were included. All primary (emergency) cases, cases undertaken by non-dedicated units and instances where critical data variables were missing were excluded. Return trips of the same patient (such as for diagnostic purposes) were also excluded.

For the second EMS, anonymised scanned copies of hand-written PRFs from the dedicated ground critical care transport services were obtained and screened according to the inclusion and exclusion criteria. After specific training in the research aims, objectives, data variables, and the contents of the PRFs; the data from eligible cases were extracted according to a dedicated, standard data abstraction form, by a clinical data capturer – a senior paramedic student. Regular meetings between the data capturer and investigators were held to ensure credibility of the extraction process. This approach is in keeping with the guidance on retrospective chart reviews in emergency care, as outlined by Gilbert and Lowenstein. (16)

Data related to demographics, patient contact times, patient diagnosis, and attachments and medications were extracted and analysed.

Data analysis
Regardless of the data source, data were extracted onto a spreadsheet and subjected to simple descriptive analysis. Categorical data are presented as frequency and proportions (%) and continuous variables as a means. In all instances, more than one diagnosis, attachment or medication is possible for one patient. Additionally, proportions are expressed in terms of number of patients.
Ethical approval was obtained from the Human Research Ethics Committee of the University of Cape Town (HREC ref: 754/2018), and from the private EMS organisations.

Results
For the period of 1 January 2017 – 31 December 2017, a total of 1839 patients (excluding the neonatal cohort) were transferred between the two services. The majority of patients were

male (n=1083; 58.9%); while the mean (range) time spent (mm:ss) at the receiving facility to ready the patient for transfer was 41:36 (01:00-241:00), and the mean (range) duration of transport after departure was 35:51 (01:00-321:00).

Table 1 outlines the predominant primary diagnoses of patients transferred. A total of 3143 diagnoses were recorded, yielding an average of ~2 diagnoses per patient. The most prevalent primary diagnosis was cardiovascular disease (n=457, 25%), followed by infection (n=180, 10%) and head injury (n=133, 7%).

Table 1. Diagnosis of Non-Neonatal Cohort Transported (n=1839)

Diagnosis	n	%
Cardiovascular Disease	456	25%
Infection	180	10%
Head Injury	133	7%
Central Nervous System Disorder	73	4%
Diagnosis Unspecified	64	3%
Central Nervous System Disease	63	3%
Conduction Disorder	56	3%
Polytrauma	55	3%
Spinal Injury	49	3%
Extremity Fracture	46	3%
Neoplasm	44	2%
Respiratory Disease	39	2%
Burns	38	2%
Endocrine Disorder	36	2%
Other, n<10	34	2%
Gunshot Injury	30	2%
Mental & Behavioural Disorders	26	1%
Overdose	26	1%
Post-Surgery	22	1%
Congenital Defect	20	1%
Trunk Fracture	19	1%
Acute Pain	17	1%
Gastrointestinal Bleed	17	1%
Respiratory Disorder	17	1%
Renal Failure	15	1%
Poisoning	13	1%

Pulmonary Embolism	13	1%
Bowel Obstruction	11	1%
Post Cardiac Arrest	11	1%
Preterm Labour	11	1%
Submersion Injury	11	1%
Pelvic Fracture	10	1%
Soft Tissue Injury	10	1%
Other N<10	174	9%
Total	1839	100%

Table 2 describes the indwelling devices and attachments. Patients had an average of ~3 attachments, with the most prevalent being patient monitoring (n=2856, 155%). The second most prevalent attachment was peripheral intravenous lines (n=794, 43%), followed by mechanical ventilation (n=445, 24%). Patients may have more than on indwelling device or attachment.

Table 2. Indwelling Devices & Attachments of Patients Transported (n=6847)

Description	**n**	**%**
Patient Monitoring	**2856**	**155%**
SpO2 monitoring	1356	74%
Electrocardiography	925	50%
Capnography	575	31%
Vascular Access	**1031**	**56%**
Peripheral Intravenous Line	794	43%
Central Venous Line	167	9%
Arterial Line	63	3%
Other, n<10	7	<1%
Ventilation	**539**	**29%**
Mechanical Ventilation	445	24%
NIPPV	51	3%
BVM Ventilation	23	1%
BVT Ventilation	18	1%
ECMO	2	<1%

Indwelling Attachments	**728**	**40%**
Urinary Catheter	487	26%
Nasogastric Tube	116	6%
Orogastric tube	29	2%
IC Drain	43	2%
PEG Tube	25	1%
Other, n<10	28	2%
Medication Infusion Devices	**773**	**42%**
Syringe Driver	299	16%
Infusion pump	161	9%
Dial A Flow	11	1%
Other, n<10	3	<1%
Supplemental Oxygen (not ventilated)	**373**	**20%**
Artificial Airways	**472**	**26%**
ET Tube	398	22%
Oropharyngeal Airway	31	2%
Tracheostomy Tube	29	2%
Other, n<10	14	1%
Nebulisers	**24**	**1%**
Incubators	**16**	**1%**
Other, n<10	**35**	**2%**
Total	**6847**	**100%**

Table 3 describes the medications running or requiring administration during transport. A total of 3584 medications were required during transport, yielding an average of ~1 medication or infusion per patient transported. The most common medications, recorded, other than fluids, were central nervous system depressants (n=588; 32%), followed by analgesics (n=482, 26%), and a further 17% of patients required inotropic or vasoactive agents (n=320, 17%).

Table 3. Medications Infused or Administered During Transportation (n=2152)

Medications	n	(%)
Analgesics	**482**	**26%**
Morphine	407	22%
Paracetamol	30	2%
Tramadol	16	1%
Remifentanil	12	1%
Other, n<10	17	1%
CNS Depressants	**588**	**32%**
Midazolam	291	16%
Ketamine	157	9%
Lorazepam	30	2%
Propofol	30	2%
Dexmedetomidine	18	1%
Etomidate	17	1%
Diazepam	13	1%
Other, n<10	32	2%
Vasoactives / Inotropes	**342**	**19%**
Adrenaline	114	6%
Dobutamine	96	5%
Glyceral Trinitrates	62	3%
Isosorbide dinitrate	33	2%
Dopamine	13	1%
Phenylephidrine	10	1%
Other, n<10	14	1%
Anti-Coagulants / Thrombolytics	**142**	**8%**
Heparin	47	3%
Tirofiban	33	2%
Aspirin	25	1%
Clopidogrel	18	1%
Tenectaplase	11	1%
Other, n<10	8	<1%
Electrolytes	**57**	**3%**
Potassium Chloride	27	1%
Sodium Bicarbonate	19	1%
Magnesium Sulphate	9	<1%

Other, n<10	2	<1%
Anti-Emetics	**51**	**3%**
Metoclopramide	34	2%
Ondansetron	12	1%
Other, n<10	5	<1%
Maintenance, Fluids, & Feeding	**1528**	**83**
Isotonic Crystalloids	1432	78%
Half Darrows Dextrose	47	3%
Dextrose 5%	25	1%
Other, n<10	24	1%
Neuromuscular Blockades	**63**	**3%**
Rocuronium	51	3%
Suxamethonium	10	1%
Other, n<10	2	<1%
Anti-Arrhythmics	**45**	**2%**
Amiodarone	39	2%
Other, n<10	6	<1%
Antibiotics	**35**	**2%**
Blood Products	**15**	**1%**
Bronchodilators	**47**	**3%**
B2 Adrenergic Stimulants	27	1%
Ipratropium Bromide	13	1%
Other, n<10	7	<1%
Furosemide	**34**	**2%**
PPI	**23**	**1%**
Insulin	**22**	**1%**
Dextrose >5%	**14**	**1%**
Other, n<10	**96**	**5%**
Total	**3584**	**100%**

Discussion

This study aimed to describe a non-neonatal cohort of patients who underwent interfacility transfers by two dedicated CCT services within the private sector of South Africa. The most common diagnosis was related to cardiovascular disease, infection or trauma. All patients had some monitoring with pulse oximetry being the most common. Just over half of patients had intravenous access that required monitoring, while almost one in three patients required ventilatory support. Sedatives and analgesic were the most common medications administered, while just under one in five patients required inotropic support. The multitude of diagnoses, indwellings, attachments, and medications in this sample illustrate the complexity and acuity of the non-neonatal population undergoing CCTs within the South African context. The sample further illustrates potential concerns in standard of care given during transfers as per inconsistencies seen in patient monitoring and indwelling devices such as intravenous access. The complexity of these patients and lack of standardised approach indicate a need for treating practitioners with specialised training, that have the necessary specialised equipment available to adequately monitor and practice initiation and continuation of care.

South Africa is currently undergoing an epidemiological transition from that of predominantly communicable diseases to that of non-communicable, cardiovascular disease (CVD).(17) Given the general shortage and inaccessibility of cardiac centres in South Africa, it is unsurprising that these patients were transported often.(18) Similarly, trauma and injury accounted for a large share of patients requiring CCT in this sample. This is expected as South Africa faces a massive trauma burden due to road traffic collision and interpersonal violence.(19)

A previous study which explored the use of an air ambulance service over a 5-year period in the Kwazulu-Natal area in South Africa found that 88.4% of all calls serviced during this period were interfacility transfers.(20) This is significant as the percentage of interfacility transfers is significantly higher than that of international air ambulance services. This may be due to the limited availability of specialised road ambulances, equipment, along with the reported scarcity of multidisciplinary teams and treating facilities.(21) The study also reported that 398 (34.5%) patient transported were for obstetric emergencies, paediatrics accounting for 322 (27.9%) of patients, and 183 (15.9%) trauma patients.(20) In contrast, our study found that cardiovascular disease accounted for majority of patients transported (25%, n=456), followed by trauma (21%, 382) and infection (10%, n=180).

It is encouraging to note that most patients undergoing CCTs within the context of this study, had continuous monitoring attached, with pulse oximetry accounting for the most common modality. Second to this, 50% of patients in this group had electrocardiography monitoring, and 31% had capnography monitoring attached. Patient monitoring has been shown to be an important factor in adverse events during transport. Pulse oximetry, electrocardiography, and capnography are of vital importance in an effort to mitigate and treat potential hypoxaemia, cardiac abnormalities, and ventilatory insufficiencies. Such high rates of monitoring could also be explained given that the data originated from the private sector, that is much better resourced.

While originating from the public health sector and in the neonatal population, another study found that 15% of adverse events experience during transfers were attributed to either equipment failure, or equipment being unavailable.(15) The study further found that 50% of the 10% physiologically related adverse events occurred due to equipment related adverse events.(15) Likely to mitigate against and to detect and respond to these risks, consensus exists regarding the need for appropriate equipment, including patient monitoring and ventilatory equipment when undertaking CCTs during CCTs.(14)

A previous study found that patients who were ventilated with Peak End Expiratory Pressures of more >6cmH_2O, sedation before transport, and fluid loading, carried an increased risk of adverse events occurring during transport.(21) These findings might have particular relevance to our results given that a large proportion of patients required ventilation, were given crystalloids or had sedation administered.

Although there is no standardised approach to the level of training required for practitioners undertaking CCTs, consensus exists regarding the need for more advanced training and equipment availability for the high acuity CCT patient.(9,11,13,22,23) Currently, within South Africa, there are few limitations relating to who can undertake CCTs, with all advanced life support (ALS) paramedics qualifying under current scope of practice.(24) ALS paramedics in South Africa consist of paramedics that have completed either a certificate, or a diploma, or a 4 year degree, with varying scopes of practice. The only limitations currently relating to CCTs is that of the mechanically ventilated neonatal patient, as well as the haemodynamically unstable interfacility transfer patient (included those on any haemodynamic support), can only be transported by degree paramedics.(24) Furthermore, there is no current training opportunities that allow for expansion of scope of practice beyond that of the degree paramedic scope of practice. This carries important implications for both the availability, as well as appropriateness of level of training, of those undertaking CCTs.

Many of the administered medications recorded are currently within scope of practice of ALS paramedics under continuation of care only, and not initiation of care. Resultantly, ALS paramedics have limited to no training during undergraduate studies for medications such as remifentanil, propofol, antibiotics, and a large variety of others found to have been administered during transportation. The onus of further training falls onto the practitioner, and no standardised training requirements for CCTs are found other than the scope of practice limitations of practitioners.(24) This may highlight the need for further training opportunities for ALS paramedics. This would enable practitioners undertaking CCTs to not only potentially further scope of practice appropriate to the population they serve, but also to ensure adequate levels of training for those working in the CCT environment in order to mitigate potential adverse events during transfers. A Delphi study, published in 2016, aimed to gain expert consensus on training and scope of practice requirements for CCTs to be undertaken safely in South Africa(25) Positive consensus was gained relating to medications such as propofol, broadened scope of analgesic agents, antibiotics and phenylephrine.(25) These findings show strong correlation with the data reported in this study, including that relating to monitoring. With more than 14% of medications administered during transport, including medications such as remifentanil, antibiotics, and propofol, which is currently outside the scope of practice of ALS under initiation of care. This translates into treating practitioners having limited to no training of these medications, as well as a potential need for an increase in scope of practice for paramedics to be able to undertake CCTs safely and confidently.

Limitations

This study has some important limitations. Firstly, the study is retrospective in nature and reports on patients transported in 2017. Diagnoses reported herein are based on what was written in the patient report forms and are thus not confirmed by the receiving facility. Furthermore, a total of 243 patient records were excluded, of which 212 had no age listed, 30 records had no correlating patient care record attached for verification, and 1 record omitted patient age. Lastly, this study only described patients transported by two dedicated, private services. While results are similar to that expected given the South Africa burden of disease, this limits the external validity of our findings. Future studies should also describe the patient case mix of public service transfers.

Conclusion

This study provides insight into the demographics, most prevalent diagnoses and interfacility transfer monitoring needs of non-neonatal patients being transported in South Africa by two private dedicated critical care transport services. The results of this study should be used to inform future specialised critical care transport courses and qualifications, as well as the scopes of practice of providers undertaking CCTs. In this manner, the providers may best be equipped to deal with the needs of these complex patients. Further research is needed in relation to current organisation training within South Africa, public sector patient epidemiology within the CCT setting, as well as correlation studies on adverse events and level of training within the local CCT setting.

Funding and Conflict Of Interest
The authors have no conflict of interest to declare. The study was self-funded by MV.

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Part C: Addenda

A Retrospective Descriptive Analysis of Critical Care Transfers in South Africa

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This study is in partial fulfilment of the MPhil EM Degree

DECLARATION

I, *Monique Venter*, hereby declare that the work on which this thesis is based is my original work (except where acknowledgements indicate otherwise) and that neither the whole work nor any part of it has been, is being, or is to be submitted for another degree in this or any other university.

I authorise the University to reproduce for the purpose of research either the whole or any portion of the contents in any manner whatsoever.

BACKGROUND

Critical Care Transfers (CCTs) happen frequently within the South African setting. A shortage in intensive care units as well as specialist physicians, especially in the more rural settings in South Africa, has been well documented.(1,2) Furthermore, it has been estimated that circa 30% - 50% of local medical graduates emigrate annually.(2) This translates to an evident need for CCTs to be undertaken to more urbanised areas where multidisciplinary teams are accessible.

Causes of adverse events during CCTs have been shown to be multifactorial, however, a substantial correlation has been identified between the levels of training of practitioners undertaking the transfers, as well as equipment available during the transfer.(1,3–6) The rate and frequency of adverse events during CCTs reported differ, largely due to the inconsistencies in the definition assigned to the term 'adverse event'. The range of frequency of adverse events during CCTs have been reported to be between 13.7% up to 79.8%.(1,3–6)

Internationally, CCTs are undertaken by specialised and dedicated teams. These teams either consist of specialist physicians and nurses, or paramedics that have undergone further training and hold qualifications in the field of critical care transport.(7–9) In contrast, CCTs in South Africa are performed by Advanced Life Support (ALS) paramedics whom have not undergone any specific additional training and hold variant forms of scopes of practice.(10) Furthermore, the Health Professions Council of South Africa has released new practice guidelines which has brought changes that will see certain ALS's, that are currently involved in CCTs, scope of practice being limited.(10)

For the CCT environment to improve within the South African context, one would seek to develop a curriculum to improve the training and potentially extend the scope of practice of local practitioners undertaking these transfers. Harden R. M. speaks about ten questions that need to be addressed when developing curricula within medical education, one of which is identifying the needs in relation to the product of the training program.(11) This question specifically focuses on addressing the needs of the local populous when developing curricula.(11) This is particularly important when exploring the potential development of a curriculum for practitioners undertaking CCTs within South Africa as data relating to the field has long been an area deficient of research.(12)

Failing the establishment of further training in the near future, a minimum aim of a benchmark assessment would want to be proposed as an interim solution as a measure to assist in setting standards for CCTs locally.(13) However, as mentioned previously, in order to establish either

an extended training program or benchmark exam, a need exists to gain a more advance understanding of the local CCT setting.

Internationally, the deficiency of data relating to CCTs has been repeatedly reported as a concern due to the increased number of critical care transfers being undertaken and the high acuity of the patients, along with the reported high number of adverse events that occur during such transfers.(1,3) The inherent understanding of the potential effects and therefore needs of the critical care transfer patient are affected due to the paucity of international, but more specifically, local data relating to CCTs.(12)

AIM & OBJECTIVES

The aim of the study is to describe CCTs within the South African setting.

The proposed study further holds the following objectives in order to achieve the aim:

- To determine basic patient demographics of patients undergoing CCTs in South Africa.
- To determine the indication behind CCTs being performed.
- To determine interventions performed on patients whilst undergoing CCTs within South Africa.
- To determine duration of CCTs in South Africa.

MOTIVATION FOR THE STUDY

Critical care transport poses significant risk to patients if undertaken by inexperienced personnel without additional training.(1,4,5) Currently, there are no training standards for personnel undertaking these transfers. Unlike in other countries, there is also no benchmarking exam that denotes a practitioner competent to undertake such transfers.(7,9) One of the first steps to the development of minimum training and competency standards, is to understand which patients personnel are being exposed to.(11) Gaining a better understanding of CCTs within the South African context could allow more patient-focused training programs to be developed in future and provide a better understanding of the risks associated with CCTs locally and potentially how to mitigate those risks. Furthermore, this will provide data which could be used to motivate the need for a set benchmark exams to ensure standardization regarding level of care rendered in regards to training.

RESEARCH METHODOLOGY

Study Design

The study proposes to use a cross-sectional retrospective chart review extracting clinical data from two private, national, South African Critical Care Transfer services, both land and air based..

Study Setting

Although both services are private emergency medical services, each does service a certain percentage of government patients and therefore data will not only include medical aid funded patient transfers. The study will seek to include data from both services' critical care transfer units operating in various geographical locations within South Africa, including the Western Cape, Gauteng, and Kwazulu-Natal. Netcare Helicopter Emergency Medical Services perform approximately 180 intra-facility transfers annually, whilst their ground operations perform an estimate of 1300 transfers annually, and their fixed wing operations servicing an estimate of between 170 – 260 transfers per annum. ER24's CCT services complete between 40-60 transfers per month on their road vehicles.

Sample

All patients transported by the specialised CCRS vehicles, helicopter emergency medical services or fixed wing aeromedical services of Netcare 911 and ER24 between the period of 1 January 2017 and 1 January 2018 will seek to be included in this retrospective cross-sectional study. The specific inclusion and exclusion criteria are provided below. Inclusion Criteria:

- Interfacility transfers,
- Performed between 1 January 2017 and 1 January 2018,
- By specialised CCRS vehicles, helicopter emergency medical services or fixed wing aeromedical services of Netcare 911 and ER24,
- Patients of all ages

Exclusion Criteria

- Primary (scene emergency) cases,
- Cases with incomplete crucial datasets (Patient age, patient gender, patient diagnosis, reason for transfer, transfer duration)

Data Collection & Management

Netcare 911 records all patient encounters on an electronic patient report form while ER24 uses written patient report forms that are scanned and digitised. For each of these services, cases completed by specialised CCRS vehicles, helicopter emergency medical services or fixed wing aeromedical services are indexed as such, and therefore easily identifiable and extracted.

Anonymised, spreadsheet extractions of data will be obtained from Netcare 911 while anonymised, scanned copies of hand-written patient report forms will be obtained from ER24. Inclusion and exclusion criteria will be applied both before and after extraction to obtain the final dataset.

Data spreadsheet extractions and patient report forms will be interrogated and data variables as defined in Appendix A, will be captured into a standardised data capture Excel spreadsheet (dummy tables are provided in Appendix B). Data will be captured by the MPhil candidate and an identified secondary data capturer. A 10% random sample will be extracted by an employed data capturer. The data capturer will sign a non-disclosure agreement and will receive specific training on the research aims and objectives, the data variables, patient report forms and extraction procedures. The data capturer will also be a student in a medical discipline (medicine, emergency care, nursing) in order to ensure an understanding of some of the physiological variables. Data will be compared and any disputes will be resolved by a third party during monthly extraction calibration and monitoring meetings. Interrater reliability will be calculated and reported on for the 10% random sample. Data will be backed up on a secure cloud-based server and stored in a password protected file on a computer only accessible to the researchers. As there is no hypotheses or comparisons being tested, the data capturers are not blinded.

Data will be captured in a password protected Excel spreadsheet (Microsoft Corporation, Washington D.C., United States), saved onto a password protected personal computer and backed up electronically on an external memory disk. Only the researchers will have access to the data files. Data sheets will be stored for a period of five years, thereafter it will be destroyed.

The eight (training, case selection, definition of variables, abstraction forms, meetings, monitoring, blinding, agreement) specified methodological considerations to ensure study rigour and mitigation of risk of bias as set out by Gilbert and Lowenstein in 1996 have all been explicitly addressed during the design of the proposed study.(15) Specific strategies such as case deletion, where appropriate, will be employed where data is missing, rather than variable deletion, as to minimise bias.

Data Analysis
Cohen Kappa testing will be performed to determine inter-rater reliability and agreement.

Descriptive analysis will be performed. Patient demographics will be presented as both frequency and proportions (%) and as mean and standard deviation, depending on whether the data is continuous or categorical.

Patient diagnosis will be recorded as proportions (%), as well as the receiving and referring facility types. Continuous variables such as duration of transfers will be recorded as means and standard deviation.

Ethical Considerations
Ethical approval will be sought from the Health Research Ethics Committee of the Faculty of Health Sciences of the University of Cape Town prior to commencement of the study. Further institutional/organisational approvals will be sought from ER24 and Netcare 911.

Expedited review, and a waiver of consent will be sought for this study. The study poses minimal risk as it is a retrospective chart review. Anonymised patient report forms will be obtained from each of the organisations (the data owners). Strict confidentiality will also be ensured. Participating organisations will not be disclosed without prior written consent from authorised individuals within the organisation.

TIMELINE

Stage of Proposal	**Proposed Date of Completion**
Proposal Completion	September 2018
Proposal Submission	September 2018
Ethics & Facility Permission	December 2018 - January 2019
Data Collection	January 2019 – February 2019
Data Analysis	March 2019 – May 2019
Final Report Submission	June 2019

Budget

Jul 2018- April 2019				
Item	**Description**	**Unit cost**	**Nº of Units**	**Total cost**
1. Data for online usage	Data package at 10 GB	R299	1	R299
2. Printing	Paper, ink and binding	R500	1	R500
3. Stationary	General Stationary	R200	1	R200
4. Memory stick	Back up	R500	1	R500
5. Data Collector	Secondary data collection, per hour	R200	10	R2000
6. Statistical Support	Statistical analysis, per hour	R550	2	R1100
Total				**R4599**

The study will be self-funded by the student.

Limitations

A limitation of concern is that the researcher will only obtain data from two private services. It is therefore that the data may not be a true representative of the national patient populous undergoing CCTs and the national state of the CCT environment within South Africa. This potentially makes the study vulnerable to skewed data, however, the data presented will be explicitly presented as such as from two private services and should thus not be misinterpreted as an all-inclusive study, but rather be recognized for its limitations and its true representation of its findings. Anecdotally through reports of previous investigators, obtaining patient report form data from provincial services is labour intensive, time-consuming and resource heavy. Unfortunately, the current team does not have these resources to their disposal. For this reason, the provincial services will be excluded.

Due to the retrospective design of the study and self-reporting nature of the charts that will undergo review, the validity of the study may be compromised as such. However, no mitigating tools are available for implementation to prohibit such bias and no other study design is better suitable for the study outcomes. Due to the descriptive design of the study, the above compromise in validity is acceptable.

Reliability is expected to be high as in-house training and standardised patient report forms are assigned for each service respectively. Furthermore, Kappa Cohen testing will be performed to establish inter-rater reliability and agreement.

Missing data will be recorded and presented in the final report.

and Types of Adverse Events in Interfacility Critical Care Transfers by Paramedics. Air Med J [Internet]. 2017;36(3):116–21.

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Dissemination and Findings

The findings of this research is aimed at the following audience:

- Emergency Care Society of South Africa
- Critical Care Society of South Africa
- Private Sector Emergency Medical Services
- Government Emergency Medical Services
- Academia

To ensure the dissemination of the research findings to the desired audience in order to ensure maximal benefit gained from the findings of the study, the Scientist Knowledge Translation Plan will be implemented.(16,17) Awareness and interest has already been generated within the critical care transfer environment by implementation of the following:

- A Critical Care Transport working group has been created consisting of several medical professionals involved in critical care transfers.
- The Critical Care Transport working group has published in the South African Journal of Critical Care regarding the need for standardised setting in the CCT environment.
- Furthermore, the CCT group has raised awareness within the above mentioned audience regarding ongoing research, including this proposed study, in order to promote and improve CCT training and standardization within the South African setting.

On completion of the proposed study, the findings will form part of a larger planned study which will look at the development and implementation of national standardised board exams for practitioners undertaking critical care transfers, and furthermore hopes to develop a curriculum for further training for practitioners undertaking critical care transfers.

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22 November 2018

HREC REF: 754/2018

Dr W Stassen
Emergency Medicine
F51, OMB

Dear Dr Stassen

PROJECT TITLE: A RETROSPECTIVE DESCRIPTIVE ANALYSIS OF CRITICAL CARE TRANSFERS IN SOUTH AFRICA (MMED Candidate - Ms M Venter)

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee.

It is a pleasure to inform you that the HREC has **formally approved** the above-mentioned study.

Approval is granted for one year until the 30 November 2019.

Please submit a progress form, using the standardised Annual Report Form if the study continues beyond the approval period. Please submit a Standard Closure form if the study is completed within the approval period.
(Forms can be found on our website: www.health.uct.ac.za/fhs/research/humanethics/forms)

Please quote the HREC REF in all your correspondence.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please note that for all studies approved by the HREC, the principal investigator **must** obtain appropriate institutional approval, where necessary, before the research may occur.

The HREC acknowledge that the student, Monique Venter will also be involved in this study.

Yours sincerely

PROFESSOR M BLOCKMAN
CHAIRPERSON, FHS HUMAN RESEARCH ETHICS COMMITTEE
Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938
This serves to confirm that the University of Cape Town Human Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical