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**Current practice in the air medical services for the inter-facility transfer  
of paediatric patients in the Western Cape, South Africa**

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A Research Dissertation (60 credits)  
Submitted to the University of Cape Town  
In partial fulfilment of the requirements for the degree

Master of Philosophy in Clinical Emergency Medicine

Department of Emergency Medicine  
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University of Cape Town

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## **Declaration**

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### **Current practice of inter-facility transfer of paediatric patients in the air medical services in the Western Cape, South Africa**

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## Letter To Examiner/Reviewer

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Sir/Madam

I would like to thank you for taking the time to serve as examiner for my dissertation (60 credits) titled:

**Current practice in the air medical services for the inter-facility transfer of paediatric patients in the Western Cape, South Africa**

Your assistance in this matter is greatly appreciated.

Sincerely

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## Glossary

- *Access time:* The total time taken from take-off until access to the patient. For helicopter cases this will time will conclude upon landing at the referring facility. For fixed-wing cases, this will include the time taken to transport the medical crew from the closest airfield to the referring facility.
- *ALS:* Advanced life support
- *AMS:* Air Medical Service
- *APACHE-2 Score (Acute Physiology and Chronic Health Evaluation II):* An ICU based severity-of-disease classification system. An integer score from 0 to 71 is calculated based on several measurements with higher scores corresponding to more severe disease and a higher risk of death.
- *Child:* Patients between the ages of 4 years up to and including 12 years 364 days.
- *District level hospital:* The first level of referral manned by generalist staff with access to basic diagnostic and therapeutic services, such as X-rays and basic laboratory tests. The following clinical disciplines are covered at district level: Family Medicine and Primary health care, Medicine, Obstetrics, Psychiatry, Rehabilitation, Surgery, Paediatrics and Geriatrics.
- *Dr:* Doctor
- *EMS:* Emergency Medical Service
- *Flight & road transfer time:* The total time, from take-off at the referring facility, to transport the patient to the receiving facility. For helicopter cases this will conclude upon landing at the referring facility. For fixed-wing cases

this will include the time taken to transfer the patient from the closest airfield to the receiving facility.

- *Handover time:* The total time taken to hand over the patient following arrival at the referring hospital. For helicopter cases, this will conclude at take off from the receiving facility. For fixed-wing cases, this will conclude following departure of the medical crew from the receiving facility.
- *High-income, middle-income, low-income country/economy:* A classification system developed by the World Bank determined by a country's Gross National Product (GNP) per capita, which is the value of all final goods and services produced in a country in one year (gross domestic product) plus income that residents have received from abroad, minus income claimed by non-residents divided by its population. This measure is an indication of how well the population in a country lives. When comparing country income levels there are several differences that can be found between each group, listed in order of examination they are GNP per capita, political stability, life expectancy, and access to education.
- *ICU:* Intensive Care Unit
- *ILS:* Intermediate Life Support
- *Infant:* Patients older than 28 days up to and including 364 days (<1 year).
- *Neonate:* New-born patients up to and including 28 days.
- *NTISS (Neonatal Therapeutic Intervention Scoring System):* A measure of patient severity developed and validated from the 76 variable Therapeutic Intervention Scoring System (TISS-76).
- *Receiving facility:* The facility at which the patient arrives and is admitted following transfer.

- *Referring facility:* The facility from which the patient is uplifted for transfer.
- *Regional level hospital:* Regional hospitals are level 2 facilities that provide care requiring the intervention of specialists and general practitioners. A general level 2 hospital would need to provide and be staffed permanently in at least five of the following eight basic specialties: surgery, medicine, orthopaedics, paediatrics, obstetrics and gynaecology, psychiatry, diagnostic radiology and anaesthetics.
- *REMS (Rapid Emergency Medicine Score):* A six variable measurement of patient severity, combining age, heart rate, respiratory rate, blood pressure, peripheral oxygen saturation and Glasgow Coma Scale.
- *RN:* Registered nurse
- *Scene time:* The total time taken to stabilize and package a patient for transfer, until lift off. For helicopter calls, this time will conclude upon take off at the referring facility. For fixed-wing cases, this will include the time taken to transfer the patient and medical crew from the referring facility to the airfield.
- *Tertiary level hospital:* These hospitals receive patients from, and provide sub-specialist support to, Regional Hospitals. Most of the care is level 3 care that requires the expertise of clinicians working as sub-specialists or in rarer specialties (e.g.: within surgery for example, sub-specialties such as urology, neurosurgery, plastic surgery and cardiothoracic surgery). A general level 3 hospital will have sub-specialty representation in at least 50% of the range of the Group 1 specialties listed above. A specialised level 3 hospital will only have one or two specialties from groups 1, 2 or 3 represented (e.g. cardiology and anaesthetics).
- *TISS-28 (Therapeutic Intervention Scoring System – 28):* A measure of severity based on the therapeutic interventions administered for the patient

being measured. The 28 variable score has been developed and validated from the 76 variable Therapeutic Intervention Scoring System (TISS-76).

- *Toddler*: Patients between the ages of 1 year up to and including 3 years and 364 days (<4 years).

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# Part 1: Background & Literature Review

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## 1.1) Background

The development of paediatric interfacility transfer has largely been influenced by two major factors. Firstly, since the early 1990s, a growing body of evidence has supported the improved patient outcomes associated with the centralisation of paediatric intensive care resources<sup>1-5</sup>. The rationale for this was that clinicians working in fewer and larger centres, caring for critical paediatric patients more frequently, are able to maintain their skill in intensive care significantly more than those clinicians working in smaller centres, caring for paediatric patients less frequently<sup>2</sup>. The result of this accumulating evidence led to the widespread acceptance and adoption of this model<sup>6-8</sup>. Secondly, there is a more recent growing body of literature that has reported an increased incidence of adverse events associated with paediatric interfacility transfer, especially when undertaken by inexperienced transfer teams<sup>9-11</sup>.

These factors ultimately led to the creation of specialised retrieval teams, consisting of staff specially trained in paediatric intensive care<sup>11-15</sup>. Supporters of this approach assert that these teams offer the benefits of focused training and experience in terms of exposure to the environment, equipment and patients<sup>11-15</sup>. This view is strengthened by the reported reduction in the incidence of interfacility adverse events, and mortality in the immediate post admission period, when compared with non-specialised transfer<sup>11-15</sup>. Despite this, the implementation of these teams remains a contentious issue. Opponents argue that this approach is resource intensive and requires substantial financial backing to be effectively introduced and maintained<sup>16,17</sup>. Furthermore, the literature has failed to demonstrate an overall reduction in length of hospital stay, hospital resource use or survival to hospital discharge following their introduction<sup>16,17</sup>.

While the specialist approach may be considered by many to be the 'gold standard' of paediatric transfer, there is evidence to suggest the existence of potential alternatives, as equally valuable<sup>10,12,13,18</sup>. Utilisation of the air

medical services for paediatric transfer has shown promising, albeit limited results<sup>12,13,18</sup>. Worldwide, these types of services are becoming an increasingly prevalent and important aspect of the emergency medical services (EMS), having already demonstrated numerous advantages regarding improved patient outcomes<sup>19-21</sup>. Chief amongst the roles these services play is as a mobile intensive care unit (ICU), with the added benefits of range of access and speed of transportation. This offers the unique advantages of extending the reach of both urban-level EMS and tertiary-level hospital care to traditionally under-resourced areas<sup>19-21</sup>. However, these types of services are not without their detractors either. In addition to their own considerable financial burden<sup>22,23</sup>, hazards unique to the aviation environment have the potential to further exacerbate a patient's underlying condition<sup>24,25</sup>.

As promising as these advances to paediatric transfer are, they have been largely addressed within the context of a 'high-income economy'. There is little evidence to guide solutions and policy within the 'low to middle-income' setting, where these issues are nonetheless still prevalent. In this context, the limitations in available healthcare resources are often confounded by long distances, poor infrastructure, and a fragmented or otherwise unequal access to healthcare<sup>26</sup>. As such, evidence from the above-mentioned trials cannot routinely be applied to the lower-income settings.

Within South Africa, significant effort is being made to address this issue, especially in the Western Cape province. The establishment of dedicated maternity and neonatal transfer units within the EMS has already started to show promising results for these patient subsets. These units have met all previously unattainable dispatch and response goals, and have reduced the average inter-hospital transfer time significantly from 177 minutes, down to 128 minutes<sup>27</sup>. However, these units are still in the early stages of development, and no clinical based data has been reported on their effects on these patients. Furthermore, they remain confined to the greater Cape Town metropolitan area, thus leaving rural areas without such a service.

In addition to this, the Western Cape has had a long tradition of successful air medical operation within the province<sup>28,29</sup>. Much of this has to do with the unique manner in which these services are utilised here. Given the limitations in rural EMS resources, the aircraft are often dispatched when the availability of local ground based ambulances are limited or unavailable, regardless of patient severity (A. Oliphant - personal communication). This stance towards the Air Medical Services (AMS can be traced back to the roots of an internal report commissioned by the Western Cape provincial EMS<sup>30</sup>. It found that within the province, the equivalent service coverage offered by the AMS is approximate to fifty conventional road-based ambulances, yet operates at only 6% of the cost of these additional vehicle. Far from the conventional perception as a luxury, when employed in this unique manner, it offers cost savings, increased access and coverage for rural areas, as well as increased safety and quality of care.

Two previous studies have examined the potential role of the AMS as an option for paediatric transfer in the Western Cape<sup>10,31</sup>. However these trials were of a mixed road and air-based cohort or of too small a sample to be considered an adequately explored option. Given the limitations in the current literature, this study was undertaken to explicitly evaluate the current use of the AMS, in the role of paediatric transfer within the Western Cape, to identify their potential as a safe, reliable option in this role.

## **1.2) Literature Review**

The aim of the study was to describe the current practice of the air medical services for the interfacility transportation of paediatric patients within the Western Cape. As such the study objectives centred on:

- Describing the utilisation of the AMS in the interfacility transfer role for paediatric patients i.e.: flight details, demographics, interventions etc.;
- Evaluating the safety of these services through the description of adverse events, and their comparison with the current literature regarding adverse events in paediatric transfer.

As such, the purpose of the literature review was to therefore:

- Firstly, identify the existing literature comparing the use of helicopters and fixed-wing aircraft in the interfacility transfer role;
- Secondly, identify the literature examining the use of air medical services for the interfacility transfer of paediatric patients - thus allowing for the uniform reporting of data obtained in this study, and
- Lastly, identify the literature regarding adverse events in the interfacility transfer of critical paediatric patients so as to allow for comparison with the results observed in this study.

### **1.3) Literature Search Strategy**

A semi-structured review of the literature was performed in order to adequately identify the most appropriate literature for inclusion in the review. The Medline, Cumulative Index of Nursing and Allied Health Literature (CINAHL), Science Direct, PubMed and Cochrane Library databases were searched in April and October 2012 given their availability via the University of Cape Town Libraries online portal. Due to the variety in objectives of the study, and to ensure as comprehensive a literature review as possible, the search was conducted utilising three separate search strings.

#### **1.3.1) Medline & CINAHL**

The Medline and CINAHL databases were selected and searched via the EBSCOHost platform. The search of these databases was accurate as of 12 October 2012. The following queries and MeSH terms were searched for separately via the “Basic Search” option:

- Search string 1: (helicopter or “rotor wing”) AND comparison AND (airplane OR “fixed wing”)
- Search string 2: (“aeromedical” OR “air medical”) AND (p?ediatric OR child OR infant OR neonate)
- Search string 3: (p?ediatric OR child\* OR neonat\*) AND transfer\* AND “adverse event”

The search options/limitations utilised for each database respectively included:

- **Medline**
  - Search string with Boolean connectors used
  - No limitations to date of publication
  - No limitations to language of publication
  - All sexes included
  - All journal and citation subsets included
  - All publication types included
  - Animal based research excluded
  
- **CINAHL**
  - Search string with Boolean connectors used
  - No limitations to date of publication
  - No limitations to language of publication
  - All journal subsets included
  - All publication types included
  - All sexes included

### 1.3.2) Science Direct

The Science Direct database was searched via the SciVerse platform. The search of this database was accurate as of 22 October 2012. From the Search page, the “Expert Search” option was utilised. In the search box, the following queries were searched for separately:

- Search string 1: (helicopter or “rotor wing”) AND comparison AND (airplane OR “fixed wing”)
- Search string 2: (“aeromedical” OR “air medical”) AND (p?ediatric OR child OR infant OR neonate)
- Search string 3: (p?ediatric OR child\* OR neonat\*) AND transfer\* AND “adverse event”

For each search string the search was limited to Journal publications only. “All journals” were selected via “Source”, including articles in press. The search was limited by subject to “Medicine and Dentistry” and “Nursing and Health Professionals” only. No limitation by document type or date was selected for each search.

### **1.3.3) Pubmed**

The Pubmed database was search via its “standalone” platform. The search of this database was accurate as of 24 October 2012. A basic search was conducted for each of the following search strings:

- Search string 1: (helicopter or “rotor wing”) AND comparison AND (airplane OR “fixed wing”)
- Search string 2: (“aeromedical” OR “air medical”) AND (p?ediatric OR child OR infant OR neonate)
- Search string 3: (p?ediatric OR child\* OR neonat\*) AND transfer\* AND “adverse event”

Within each search, the following options/filters were utilised:

- No limitations to date of publication
- No limitations to language of publication
- No limitation to article type
- Animal based research excluded
- All sexes included
- No limitation to subject
- No limitation to subject category
- No limit to age

### **1.3.4) Cochrane Library**

Lastly, the Cochrane Library database was also searched via its “standalone” platform. The search of this database was accurate as of 28 October 2012.

A basic search was conducted amongst the Title, Abstract or Keywords, utilising the following queries:

- Search string 1: (helicopter or “rotor wing”) AND comparison AND (airplane OR “fixed wing”)
- Search string 2: (“aeromedical” OR “air medical”) AND (p?ediatric OR child OR infant OR neonate)
- Search string 3: (p?ediatric OR child\* OR neonat\*) AND transfer\* AND “adverse event”

Additionally, the following search limits were utilised for each search:

- All product types included
- Word variations not included
- No limit to dates

#### **1.4) Quality Criteria**

For each search string used, the titles of the results returned were read, and abstracts scanned for relevancy to any of the study objectives. The articles set aside were then read in their entirety and included in the review if they complied with the inclusion and exclusion criteria (See below). Lastly, the references of this final collection were also examined to identify any additional articles potentially missed during the initial search. All original research returned during the search was considered for the literature review. No limiter was applied based on study design. All duplicates, commentaries, editorials, clinical guidelines, position statements and case reports were excluded (See Figure 1 below for Literature Review search results).

##### **1.4.1) Inclusion criteria**

Given the aim and objectives of the study, the following criteria were adopted when appraising the research for inclusion in the literature review:

- Research with a paediatric sample/population (as defined in the study protocol – See Box 1). For research involving adult and paediatric

samples, the results of just the paediatric cohort were evaluated, where possible.

#### **Box 1: Age Definitions**

- **Neonate:** Newborn patients up to and including 28 days
- **Infant:** Patients older than 28 days up to and including 364 days (<1 year)
- **Toddler:** Patients between the ages of 1 year up to and including 3 years and 364 days (<4 years)
- **Child:** Patients between the ages of 4 years up to and including 12 years 364 days

- Research focusing on the interfacility transfer of patients. This was restricted to transfer by either helicopter or fixed-wing aircraft. For research that included a road-based cohort, the results of just the helicopter and fixed-wing cohorts were evaluated, where possible.
- There was no restriction with regards to underlying medical pathology or traumatic injuries examined in the research.
- With regards to physiological adverse events, the literature is somewhat limited for strictly air medical based research. For the purposes of identifying the most commonly measured clinical dataset or clinical variables, research in which a road-based cohort was present, or research for which only a road-based sample was used, was also included. Non-clinical adverse events (i.e.: technical) of any road-based cohort were not included.

#### **1.4.2) Exclusion criteria**

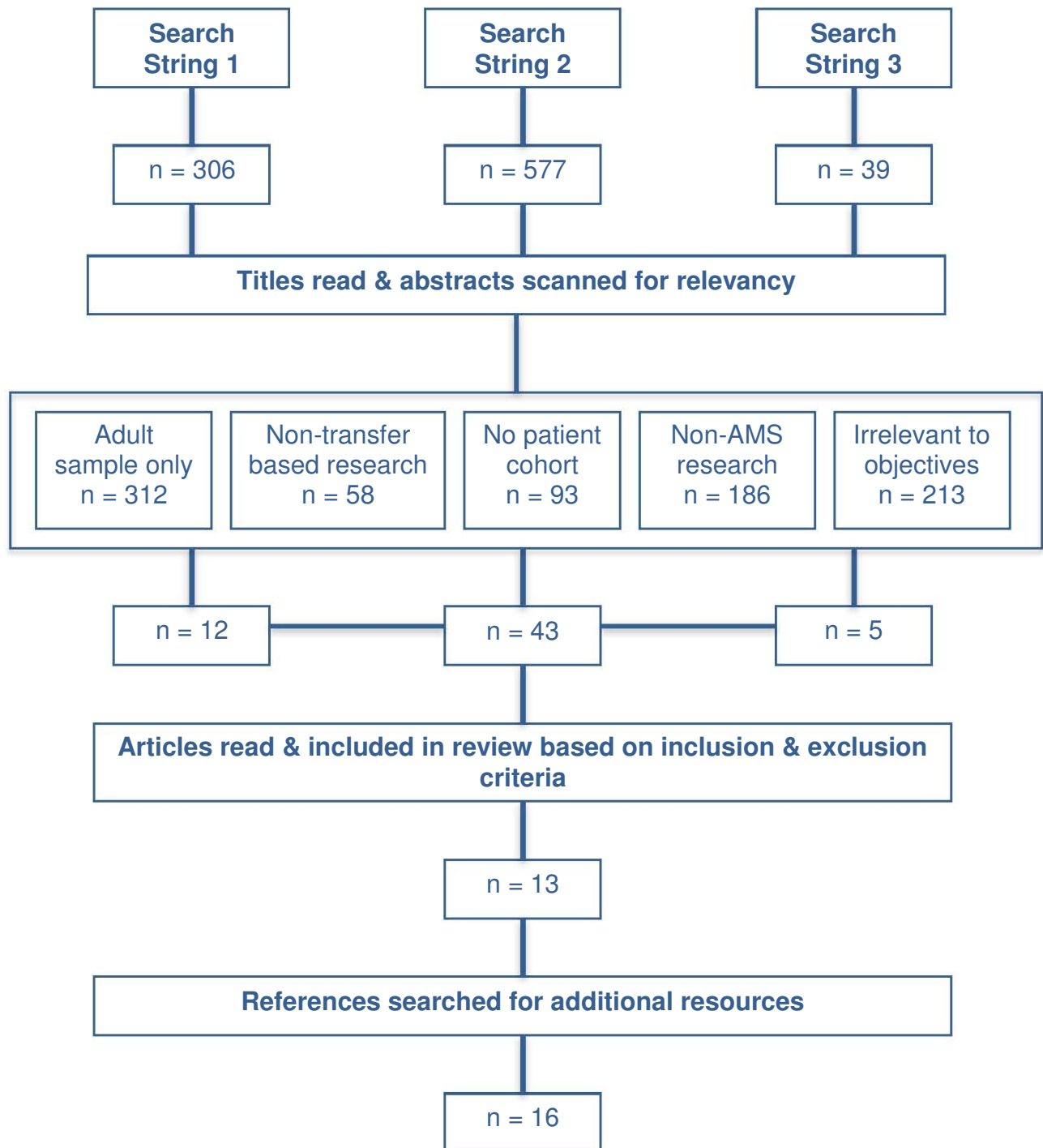
Given the aim and objectives of the study, the following criteria were adopted when appraising the research for exclusion from the literature review:

- Research with only an adult sample/population. If the research involved a combined adult and paediatric sample, and the analysis of the paediatric population in isolation was not possible, then the article was excluded.
- Research focusing on primary/scene calls (i.e.: non interfacility transfers)

- Research focusing only on ground based emergency services
- Research focusing on adverse events for other than the interfacility transfer of paediatric patients (i.e.: adult patients)
- Due to the aviation component of the AMS, the intricacy of detail for adverse technical events was potentially beyond the scope required for the purposes of this study. As such, the adverse technical events were limited to those defined in the study protocol – See Box 2.

**Box 2: Adverse technical Events**

- Malfunction of monitoring and other medical equipment
- Absence of equipment generally available as per equipment checklist
- No monitoring equipment in place ab initio
- Aircraft fault resulting in delay or cancellation of a call, following commencement of the call i.e.: lift off
- Adverse weather resulting in delay or cancellation of a call following commencement

**Figure 1: Literature Review Search Results**

Search string 1: (helicopter or “rotor wing”) AND comparison AND (airplane OR “fixed wing”)

Search string 2: (“aeromedical” OR “air medical”) AND (p?ediatric OR child OR infant OR neonate)

Search string 3: (p?ediatric OR child\* OR neonat\*) AND transfer\* AND “adverse event”

## 1.5) Summary

### 1.5.1) Fixed-wing vs. Helicopter

Comparing the use of helicopters and fixed-wing aircraft for critical care transfer is inherently complicated, given the multitude of confounding variables. Common variations in services include aircraft type, range, capacity and performance, as well as extraneous factors such as location of referring and receiving facility and presence and type of landing facilities<sup>22,32</sup>. While it is clear that helicopter transport is preferred over short distances, and fixed-wing transfer preferred over long distances, there is often a large area of overlap in the “middle” distances (i.e.: 150 – 300 km) for which each resource is utilised<sup>22,32</sup>. The purpose of this aspect of the literature review was to therefore firstly identify whether or not any non-clinical differences exist in utilising each modality in the transfer role over this common overlap; and secondly, from a clinical point of view, identify any potential differences that may exist in terms of patient demographics, clinical condition or other clinical outcomes between each mode over this common distance.

Table 1 provides a summary of the variables measured for the research comparing fixed-wing with helicopter use for interfacility transport. Thomas *et al.*<sup>22</sup> first compared the use of helicopter and fixed-wing aircraft in the interfacility transfer role. No significant differences were observed between cohorts for patient severity, length of hospital stay or mortality for each mode of transport. As is generally perceived, for shorter distances (100 miles/160 km) helicopter transport was more commonly utilised (96% of cases); and for greater distances (>160 miles/240 km) transport by fixed-wing aircraft was most common (95% of cases). For the distances in-between, utilisation was equal between each mode, with no significant differences in transfer intervals, or patient outcomes observed. However, analysis of the cost per mile found helicopter transport to be 400% higher than fixed-wing transport over this range.

Table 1: Summary of variables measured from published literature comparing fixed-wing with helicopter interfacility transport

Author	Study Type	Setting & Population	Variables	Additional
<b>Thomas <i>et al.</i><sup>22</sup> (1990)</b>	Single centre retrospective observational	Interfacility transfer of trauma & non-trauma subgroups by fixed-wing & helicopter transport	<ul style="list-style-type: none"> <li>- Flight interval times</li> <li>- Flight interval distances</li> <li>- Patient age</li> <li>- Injury Severity Score</li> <li>- Length of hospital stay</li> <li>- Hospital mortality</li> <li>- Discharge disability</li> <li>- Cost per mile</li> </ul>	<ul style="list-style-type: none"> <li>- Mixed adult &amp; paediatric sample</li> <li>- Cost per mile assessed based on specific aircraft type</li> </ul>
<b>Diller <i>et al.</i><sup>23</sup> (1999)</b>	Single centre retrospective observational	Interfacility transfer of trauma & non-trauma subgroups by fixed-wing; helicopter and road based transport, to a single paediatric tertiary care centre	<ul style="list-style-type: none"> <li>- Patient demographics</li> <li>- Diagnostic category</li> <li>- Treatment during transport</li> <li>- Injury Severity Score</li> <li>- Length of hospital stay</li> <li>- Hospital mortality</li> <li>- Financial data</li> </ul>	<ul style="list-style-type: none"> <li>- Patients &gt; 17 &amp; newborns excluded</li> <li>- Data compared with previously reported, similar road transport cohort</li> </ul>

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<b>Goldstein <i>et al.</i><sup>32</sup> (2003)</b>	Single centre retrospective cohort	Interfacility transfer of trauma patients by fixed-wing; helicopter & road based transport	<ul style="list-style-type: none"><li>- Flight interval times</li><li>- Geographical zones</li><li>- Patient demographics</li><li>- Prehospital &amp; Pre-transport index triage tools</li><li>- Length of hospital stay</li><li>- Length of ICU stay</li><li>- Mortality</li></ul>	- Mixed adult & paediatric sample
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In a similar trial comparing the use of helicopter, fixed-wing and road vehicle use, a similar significant increase in cost per patient was observed with helicopter compared to fixed-wing use. As with the previous study<sup>22</sup>, no significant differences were observed in patient severity, length of hospital stay or mortality between the air medical cohorts (fixed-wing and helicopter). However, it was found that this group was reportedly more critically ill or injured than the road based cohort, and were transported to receiving facility in significantly shorter intervals.

In a mixed adult and paediatric cohort comparing the transfer of trauma patients by helicopter, fixed-wing and ground transport<sup>32</sup>, again, no significant differences were observed in terms of patient severity, length of hospital or ICU stay, or mortality between the two air medical cohorts (helicopter and fixed-wing). Similar to results from the study by Thomas *et al*<sup>2</sup>, it was reported that for distances less than 240 km, transfer by helicopter was the fastest method and more commonly utilised. For distances greater than this, transfer by fixed-wing was ultimately faster and employed more often.

### **1.5.2) Transfer of paediatric patients by air - International**

In spite of the dearth of literature on paediatric air transfers, unlike the above comparison, there are a number of important conclusions that were found amongst these studies, which warrant highlighting:

- There is general consistency between each study in terms of the minimum data set utilised for the analyses
- Paediatric patients transported by the AMS are in general, more severely ill or injured than similar road transported cohorts, despite which
- There is a noticeable tendency for paediatric patients transported by the AMS to be over-triaged, thus raising concerns over appropriateness of use (see “Gaps in Research” below)
- Specialised paediatric retrieval teams offer no significantly demonstrable benefit over non-specialised teams within the air medical environment

Table 2 below provides a summary of the variables measured from published literature for the interfacility transfer of paediatric patients by The AMS. The study cited earlier by Diller *et al.*<sup>23</sup>, set in the USA, compared patients transported helicopter, fixed-wing and traditional ground based emergency services. This retrospective analysis documented patient demographic details, broad diagnoses, length of hospital stay and financial data for each cohort. It was found that more patients were transported by helicopter, when compared with fixed-wing, with the majority of helicopter transfers being trauma related (56% of all helicopter paediatric patients). Transportation by fixed-wing aircraft on the other hand was more common for medical related pathologies (62% of all fixed-wing paediatric patients). No differences in patient severity, length of hospital stay or mortality were reported amongst these two groups. It was also found that when compared to a similar road ambulance cohort, patients transported by air medical service were more severely ill or injured. Despite this, it was also observed that a significant number of patients transferred by air were over-triaged and could ostensibly have been transferred by road, without affecting outcomes.

A study set in rural Norway described the transfer of critically ill neonates by air medical service<sup>18</sup>. In this 10-year retrospective analysis; patient demographics, broad case categories, interventions performed and transport intervals were documented for all patients in this retrospective analysis. The majority of patients were transported by fixed-wing (85%) when compared with helicopter transfer (15%). In addition to this, it was found that respiratory disorders (55.6%) accounted for the most common broad diagnoses, followed by congenital malformations (15.3%). Across both cohorts, there was a 13% adverse event rate, all of which were attributed to equipment faults. Of these, 16% resulted in a documented deterioration in the patient's condition.

A study by Soundappan and colleagues<sup>12</sup> in Australia reported on the interfacility transfer of critical trauma patients to a tertiary trauma centre.

In this prospective audit: mechanism of injury; injury severity; transport intervals and interventions performed were documented. In addition to this, the above variables were analysed and compared between specialised paediatric retrieval teams, and non-specialised retrieval teams. The majority of the patients were in the category of ages 1 – 5 years (50%), with falls accounting for the most common mechanism of injury, followed by burns. For the comparison between the specialised and non-specialised retrieval teams, there were no significant differences in patient severity. It was however reported that the overall transfer times were longer for specialised retrieval team than for non-specialised teams, although this was not statistically significant, and had no impact on mortality or morbidity. Across all cohorts, it was found that the more severely injured patients were associated with longer overall retrieval times. Lastly, as similarly reported by Diller *et al*<sup>23</sup>, just less than a third of the air ambulance (helicopter and fixed-wing) cohorts were found to be over-triaged and transferred for relatively minor injuries.

In a similar trial set in the USA, a prospective cohort study evaluating the utilisation of specialised paediatric retrieval teams for the interfacility transfer of paediatric patients by road and air reported on; patient demographics; broad case diagnoses and patient severity; transport intervals; interventions performed and adverse events were documented for all patients. Air transported was utilised for just over half of both the specialised team cohort (55%), and the non-specialised team cohort (56%). Respiratory dysfunction (34%) accounted for the most common reason for transfer and diagnosis, followed by central nervous dysfunction (19%). Patient severity was found to be higher in the non-specialised team cohort, which could have accounted for the higher incidence of adverse events and higher mortality also seen amongst this cohort. However, it was also reported that transport by specialised retrieval team was associated with longer response, scene, and total transfer times.

Table 2: Summary of variables measured from published literature for the interfacility transfer of paediatric patient by air medical service

Author	Study Type	Setting & Population	Variables	Additional
<b>Diller <i>et al.</i><sup>23</sup> (1999)</b>	Retrospective observational	Interfacility transfer of trauma & non-trauma subgroups by fixed-wing & helicopter transport, to single paediatric tertiary care centre	<ul style="list-style-type: none"> <li>- Patient demographics</li> <li>- Diagnostic category</li> <li>- Transfer interval times</li> <li>- Transfer interval distances</li> <li>- Treatment during transport</li> <li>- Injury Severity Score</li> <li>- Length of hospital stay</li> <li>- Hospital mortality</li> <li>- Financial data</li> </ul>	<ul style="list-style-type: none"> <li>- Patients &gt; 17 &amp; newborns excluded</li> <li>- Data compared with previously reported, similar road transport cohort</li> </ul>
<b>Holt &amp; Fagerli<sup>18</sup> (1999)</b>	Retrospective descriptive analysis	Interfacility transfer of neonatal patients by fixed-wing & helicopter transport, to single paediatric tertiary care centre	<ul style="list-style-type: none"> <li>- Patient demographics</li> <li>- Diagnostic categories</li> <li>- Transfer interval times</li> <li>- Interventions performed</li> <li>- Adverse Events during transfer</li> </ul>	
<b>Soundappan <i>et al.</i><sup>12</sup> (2007)</b>	Prospective descriptive analysis	Interfacility transfer of paediatric trauma patients by road based transfer service and air medical service to single paediatric tertiary trauma care centre	<ul style="list-style-type: none"> <li>- Patient demographics</li> <li>- Diagnostic category &amp; mechanism of injury</li> <li>- Reasons for transfer</li> <li>- Transfer interval times</li> <li>- Transfer interval distances</li> <li>- Injury Severity Score</li> <li>- Length of hospital stay</li> </ul>	<ul style="list-style-type: none"> <li>- Comparison of specialised paediatric retrieval teams with non-specialised retrieval teams</li> </ul>

<b>Orr <i>et al.</i><sup>13</sup> (2009)</b>	Prospective cohort	Interfacility transfer of trauma & non-trauma subgroups by road based transfer service and air medical service to single paediatric tertiary care centre	<ul style="list-style-type: none"> <li>- Patient demographics</li> <li>- Diagnostic categories</li> <li>- Transfer interval times</li> <li>- Interventions performed</li> <li>- Adverse Events during transfer</li> <li>- Length of hospital stay</li> <li>- Paediatric Risk of Mortality Score</li> <li>- Mortality</li> </ul>	- Comparison of specialised paediatric retrieval teams with non-specialised retrieval teams
<b>Pieper <i>et al.</i><sup>31</sup> (1991)</b>	See Table 4 below for the comparison of published literature regarding the interfacility transfer of paediatric patients by air medical service in South Africa			
<b>Hatherill <i>et al.</i><sup>10</sup> (2003)</b>				

### 1.5.3) Transfer of paediatric patients by air – South Africa

South Africa lends itself to the utilisation of the AMS. Given the current state of the healthcare system within the country<sup>36</sup>, they offer the advantages of extending the reach of both urban-level EMS and tertiary-level care to traditionally under-resourced areas. The utilisation of the AMS in paediatric transfer has locally been reviewed in two studies. Table 3 below provides a summary of the comparison of these two trials.

The earlier retrospective analysis from 1991<sup>31</sup> compared the interfacility transfer of neonatal patients by road versus air, documenting; patient demographic details; broad patient diagnoses; reasons for transfer; and outcomes in terms of survival following admission. No deaths in-transit were reported, however post admission survival amongst the fixed-wing cohort was 100%, 94% amongst the helicopter cohort and down to 70% for the road ambulance cohort. Overall, respiratory pathologies were the most commonly cited reason for transfer, followed by surgical pathologies. The highest mortality was associated with higher mean gestational age, lower mean mass and lower mean admission age. Despite these promising results, little inference can be drawn from the study as the power was hampered by a small sample size (n = 58).

In 2003 Hatherill *et al*<sup>10</sup> reported on the results of a one-year prospective audit of all patients transferred to their Paediatric Intensive Care Unit (PICU). Patient demographics; diagnostic category; mode of transport; and post-admission mortality were analysed for all patients, and described. Transfer by road ambulance occurred most commonly (76% of patients), followed by fixed-wing (14%) then helicopter transport (10%). Medical related pathologies accounted for the most common diagnoses and reasons for transfer (50%), followed by surgical related pathologies (33%). The highest post admission mortality was seen amongst the road ambulance cohort (76% of non-survivors) when compared with the FW (12%) and helicopter (12%) cohorts.

**Table 3: Comparison of published literature regarding the interfacility transfer of paediatric patients by air medical service in South Africa**

<b>Authors</b>	<b>Pieper <i>et al.</i><sup>9</sup></b>	<b>Hatherill <i>et al.</i><sup>10</sup></b>
<b>Study Aim</b>	To describe the mode of transport, type of patient transferred and outcome as defined by death or discharge from hospital	To audit paediatric intensive care unit transfer activity and transfer-related adverse events in a resource-limited setting
<b>Study Type</b>	Retrospective descriptive analysis	Prospective audit
<b>Study Period</b>	01 Jan 1991 – 30 Sept 1991	01 Nov 2000 – 31 Oct 2001
<b>Geographic Location</b>	Cape Province (Present day Western Cape & Northern Cape)	Western Cape
<b>Setting</b>	Level 3 Neonatal Intensive Care Unit at Tygerberg Hospital	Paediatric Intensive Care Unit at the Red Cross War Memorial Children's Hospital
<b>Population</b>	Neonates	Paediatric patients < 14 yrs. old
<b>Sample Size</b>	n = 52	n = 202

<p><b>Variables measured</b></p>	<ul style="list-style-type: none"> <li>- Patient demographics</li> <li>- Diagnostic category</li> <li>- Reasons for transfer</li> <li>- Mode of transfer</li> <li>- Transfer interval distances</li> <li>- Length of hospital stay</li> <li>- Hospital mortality</li> </ul>	<ul style="list-style-type: none"> <li>- Patient demographics</li> <li>- Diagnostic category</li> <li>- Referring hospital</li> <li>- Mode of transfer</li> <li>- Transfer personnel</li> <li>- Adverse events</li> <li>- Outcome at ICU discharge</li> </ul>
<p><b>Other</b></p>	<ul style="list-style-type: none"> <li>- Comparison of fixed-wing vs. helicopter vs. road transfer</li> </ul>	<p>Adverse Events measured include:</p> <ul style="list-style-type: none"> <li>- <b>Technical:</b> No monitoring equipment in place; malfunction of monitoring or other equipment; failure to place venous access; loss of venous; malposition of the endotracheal tube</li> <li>- <b>Clinical:</b> shock; hypoxia; hypoglycaemia</li> <li>- <b>Critical:</b> Emergency intubation and/or an arrest</li> <li>- Patient severity measured by Paediatric Index of Mortality (PIM) score, however only at receiving facility</li> </ul>

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Both trials share a number of similarities in that they are set in the Western Cape and examine the transfer of a fixed-wing cohort, helicopter cohort and road based cohort from surrounding rural areas to a central hospital within Cape Town. While not statistically significant, they nonetheless offer insight into the potential role the AMS can play in paediatric transfer, and the advantages they offer over conventional ground based transport.

#### **1.5.4) Adverse events in paediatric transfer - International**

Measuring the safety and performance of a paediatric interfacility transfer service whether by road or air, can be difficult considering the multitude of confounding variables affecting such analyses. In addition, there is significant variation in the definition of an adverse event, which has come to represent a myriad of variables used to describe this. From the benign physiological event - defined by alterations in vitals signs; to the life threatening critical adverse events defined by cardiopulmonary resuscitation for example. Furthermore, this has also recently come to include adverse technical events, given the variety in monitoring, ventilatory and medication-delivery devices required for these types of transfers. Table 4 gives a summary of the literature outlining the development of variables used to measure adverse events for the inter-facility transfer of paediatric patients.

Table 4: Summary of criteria defining adverse events from published evidence regarding the interfacility transfers by air

Authors	Study Type	Setting & Population	Variables	Additional
<b>Barry &amp; Ralston<sup>9</sup></b> (1994)	Single centre prospective observational	Road based transfer of paediatric patients	<ul style="list-style-type: none"> <li>- <b>Critical:</b> Apnoea; hypoventilation; bradycardia; hypotension; inadequately positioned/secured ETT</li> <li>- <b>Serious:</b> Neurological deterioration; poor temperature control; inappropriate administration/non-administration of drugs; procedures indicated but not performed/attempted &amp; failed; loss of IV access</li> </ul>	<ul style="list-style-type: none"> <li>- Patient severity measured by Paediatric Risk of Mortality (PRISM) score, however only at receiving facility</li> </ul>
<b>Holt &amp; Fagerli<sup>18</sup></b> (1999)	Retrospective descriptive analysis	Helicopter & fixed-wing transfer of neonates	<ul style="list-style-type: none"> <li>- No predetermined/predefined variables. Data collected from patient records</li> </ul>	<ul style="list-style-type: none"> <li>- Inclusion of adverse events resulting from equipment failure/ malfunction</li> </ul>
<b>Hatherill <i>et al.</i><sup>10</sup></b> (2003)	Single centre prospective observational	Transfer of paediatric patients by road, helicopter & fixed-wing to a single PICU	<ul style="list-style-type: none"> <li>- <b>Technical:</b> No monitoring equipment in place; malfunction of monitoring or other equipment; failure to place venous access; loss of venous; malposition of the endotracheal tube</li> <li>- <b>Physiological:</b> shock; hypoxia; hypoglycaemia</li> <li>- <b>Critical:</b> Emergency intubation and/or an arrest</li> </ul>	<ul style="list-style-type: none"> <li>- Patient severity measured by Paediatric Index of Mortality (PIM) score, however only at receiving facility</li> </ul>
<b>Mori <i>et al.</i><sup>33</sup></b> (2007)	Systematic review & retrospective descriptive analysis	Transfer of neonates	<ul style="list-style-type: none"> <li>- Association between duration of interfacility transfer and perinatal mortality</li> </ul>	

<b>Lim &amp; Ratnavel<sup>34</sup> (2008)</b>	Prospective observational	Transfer of paediatric & neonatal patients by specialised road based retrieval teams	<ul style="list-style-type: none"> <li>- No predetermined/predefined variables. Data collected directly from referral teams, referring &amp; receiving staff</li> </ul>	<ul style="list-style-type: none"> <li>- Adverse events additionally divided into 6 categories of severity, from catastrophic to insignificant.</li> <li>- Documentation and communication errors additionally documented</li> </ul>
<b>Orr <i>et al.</i><sup>13</sup> (2009)</b>	Single centre prospective cohort	Transfer of paediatric patients by specialised road, helicopter & fixed-wing retrieval teams	<ul style="list-style-type: none"> <li>- <b>Airway events:</b> Oesophageal intubation; accidental extubation; respiratory insufficiency necessitating immediate intubation; blocked endotracheal tube requiring immediate re-intubation</li> <li>- Cardiac or respiratory arrest requiring Cardiopulmonary resuscitation</li> <li>- Pneumothorax</li> <li>- <b>Medication-related:</b> Dosage errors or lack of administration of medications prescribed by the command physician</li> <li>- Equipment malfunctions associated with patient deterioration</li> <li>- <b>Physiological variables:</b> Sustained systolic hypotension (&lt; 5<sup>th</sup> percentile for age) for &gt; 5 minutes with no documented therapy; sustained hypoxia for &gt; 5minutes (oxygen saturation of &lt; 90%) with no documented therapy (with the exclusion of patients with fixed pulmonary or cardiac shunts); hypothermia (patient temperature of &lt; 34°C at arrival excluding patients receiving therapeutic hypothermia)</li> </ul>	<ul style="list-style-type: none"> <li>- Patient severity measured by Paediatric Risk of Mortality (PRISM) score prior to referral and following arrival at receiving hospital</li> </ul>

**Ramnarayan<sup>35</sup>**  
**(2009)**

Retrospective  
descriptive analysis

Transfer of  
paediatric  
patients by  
specialised road  
based retrieval  
teams

- **Patient related:** Respiratory arrest; cyanosis; cardiac arrest; loss of brainstem reflexes; core temperature < 34°C; and loss of consciousness (GCS <7)
  - **Technical/care related:** Endotracheal tube occlusion; unplanned extubation; loss of IV access; pulmonary aspiration; loss of monitoring; critical ventilator malfunction; exhaustion of oxygen supply
  - **Physiological variables:** Systolic hypotension (child < 65 mm Hg, infant < 55 mm Hg); tachycardia (child > 200/min, infant > 220/min); bradycardia, (child < 40/min, infant < 50/min); and hypoglycaemia (< 2.5 mmol/l)
- Ambulance accident rate/10 000 journeys was additionally measured
  - Efficiency of use was measured by the number of patients incorrectly triaged; number of requests for which the transfer service was unavailable or unable to complete immediately; and the number of unplanned re-transfers – accounting for 11 of transfers.

### 1.5.5) Adverse events in paediatric transfer – South Africa

Adverse events in the paediatric transfer by air, within SA have been described in a single previous trial. Hatherill *et al.*<sup>10</sup> defined adverse events to include:

- Technical adverse event
  - No monitoring equipment in place
  - Malfunction of monitoring or other equipment
  - Failure to place venous access
  - Loss of venous access due to displacement or blockage
  - Malposition of the endotracheal tube
  
- Clinical adverse events
  - Shock (capillary refill >4 s or hypotension for age, requiring either fluid resuscitation or inotropic support)
  - Hypoxia (defined as oxygen saturation <80% in the absence of a cyanotic heart defect)
  - Hypoglycaemia (defined as blood glucose <2.5 mmol/l)
  
- Critical adverse events
  - Emergency intubation
  - Cardiac, cardio-respiratory, or respiratory arrest

Clinical adverse events occurred in 27% of all cases, critical adverse events in 9% of cases, and technical events in 36%. In addition, up to 36% were seen to be preventable. Despite being seemingly high, these represent the adverse events of the entire sample, 76% of which were transported by road. As of yet, no study, set in SA has examined the adverse event rate from purely an AMS point of view.

### 1.6) Identification of gaps or needs for further research

Utilisation of the AMS and their potential benefits has been investigated numerous times, and in-depth since their inception<sup>20-22</sup>. However, much of this research has focused on helicopter operations, involving primary/ scene

calls. Only recently have the benefits of the AMS for interfacility transfer began to be realised and become the focus for research. As the large existing gaps are filled, additional information that can guide policy towards the maximisation of these services will become available.

Research regarding utilisation is somewhat linked to another major gap in the research. Questions surrounding appropriateness of use have dogged the AMS since their inception. With an increasing scope of utilisation, these questions will only serve to hamper the development of AMS programs in the future. As such, significant research will be required into identifying appropriate use of the AMS. However, as simple as this may seem, the variety of local circumstances in which these services operate will dictate significantly what defines “appropriate use”. Therefore it is important that research in this regard be conducted in multiple locations, under numerous conditions. This too will allow operators to maximise use, while minimising cost and easing the burden of resources required for such services.

As highlighted, the establishment and maintenance of an AMS is without a doubt an enormous financial undertaking. This is further complicated by the various “configurations” in which these services can operate, which to name a few, can include:

- Daylight only vs. 24 hour service; helicopter vs. fixed-wing vs. combined service; inclusion of a helicopter rescue service
- Single engine vs. multi-engine aircraft
- Hospital based vs. EMS based service
- Medical crew composition

Data regarding the financial requirements of these various configurations is of immense benefit. This can not only assist current operators in maximising performance, but also allow for new programs to select the best combination based on their local circumstances.

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# Part 2: Journal Article

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## Cover Page

**Title:** Current practice in the air medical services for the inter-facility transfer of paediatric patients in the Western Cape, South Africa

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## **Abstract**

### **Aim**

To describe the utilisation and transfer activity of the air medical services, for interfacility transfer of paediatric patients in the Western Cape province of South Africa.

### **Methods**

A retrospective descriptive analysis was conducted between January 2010 and December 2011. Data were recorded from the Cape Town base of the air medical service provider for the Western Cape Provincial Department of Health. Patient demographics, flight and transfer details, interventions performed and adverse events encountered were documented for all patients <13 years of age transferred by either helicopter or fixed-wing aircraft.

### **Results**

A total of 485 patients were analysed. More patients were transported by helicopter (54%), with neonates making up the largest category for both modes of transfer. Respiratory (29%), neurological (18%), cardiac (14%) and gastrointestinal disorders (14%) made up the majority of non-traumatic reasons for transfer. Overall, transfers by helicopter were quicker [median mission time 03:00 (IQR 02:32 – 03:25)] compared with fixed wing transfer [05:24 (04:22 – 06:20)]. The incidence of adverse technical events was relatively high (20%). Physiological adverse events ranged between 2% and 16% overall depending on the variable measured. The incidence of cardiac/respiratory arrest and endotracheal tube obstruction/dislocation remained low (<2%). Emergency intubation and desaturation >10% from baseline were the most common critical adverse events encountered (6%).

**Conclusion**

Current utilisation of the air medical services for paediatric interfacility transfer is relatively high. Across both platforms, patients with a diverse range of pathologies of equally varying severities were transferred. The adverse events observed were found to be lower than those of trials examining non-specialised paediatric transfer, and were comparable to those seen with transfer by specialised paediatric retrieval teams. The air medical services remain a safe and viable alternative to non-specialised paediatric transfer, and may serve as a potential alternative to specialised paediatric transfer, in the Western Cape.

## 2.1) Introduction

Over the last decade, two major factors have shaped the development of paediatric interfacility transfer. Since the early 1990's, a growing body of evidence supported the improved patient outcomes associated with the centralisation of paediatric intensive care resources<sup>1-5</sup>. This led to the widespread acceptance and adoption of this model as a result<sup>6,7</sup>. In conjunction, there has been a reported increase in incidence of preventable adverse events associated with paediatric transfer, especially when undertaken by inexperienced transfer teams<sup>8-10</sup>.

These developments led to the formation of specialised paediatric retrieval teams made up of staff trained in paediatric intensive care. Considered by many to be the "gold standard" of paediatric transfer, utilisation of these teams is supported by a demonstrated reduction in interfacility adverse events and mortality in the immediate post admission period, when compared with non-specialised transfer<sup>10-14</sup>. Supporters of this approach assert that these teams offer the benefits of focused training and experience in terms of exposure to the environment, equipment and patients<sup>10-14</sup>. Opponents argue that this approach is resource intensive and requires substantial financial backing to be effectively introduced and maintained<sup>16,17</sup>. Furthermore, these teams fail to demonstrate an overall reduction in length of hospital stay, hospital resource use or survival to discharge, following their introduction<sup>16,17</sup>.

Recent evidence also suggests the utilisation of the air medical services (AMS) to be an additional, alternative option for paediatric transfer, in both a specialised and non-specialised structure<sup>9,11,12,17</sup>. Worldwide, the AMS are becoming an increasingly prevalent and important aspect of the emergency medical services (EMS), having already demonstrated numerous advantages. Chief amongst these are the benefits of range of access and speed of transportation<sup>18-20</sup>. However, these services are also not without significant financial strain, or their own unique potential hazards<sup>21-24</sup>.

While these advances in the challenges to paediatric interfacility transfer are promising, they have been addressed largely within the context of a 'high-

income economy'. There is little evidence to guide solutions and policy within the 'low to middle-income' setting, where the issues regarding paediatric transfer are nonetheless still prevalent. Within South Africa however, there is significant effort being made to address this problem in the Western Cape province.

Early data from the establishment of dedicated maternity and neonatal transfer units has shown reduced transfer intervals for these patient subsets<sup>25</sup>. However, these units are in the early stages of development, with limited data to report on. Furthermore, they remain confined to the greater Cape Town metropolitan area, thus leaving rural areas wholly underserved. Two previous studies also examined the potential role of the AMS as an alternative to transfer in the Western Cape<sup>9,26</sup>. However these trials were of a mixed road and air-based cohort or of too small a sample to be considered an adequately explored option. Despite this, the Western Cape has had a long tradition of air medical operation, and these services remain the most readily available and "transferable" alternative to paediatric transfer. As a result, this study was undertaken to explicitly evaluate the current use of these services, in the role of paediatric transfer within the Western Cape.

## **2.2) Materials and Methods**

### **2.2.1) Study Setting**

The study was set in the Western Cape province of South Africa, covering an area of approximately 130 000 square kilometres, with a population of approximately 5.8 million people<sup>27</sup>. Data was collected from the records of the air medical service provider for the provincial Department of Health, located at Cape Town International Airport. From this base the service operates a 12-hour/daytime-helicopter service, utilising an Agusta-Westland A119Ke for short to medium distance transfers (<200 km); and a 24-hour FW service utilising a Pilatus PC-12 for long distance transfers (>200 km). The aircraft are primarily staffed by prehospital Advanced Life Support (ALS) practitioners, supported by a variety of voluntary and seconded crew consisting of prehospital ALS and intermediate life support (ILS) practitioners, nursing sisters, and doctors of varying specialties.

## 2.2.2) Study Design

All data was collected retrospectively for the period 01 January 2010 to 31 December 2011 from the service provider's patient report forms, captain's logs and flight folios. For each flight: patient demographic data, flight and transfer details, interventions performed and adverse events were recorded.

### 2.2.2.1) Demographic data

All patients <13 years of age, undergoing interfacility transfer by the air medical service provider, within the defined study period were included for the analysis. Patients were divided into five age based categories, namely: *Neonate*: New-born patients up to and including 28 days; *Infant*: older than 28 days up to and including 364 days (<1 year); *Toddler*: between the ages of 1 year up to and including 3 years and 364 days (<4 years); *Child*: between the ages of 4 years up to and including 12 years 364 days. Diagnostic categories were recorded as: medical, surgical (non-traumatic) or trauma. The medical and surgical designations were further classified according to the predominant system affected by the underlying pathology. Patient severity was primarily assessed via Rapid Emergency Medical Score (REMS), and was calculated for each patient at the referring facility, based on the initial set of presenting vitals signs. The score has previously been validated and shown to be comparable in its predictive value to the more complex APACHE 2 score<sup>28,29</sup>.

### 2.2.2.2) Flight and Transfer data

Mode of transport was categorised as either helicopter or fixed-wing. The time intervals of each mission were divided and classified according to: access time; hospital time; transfer time and handover time. Transferring medical personnel were classified according to their primary qualification, including: Registered Nurse (RN); ILS practitioner; ALS practitioner and Doctor (Dr). Interventions performed on each patient during both stabilisation at the referring facility and en route during transportation were documented. In addition, the interventions performed were used to calculate therapeutic intervention scores, a secondary measure of severity. The Neonatal Therapeutic Intervention Scoring System (NTISS)

was used for the *Neonate* category; and the Therapeutic Intervention Scoring System – 28 (TISS-28) for the *Infant, Toddler* and *Child* categories. Both scores have been validated in previous studies and have shown to be both a valid measure of patient severity and reliable indicator of resource utilisation<sup>30,31</sup>. Receiving and referring hospitals were classified according to traditional definitions based on their services offered, surrounding drainage area and bed capacity to include: day clinic; district level; regional level and central/tertiary level hospital.

### **2.2.2.3) Adverse Events**

All documentation was scrutinised for the presence of adverse events encountered during both stabilisation at the referring facility as well en route during transportation. The events were classified into the following categories:

- **Adverse Technical Events:** Malfunction of monitoring and other medical equipment; absence of equipment generally available as per aircraft equipment checklist; no monitoring equipment in place ab initio; aircraft fault resulting in delay or cancellation of a flight; adverse weather resulting in delay or cancellation of a flight.
- **Adverse Physiological Event:** For each patient, respiratory rate (RR); heart rate (HR); blood pressure (BP); oxygen saturation (SpO<sub>2</sub>) and capillary refill time (CRT) were evaluated against predefined, age category specific criteria to determine whether abnormal or unexpected for the patient's age category or baseline (See Table 1).
- **Adverse Critical Event:** This category indicated a more critical decline in a patient's condition, or otherwise requiring life-saving intervention. This included: Cardiac, cardio-respiratory or respiratory arrest during stabilization or transfer; emergency intubation; endotracheal tube obstruction or dislocation; desaturation of 10% from baseline for longer than 10 mins, in the absence of a technical malfunction or misplaced probe; decrease in Glasgow Coma Scale of 3 or more points from baseline (where applicable).

Table 1 – Adverse Physiological Event Parameters				
	Neonate	Infant	Toddler	Child
<b>Heart rate</b>	<100 b/min >220	<100 b/min >200	<90 b/min >160	<60 b/min >160
<b>Respiratory Rate</b>	<40 br/min >60	<30 br/min >40	<20 br/min >40	<15 br/min >35
<b>SpO<sub>2</sub></b>	5% reduction from baseline for longer than 10 minutes			
<b>Blood Pressure</b>	<50mmHg Systolic BP >100mmHg	<60mmHg Systolic BP >110mmHg	<80mmHg Systolic BP >130mmHg	<90mmHg Systolic BP >140mmHg
<b>Capillary Refill</b>	Delayed > 4 sec			

### 2.2.3) Statistical Considerations

Data was entered into a Microsoft Excel™ (2010) database (Microsoft Corporation, Seattle, WA) and analysed using Microsoft Excel™ (2010). Medians or means were used as the measures of central location for ordinal and continuous responses, and standard deviations and quartiles as indicators of spread. Distributions of variables were presented with frequency tables. Categorical and binary data were presented using frequency tables and proportions. Appropriate 95% confidence intervals were presented for all descriptive statistics. Analyses of the objectives of the study included the use of the following inferential statistical techniques:

- For the comparison of continuous variables, a T-test or Mann-Whitney test was utilised.
- For the comparison of groups of continuous variables, an analysis of variance (ANOVA) – post hoc test was utilised.
- For the comparison of categorical variables, a Chi<sup>2</sup> test was used.

A p-value of  $p < 0.05$  will represent statistical significance in hypothesis testing and 95% confidence intervals will be used to describe the estimation of unknown parameters.

## 2.3) Results

### 2.3.1) Demographic Data

The results of the demographic data collected are detailed in Table 2. Paediatric interfacility transfers represented approximately 25% of all flights over the study period. More patients were transported by helicopter overall (patients = 286 vs. flights = 286; rate ratio = 1), however the greater cabin capacity of the fixed-wing allowed more patients to be carried for fewer flights (patients = 242 vs. flights = 206; rate ratio = 1.2). Consistent with the overall results, general medical cases made up for the majority of patients in the helicopter group (72%). Non-traumatic surgical cases made up the majority in the fixed-wing group (54%). Neonates comprised the single biggest group for each mode of transport, as well as for each of the above-mentioned diagnostic categories. Respiratory (42%), neurological (16%) and gastrointestinal disorders (10%) accounted for the majority of non-traumatic pathologies affecting patients. Based on the REMS calculated for each patient, those transported by helicopter were found to be more critically ill or injured compared with the fixed-wing group ( $p < 0.001$ ). In addition, using REMS as a measure of severity, there was a significant number of patients of low acuity transferred [(REMS  $\leq 5$ ,  $n=109$  (22%)), more so for the fixed-wing patients compared to the helicopter group.

### 2.3.2) Flight and Mission Data

Flight and mission data collected are detailed in Table 3. ALS practitioners were the most common medical crew, present on all flights. The greater capacity of the fixed-wing allowed an ILS practitioner to be present for every flight, in addition to a third medical crew member on a further 21% of flights. Consistent with the overall results, Regional facilities largely accounted for referral by fixed-wing (72%). District facilities accounted for the majority of helicopter referrals (62%). When evaluating the most critical patients (REMS  $\geq 12$ ), more were referred from Regional level facilities [ $n=60$  (25%)], compared to district level facilities [ $n=38$  (18%)] [(Odds ratio 1.4 (95% CI 0.89 – 2.12)]. Similarly, patients requiring a higher level of intervention (N/TISS-28  $\geq 15$ ), were more often referred from Regional level facilities [ $n=96$  (38%)], compared to district level facilities [ $n=59$  (29%)] [(Odds ratio 1.56 (95% CI

1.05 – 2.32)]. Tertiary facilities made up the majority of receiving facilities in both samples (helicopter – 70%; fixed-wing – 92%), however, for the helicopter group, regional facilities were more commonly referred to when compared with the fixed-wing.

<b>Table 2 - Demographic Data</b>				
<b>Data expressed as n (%)</b>				
	<b>Total</b>	<b>Fixed-wing</b>	<b>Helicopter</b>	<b>p Value</b>
<b>Total flights (All)</b>	2010	714	1122	
<b>Total flights (Paediatric)</b>	512 (25%)	226 (32%)	286 (26%)	
<b>Total patients (All)</b>	1898	969	929	
<b>Total patients (Paediatric)</b>	536 (28%)	242 (25%)	286 (31%)	
<b>Aborted/Cancelled flights</b>	13	3	10	
<b>Missing/Incomplete records</b>	30	17	13	
<b>Paediatric flights analysed</b>	469	206	263	
<b>Paediatric patients analysed</b>	485	222	263	
<b>Male</b>	277 (57%)	123 (55%)	154 (59%)	
<b>Female</b>	208 (43%)	99 (45%)	109 (47%)	
<b>Age Category (% of patients analysed)</b>				<i>p</i> < 0.003
<b>Neonate</b>	199 (41%)	71 (32%)	128 (49%)	
<b>Infant</b>	134 (28%)	67 (30%)	67 (25%)	
<b>Toddler</b>	68 (14%)	35 (16%)	33 (13%)	
<b>Child</b>	84 (17%)	49 (22%)	35 (13%)	
<b>Diagnostic Category (% of patients analysed)</b>				<i>p</i> < 0.001
<b>Medical</b>	263 (54%)	73 (33%)	190 (72%)	
<b>Non-trauma Surgical</b>	164 (34%)	121 (54%)	43 (16%)	
<b>Trauma</b>	58 (12%)	28 (13%)	30 (12%)	
<b>System affected/Reason for transfer (% of patients analysed)</b>				<i>p</i> < 0.001
<b>Respiratory/Pulmonary</b>	141 (29%)	30 (14%)	111 (42%)	
<b>GIT</b>	67 (14%)	42 (19%)	25 (10%)	
<b>ENT</b>	20 (4%)	12 (5%)	8 (3%)	
<b>Cancer</b>	11 (2%)	10 (5%)	1 (<1%)	
<b>Neurological</b>	89 (18%)	46 (21%)	43 (16%)	
<b>Ortho</b>	18 (4%)	8 (4%)	10 (4%)	
<b>Metabolic</b>	30 (6%)	4 (2%)	26 (10%)	
<b>Cardiac</b>	69 (14%)	48 (22%)	21 (8%)	
<b>Burns</b>	8 (2%)	4 (2%)	4 (2%)	
<b>Renal</b>	5 (1%)	5 (2%)		
<b>Hepatic</b>	8 (2%)	3 (1%)	5 (2%)	
<b>Genitourinary</b>	1 (<1%)	1 (<1%)		
<b>Poisoning</b>	9 (2%)	1 (<1%)	8 (3%)	
<b>Ocular</b>	6 (1%)	6 (3%)		
<b>Musculoskeletal</b>	1 (<1%)	1 (<1%)		
<b>Vascular</b>	1 (<1%)	1 (<1%)		
<b>Near drowning</b>	1 (<1%)		1 (<1%)	
<b>Rapid Emergency Medicine Score (% of patients analysed)</b>				<i>p</i> < 0.001
<b>1 - 5</b>	109 (22%)	75 (34%)	34 (13%)	
<b>6 - 10</b>	226 (47%)	106 (47%)	120 (46%)	
<b>11 - 15</b>	135 (28%)	37 (17%)	98 (37%)	
<b>&gt; 15</b>	15 (3%)	4 (2%)	11 (4%)	

<b>Table 3 - Flight and Mission Data</b> Data expressed as <i>n</i> (%) or mean (IQR)			
<b>Flight Intervals</b>	<b>Fixed-wing</b>		<b>Helicopter</b>
<b>Access time</b>	1:30 (1:09 – 1:40)		00:33 (00:23 – 00:42)
<b>Stabilisation time</b>	00:57 (00:29 – 01:27)		00:50 (00:39 – 01:00)
<b>Transfer time</b>	01:41 (01:22 – 01:54)		00:31 (00:20 – 00:49)
<b>Handover time</b>	00:27 (00:15 – 00:37)		00:39 (00:30 – 00:49)
<b>Total flying time</b>	02:04 (01:48 – 02:00)		01:11 (00:48 – 01:30)
<b>Total mission time</b>	05:24 (04:22 – 06:20)		03:00 (02:32 – 03:25)
<b>Crew Composition</b>			
<b>ALS</b>	206 (100%)		263 (100%)
<b>ILS</b>	206 (100%)		60 (23%)
<b>Dr</b>	41 (20%)		94 (36%)
<b>RN</b>	2 (1%)		9 (3%)
	<b>Total</b>	<b>Fixed-wing</b>	<b>Helicopter</b>
<b>Referring Facility</b>			
<b>Tertiary/Central</b>	3 (1%)		3 (1%)
<b>Regional</b>	237 (51%)	147 (72%)	90 (34%)
<b>District</b>	204 (44%)	42 (20%)	162 (62%)
<b>Day hospital/Clinic</b>	2 (<1%)		2 (1%)
<b>Receiving Facility</b>			
<b>Tertiary/Central</b>	373 (80%)	189 (92%)	184 (70%)
<b>Regional</b>	80 (17%)	4 (2%)	76 (29%)
<b>Private facility</b>	16 (3%)	13 (6%)	3 (1%)

### 2.3.3) Interventions

The results of the Intervention data collected are detailed in Table 4. Patients transported by helicopter required significantly more intervention, as per intervention score compared to fixed-wing ( $p = 0.07$ ). Similarly, medication administration was higher amongst the helicopter group. When comparing specific interventions, higher rates were observed for the helicopter group compared to fixed-wing. Of most significance were the number of ventilated patients (helicopter - 50%; fixed-wing - 24%;  $p < 0.001$ ), and the number of patients requiring intubation by retrieval team (helicopter sample - 9%; fixed-wing sample - 2%;  $p = 0.02$ ). Using the intervention scores as a secondary measure of patient severity [NTISS/TISS-28  $\leq 10$ ,  $n=111$  (56%)], as with the REMS, high incidence of low acuity patients can similarly be seen with this measure.

<b>Table 4 - Intervention Data</b>				
<b>Data expressed as n (%)</b>				
	<b>Total</b>	<b>Fixed-wing</b>	<b>Helicopter</b>	<b>p Value</b>
<b>NTISS (Neonate category only) (% of patients analysed)</b>				<i>p</i> = 0.07
<b>1 - 10</b>	111 (56%)	52 (73%)	59 (46%)	
<b>11 - 20</b>	86 (43%)	17 (24%)	69 (64%)	
<b>&gt; 20</b>	2 (1%)	2 (3%)		
<b>TISS-28 (Infant, Toddler and Child categories) (% of patients analysed)</b>				<i>p</i> < 0.001
<b>1 - 10</b>	129 (45%)	86 (57%)	43 (32%)	
<b>11 - 20</b>	129 (45%)	53 (35%)	76 (56%)	
<b>&gt; 20</b>	28 (10%)	12 (8%)	16 (12%)	
<b>Interventions – Specific (% of patients analysed)</b>				
<b>Supplemental O<sub>2</sub></b>	465 (96%)	205 (92%)	260 (99%)	<i>p</i> < 0.001
<b>Intubated &amp; ventilated</b>	186 (38%)	54 (24%)	132 (50%)	<i>p</i> < 0.001
<b>Intubated by AMS crew</b>	28 (6%)	5 (2%)	23 (9%)	<i>p</i> = 0.02
<b>IV Access in place – 1</b>	435 (90%)	187 (84%)	248 (94%)	<i>p</i> < 0.001
<b>IV Access in place &gt;1</b>	17 (4%)	8 (4%)	9 (3%)	<i>p</i> = 0.51
<b>Incubator</b>	204 (42%)	70 (32%)	134 (51%)	<i>p</i> < 0.001
<b>Vital signs monitored</b>	478 (99%)	220 (99%)	258 (98%)	<i>p</i> = 0.36
<b>Immobilised</b>	25 (5%)	9 (4%)	16 (6%)	<i>p</i> = 0.31
<b>NGT insertion</b>	1 (<1%)	1 (<1%)		<i>p</i> = 0.63
<b>Nebulisation</b>	14 (3%)	5 (2%)	9 (3%)	<i>p</i> = 0.63
<b>ICD insertion</b>	2 (<1%)	1 (<1%)	1 (<1%)	<i>p</i> = 0.63
<b>Medications (% of patients analysed)</b>				
<b>1</b>		85 (38%)	146 (56%)	<i>p</i> < 0.001
<b>2</b>		51 (23%)	89 (34%)	<i>p</i> = 0.24
<b>3</b>		29 (13%)	44 (17%)	<i>p</i> = 0.1
<b>4</b>		12 (5%)	15 (6%)	<i>p</i> = 0.16
<b>5</b>		4 (2%)	6 (2%)	<i>p</i> = 0.45
<b>6</b>		2 (1%)	2 (1%)	<i>p</i> = 0.4
<b>7</b>			1 (<1%)	<i>p</i> = 0.36
<b>8</b>			1 (<1%)	<i>p</i> = 0.36
<b>Top 5 Most Common Medications (% of patients received medications)</b>				
<b>Fixed-wing</b>		<b>Helicopter</b>		
Morphine – 47 (55%)		Midazolam – 78 (53%)		
Dobutamine – 26 (31%)		Morphine – 66 (45%)		
Midazolam – 23 (27%)		Dobutamine – 24 (16%)		
Vecuronium – 17 (20%)		Dopamine – 22 (15%)		
Ketamine – 16 (19%)		Ketamine – 20 (14%)		

### 2.3.4) Adverse Events

The results of the Adverse Event data collected are detailed in Table 5. The incidence of aborted or cancelled flights was higher amongst the helicopter group (3%) compared to the fixed-wing group (1%), with half of these due to the patient dying prior to arrival of the aircraft. Overall, there were no in-flight deaths recorded. The number of adverse technical events was relatively high in this study, occurring in just under a quarter of all patients transferred. Adverse physiological events were observed in more helicopter patients [(*n*=124 (47%)), compared to patients transported by fixed-wing [(*n*=98 (44%))]

[Relative risk 1.07 (95% CI 0.88 – 1.29)]. Similarly, more patients experienced a critical adverse event in the helicopter group [ $n=41$  (16%)] compared to the fixed-wing group [ $n=11$  (5%)] [(Relative risk 3.15 (95% CI 1.66 – 5.97)]. Overall, for the most critical patients (REMS  $\geq 12$ ) [ $n=104$  (21%)], the prevalence of both adverse physiological events [Odds ratio 2.13 (95% CI 1.38 – 3.12)] and adverse critical events [Odds ratio 5.25 (95% CI 2.89 – 9.49)] was higher amongst the helicopter group.

	Total	Fixed-wing	Helicopter	$p$ Value
<b>Aborted/Cancelled flights</b>				
Patient too unstable for transport	1	1		
Bad weather	2		2	
Aircraft technical issue	2	1	1	
Duplicate case	1		1	
Patient stable being transferred by road	1		1	
Patient died at referring hospital	6	1	5	
<b>Adverse Technical Events</b>	114 (24%)	62 (28%)	52 (20%)	$p = 0.03$
<b>Adverse Physiological Events</b>				
HR	55 (11%)	17 (8%)	38 (14%)	$p = 0.02$
RR	73 (15%)	36 (16%)	37 (14%)	$p = 0.51$
SpO2	61 (13%)	24 (11%)	37 (14%)	$p = 0.28$
BP	77 (16%)	19 (9%)	58 (22%)	$p < 0.001$
CRT	11 (2%)	2 (1%)	9 (3%)	$p = 0.63$
<b>Adverse Critical Event</b>				
Cardiac/cardioresp./resp. arrest	1 (<1%)		1 (<1%)	$p = 0.36$
Emergency Intubation	28 (6%)	3 (1%)	25 (10%)	$p < 0.002$
Endotracheal tube obstruc/dislocation	9 (2%)	1 (<1%)	8 (3%)	$p = 0.35$
Desaturation >10% from baseline	30 (6%)	7 (3%)	23 (9%)	$p = 0.01$
Decrease GCS >3 from baseline	1 (<1%)	1 (<1%)		$p = 0.28$

## 2.4) Discussion

### 2.4.1) Current Practice

Utilisation of the air medical services for paediatric transfer has increased significantly compared with previous studies set in the Western Cape<sup>9,26</sup>. While this shows an increasing trend in use, the high incidence of low acuity patients observed in this study was unreported in these early trials. Despite this, there is evidence to suggest that over-utilisation of the air medical services for paediatric transfer is common<sup>11,22</sup>.

Accounting for this can be difficult, especially considering the AMS dispatch criteria currently employed in the Western Cape province. Many of the criteria are subjective in nature and generally include a final clause highlighting “logistical need”. Given the limitation in rural resources, the aircraft are often dispatched when the availability of local ground based resources are limited or unavailable, regardless of patient severity (A. Oliphant - personal communication). This unique stance towards the AMS within the Western Cape can be traced back to the roots of an internal report commissioned by the provincial emergency medical services<sup>32</sup>. It found that within the Western Cape, the equivalent service coverage offered by the AMS is approximate to fifty conventional road-based ambulances, yet operates at only 6% of the cost of these additional vehicles. Far from the conventional perception as a luxury, when utilised in the unique way that these services are, they offer cost savings, increased access and coverage for rural areas, as well as increased safety and quality of care<sup>32</sup>.

From a referral point of view, regional and district level facilities accounted for the majority of cases. Contrary to the general perception, there was a higher proportion of more severely ill or injured patients transferred from regional centres, requiring more intervention when compared to similar patients from district facilities. Comparable results have not been reported in previous studies, however. Hatherill *et al.* found an even spread of referrals between academic, metropolitan and rural hospitals in their study<sup>9</sup>. However, the majority of these patients were road-based transfers. In this study, the majority of transfers amongst the helicopter group were from District hospitals, and could be similarly classified as rural. For the fixed-wing group, Regional level facilities made up the majority, which while not academic in nature, cannot be classified as rural or metropolitan either.

Examination of the specific interventions and medications administered, showed a tendency towards that focused on airway management and ventilation. This is consistent with the observation that respiratory disorders accounted for approximately a third of all medical and surgical related transfers ( $p < 0.001$ ). This is similarly consistent with previously reported

results from other trials, including early studies examining paediatric transfer in the Western Cape<sup>9,12,17,21,26</sup>.

#### **2.4.2) Adverse Events**

The incidence of adverse technical events reported in this study appears to be high. Furthermore, the majority of these were seen to be preventable, as they were largely as a result of missing or malfunctioning equipment. Despite this, the incidence in this trial is lower than that reported in a previous trial of non-specialised paediatric transfer in SA<sup>9</sup>. Adverse technical events reported in specialised paediatric transfer have varied from 0% - 16%, significantly lower than that reported in this trial<sup>10-13,17</sup>. Despite this, none of the adverse technical incidents observed translated into a noticeable deterioration in patient status; a result consistent with that seen in these above-mentioned trials of specialised teams.

Physiological related adverse events were strictly defined in this study. Few trials have reported details in this category of events. For non-specialised transfer, the previously reported incidence has varied from 13% - 23%<sup>8-10</sup>. The incidence observed in this trial was found to be lower, varying from 2% ( $p=0.63$ ) up to 16% ( $p=0.51$ ) depending on the variable. These results were more comparable to the incidence of these events seen with specialised transfer<sup>10</sup>.

Adverse critical events encompass the potential incidents considered the most severe or life threatening. Early observations for this type of adverse event were reported to be as high as 52% for non-specialised transfer<sup>8</sup>. Recent studies have reported more modest rates varying between 9% and 20%<sup>9,10</sup>. The incidence observed in this trial was significantly lower than these previously reported results. The incidence of critical events in specialised transfer varied from 0 – 3%<sup>11-14,17,33</sup>.

With the exception of emergency intubation, the incidence reported in this trial is consistent with these previously observed results<sup>11-14,17,33</sup>. In the case of emergency intubation, it is difficult to speculate on the cause of such a high incidence, especially considering the retrospective nature of this trial, and as such remains beyond the scope of this study.

## **2.5) Conclusion**

Utilisation of the AMS for the transfer of critical paediatric patients was found to be significant in this trial. Across both helicopter and fixed-wing platforms, the AMS transfers a diverse range of pathologies of equally varying severities. However, a high incidence of low patient acuity was apparent across both platforms, more so for patients transferred by fixed-wing. Despite this, there is some evidence, that this 'method' of utilisation may be beneficial in the setting of the Western Cape.

The adverse events encountered in this study were found to be lower than those reported in other trials examining non-specialised paediatric transfer. With the exception of adverse technical incidents, many of the results of this trial were comparable to those seen in transfer by specialised paediatric retrieval teams. However, the limitations of this study reduce the strength of the conclusions that can be drawn. Based on the results observed, there is however, evidence to suggest the utilisation of the AMS to be a safe and viable option to paediatric transfer within the Western Cape. However, to justify this would require further prospective study in this regard.

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# Part 3: Limitations

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### **3.1 Bias**

Reporting bias is amongst the single biggest contributors to the limitations of this study. The descriptive analysis of both the current practice and adverse events encountered by the service provider were largely reliant on the accurate reporting of these incidents in the patient report forms. Most notable was the reporting bias associated with the adverse events. The potential negative connotations associated with documenting such data was of particular concern with regards to the quality of reporting.

Linked to this was the potential for measurement bias. There was no control in this study to account for inaccurately calibrated equipment, and thus opens the potential to such bias for the recording of vitals signs and other measured parameters. In addition to this, the unique operating circumstances of the aviation environment, most notably – vibration, had the potential to further add to this bias.

### **3.2 Methodology**

The study utilised a retrospective design due to the availability of the source material, as well as the cost and time benefits offered with this design. The most significant limitation of this design however, is the inability to draw associations between relationships observed in the study. As such, the conclusions are largely confined to a commentary on such relationships. Furthermore, given this retrospective nature the data recorded may not be representative of the current situation, and too remains a major limitation with regards to making recommendations.

### **3.3 Validity**

The data obtained for this study was from a single base, of a single state run service, within a single province. As such, many of the results will potentially not be applicable to other settings, and should be viewed in such a manner when interpreting. Furthermore, several definitions and parameters used in the data collection and analysis were defined for this study alone. Without previous validation, these too may not be applicable outside of this study.

# **Part 4: Journal Instructions**

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## 5.1 Original Proposal

Current practice of the air medical services for the inter-facility transfer of  
paediatric patients in the Western Cape, South Africa

Research Proposal

Submitted to the University of Cape Town in partial fulfilment of the  
requirements for the degree: MPhil: Emergency Medicine

Student: Ian Howard

Student number: HWRIAN001

Supervisor: Dr T Welzel

Division of Emergency Medicine  
Faculty of Health Sciences  
University of Cape Town

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## 1 - Introduction

The inter-facility transfer of paediatric patients is a contentious issue and serves as a source of constant debate not just within South Africa, but internationally<sup>1,2</sup>. A number of studies have reported an increased incidence of adverse events and mortality in this population, especially during the transfer of the critically ill, when in the care of inexperienced or non-specialised personnel<sup>1-4</sup>. Dedicated paediatric retrieval teams have been suggested as one of the most promising potential solutions, however this too remains a contentious issue as the literature is equivocal regarding the success of these teams: Supporters of this approach assert that these teams offer the benefits of focused training and experience in terms of exposure to the environment, equipment and patients<sup>3-7</sup>. This view has been bolstered by a number of studies that have observed a reduction in adverse events and mortality associated with transportation by these specialised paediatric retrieval teams<sup>3-7</sup>. Opponents however argue that this approach is resource intensive and requires substantial fiscal backing to be effectively introduced and maintained. In addition, the literature has also demonstrated a lack of reduction in adverse events and mortality following the introduction of specialised paediatric retrieval teams<sup>8,9</sup>.

In South Africa (SA), the questions surrounding the inter-facility transfer of critically ill or injured paediatric patients take on an even greater significance. The country is characterised by vast distances, disparities in the provision of healthcare not only between provinces, but between rural and urban areas within each province; as well as the general lack of adequate healthcare resources throughout SA<sup>10</sup>. These factors are further confounded by the burden of HIV and other communicable diseases, as well as the immense socio-economic variation found throughout the population – SA is ranked amongst the countries with the worst Gini index, a measure of income inequality for a country<sup>11</sup>.

As an alternative solution, use of the air medical services for the inter-facility transfer of critically ill or injured paediatric patients has been proposed.

Despite the above-mentioned factors plaguing healthcare in SA, a relatively extensive network of fixed wing (FW) and rotor wing (RW) air ambulances already exists throughout the country. These types of services have shown to offer countless advantages<sup>12-14</sup>. Chief amongst these are the air medical services' primary role as intensive care unit (ICU) staffed and equipped vehicles, with the benefits of speed and range of access and transportation. They offer the unique advantages of extending the reach of both the emergency medical services (EMS) and tertiary level care to conventionally under-resourced areas. However, the air medical services are not without their own complications. The aviation environment is fraught with stressors that may have a potential negative impact on the patient's underlying condition if not mitigated against<sup>15,16</sup>. It is therefore important to evaluate the current use of these services in this role to determine the types of patients currently transported and adverse events currently experienced. This will provide the first step into determining whether or not these services can prove to be a safe, practical alternative to the transportation of these patients by specialised paediatric retrieval teams in SA.

### **1.1 - Literature Review**

Comparing the use of RW and FW aircraft for the inter-hospital transfer of the critically ill or injured patient is inherently complicated given the multitude of confounding variables affecting such a comparison. While it is clear that RW transport is preferred over short distances, and FW transfer preferred over great distances, there is commonly a large area of overlap in distance for which each resource is utilised, in which case preference is less clear. Variations in aircraft type, performance and costs, as well as additional factors such location of referring facility or presence and type of landing facilities are amongst the most common variables affecting such a comparison<sup>17,19</sup>. This is evident in the somewhat inconclusive and limited literature available regarding this subject.

Thomas *et al.* first compared the use of RW and FW aircraft in the inter-facility transfer role, for ranges of 101 to 150 miles (approx. 160 – 240 km)<sup>17</sup>. While no significant differences were observed for patient severity, outcomes and

transfer intervals, transport by RW aircraft was reported to be 400% higher in cost than for FW. In a comparison of RW, FW and road transfer of paediatric patients, Diller *et al.* reported a similar significant increase in cost with RW use when compared with FW use<sup>18</sup>. Goldstein *et al.* later compared the inter-facility transfer of trauma patients by RW, FW and ground transport<sup>19</sup>. The air ambulance cohort (RW and FW) was reported to be more critically ill or injured, and transferred faster than the road cohort<sup>19</sup>. Amongst the air ambulance cohort, transfer by RW was found to be significantly faster than transfer by FW for distances less than 225 km<sup>19</sup>.

As with the above, the literature regarding the interfacility transfer of paediatric patients by air medical service is also limited. A retrospective study by Diller *et al.* In the USA found that more patients were transported by RW, when compared with FW, with the majority of RW transfers being trauma related (56% of all RW paediatric patients). Transportation by FW aircraft was more common for medical related pathologies (62% of all FW paediatric patients). It was also found that when compared to a similar road ambulance cohort, patients transported by air medical service were more severely ill or injured than the road ambulance cohort. Lastly, when the severity of similar air ambulance and ground ambulance patients were compared, it was found that a significant number of patients transferred by air were over-triaged and could ostensibly have been transferred by road without affecting outcomes.

A separate study in the USA, by Orr<sup>4</sup> and colleagues evaluated the utilisation of specialised paediatric retrieval teams for the inter-facility transfer of paediatric patients. Air transported was utilised for just over half of both the specialised team cohort (55%), and the non-specialised team cohort (56%). Patient severity was found to be higher in the non-specialised team cohort, which could have accounted for the higher incidence of adverse events and higher mortality also seen amongst this cohort. Transport by the specialised team was associated with longer response, scene, and total transfer times. A study by Soundappan and colleagues<sup>3</sup> in Australia reported similar conclusions. Just less than a third of the air ambulance (RW and FW) cohorts were found to be over-triaged and transferred for relatively minor injuries.

Amongst the two air ambulance cohorts examined in this study, it was also observed that the overall transfer times were longer for specialised retrieval teams than for non-specialised teams, although this was not statistically significant, and had no impact on mortality or morbidity. Lastly, it was found that across all cohorts, the more severely injured patients were associated with longer overall retrieval times.

Lastly, Holt and Fagerli<sup>20</sup> described the transfer of critically ill neonates by air medical service in rural Norway over 10 years. The majority of patients were transported by FW (85%) when compared with RW transfer (15%). Across both cohorts, there was a 13% adverse event rate, all of which were attributed to equipment faults. Of these, 16% resulted in a documented deterioration in the patient's condition.

The inter-facility transfer of paediatric patients by air medical services in South Africa has been reported in only two studies. Pieper *et al.* in 1994<sup>21</sup> described reasons for transfer and outcomes in terms of survival following admission, between patients transported by road ambulance, FW and RW. Although there were no deaths in-transit, post admission survival amongst the FW cohort was 100%, and 94% amongst the RW cohort. Post admission mortality for the road ambulance cohort was 70%. Overall, pathologies of respiratory origin were the most commonly cited reason for transfer, followed by surgical pathologies. The highest mortality was associated with higher mean gestational age, lower mean mass and lower mean admission age. In 2003 Hatherill *et al.*<sup>1</sup> similarly reported the results of a 1-year audit of all patients transferred to their Paediatric Intensive Care Unit (PICU). Mode of transport, patient demographics, diagnostic category and incidence of adverse events were analysed for all patients and described. Transfer by road ambulance occurred most commonly (76% of patients), followed by FW (14%), then RW (10%). Highest post admission mortality was also seen amongst the road ambulance cohort (76% of non-survivors) when compared with the FW (12%) and RW (12%) cohorts. A high incidence of adverse events was observed across all cohorts, of which up to 36% were seen to be preventable.

Measuring the safety and performance of a paediatric inter-hospital transfer, whether by road or air, can be difficult considering the multitude of factors with the potential to impact these aspects. Table 1 below gives a summary of the literature outlining the development of variables used to measure the above, in the inter-facility transfer of paediatric patients.

## **1.2 - Title**

Current practice of the air medical services for the inter-facility transfer of paediatric patients in the Western Cape, South Africa

## **1.3 - Research question**

What is the current practice of the air medical services utilised for the inter-facility transfer of paediatric patients in the Western Cape, South Africa?

## **1.4 - Aim**

To describe the utilisation of the air medical services for the inter-facility transportation of paediatric patients in the Western Cape, South Africa

## **1.5 – Objectives** (See *Definitions* for criteria for below)

- To describe the flight details of the inter-facility transfer of paediatric patients by RW and FW aircraft in the Western Cape, South Africa.
- To describe the demographic details of paediatric patients transported by RW and FW aircraft in the Western Cape, South Africa.
- To describe the interventions performed and/or maintained by the flight medical crew during transportation of paediatric patients by RW and FW in the Western Cape, South Africa.
- To describe the adverse technical, clinical and critical events during the inter-facility transportation of paediatric patients by RW and FW aircraft in the Western Cape province, South Africa

Authors	Study Type	Setting & Population	Variables	Additional
<b>Barry &amp; Ralston<sup>2</sup></b>	Single centre prospective observational	Road based transfer of paediatric patients	<ul style="list-style-type: none"> <li>- <b>Critical:</b> Apnoea; hypoventilation; bradycardia; hypotension; inadequately positioned/secured ETT</li> <li>- <b>Serious:</b> Neurological deterioration; poor temperature control; inappropriate administration/non-administration of drugs; procedures indicated but not performed/attempted &amp; failed; loss of IV access</li> </ul>	<ul style="list-style-type: none"> <li>- Patient severity measured by Paediatric Risk of Mortality (PRISM) score, however only at receiving facility</li> </ul>
<b>Holt &amp; Fagerli<sup>20</sup></b>	Retrospective descriptive analysis	RW & FW transfer of neonates	<ul style="list-style-type: none"> <li>- No predetermined/predefined variables. Data collected from patient records</li> </ul>	<ul style="list-style-type: none"> <li>- Inclusion of adverse events resulting from equipment failure/ malfunction</li> </ul>
<b>Hatherill <i>et al</i><sup>1</sup></b>	Single centre prospective observational	Transfer of paediatric patients by road, RW & FW to a single PICU	<ul style="list-style-type: none"> <li>- <b>Technical:</b> No monitoring equipment in place; malfunction of monitoring or other equipment; failure to place venous access; loss of venous; malposition of the ETT</li> <li>- <b>Clinical:</b> shock; hypoxia; hypoglycaemia</li> <li>- <b>Critical:</b> Emergency intubation and/or an arrest</li> </ul>	<ul style="list-style-type: none"> <li>- Patient severity measured by Paediatric Index of Mortality (PIM) score, however only at receiving facility</li> </ul>
<b>Orr <i>et al</i><sup>4</sup></b>	Single centre prospective cohort	Transfer of paediatric patients by specialised road, RW & FW retrieval teams	<ul style="list-style-type: none"> <li>- <b>Airway events:</b> Oesophageal intubation; accidental extubation; respiratory insufficiency necessitating immediate intubation; blocked ETT requiring immediate re-intubation</li> <li>- Cardiac or respiratory arrest requiring CPR</li> <li>- Pneumothorax</li> <li>- <b>Medication-related:</b> Dosage errors or lack of administration of medications prescribed by the</li> </ul>	<ul style="list-style-type: none"> <li>- Patient severity measured by Paediatric Risk of Mortality (PRISM) score prior to referral and following arrival at receiving hospital</li> </ul>

			<p>command physician</p> <ul style="list-style-type: none"> <li>- Equipment malfunctions associated with patient deterioration</li> <li>- <b>Physiological variables:</b> Sustained systolic hypotension (&lt; 5<sup>th</sup> percentile for age) for &gt; 5 minutes with no documented therapy; sustained hypoxia for &gt; 5 minutes (oxygen saturation of &lt; 90%) with no documented therapy (with the exclusion of patients with fixed pulmonary or cardiac shunts); hypothermia (patient temperature of &lt; 34°C at arrival excluding patients receiving therapeutic hypothermia)</li> </ul>	
<b>Ramnarayan</b> <sup>22</sup>	Retrospective descriptive analysis	Transfer of paediatric patients by specialised road based retrieval teams	<ul style="list-style-type: none"> <li>- <b>Patient related:</b> Respiratory arrest; cyanosis; cardiac arrest; loss of brainstem reflexes; core temperature &lt; 34°C; and loss of consciousness (GCS &lt;7)</li> <li>- <b>Technical/care related:</b> ETT occlusion; unplanned extubation; loss of IV access; pulmonary aspiration; loss of monitoring; critical ventilator malfunction; exhaustion of oxygen supply</li> <li>- <b>Physiological variables:</b> Systolic hypotension (child &lt; 65 mm Hg, infant &lt; 55 mm Hg); tachycardia (child &gt; 200/min, infant &gt; 220/min); bradycardia, (child &lt; 40/min, infant &lt; 50/min); and hypoglycaemia (&lt; 2.5 mmol/l)</li> </ul>	<ul style="list-style-type: none"> <li>- Ambulance accident rate/10 000 journeys was additionally measured</li> <li>- Efficiency of use was measured by the number of patients incorrectly triaged; number of requests for which the transfer service was unavailable or unable to complete immediately; and the number of unplanned re-transfers – accounting for 11 of transfers.</li> </ul>
<b>Lim &amp; Ratnavel</b> <sup>9</sup>	Prospective observational	Transfer of paediatric & neonatal patients by specialised road based retrieval teams	<ul style="list-style-type: none"> <li>- No predetermined/predefined variables. Data collected directly from referral teams, referring &amp; receiving staff</li> </ul>	<ul style="list-style-type: none"> <li>- Adverse events additionally divided into 6 categories of severity, from catastrophic to insignificant.</li> <li>- Documentation and communication errors additionally documented</li> </ul>

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**Mori *et al*<sup>23</sup>**

Systematic  
review &  
retrospective  
descriptive  
analysis

Transfer of neonates

- Association between duration of inter-facility transfer  
and perinatal mortality

## **2. - Methodology**

### **2.1 - Study Design**

The study will be a retrospective review of patient records and aviation flight logs for the period 01 January 2009 to 31 December 2011. A retrospective study design is to be used due to the current availability of the source material, as well as the cost and time benefits offered with this design. This time period has been chosen due to the implementation of a structured, formal, comprehensive continuous quality improvement program in 2008/2009 focusing on, amongst other areas, improvement in patient documentation. Samples of patient report forms taken from the above periods show a significant improvement in the level of detail of documentation compared with reports prior to this time.

### **2.2 - Study Setting**

The study will be set in the province of the Western Cape of South Africa, which covers an area of approximately 130 000 square kilometres, with a population of approximately 4.5 million people. Data will be collected from the records of the Red Cross Air Mercy Service (RCAMS), the air medical service provider for the Western Cape Provincial Department of Health. For the purposes of the study, the patient report forms and aviation flight logs of the Cape Town Base, located at Cape Town International Airport, will be examined. This base operates a 12 hour/daytime RW service as well as a 24-hour FW service. The medical care provided on these aircraft is primarily provided by prehospital advanced life support practitioners, supported by a variety of voluntary and seconded crew consisting of prehospital advanced and intermediate life support practitioners, nursing sisters and doctors.

### 2.3 - Study Population

All cases of the RCAMS, for the defined study period, that meet inclusion criteria will be included in the analysis:

- *Inclusion criteria*

All calls having been initiated (i.e.: take off) between 00:01 on the 01<sup>st</sup> January 2010 until 23:59 on the 31<sup>st</sup> December 2011

Any new-born infant up to children aged 12 years 364 days, transferred from any health-care facility to a regional or tertiary level hospital within the Western Cape, by RW and FW aircraft of the provincial air medical service provider.

- *Exclusion criteria*

- Missing or duplicate patient report forms.
- Patients outside of the age criteria i.e.: 13 years of age or older.
- Patients transferred to a regional or tertiary health-care facility outside of the Western Cape.
- Non-transfers i.e.: scene calls.

### 2.4 - Study Sample

For the above-defined population, the RCAMS transports approximately 150 – 250 paediatric patients per year across both the RW and FW service. This will provide an approximate sample size of 400 - 600 patients over the defined study period.

### 2.5 - Definitions of concepts and terms

The following is a list of definitions of terms and concepts to be used for the purposes of the study. All definitions are novel and defined as so for the purposes of this study.

- *Flight details*

This will include all non-medical related information pertaining to each flight undertaken by the air medical service provider, including:

- *Access time:* The time taken from take-off until access to the patient. For RW cases this will time will conclude upon landing at the referring facility. For FW cases, this will include the time taken to transport the medical crew from the closest airfield to the referring facility.
- *Scene time:* The time taken to stabilize and package a patient for transfer, until lift off. For RW calls, this time will conclude upon take off at the referring facility. For FW cases, this will include the time taken to transfer the patient and medical crew from the referring facility to the airfield.
- *Flight & road transfer time:* The time, from take-off, to transport the patient to the receiving facility. For RW cases this will conclude upon landing at the referring facility. For FW cases this will include the time taken to transfer the patient from the closest airfield to the receiving facility.
- *Handover time:* The time taken to hand over the patient following arrival at the referring hospital. For RW cases, this will conclude at take off from the receiving facility. For FW cases, this will conclude following departure of the medical crew from the receiving facility.
- *Medical crew composition:* The level of medical qualification of the flight medical crew.
- *Referring facility:* The facility from which the patient is uplifted for transfer.
- *Receiving facility:* The facility at which the patient arrives and is admitted following transfer.

- *Demographics*

This will include all non-identifiable patient details. For the purposes of the study, the age related inclusion criteria have been broken down into the following categories:

- *Neonate*: New-born patients up to and including 28 days
- *Infant*: Patients older than 28 days up to and including 364 days (<1 year)
- *Toddler*: Patients between the ages of 1 year up to and including 3 years and 364 days (<4 years)
- *Child*: Patients between the ages of 4 years up to and including 12 years 364 days

This will additionally include information such as patient gender and triage, as well as:

- Broad case type definition: Such as medical, surgical, trauma etc.
- Specific case type definition: Such as neurological, cardiac, etc.

- *Adverse events*

This includes events encountered during any time of each call in its entirety, including:

- *Adverse technical incident*:
  - Malfunction of monitoring and other medical equipment
  - Absence of equipment generally available as per equipment checklist
  - No monitoring equipment in place ab initio
  - Aircraft fault resulting in delay or cancellation of a call, following commencement of the call i.e.: lift off
  - Adverse weather resulting in delay or cancellation of a call following commencement
- *Adverse clinical incident*: For the following age groups, documentation of the corresponding vital signs shall constitute an adverse clinical event.

- *Neonate*
  - = Heart rate (HR) < 100 beats per min (bpm) or > 220 bpm
  - = Respiratory rate (RR) (for patients not mechanically ventilated) < 40 breaths per min (br/min) or > 60 br/min
  - = Oxygen saturation (SpO<sub>2</sub>) 5% change from baseline measurement for longer than 10 mins, in the absence of a faulty monitor or misplaced probe
  - = Blood pressure (BP) < 50 mmHg or > 100 mmHg
  - = Delayed capillary refill (CRT) > 4 seconds
  
- *Infant*
  - = HR < 100 bpm or > 200 bpm
  - = RR (for patients not mechanically ventilated) < 30 br/min or > 40 br/min
  - = SpO<sub>2</sub> 5% changes from baseline measurement for longer than 10 mins, in the absence of a faulty monitor or misplaced probe
  - = BP < 60 mmHg or > 110 mmHg
  - = CRT > 4 seconds
  
- *Toddler*
  - = HR < 90 bpm or > 160 bpm
  - = RR (for patients not mechanically ventilated) < 20 br/min or > 40 br/min
  - = SpO<sub>2</sub> 5% changes from baseline measurement for longer than 10 mins, in the absence of a faulty monitor or misplaced probe
  - = BP < 80 mmHg or > 130 mmHg
  - = CRT > 4 seconds
  
- *Child*
  - = HR < 60 bpm or > 160 bpm

= RR (for patients not mechanically ventilated) < 15 br/min or > 35 br/min

= SpO<sub>2</sub> 5% changes from baseline measurement for longer than 10 mins, in the absence of a faulty monitor or misplaced probe

= BP < 90 mmHg or > 140 mmHg

= CRT > 4 seconds

- *Adverse critical incident:*
  - Cardiac, cardio-respiratory or respiratory arrest during stabilization or transfer
  - Emergency intubation
  - Endotracheal tube obstruction or dislocation
  - Desaturation of 10% from baseline for longer than 10 mins, in the absence of a faulty monitor or misplaced probe
  - Decrease in Glasgow Coma Scale of 3 or more points from baseline (where applicable)

- *Rapid Emergency Medicine Score (REMS) (See Section 7: Annexure 1)*

- The REMS is a six variable measurement of patient severity, combining age, HR, RR, BP, SpO<sub>2</sub> and GCS. It has been prospectively validated in numerous large-scale trials, for a variety of populations, and has shown to be comparable to the more complicated Acute Physiology and Health Exam (APACHE-II) score in predictive value<sup>24-26</sup>. A REMS will be calculated for each patient following departure from referring facility, as well as following arrival at the receiving facility

- *Interventions*
  - All interventions performed or medications administered at the referring hospital by the flight medical crew or under direction by the flight medical crew.

- All interventions performed or medications administered in-flight by the flight medical crew.
- All interventions performed or medications administered by the flight medical crew at the receiving hospital, by the flight medical crew or under direction by the flight medical crew.
- All documented interventions performed shall be utilised to calculate a therapeutic based patient severity score. For neonatal patients, the – Neonatal Therapeutic Intervention Scoring System (NTISS) is a scoring system developed and validated from the Therapeutic Intervention Scoring System (TISS-76)<sup>27</sup>. For the remaining age categories, the condensed version of TISS-76, the TISS-28 shall be utilised (See Section 7: Annexure 2 & Annexure 3).

## **2.6 - Data Collection, Management and Analysis**

All patient and flight data from the air medical service provider is documented via a patient report form and aviation flight log. In addition, a daily occurrence and handover book documents basic information regarding the flights for each day. This log shall be initially examined for all cases that meet criteria. Following this, all relevant documents shall be retrieved, investigated and the applicable information entered directly onto Microsoft® Excel™ (2007) spreadsheet.

All data will be captured directly from the source material i.e.: patient report forms and aviation flight logs. The research student (I Howard) shall capture all the research data to a password protected external USB storage device. A copy of this data shall be backed up to a second password protected external USB storage device on a daily basis, for the duration of the study period. The patient report form number, aviation flight log number and mission number for each call shall be assigned to a unique study number, entered onto a separate master spreadsheet (Microsoft® Excel™ 2007) and stored separately from the remainder of the research data onto third password protected external USB storage device. A copy of this master spreadsheet shall be backed up to an online, password-protected cloud computing storage

space (Dropbox). This will be done to avoid having to return to the source material to correct any discrepancies. The copies of the master spreadsheet shall too be backed up on a daily basis.

All passwords, data and devices shall be stored with and maintained by the research student, and only be made available to the study supervisors. The following variables will be collected for analysis (See *Definitions* above) (See Section 7: Annexure 4):

- Flight details
  - Date
  - Referring facility
  - Receiving facility
  - Take off time
  - Access time
  - Scene time
  - Flight & road transfer time
  - Hand over time
  - Medical crew composition
  
- Demographics
  - Age
  - Age category
  - Gender
  - Broad case type
  - Specific case type
  
- Interventions
  - Number and type of interventions performed at the referring facility, in-flight or at the receiving facility by the air medical crew
  - Number and type of medications administered at the referring facility, in-flight or at the receiving facility by the air medical crew
  - NTISS

- Adverse Events
  - Number and type of adverse technical incidents per case
  - Number and type of adverse clinical incidents per case
  - Number and type of adverse critical incidents per case
  - REMS at departure from referring facility and arrival at receiving facility

It is recognised that there may be forms that will be incomplete or illegible. The data from these forms that is complete or legible will still be captured and included in the analysis, and the missing fields recorded as missing. Entire patient report forms or aviation flight logs that are missing shall too be recorded as missing. The percentage of incomplete and/or missing reports will be used to perform a sensitivity analysis to determine the effect of this on the final results. Duplicate patient report forms shall not be captured. In instances where more than one patient is transported per flight, these patients shall be captured as separate entries for the final analysis. Data analysis shall be conducted using Statsoft Statistica (Version 10).

## **2.7 Statistical Considerations**

The study is descriptive in nature and as such descriptive statistics shall be utilised to analyse the data. Distributions of variables will be presented with histograms and/or frequency tables. Medians or means will be used as the measures of central location for ordinal and continuous responses and standard deviations and quartiles as indicators of spread. Categorical and binary data will be presented using frequency tables and proportions. Appropriate 95% confidence intervals will be presented for all descriptive statistics. Analyses of the objectives will include the use of the following inferential statistical techniques:

- For continuous variables, such as the comparison of RW flight times

with FW flight times, a T-test or Mann-Whitney test shall be utilised.

- For the comparison of continuous variables, such as the reporting the differences between age groups or differences between diagnostic, an analysis of variance (ANOVA) – post hoc test shall be utilised.
- For the comparison of categorical variables, such as the time intervals between RW and FW flights, a Chi<sup>2</sup> test shall be used.

Those variables and tests for which the assumption of normality is required will be tested for normality and if found to be deviating from normal they will be analysed using the appropriate non-parametric tests. A significance level of 5% will be applied to all analyses. A p-value of  $p < 0.05$  will represent statistical significance in hypothesis testing and 95% confidence intervals will be used to describe the estimation of unknown parameters.

### 3. - **Ethics**

- This study complies with the 2008 revision of the Declaration of Helsinki.
- Only anonymised data will be used for the study. Any identification information shall be documented separately and only be utilised for data capturing purposes.
- Ethical approval for the study will be applied for via the University of Cape Town.
- Permission to access the patient records and aviation flight logs has been applied for and approved by the AMS Research Committee (See Section 7: Annexure 5). AMS has been given the contact details of the supervisors should any grievances with the research student arise at any time during the study.
- A waiver of informed consent is requested due to:
  - The study is a low risk descriptive analysis.
  - The study is retrospective, examining a period of 3 years. Informed consent will significantly add to the timeframe and workload of the study overall.
  - No identifiable patient data will be recorded during any phase of the study. In addition, all information captured during the study shall be securely stored by the research student on three password protected external USB storage devices and an online storage site.. Access to this information shall only be made available to the study supervisors.

#### 4. – Limitations

- The study is retrospective in nature and as such is constrained by the limitations of this study design. This design is limited by the reliability of the source material as well as the ability to predefine parameters or end points to be measured. As a result of this, the study will be limited in the conclusions that can be drawn, and as such is confined to a descriptive nature.
- There is only one data capturer, the research student, who will not be blinded to the study details and objectives.
- There will be no supervision of the data collection process. However, the data will be separately transcribed onto two data capture templates, to be continually compared on a weekly basis throughout the data collection process. This will be done to avoid transcription errors and to ensure the data is transcribed correctly and in its entirety.
- The data collection is confined to the Cape Town Base only and does not include data from other bases of the RCAMS across the country.
- Due to the retrospective nature of the study, there is the possibility of missing, incomplete or illegible patient report forms and aviation flight logs. This has potential to impact the results of the final analysis.
- RCAMS is the official air medical service provider of the Western Cape Provincial Department of Health and as such, data from this service represents the population who utilise the provincial health services. While the RCAMS does also transport patients utilising private health care facilities, the RCAMS is not the only service provider offering this service to this population. The study does not take into account the data of private air medical service providers.

## 5. – Timeline

Following ethical approval, the study will be completed for final submission in 5 months.

Month	Activity
1	- Data collection
2	- Data collection - Statistical analysis
3	- Statistical analysis - Write up of 1st draft - Submission of 1st draft to supervisor
4	- Feedback and corrections
5	- Submission of final draft

## 6. – Resources and Budget

### 6.1 – Resources

Description	Source
Statistical services	- Centre for Statistical Consultation, Stellenbosch University
Telephone & cellular communication	- Research student
Internet access & email facilities	- Research student
Computer access & data storage	- Research student
Printing & copying	- Research student

**6.2 – Budget**

<b>Item</b>	<b>Description</b>	<b>Unit cost</b>	<b>No. units</b>	<b>Sub-total</b>
Statistical analysis	Analysis of data for final write up	R 185.00	5	R 925.00
Communication	Telephone & cellular			R 500.00
Internet access and email facilities				R 500.00
Computer access and data storage	External USB storage device	R 500.00	3	R 1500.00
Printing & copying		R 0.30/pg.	300	R 900.00
<b>Total</b>				<b>R 4325.00</b>

## **7. Reporting and Implementation of Results**

Upon completion of the study, the results will be made available to both the RCAMS and the Western Cape Provincial Department of Health. The study will potentially serve to form the basis of on-going research into the inter-hospital transfer of paediatric patients in SA and may assist in the development of a national guideline or protocol regarding this subject. The results will also be published in a peer-reviewed journal following completion of a manuscript.

**8. – Annexure****Annexure 1**

<b>Rapid Emergency Medicine Score</b>							
Variable	Score						
	0	1	2	3	4	5	6
Age	< 45		45 - 54	55 - 64		65 - 74	> 74
HR	70 - 109		55 - 69	40 - 54	< 40		
			110 - 139	140 - 179	> 179		
RR	12 - 14	10 - 11	6 - 9		< 6		
		25 - 34		35 - 46	> 49		
SBP	90 - 129		70 - 89		< 69		
			130 - 149	150 - 179	> 179		
GCS	> 13	11 - 13	8 - 10	5 - 7	< 5		
SpO2	> 89	86 - 89		75 - 85	< 75		

## Annexure 2

<b>Neonatal Therapeutic Intervention Scoring System</b>	
<b>Respiratory</b>	<b>Score</b>
Supplemental oxygen	1
Surfactant administration	1
Tracheostomy care	1
Tracheostomy placement	1
CPAP	2
Endotracheal intubation	2
Mechanical ventilation	3
Mechanical ventilation with muscle relaxants	4
High frequency ventilation	4
ECMO	4
<b>Cardiovascular</b>	
Indomethacin administration	1
Volume expansion ( $\leq 15$ ml/kg)	1
Vasopressor administration (1 agent)	2
Volume expansion ( $> 15$ ml/kg)	3
Vasopressor administration ( $> 1$ agent)	3
Pacemaker on standby	3
Pacemaker used	4
CPR	4
<b>Drug Therapy</b>	
Antibiotic administration ( $\leq 2$ agents)	1
Diuretic administration (enteral)	1
Steroid administration (post natal)	1
Anticonvulsant administration	1
Aminophylline administration	1
Other unscheduled medications	1
Antibiotic administration ( $> 2$ agents)	2
Diuretic administration (parenteral)	2
Treatment of metabolic acidosis	3
Potassium binding resin administration	3
<b>Monitoring</b>	
Frequent vital signs	1
Cardiorespiratory monitoring	1
Phlebotomy (5 - 10 blood draws)	1
Thermoregulated environment	1
Non-invasive oxygen monitoring	1
Arterial pressure monitoring	1
Central venous pressure monitoring	1
Urine catheter	1

Quantitative intake and output	1
Extensive phlebotomy (> 10 blood draws)	2
<b>Metabolic/Nutritional</b>	
Gavage feeding	1
Intravenous fat emulsion	1
Intravenous amino acid administration	1
Phototherapy	1
Insulin administration	2
Potassium infusion	3
<b>Transfusion</b>	
Intravenous gamma globulin	1
Red blood cell transfusion ( $\leq 15$ ml/kg)	2
Partial volume exchange transfusion	2
Red blood cell transfusion (> 15 ml/kg)	3
Platelet transfusion	3
White blood cell transfusion	3
Double volume exchange transfusion	3
<b>Procedural</b>	
Transportation of patient	2
Single chest tube in place	2
Minor operation	2
Multiple chest tubes in place	3
Thoracentesis	3
Major operation	4
Pericardiocentesis	4
Pericardial tube in place	4
Dialysis	4
<b>Vascular Access</b>	
Peripheral intravenous line	1
Arterial line	2
Central venous line	2

## Annexure 3

<b>Therapeutic Intervention Scoring System - 28</b>	
<b>Basic Activities</b>	<b>Score</b>
Standard monitoring, hourly vital signs, regular registration of fluid balance	5
Lab, biochemical & microbiological investigations	1
Single medication, any route	2
Multiple IV medications (bolus or infusion)	3
Routine dressing changes. Care & prevention of decubitus and daily dressing change	1
Frequent dressing changes (at least one per shift) and/or extensive wound care	1
Care of drains. All (except gastric tube)	3
<b>Cardiovascular</b>	
Single vasoactive medication. Any	3
Multiple vasoactive medications	4
Intravenous replacement of large fluid losses. Fluid replacement > 3 litres per square meter per day, irrespective of fluid type	4
Peripheral arterial catheter	5
Left atrium monitoring. Pulmonary artery flotation catheter with or without cardiac output measurement	8
Central venous line	2
CPR after arrest in the past 24 hours (single precordial percussion not included)	3
<b>Specific Interventions</b>	
Single specific interventions. Naso or orotracheal intubation, introduction of a pacemaker, cardioversion, endoscopies, emergency surgery in the past 24 hours, gastric lavage. Routine interventions without consequences to the clinical condition of the patient, such as radiographs, echocardiography, EKG, dressings or introduction of venous or arterial catheters are not included.	3
Multiple specific interventions. More than 1 as described above	5
Specific interventions outside of ICU. Surgery or diagnostic procedures	5
<b>Ventilatory Support</b>	
Mechanical ventilation. Any form of mechanical ventilation or assisted ventilation with or without PEEP; with or without muscle relaxants	5
Supplementary ventilatory support. Breathing spontaneously through endotracheal tube without PEEP; supplementary oxygen by any method except if mechanical ventilation parameters apply.	2
Care of artificial airways. Endotracheal tube or tracheostoma	1
Treatment for improving lung function. Thorax physiotherapy, incentive spirometry, inhalation therapy, intratracheal suctioning	1
<b>Renal Support</b>	

Hemofiltration techniques. Dialytic techniques.	3
Quantitative urine output measurement	2
Active diuresis	3
<b>Neurological Support</b>	
Measurement of ICP	4
<b>Metabolic Support</b>	
Treatment of complicated metabolic acidosis/alkalosis	4
Intravenous hyperalimentation	3
Enteral feeding. Through gastric tube or other GI route	2

Annexure 4

Patient/Call Code						
<b>Flight Details</b>						
Date	Month	Year	Referring facility	Receiving facility	T/O time	Access time
<b>Flight Details</b>						
Scene time	F&R transfer time	Handover time	Total flight time	Total mission time	Crew 1	Crew 2
<b>Patient Demographics</b>						
Crew 3	Age	Age category	Gender	Broad case type	Specific case type	
Clinical Adverse Events					REMS	
HR	RR	SpO2	BP	CRT	REMS Referring	REMS Receiving
Critical Adverse Events						
CI-A-C1	CI-A-C2	CI-A-C3	CI-A-C4	CI-A-C5		

CI-A-C1: Cardio/cardio-respiratory/respiratory arrest

CI-A-C2: Emergency intubation

CI-A-C3: Endotracheal tube obstruction or dislocation

CI-A-C4: Desaturation of 10% from baseline for longer than 10 mins

CI-A-C5: Decrease in Glasgow Coma Scale of 3 or more points from baseline

Interventions						
NTISS	Total no. interven.	Total no. drugs	Interven. 1	Interven. 2	Interven. 3	Interven. 4
Interventions						
Interven. 5	Interven. 6	Interven. 7	Interven. 8	Interven. 9	Interven. 10	Interven. 11
Interventions						
Drug 1	Drug 2	Drug 3	Drug 4	Drug 5	Drug 6	Drug 7

## Annexure 5



20 March 2012

Dear Sir

**Re: Access to AMS Records for research purposes**

The AMS Research Committee has received your research protocol and supports you in this study.

Access to the SA Red Cross Air Mercy Service (AMS) records for the Western Cape – Cape Town Operations has been granted. The records will be made available to you from our Regional Office located at the General Aviation Area - Cape Town International Airport.

Guidance to the use and maintenance of the record files will be advised on site by local management.

Standard Ethical Rules Apply.

Thank You

Yours faithfully

A handwritten signature in black ink, appearing to read 'Ashwin Krishna', is written over a date '2012/04/18'.

**Ashwin Krishna**  
**Operations Manager**

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**Website: [ams.org.za](http://ams.org.za), E-mail: [info@ams.org.za](mailto:info@ams.org.za)**  
**Established by SA Red Cross Society, Trust Reg No: T340/94, NPO Reg No: 017-180**

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## 5.2 Organisation Consent



20 March 2012

Dear Sir

**Re: Access to AMS Records for research purposes**

The AMS Research Committee has received your research protocol and supports you in this study.

Access to the SA Red Cross Air Mercy Service (AMS) records for the Western Cape – Cape Town Operations has been granted. The records will be made available to you from our Regional Office located at the General Aviation Area - Cape Town International Airport.

Guidance to the use and maintenance of the record files will be advised on site by local management.

Standard Ethical Rules Apply.

Thank You

Yours faithfully

signature removed

2012/04/18

**Ashwin Krishna**  
Operations Manager

**Tel:** 086 11 MERCY(63729) (SA Only)      **Ext:** 135  
**Tel:** (+27) 21 935 6900 (International)  
**Fax:** (+27) 86 644 9504  
**Mobile:** (+27) 83 793 2476  
**E-mail:** [ashwin@ams.org.za](mailto:ashwin@ams.org.za)  
**AMS Website:** [www.ams.org.za](http://www.ams.org.za)

**Head office: P O Box 93, Cape Town International, 7525**  
**Tel: 0861163729, 24 Hour Emergency Number: 0861 267 267**  
**Website: [ams.org.za](http://ams.org.za), E-mail: [info@ams.org.za](mailto:info@ams.org.za)**  
**Established by SA Red Cross Society, Trust Reg No: T340/94, NPO Reg No: 017-180**

## 5.3 Department of Surgery Research Committee Consent



UNIVERSITY OF CAPE TOWN

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### Department of Surgery

#### Departmental Research Committee

**Professor Anwar Suleman Mall**

J-45 Room Old Main Building, Groote Schuur Hospital,  
Observatory 7925, South Africa

Tel (021) 406 6168/6232/6227 FAX (021) 448 6461

Email: [Anwar.Mall@uct.ac.za](mailto:Anwar.Mall@uct.ac.za)

25<sup>th</sup> June 2012

Dr I Howard  
Department of Surgery  
Division of Emergency Medicine  
Groote Schuur Hospital  
University of Cape Town

Dear Dr Howard,

**RE: PROJECT 2012/054**

**PROJECT TITLE: Current practice in the air medical services for the inter-facility transfer of paediatric patients in the Western Cape, South Africa**

The above proposal was reviewed by the Department of Surgery Research Committee and I am pleased to inform you that the committee approved the study.

Please use the above project number in all future correspondence.

Yours sincerely

A redacted signature, represented by a greyed-out area.

signature removed

**PROFESSOR ANWAR S MALL  
CHAIRMAN: RESEARCH COMMITTEE**

## 5.4 Ethical Approval

UNIVERSITY OF CAPE TOWN



Faculty of Health Sciences  
Human Research Ethics Committee  
Room E52-24 Grootte Schuur Hospital Old Main Building  
Observatory 7925  
Telephone [021] 406 6338 • Facsimile [021] 406 6411  
e-mail: shuretta.thomas@uct.ac.za

28 June 2012

**HREC REF: 325/2012**

**Mr I Howard**  
c/o Dr T Welzel  
Emergency Medicine  
Division of Surgery

Dear Mr Howard

**PROJECT TITLE: CURRENT PRACTICE IN THE AIR MEDICAL SERVICES FOR THE INTER-FACILITY TRANSFER OF PAEDIATRIC PATIENTS IN THE WESTERN CAPE, SOUTH AFRICA**

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

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

**Approval is granted for one year till the 15<sup>th</sup> July 2013**

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/research/humanethics/forms](http://www.health.uct.ac.za/research/humanethics/forms))

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

**Please quote the HREC. REF in all your correspondence.**

Yours sincerely

signature removed

**PROFESSOR M BLOCKMAN**  
**CHAIRPERSON, FHS HUMAN ETHICS**

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 Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.

The Human Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

s.thomas

## 5.5 Acknowledgements

I would like to acknowledge the following individuals for their assistance in the completion of this research project.

- Dr. Tyson Welzel for assisting with the development of the research in his role as supervisor.
- Dr. Justin Harvey for his advice on statistical analysis.
- The Red Cross Air Mercy Service for access to their patient and aviation records