Chapter 1

Introduction and Literature Review

1.1. Introduction.

"Inter-hospital transport services have developed in response to centralisation of specialist services such as intensive care, with the aim of ensuring safe and rapid transport of sick children to tertiary centres", says Ramnarayan in a 2009 paper on measuring the performance of an inter-hospital transport service (1). Neonatal and infant critical care transport systems form a major part of providing intensive care to many patients who are often referred from hospitals that are invariably a long distance away from tertiary centres (2). This is especially true for a country like South Africa where secondary and tertiary care services are mainly offered in major towns or cities and metropolitan areas.

The shortage of intensive care beds is a well-recognised international problem and transport of patients between health facilities makes transport systems an integral part of intensive care (2;3). Transferring critically ill neonates without specialised staff has been noted to increase morbidity and mortality (3;4). Despite this, in most parts of South Africa, transport teams are made up of non-specialised paramedic personnel without any logistical or skilled personnel support for all day to day transport needs. The improved outcomes of patients managed in paediatric intensive care units (owing to the improved levels of care and the advancement of technology used), has increased pressure on both the referring units and transport teams to transfer these patients safely and timeously (5).

There is considerable risk of deterioration of critically-ill patients during transfer, either due to the primary illness, complications of treatment or due to the transfer process itself (5). Studies have conclusively shown that utilising specialised retrieval units greatly improves clinical outcomes of these patients in intensive care units (1;5;6). The transfer of critically-ill patients is inherently risky with up to 75% of patients transferred by non-specialised teams suffering from serious complications (5). These complications range from minor (e.g. loss of intravenous access) to major life-threatening complications (e.g. dislodged endotracheal tube) as well as equipment failure. There is often a lack of proper monitoring of patients during the transfer process from non-specialised units and hence a lack of detection of clinical deterioration in transit (5). This makes auditing of such units extremely difficult and hence difficult to apply any quality assurance and improvement measures. A multi-centre study in Turkey found that there were no established guidelines for the emergency transport of paediatric patients in Turkey (6). The situation is the same in South Africa.

At the time of writing this review (June 2009), there was a nationwide 'illegal' doctor's strike. One of the doctor's main grievances was the need for improvement of the quality of healthcare provided to patients in the public sector. Similarly, the issue of transporting critically-ill patients from one facility to the other, as is currently done within the public sector, is an example of how poorly transit patients are managed.

Whilst resource-rich countries have made great strides in developing and improving their critical care transport facilities as well as developing retrieval teams, poorer countries have largely turned a blind eye to the needs of transported critically-ill patients, both adult and children. In South Africa the responsibility of transporting patients between health facilities within the public sector has been left solely in the hands of paramedic staff, who may be managing these patients beyond their scope of practice. As with other health professionals, more experienced senior paramedic staff are poached by the private sector. This is understandable as these medical personnel are in search of better working conditions, including better remuneration and general career progression. (Incidentally, emergency care services personnel in the public sector were also on strike at the time of the doctor's strike).

Up to now, there is very limited data in South African literature regarding outcomes of transported children between different health facilities.

1.2 Organisation and composition of transport teams

The American Academy of Paediatrics' (AAP) Guidelines for Air and Ground Transportation of Paediatric Patients state that:

> *"A Paediatric transport system should be capable of rapidly delivering advanced paediatric skilled critical care to the patient's bedside at the referring hospital and maintaining that level of care during transport to the receiving hospital" (7;8).*

In resource-rich settings (such as Europe, USA, Canada and Australia) neonatal and infant critical care transport has been a rapidly developing subspecialty in paediatric critical care, with interventions including mobile Extracorporeal Membrane Oxygenation (ECMO) and Continuous Positive Airway Pressure (CPAP) being offered during transfer, amongst other interventions (9).

In many parts of the United Kingdom, retrievals are undertaken by staff dispatched from the receiving Intensive Care Unit (ICU), although dedicated regional transport teams, similar to those in North America and Australia, have also evolved recently for neonatal and paediatric transfers (1;10). Cornett *et al* argue that owing to increasing demands for specialisation and special skills for staff involved in neonatal transport systems, more resources should be allocated to developing regionalised transport teams whose sole purpose would be to undertake transport between facilities (10).

Staffing of the retrieval teams is a difficult problem to resolve even for resource-rich countries which have the resources to fund such units, as they require highly specialised personnel, but such calibre of staff may not be always available to undertake all the referrals.

Leslie *et al* compared neonatal transfers undertaken by Advanced Neonatal Nurse Practitioners (ANNP) with those performed by paediatric registrars and concluded that ANNP led neonatal transport was a practical possibility and appeared to be safe for the babies (11). King *et al* observed that non-physician led teams responded more quickly, and spent less time at the referring facility (12).

1.3 Tools for measuring quality of care rendered by the transport team.

There are a number of indicators used to measure the quality of paediatric intensive care (13). However, there is no consensus on how the performance of an inter-hospital transport service should be measured (1). The absence of agreed upon key performance indicators or reference values means that transport teams are unable to log their own performance over time (1). This makes it difficult for health managers or anyone else to compare key performance areas and quality of care rendered between different inter-hospital transport teams (1).

Different retrieval units use different outcome measuring tools which help them to both improve the quality of their services and to also prognosticate the outcomes of the transported patients prior to transfer. As such, there are many different scoring systems that have been devised for the above purposes; including the Mortality Index for Neonatal Transportation (MINT) and the Transport Risk Index of Physiologic Stability (TRIPS) scores amongst others (14;15).

1.3.1 The Children's Acute Transport Service (CATS)

The Children's Acute Transport Service (CATS), a busy regional retrieval service based in London, has described some of the potential indicators that can be used to assess the performance of inter-hospital transport services (1). These quality assessment tools are not internationally agreed tools, but are specifically developed for use by the CATS retrieval team. There are four main areas that CATS teams focused on when establishing their tools for quality indicators of the inter-hospital transport service rendered (1).

1.3.1.1 Safety Aspects

This evaluates the number of adverse events reported, which include patient physiology related and technical or care related issues. Patient related events include physiological parameters such as cyanosis; respiratory arrest; cardiac arrest; systolic hypotension; cardiac arrhythmias; hypothermia; hypoglycaemia; loss of consciousness and loss of brainstem function.

Technical or care-related events include an occluded endotracheal tube; accidental tracheal extubation; loss of intravenous access; pulmonary aspiration; loss of monitoring, or critical malfunction of ventilator and exhaustion of oxygen supply. Other parameters looked at include death in transit; unexplained re-transfers; urgent intervention within the first hour of ICU admission (including re-intubation, cardiopulmonary resuscitation or central venous access) and ambulance accident rate.

1.3.1.2 Speed

A variety of median time intervals are reported in the CATS data report. Referring clinicians frequently rate availability of retrieval team as an important requirement. The following time intervals are then utilised as quality indicators: acceptance time; team mobilisation time; time to patient bedside; stabilisation time as well as the total transport time.

1.3.1.3 Efficiency of resource use

Intensive care beds are a scarce resource and are also very expensive to fund for any health department, and as such need to be utilised with great care. The CATS team also looks at the appropriate use of these resources as part of their quality indicators. Faulty initial triage, averted transfers and refusal rates are some of the indicators used in this regard.

1.3.1.4 Satisfaction

Satisfaction levels of the transport/retrieval team are measured using a Likert-type scale rating (1=very dissatisfied to 5=very satisfied) performed by the patient, referring clinician and the admitting clinician. Realistically, all these quality measures can only be achieved if there are dedicated transport teams for critically-ill children and neonates, who continuously strive for excellence.

1.3.2 Mortality Index of Neonatal Transportation (MINT)

The MINT score is a scoring system designed specifically for transported neonates in order to predict their mortality at the time the referring hospital makes the initial telephone call (14). It utilises data collected at the time the initial call is made to the regional transport team using seven variables, i.e. Apgar score at 1 min, birth weight, presence of a congenital anomaly, infant's age, blood pH, arterial partial pressure of oxygen and heart rate. Once data is collected, a score is calculated and the transport team is able to identify neonates with the greatest risk of dying prior to being transported (14). Once this data is collected, the MINT score is therefore applied, often telephonically prior to the actual transport of the infant occurs. The data received telephonically is then entered into a multivariate regression analysis with neonatal death as an outcome, which gave areas under ROC curves of 0.80 for both neonatal and perinatal death. The presence of such data prior to the actual transport of the infant would have helped us identify objectively the quality of the transport team.

1.3.3 Transport Risk Index of Physiologic Stability (TRIPS)

The Canadian Neonatal Network devised a scoring system (TRIPS score) for neonates transported between two different facilities to help them prognosticate outcomes. Mortality rates at seven days in Neonatal Intensive Care Unit (NICU), total NICU mortality (until discharge from NICU), as well as the risk for developing severe intra-ventricular haemorrhage (i.e. IVH – Grade 3) are measured (15).

TRIPS comprises of four physiological parameters, i.e. temperature, blood pressure, respiratory status and response to noxious stimuli. There was good correlation of the TRIP scores with the gestational age of patients, compared to the expected clinical outcomes (there was a direct relationship between the TRIP score and the overall mortality or adverse outcome) (15). Availability of such data would have greatly enhanced our audit by enabling us to compare immediately and long term outcomes between inborn and outborn infants admitted to neonatal ICU, and thus measure the overall quality of the transport teams objectively.

1.3.4 Other scoring systems

Scoring systems used for patients admitted to intensive care, either neonatal or paediatric, are not specific for transported patients. These include the: Clinical Risk Index for Babies (CRIB II) score (16), Paediatric Index of Mortality (PIM-2) (17), the Berlin score (18), and the Score for Neonatal Physiology (SNAP) (19).

As can clearly be seen from this brief review, there is currently no consensus on the accepted norms of monitoring the quality of care provided to transferred patients. This therefore, makes it difficult to standardise practise norms for inter-hospital transport teams. Each retrieval team is pretty much left to evaluate their own quality of care based on what each team deems to be acceptable and relevant clinical standards. Ideally one should compare clinical standards for quality with transport units from similarly resourced settings, but absence of quality data makes assessment difficult to achieve.

1.4 Ambulance safety aspects

A road traffic accident in the Northern Region of the United Kingdom involving an ambulance returning to a hospital with a baby requiring intensive care highlighted some of the ambulance safety issues that were neglected. This led to the Medical Devices Agency carrying out a review of neonatal and paediatric intensive care transfers in the UK ("TINA" inquiry) (3;20). Subsequent to that, there was an agreed European Standard of Neonatal and Paediatric transport policy which is now being used as a standard for care among the European Union countries. Currently, the ambulances in use ensure safety of both the staff and the baby that is being transported with strong emphasis on the securing of transport incubators within the ambulance (20).

To date, no such review of transport safety issues has been published in South Africa and despite local ambulances frequently being involved in road traffic accidents (sometimes fatal) whilst carrying patients (21;22). Ambulance accident rates, including both major or minor accidents, were reported to be 5 per 10 000 journeys by the CATS team, as part of their safety monitoring exercise, but unfortunately there is no such data in South Africa to compare with (1).

As part of the safety aspects of the ambulances used, equipment used to monitor patients in transit should be checked frequently and made sure that it is in proper working condition. This was, however, not the case in Turkey where only 16% of the ambulances used to transport sick children were fully equipped (6).

1.5 Current Organization of paediatric transport systems in South Africa

The South African national health department-appointed *Paediatric Neonatology work group*– observed that “Referral and transport services (road and air) are totally inadequate, uncoordinated and disorganised (including in-utero transport/referrals)” (23). Inadequate referral and transport services and insufficient neonatal high-care and intensive-care beds are limiting factors for access to neonatal care. Inappropriately trained transport staff also contribute to increased mortality and morbidity (20). Anecdotal evidence from various South African settings suggests that a significant number of neonates arrive at the receiving hospitals in a suboptimal clinical physiological condition, i.e. hypoxic, hypothermic and even hypoglycaemic because of the lack of pre-transport stabilisation and proper monitoring in transit.

A study by Hadley *et al* found that neonatal transport of surgical patients in poorly resourced settings remains hazardous because of a shortage of human and material resources (24). They found that failure to maintain simple interventions such as intravenous fluid replacement and nasogastric drainage were more important factors than inadequate technology in defining the status of the patient on arrival at the receiving health facility (24).

Currently, within the Johannesburg metropolitan area, transport of paediatric patients requiring intensive care within the public sector hospitals is almost exclusively provided by private ambulance services, and the referring hospitals as well as the provincial department of health pay a substantial amount for such a service. The problem with these units is that they are largely left to decide on their own terms on how this service is rendered, without any auditing of their overall quality of the service rendered as well as the clinical performance (either from themselves as service providers or from the hospitals they render service to).

There is also no accountability for any adverse outcomes suffered by patients in transit when they transfer critically-ill children. The decision as to which company is used by the Johannesburg City, is not based on the performance of the unit but based solely on which company the individual hospital is contracted to. Previously, individual hospitals could decide on their preferred tender, but recently the responsibility was allocated to the provincial Gauteng Emergency Services (GEMS) to assess individual cases requiring transport and they would dispatch an "appropriate" transport team.

1.5.1 Typical transfer process

The typical transfer process currently is as follows:

- A call is made by the referring unit to the control office of the GEMS to inform them of the pending transfer of a patient to another hospital.
- The ICU bed would have been arranged prior to this process by the referring doctor. Only when the ICU bed is available and the patient is accepted by the receiving hospital consultant(s), will the transport arrangements be made.
- Referring doctors, most often medical officers and registrars, spend hours on the phone looking for an ICU bed at surrounding hospitals with paediatric ICU facilities, leaving their units and other clinical responsibilities unattended.
- If a unit with Advanced Life Support personnel is available at the time the transport is booked, then they would be the ones who would undertake the transfer, or try to, because many of the ambulances available are ill-equipped with dealing with sick

children in transit e.g. most ambulances used, do not have transport incubators for infants and children and those that do have them have no proper mounting of these incubators or they are simply non-functional.

- In cases where the wrong equipment is brought to undertake the retrieval or missing equipment is noted on arrival, these units are then turned back resulting in loss of precious time for the baby who might be receiving manual ventilation at the time whilst waiting for an ICU bed. One can only imagine the amount of unnecessary barotrauma, volutrauma and atelectotrauma occurring to the lungs of the infants during that time of manual ventilation, which will obviously worsen the overall outcomes and increase the risk of development of chronic lung disease later on, if they survive (25).

In the short term, this current arrangement may seem cost-effective for the provincial health department, but ultimately, patients will continue to pay the price for the sub-standard care they receive from these units if they continue operating unmonitored. Rewarding good clinical performance or even a pay-by-results (1;26) approach may be what is required in the short and medium term in order to improve the service standards rendered by these private units.

Going forward, however, having properly established regional retrieval teams is what is needed to ensure high standard of care for critically-ill children and much improved clinical outcomes in intensive care units (1;5). This requires substantial funding to establish and maintain such retrieval units, as well as recruiting appropriately trained staff to undertake such a task. Ideally paediatric intensivists should take a lead in such retrieval teams, but the general shortage of such highly skilled subgroup of clinicians is a limiting factor. An alternative solution may be to train professional nurses with intensive care experience to be skilled in managing patients in transit (10;12).

Transfers of newborns from the surrounding Midwife Obstetric Units (MOUs) to hospitals are almost exclusively done by the Gauteng Emergency services that are mainly Basic Life Support (BLS) staff equipped units. Their performance, although not audited, has anecdotally been noted to be sub-standard at best. Many transport staff (i.e. paramedics) just “drop-and-go” without offering any proper handing over of patients to the next medical team at the receiving health facility. There is no prior discussion or arrangement made concerning the transfer of these patients in most circumstances between the referring health care practitioner and the receiving doctor.

Common medical reasons for transfer from these units include low birth weight, respiratory distress and congenital abnormalities amongst others. Unfortunately, there are no mechanisms in place to give important or critical information to the retrieval teams to ensure the best outcome of patients as they transport patients between health facilities. This faulty system is not solely due to some unscrupulous transport teams, but the medical team is also part of the problem whereby critical mishaps or omissions are not taken up by them with the relevant authorities to ensure optimal outcomes of the transported patients. Some of the retrieval teams, especially those who do ICU retrievals, are mostly private companies, who are at present not duty bound to do follow up on the clinical outcomes of the infants that they have transported in an effort to improving the quality of their service.

1.6 Reasons for undertaking the clinical audit

As a doctor and medical researcher, I undertook this study to objectively audit the outcomes of neonates that were transported to the three selected academic hospitals in order to identify areas where improvements can be made and, hopefully, improve both the inter-facility transport systems used and the clinical outcomes of transported infants. Over time and with better investment, both financial and human resources, better retrieval teams can be developed and which would be run by provincial health departments, with the sole purpose of delivering quality health care to infants and young children in transit and hence improve clinical outcomes of patients and not just be profit-driven as is currently the case with the private ambulance services.

Chapter 2: Methodology

2.1. Study Design

This was a cross-sectional, descriptive study with analytic components. Infants transported to any of the three academic hospitals in Johannesburg during the study period were enrolled and routine clinical parameters were documented on arrival.

2.2. Study site

The study data was collected wherever neonates were first received, i.e. the neonatal intensive care unit (NICU), high care wards or neonatal admission units of the three academic hospitals of the University of Witwatersrand.

2.3. Study Sample

2.3.1 Inclusion Criteria

All newborn infants up to 28 days of life that were received from another health facility and that were transported using an ambulance or any other health service provided transport (road or air transport) to any of the three Johannesburg academic hospitals (i.e. CH Baragwanath, Johannesburg General and Coronation) requiring further medical and/or surgical care, were enrolled. Convenience sampling was used, whereby infants were enrolled by those receiving clinicians who were well informed about the study.

2.3.2 Exclusion Criteria

All babies (n=8) from whom I could not get parental consent for participation in the study were excluded, except where the obtaining of consent was waived by the University of Witwatersrand's Committee for Research in Human Subjects (Medical) (see ethical considerations section below).

2.4 Study Period

The study took place over a ten week period, from the 15th October 2007 to the 30th December 2007.

2.5 Sample Size

The sample size was determined by the study period. The study period was determined by the time available to the researcher for data collection. A total of 104 patients were recruited to the study, but consent was secured for 96 babies. Outcomes are reported for these 96 infants.

2.6 Data Collection

The study was questionnaire based, where the receiving clinicians (doctor or professional nurse) documented the routine clinical physiological parameters as observed on arrival of the baby on a data capturing sheet developed by the researcher. Only the observations that were necessary for routine management of patients were captured by the receiving nursing and/or medical personnel and no additional procedures were done on babies simply for the sake of the study.

The data was collected by the receiving clinician or nursing sister as soon as the baby arrived at the receiving facility. In cases where the receiving doctor was not available at the time of arrival of the baby, clinical observations were documented from the nurse's observation chart when the baby arrived.

2.6.1 Data capturing sheet

The data capturing sheet was in a form of a questionnaire which was subdivided into five subsections where different clinical data was documented (Appendix C):

Section A on the questionnaire captured demographic details of the baby, i.e. baby's initials, hospital number and the date of birth.

Section B of the questionnaire had the referral details of the baby, i.e. referring health institution, receiving hospital, ambulance used, reason for referral, gestation of the baby (if newborn), weight of the baby, ward that the baby was admitted to, date of admission and also who brought the baby to hospital.

Section C documented information of the baby's condition on arrival at the receiving hospital, i.e. general appearance of the baby, muscle tone, oxygen saturation, heart rate, axillary temperature and blood glucose. Two items were only documented where applicable, i.e. when babies were admitted to NICU i.e. blood pressure and arterial blood gas.

Section D captured en-route interventions and mishaps, such as whether the baby was intubated or not, mode of ventilation used, oxygen administration, inotrope usage, use of an intravenous line, type of fluid used as well as whether the baby was fed prior to transfer.

Section E was for the receiving clinician's rating of his or her overall level of satisfaction with the transfer of the baby.

Lastly, the final outcome (death or alive) of the baby within the 48 hour period, and the ward that the baby was admitted to was documented.

2.7 Study Procedures

The study data was captured on a data sheet, where the receiving clinicians (doctor or professional nurse) documented the routine clinical physiological parameters as observed on arrival of the baby. All doctors and nursing staff who were working in the paediatric department, neonatal medicine division of the three academic hospitals, at the time of the study were updated about the study, and were asked to assist with data capturing when they received infants from another health facility. Details of the data capturing sheet were explained to them and how it was to be completed. The staff then entered the admission clinical parameters on their routine clinical notes as well as on the data forms provided it was done within half hour after arrival to the hospital.

I collected the completed forms on a daily basis from the three hospitals and followed up on all the infants that died prior to 48 hours and those who did not have a completed data capturing sheets, in which case I enrolled the eligible infants. Consent from the parents was also sought at the time of visit to the hospital.

2.8 Outcome Measures

2.8.1 Mortality

Death within the first 48 hours after arrival was the primary outcome measure. I did not capture mortality at discharge as some patients were admitted for a much longer period than the study's duration.

2.8.2 Adverse clinical events

A number of clinical adverse events were documented on arrival of the infant at the receiving hospital. Critical adverse events captured included mishaps such as a dislodged endotracheal tube requiring immediate intubation at the receiving hospital, or a cardiac or cardio-pulmonary arrest requiring resuscitation and/or CPR.

Other clinical adverse events documented were as follows:

- Hypoxia - defined as oxygen saturations less than 85% in the absence of a cyanotic cardiac lesion.
- Hypoglycaemia - defined as the blood glucose measurement of less than 2.5 mmol/l measured on a haemoglucometer machine.
- Hypotension – defined as a blood pressure less than 2 standard deviations (SD) below the mean, based on the infant's gestation in the first 72 hours.
- Acidosis - defined as a blood pH less than 7.25 or severe acidosis (defined as pH less than 7.0) on a blood analysis done within half an hour after arrival.
- Hypothermia - defined as an axillary temperature on admission less than 36°C measured with a mercury thermometer.
- Hypotonia – based on the receiving clinician's assessment of the infant's muscle tone/strength in the absence of drug induced effects.
- Cardiac instability including bradycardia (heart rate less than 100 beats/min) and tachycardia (heart rate > 180 beats/min), both in the absence of drug-induced effects, as well as any cardiac arrhythmias.

2.8.3 Technical Adverse Events

Major or minor equipment failures and mechanical adverse events occurring prior to or on arrival at the receiving hospital could not be adequately captured as the receiving clinician might not have been present at the time of arrival of the infant. These included mechanical failure of a ventilator, the transport team running out of oxygen or infants brought without proper transport incubators.

2.8.4 Level of satisfaction of the receiving clinician

Receiving clinicians were asked to subjectively rate the overall quality of the transport team that retrieved the infant, based on their expectations of how sick infants should be cared for in transit.

2.9 Statistical Considerations

The data was entered onto a pre-coded questionnaire and later entered on an Excel 2007 (Microsoft, Seattle, USA) spreadsheet for analysis. Statistical analysis was done using Stata 9 programme (Stata Corp, Texas USA) as well as Statistica version 8 (Statistica, Oklahoma, USA). Some basic descriptive statistical analysis was done using Windows Excel 2007 programme (Microsoft, USA). Comparative statistics were analysed using Stata 9 and Statistica. A p-value <0.05 was defined as being statistically significant.

2.9 Financial Assistance

A grant for the study was received from the University of Witwatersrand Medical Research Endowment Fund.

2.10 Ethical Considerations

- Approval was granted by the Committee for Research in Human Subjects at the University of Witwatersrand (Medical) for the overall study – Ethics Clearance number **M070910**.

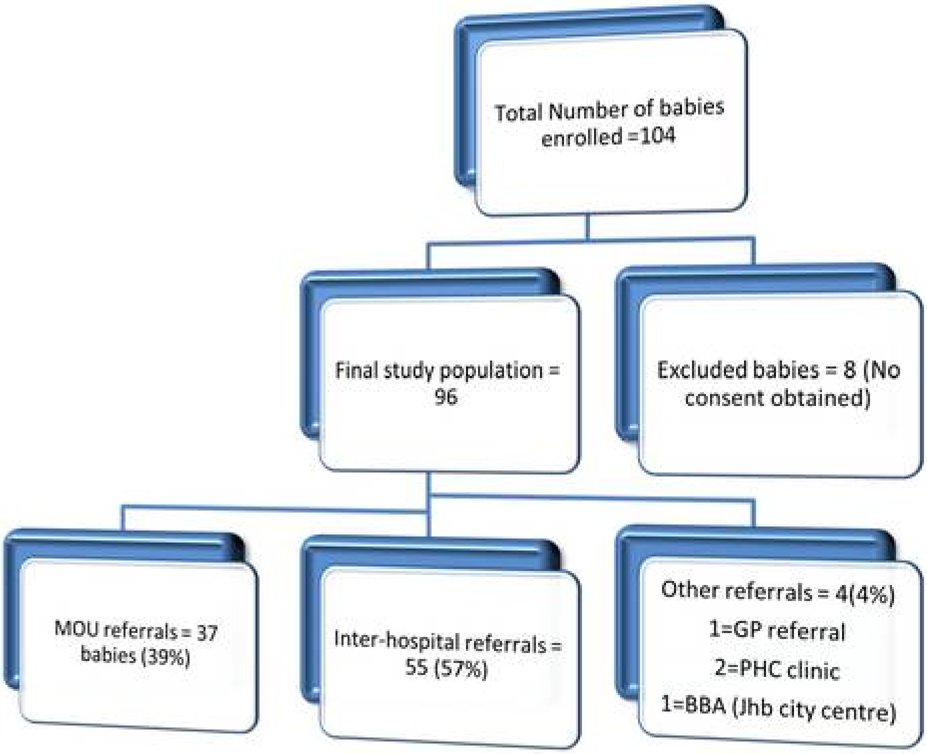
- Further ethical clearance and permission was provided by the Gauteng Department of Health for the study to be undertaken at the different midwife obstetric units (MOUs and the three hospitals.
- Permission was also granted from each of superintendents of the three academic hospitals to undertake the study at their respective hospitals.
- Individual parental consent was granted by the parents or guardians of the babies to use the study data, at the time of data collection or retrospectively.
- Data collected and where parental consent was not obtained was not included in the study and the data sheet was subsequently destroyed.
- The Committee for Research in Human Subjects of the University of Witwatersrand waived the need for consent for all babies who died prior to consent being granted by their parents.

Chapter 3: Results

3.1. Study sample

A total of 104 infants were enrolled in the study. It was not possible to obtain written consent from parents of 8 infants and these infants were excluded. Thus, 96 infants were included in the study, of whom 37 (39%) were Midwife Obstetric Unit (MOU) referrals and 55 (57%) were from other hospitals. Four infants were from other referral sources, two were from primary health care clinics, one infant from a general practitioner's rooms and the other was "Born before Arrival" (BBA) and was on the street at Johannesburg city centre (figure 3.1)

Figure 3.1 Study flow diagram



3.2 Study demographics

3.2.1 Age on arrival

Just over half the infants (53[55%]) admitted at the receiving hospitals were newborns aged less than 24 hours of age, of whom two thirds (66%) were referred from MOUs (table 3.1).

3.2.2 Gestational Age at birth

Over two thirds (70%) of all infants were preterm infants with most (42%) having a gestational age of between 28-32 weeks. Term infants comprised just under a third (30%) of the total admissions (figure 3.2).

3.2.3 Weight categories at birth

The majority of infants (73%) were low birth weight (weighing less than 2500g), and 37% of the total admissions weighed between 1500g and 2500g, the single largest weight category (figure 3.3).

Table 3.1 Age of infants on arrival (study entry) (N=96)

Age of infants (days)	Number	Percentage (%)
< 24 hours	53	55
1-5 days	30	31
6-10 days	7	7
11-20 days	1	1
21-28 days	5	5

Figure 3.2 Gestational age of infants

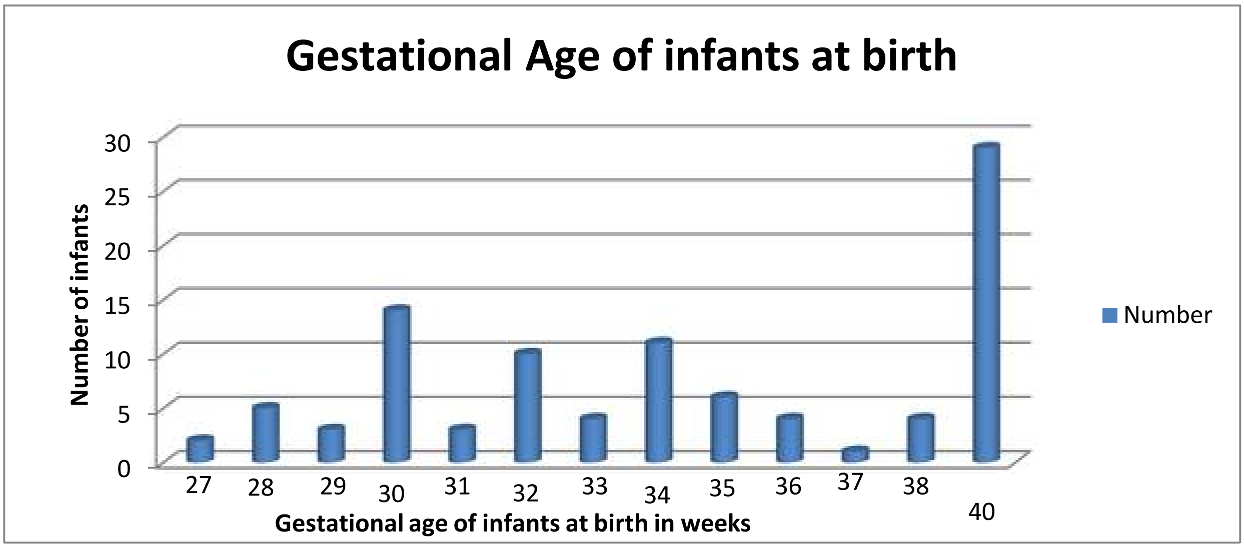
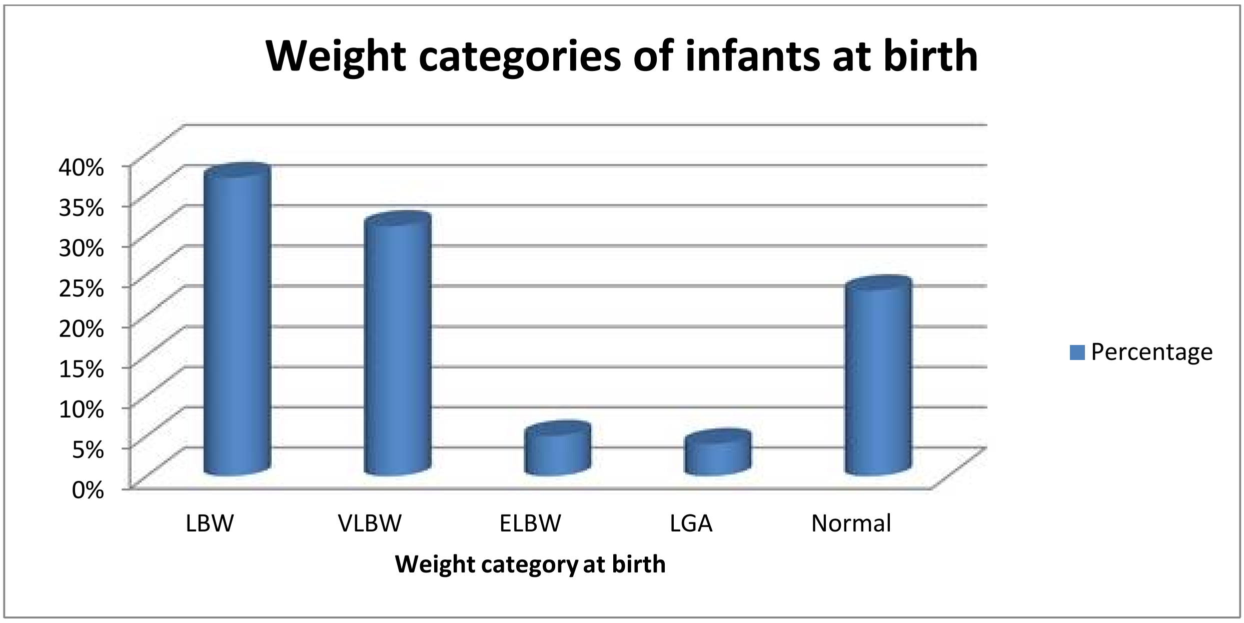


Figure 3.3 Weight category of infants at enrollment



Abbreviations: **LBW=** low birth weight (between 1500g and 2499g); **VLBW=** very low birth weight (between 1000g – 1499g); **ELBW** = extreme low birth weight (below 1000g); **LGA** = large for gestational age (>4000g) and **normal** weight category (between 2500g and 4000g).

Table 3.2 Summary of demographic profile (N=96)

Age of infants on admission (days)	Number	Percentage (%)	Cumulative %
<1	53	55	55
1 – 5	30	31	86
6 – 10	7	7	93
11 – 20	1	1	94
21 – 28	5	5	100
Gestational age at birth (weeks)			
< 28	2	2	2
28 – 31.9	26	27	29
32 – 33.9	14	15	44
34 – 37.9	22	23	67
38 – 41.9 (term)	32	33	100
Weight categories of infants			
Extreme Low Birth Weight (<1000 g)	5	5	5
Very Low Birth Weight (1000 – 1499 g)	30	31	36
Low Birth Weight (1500 – 2499 g)	35	37	73
Normal (2500 – 4000 g)	22	23	96
Large weight for age (>4000 g)	4	4	100

3.3 Referring and recipient hospitals

More than half (51%) of all infants were received at Johannesburg General Hospital, mainly because the researcher was based at this hospital during the data collection phase of the study and could better influence study enrolment through promoting registrar compliance (table 3.3).

Table 3.3 Receiving hospitals for infants

Name of Hospital	No. of infants received	Percentage (%)
CH Baragwanath	38	40
Coronation	9	9
Johannesburg General	49	51

Patients were referred from a number of health institutions with the majority of the inter-hospital transfers coming from within the University of the Witwatersrand (Wits) group of academic complex hospitals themselves. The infants who came from MOUs were mainly referred from Hillbrow and Alexandra MOUs (Table 3.4).

Table 3.4 Referring and recipient health institutions for infants

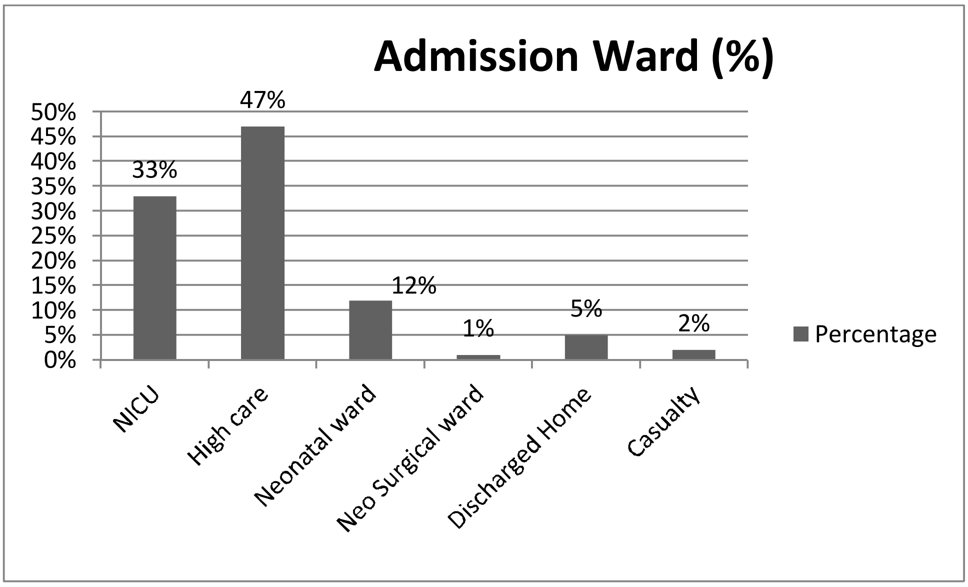
Referring health institution	No. (%)	Receiving hospital	No. (%)	Distance transported (km)
MOU				
Hillbrow MOU	14 (15)	Johannesburg		5
Alexandra CHC	10 (10)	Johannesburg		10
Chiawelo MOU	5 (5)	CH Baragwanath		12
Dobsonville MOU	2 (2)	CH Baragwanath		20
Zola MOU	1 (1)	CH Baragwanath		4
Jeppe Clinic	1(1)	Johannesburg		6
Jourbert Park Clinic	1(1)	Johannesburg		6
Mofolo MOU	3(3)	CH Baragwanath		5
Doornfontein Clinic	2(2)	Johannesburg		10
Hospitals				
CH Baragwanath	8(8)	Coronation	5 (5)	13
		Johannesburg	3 (3)	12
Johannesburg Hospital	5(5)	CH Baragwanath	3 (3)	12
		Coronation	2 (2)	10
Coronation Hospital	8(8)	CH Baragwanath	7 (7)	13
		Johannesburg	1 (1)	10
Klerksdorp Hospital	6(6)	CH Baragwanath	5 (5)	155
		Johannesburg	1 (1)	168
Natalspruit Hospital	5(5)	Johannesburg	3 (3)	32
		Coronation	1 (1)	36
		CH Baragwanath	1 (1)	39

Potchefstroom Hospital	4(4)	CH Baragwanath	3 (3)	116
		Johannesburg	1 (1)	130
Tembisa Hospital	4(4)	CH Baragwanath	2 (2)	51
		Johannesburg	1 (1)	32
		Coronation	1 (1)	40
South Rand Hospital	2(2)	CH Baragwanath	1 (1)	15
		Johannesburg	1 (1)	9
Sebokeng Hospital	1(1)	Johannesburg	1 (1)	62
Leratong Hospital	2(2)	CH Baragwanath	1 (1)	23
		Johannesburg	1 (1)	22
Tambo Memorial Hospital	1(1)	Johannesburg	1 (1)	32
1 Military Hospital	1(1)	CH Baragwanath	1 (1)	72
Sunshine Clinic (private)	2(2)	Johannesburg	2 (2)	38
Glynnwood Hospital (private)	1(1)	Johannesburg	1 (1)	23
Clinix - Lesedi Soweto	1(1)	Johannesburg	1 (1)	15
Far East Rand Hospital	2(2)	CH Baragwanath	3 (3)	32
Heidelberg Hospital	2(2)	Johannesburg	2 (2)	60
Orange Groove GP rooms	1(1)	Johannesburg	1 (1)	8
BBA	1(1%)	Johannesburg	1 (1)	6

3.4 Admission Ward

Almost half (47%) of the infants transferred were admitted to a high care ward (a ward where infants with high risk profile or unstable infants are admitted). A third (33%) of all infants received were admitted to NICU. This reflects the tertiary nature of services that are provided by the Wits academic complex of hospitals. Only 12% of infants were admitted directly to the neonatal general ward. Most infants requiring surgical care were admitted to NICU as it provides multidisciplinary care to critically-ill infants. As such, only one infant was admitted directly to the surgical ward. There was also a small group of infants (5%), referred from the MOUs for assessment or opinion of the doctors that were discharged home directly after clinical evaluation. Two infants (2%) arrived in casualty and demised there prior to being transferred to another ward (figure 3.4).

Figure 3.4 Ward of admission



3.5 Composition of inter-hospital transport team

Most infants (92%) were transferred by transport teams comprising only of paramedics - either from a public or private sector institution. This reflected the existing transport protocol for neonates within the public sector. Three infants (3%) were transferred by a doctor/paramedic combination transport team. For five infants (5%) there were no details about who brought the infant to the receiving hospital as there was no formal handover of the patient to the receiving doctor (who completed the study form) which would have disclosed the medical personnel who physically attended the transfer.

3.6 Ambulance services responsible for transfer

A number of ambulance companies were utilised in transporting infants to the various receiving hospitals. Gauteng Emergency Medical Services (the only public emergency medical transport service) was responsible for the single biggest proportion of all the transfers, but this only accounted for only a third (34%) of all transfers. All other emergency transport services were run by private companies i.e. Vosloorus Ambulance Services, Intercity, ER24, Netcare 911, Clinix, and International Medical Rescue (IMR), and these companies were collectively responsible for the majority of transfers (table 3.5).

Table 3.5 Ambulance service responsible for transfer (N=96)

Name of Ambulance Company	Number of infants transported	Percentage (%)
Gauteng Emergency Medical Services GEMS)	33	34
Vosloorus Ambulance Services (VAS)	25	26
Intercity	12	13
Netcare 911	10	10
Clinix	5	5
Emergency Room 24 (ER 24)	5	5
International Medical Rescue (IMR)	4	4
Not specified	2	2

3.7 Clinical diagnosis of infants on arrival at the receiving hospital

Over two thirds (68%) of infants referred, had a respiratory problem stated as the main reason for referral. More than a third of referrals were due to respiratory distress syndrome, followed by pneumonia and meconium aspiration syndrome. Seven infants were referred for a surgical problem, most of who were transferred to NICU. Other diagnoses included neonatal sepsis, perinatal asphyxia, large for gestational age and cardiac problems (Table 3.6).

Neonates referred for surgical care were mainly those who had perforated necrotising enterocolitis – Stage III (3 patients) requiring exploratory laparotomy and two infants had a congenital diaphragmatic hernia, both of whom were admitted to NICU for ventilation. Other surgical infants had an oesophageal atresia unspecified type (1), and an imperforate anus (1).

Table 3.6 Clinical diagnosis of infants made by referring institution

Diagnosis	Number	Percentage (%)
Respiratory distress syndrome	36	38
Pneumonia	16	17
Meconium aspiration syndrome	13	14
Low birth weight	8	8
Surgical condition	7	7
Perinatal asphyxia	4	4
Cardiac problem	4	4
Large for gestational age	3	3
Other	3	3
Neonatal sepsis	2	2

3.8 Mortality

3.8.1 Primary Outcome (Death in the first 48 hours)

Overall, seven infants died in the first 48 hours after transfer; this translates to a 7% mortality for transported neonates. Four babies died out of a total of 37 MOU transfers (11%) and three infants transferred from other hospitals died out of a total of 55 inter-hospital transfers (5%) (table 3.7). Deaths of infants referred from MOUs represented a larger proportion compared to the inter-hospital transfers, but this was not statistically significant (11% vs. 5%, p=0.34).

A sizeable proportion of the deaths (3/7 [43%]) were infants referred from Alexandra MOU, followed by the referrals from private hospitals (2/7 [29%]). One infant who died was of the extremely low birth weight category (800 g). Three deaths (42%) occurred in infants who had respiratory distress syndrome as their primary diagnosis. Other diagnoses included meconium aspiration syndrome (1/7); neonatal sepsis (1/7); perinatal asphyxia (1/7) and pneumonia (1/7).

Infants who demised had cyanosis (6/7), hypotonia (6/7) and hypothermia (4/7) as the three commonest clinical signs on admission (table 3.7).

Table 3.7 Summary of deaths (N=7)

Adverse clinical signs	**Number**	**Percentage (%)**
Cyanosis (oxygen saturation <85%)	6	86
Hypotonia	6	86
Hypothermia	4	57
Hypoglycaemia	1	14
Ambulance service used		
Gauteng Emergency Medical Services	3	43
Netcare 911	3	43
Clinix	1	14
Referring health institutions		
Alexandra MOU	3	43
Private Hospitals	2	29
Mofolo MOU	1	14
Natalspruit Hospital	1	14
Overall rating of infant's status by the receiving clinician		
Poor	5	71
Satisfactory	1	14
Good	1	14

A detailed account of the infants who died before 48 hours is represented in table 3.8. A breakdown of the referring institution, diagnosis of the infant, weight, age and gestational age of the infant at the time of referral is also documented.

Table 3.8 Detailed profile of infants who died within 48 hours of arrival at the receiving hospital (N=7)

Name of referring health institution	Diagnosis	Weight (kg)	Age of the infant	Gestational age (weeks)	Rating of transfer by receiving clinician	Significant clinical physiological parameters	Retrieval team
Alexandra Clinic	Meconium aspiration syndrome	3.2	< 24 hours	40	Poor	Cyanosed (sats = 35%) Floppy Hypothermic (temp 34.5°C) HGT – 6.4 mmol/l	GEMS (paramedic led team)
Sunshine Hospital (Private)	Neonatal sepsis	2.0	6 days	28	Satisfactory	Cyanosed (oxygen sats = 58%) Floppy Temp 37.7°C HGT – 3.6 mmol/l	Netcare 911 - paramedic led team
Alexandra Clinic	Respiratory Distress Syndrome	0.8	<24 hours	27	Poor	Cyanosed (O2 sats = 30%) Floppy Hypothermia (temp 31°C) Hypoglycaemia (HGT = 1.5 mmol/l)	Clinix - paramedic led team
Alexandra Clinic	Respiratory Distress Syndrome	1.4	<24 hours	30	Poor	Cyanosed (O2 sats 80%) Floppy Hypothermia (temp 35°C) HGT – 3.5 mmol/l	GEMS – paramedic led team

Mofolo Clinic MOU	Perinatal Asphyxia	3.7	< 24 hours	40	Poor	Cyanosed (unrecordable sats Floppy Hypothermia (temp 35°C) HGT = 8.3 mmol/l	GEMS – paramedic led team
Glynwood Hospital (Private)	Pneumonia	2.4	6 days	35	Poor	Cyanosed (O2 sats = 55%) Floppy Borderline temperature = 36°C HGT = 14.0mmol/l	Netcare 911 – doctor/ paramedic team
Natalspruit Hospital	Respiratory Distress Syndrome	1.0	<24 hours	29	Good	Not cyanosed (sats 96%) Sedated Normal temperature = 37°C HGT = 3.9 mmol/l	Netcare 911 – paramedic led team

3.9 Physiological status of infants on arrival at the receiving hospital

3.9.1 Cardio-respiratory status

Over a fifth of all infants (21 [22%]) had hypoxia (oxygen saturations less than 85%) on arrival; 18 of whom were clinically centrally cyanosed as well on admission. Three infants were diagnosed with congenital cyanotic cardiac disease - 2 with transposition of the great vessels and 1 with an unspecified cyanotic cardiac disease. Four infants had gasping respiration and two infants had apnoea on arrival. Seven infants presented with a bradycardia at the receiving hospital; one of whom had a diagnosis of congenital heart block. No infant had a cardiac arrhythmia documented on arrival at the receiving hospital (table 3.9)

Table 3.9 Cardio-respiratory status of infants on arrival (N=96)

Cardio-respiratory status on arrival	Number	Percentage (%)
Hypoxia	21	22
Cyanosis	18	19
Gasping	4	4
Apnoea	2	2
Bradycardia	7	7
Tachycardia	2	2
Hypotension	7, n=36	19

3.10 En-route interventions and adverse events

A total of 32 infants were admitted to NICU for intensive care. Most (26 [81%]) of the infants admitted to NICU received intubation and ventilation en-route, while two infants received bag and mask ventilation. Four non-ventilated infants during transfer also qualified for NICU admission (table 3.10).

Table 3.10 Infants admitted to NICU and their mode of ventilation during transfer (N=32)

Mode of ventilation	Number	Percentage (%)
Intubated and ventilated	26	81
Not intubated	4	13
Bag and Mask Ventilation	2	6

Three infants (12%) had a major clinical adverse event during transfer, as they had a dislodged endotracheal tube on arrival at the receiving hospital requiring immediate re-intubation. This was the only adverse event that was documented on the data capturing sheet. Minor adverse events, such as the loss of intravenous access or tissued drip (loss of intravenous access) that occurred en-route, were not captured on the data sheet by the doctors completing the form.

Six infants (7%) received bag and mask ventilation whilst being transferred. Two infants died in casualty and the others went to NICU (2), high care ward (1) and general neonatal ward (1).

3.10.1 Oxygen Administration

Most infants (81/96 [84%]) received oxygen while in transit. There was, however, a small proportion of infants (5/96 [5%]) who were not given oxygen when this was clinically indicated. A third of infants were intubated, while a quarter of infants were offered oxygen via headbox or nasal prongs during transfer, 28% and 24% respectively. A few other methods of oxygen delivery were also used (table 3.11).

Table 3.11 Method of Oxygen Administration during transfer (N=81)

Method of Oxygen Administration	Number	Percentage (%)
Intubated and ventilated	26	32
Head box	23	28
Nasal prongs	19	24
Bag and mask ventilation	6	7
Face mask	5	6
Polymask	1	1
Incubator	1	1

3.11 Cardiac stability on arrival

3.11.1 Heart Rate

Seven patients presented with a heart rate of 100 beats/min or less, four of whom died before 48 hours. One infant had a congenital heart block diagnosed as a cause for the bradycardia (table 3.12).

3.11.2 Blood Pressure

Only 36 infants out of the 96 (38%) that were transported had a blood pressure (BP) measurement done on admission. The majority of infants, 32/36 (89%) who had a blood pressure measurement performed were infants admitted to NICU. Seven infants were hypotensive on admission, based on their mean BP and gestational age, three of whom had an un-recordable BP. None of these infants had inotropic support prior to arrival to hospital. Table 3.13 profiles all the infants who were hypotensive on admission. Four of the seven infants died within the first 48 hours.

Table 3.12 Profile of infants presenting with a bradycardia (heart rate < or = 100b/min)

Patient No.	Heart rate (b/min)	Referring institution	Ambulance company used	Diagnosis	Age of infant (days)	Gestational age (weeks)	Weight (kg)	Death within 48 hrs.
76	0	MOU	GEMS	Perinatal asphyxia	0	40	3.7	Yes
64	30	MOU	Clinix	Respiratory distress syndrome	0	27	0.8	Yes
17	50	Hospital	IMR	Cardiac	1	40	2.4	No
86	60	BBA	GEMS	Respiratory distress syndrome	0	29	1.0	No
88	80	MOU	Netcare 911	Pneumonia	6	35	2.4	Yes
6	87	MOU	GEMS	Respiratory distress syndrome	0	28	0.9	No
41	100	Hospital	Netcare 911	Neonatal sepsis	6	28	2.0	Yes

Table 3.13 Profile of infants presenting with hypotension

Patient number	Mean BP	Death <48 hours	Admission ward	Gestational age (weeks)	Age(days)	Diagnosis
41	0	Yes	Casualty	28	6	Neonatal Sepsis
88	0	Yes	Casualty	35	6	Pneumonia
76	0	Yes	High care	40	0	Perinatal Asphyxia
55	21	No	NICU	28	0	RDS
18	24	No	NICU	30	0	RDS
90	29	Yes	NICU	29	0	RDS
83	30	No	NICU	32	0	RDS

3.11.3 Cardiovascular interventions

Five infants were transferred with some form of inotropic support or cardiac medication administered, four of whom were for NICU admission. Two infants, 2/5 (40%) were receiving prostaglandin E1 (Prostin) to maintain ductal patency. Both infants had transposition of the great vessels - one of these infants was a high care admission and the other one was admitted to NICU. Two other infants were surgical infants and were admitted to NICU, one for necrotising enterocolitis - stage IIIb (according to the modified Bell's criteria) and the other infant had a congenital diaphragmatic hernia. The last infant had respiratory distress syndrome as the referring diagnosis and was admitted to NICU as well. All infants transferred on inotropic support were normotensive (no hypotension documented) on arrival at the receiving hospital.

3.11 Metabolic stability of infants on arrival at the receiving hospital

3.11.1 Blood gas results

Blood gas analyses were done on 52 infants (54%) on arrival where clinically indicated as part of routine clinical management. Only blood gases done within half an hour after arrival were documented. No blood gases were done solely for the sake of the study. Some information was however incomplete especially the bicarbonate and lactate (not included in the summary) (table 3.14).

3.11.2 Temperature on arrival

The mean temperature of infants was of 36.2°C on arrival at the receiving hospital (table 3.14). A total of 20 infants (21%) had hypothermia (temp < 36°C) on admission, four (20%) of whom died within 48 hours of admission (table 3.14).

3.11.3 Blood glucose on admission

Most infants had a normal blood glucose level on admission with a mean of 5.9 mmol/l as measured by the haemoglucotest (Figure 3.14). Thirteen infants (13%) had documented hypoglycaemia (HGT<2.5 mmol/l) on admission requiring intravenous glucose bolus administration (table 3.14).

Table 3.14 Summary of blood gas analysis, temperature and blood glucose of infants at the receiving hospital

Parameter	Number of observations (N)	Mean	Standard deviation (SD)	Minimum (Min)	Maximum (Max)
pH	52	7.25	0.19	6.50	7.55
PaO2 (mmHg)	52	105	60	28	305
PaCO2 (mmHg)	52	43	18	18	83
Bicarbonate (mmol/l)	20	15.5	6.6	5	28
Base deficit	51	-7.7	-7.9	-33.6	6
Temperature (°C)	96	36.2	1.3	31.0	39.0
Blood glucose (mmol/l)	96	5.9	5.1	1.2	34

3.12 Detailed analysis of the clinical metabolic status of infants on arrival

3.12.1 Acidosis

A total of 21/52 infants (40%) had acidosis (pH <7.25) on admission of whom 5 (24%) were severely acidotic with a pH < 7.0. The most common type of acidosis was of a respiratory type in 9/21 infants (43%) followed by a mixed type acidosis at 8/21 (38%) and lastly metabolic 4/21 (19%).

Four of the seven infants who died within the first 48 hours were acidotic on arrival, two of whom had a mixed type acidosis and one each had a metabolic and respiratory acidosis. Mortality was not significantly higher in infants presenting with acidosis on admission (OR=2.75, 95% CI 0.45 - 17.91, p=0.19).Three other infants who died (not included in the tables), had no blood gas analysis done within the first half-hour of admission.

Table 3.15 Infants presenting with severe acidosis (pH<7.0)

Patient N0.	pH	PCO2 (mmHg)	PO2 (mmHg)	Base deficit	HCO3 (mmol/l)	Lactate (mmol/l)	Diagnosis	Admission ward	Death
76	6.50	82	111	-33.6	5	_	Perinatal Asphyxia	High care	Yes
86	6.81	58.5	67.8	-25	_	_	RDS	High care	No
41	6.90	72.7	32.8	-17.7	6	9.9	Neonatal Sepsis	Casualty	Yes
48	6.90	44	125	-19	_	_	Surgical infant	NICU	No
88	6.90	25	45	-28.5	_	_	Pneumonia	Casualty	Yes

3.12.2 Body temperature of infants on arrival

A detailed analysis of infants presenting with hypothermia is presented in table 3.16 below. A total of 20 infants (21%) had hypothermia (temperature <36.0°C). Three quarter (15/20 [75%]) of all the infants with hypothermia were infants from MOUs and brought to hospital by the provincial ambulance service (GEMS). Most (16/20 [80%]) of the retrieval teams who had infants presenting with hypothermia on arrival at the receiving hospital, were also given a "poor" rating by the receiving clinician.

Table 3.16 Profile of infants with hypothermia (temp < 36°C) on admission

Patient No.	Temp on admission	Ambulance service used	Age of infant (days)	Diagnosis	Weight (kg)	Overall rating by doctor	Death before 48 hours
44	35.9°C	GEMS	0	LBW	2.1	Poor	No
67	35.5°C	VAS	0	Pneumonia	2.4	Excellent	No
54	35.5°C	GEMS	1	MAS	3.5	Poor	No
76	35°C	GEMS	0	Perinatal asphyxia	3.7	Poor	Yes
73	35°C	GEMS	0	RDS	1.4	Poor	Yes
91	35.0°C	GEMS	0	MAS	2.8	Poor	No
95	35.0°C	GEMS	0	LBW	1.6	Fair	No
49	35°C	VAS	0	RDS	1.2	Poor	No
12	35°C	GEMS	0	Perinatal asphyxia	1.7	Fair	No
25	35°C	GEMS	0	RDS	1.0	Poor	No
29	35°C	GEMS	0	RDS	1.5	Poor	No

53	35°C	GEMS	0	RDS	1.3	Poor	No
56	35°C	Clinix	0	MAS	2.3	Fair	No
58	35°C	ER24	3	RDS	1.5	Poor	No
7	34.8°C	GEMS	0	RDS	1.1	Poor	No
26	34.5°C	GEMS	0	MAS	3.2	Poor	Yes
6	34°C	GEMS	0	RDS	0.9	Poor	No
64	31°C	Clinix	0	RDS	0.8	Poor	Yes
85	31.0°C	GEMS	0	RDS	0.9	Poor	No
86	31.0°C	GEMS	0	RDS	1.0	Poor	No

Abbreviations: GEMS – Gauteng Emergency Medical Services, VAS – Vosloorus Ambulance Services, RDS-Respiratory Distress Syndrome, MAS – Meconium Aspiration Syndrome, LBW – Low Birth Weight infants.

A comparison was done of the proportion of infants presenting with hypothermia, based on which transport team transported the infants (table 13). Overall, a fifth of all infants arrived hypothermic. Almost half (46%) of infants transported by the provincial ambulance team were hypothermic on arrival, followed by the Clinix ambulance service with 40% (table 3.17). There was a six fold increased mortality at 48 hours in infants with hypothermia on arrival at the receiving hospital, OR = 6.08, 95% CI (1.01 – 39), p=0.03.

Table 3.17 Comparison between infant's body temperature and the ambulance company used (N=96)

Ambulance company name	Total retrievals	Temp < 36°C N (%)	Temp > or = 36°C N (%)
Gauteng Emergency Medical Services	33	15 (46)	18 (54)
Clinix	5	2 (40)	3 (60)
ER24	5	1 (20)	4 (80)
Vosloorus Ambulance Services	25	2 (8)	23 (92)
Netcare 911	10	0 (0)	10 (100)
Intercity	12	0 (0)	12 (100)
IMR	4	0 (0)	4 (100)
Other	1	0 (0)	1 (100)
Not Specified	1	0 (0)	1 (100)
Total	96	20 (21)	76 (79)

3.12.3 Infant's blood glucose level on admission

Thirteen infants (14%) had hypoglycaemia (blood glucose <2.5 mmol/l) on arrival at the receiving hospital; most (9/13 [69%]) had neither intravenous fluids running nor a feed provided prior to transfer. Infants without a drip on arrival at the receiving hospital were significantly more likely to develop hypoglycaemia compared to infants who were either receiving intravenous access or fed prior to transfer (p-value = 0.002). Mortality was not significantly increased on infants with hypoglycaemia, OR = 1.07, 95% CI (undefined), p=0.65).

3.12.4 Rating of the overall transfer process by the receiving clinician

Clinicians were asked to subjectively rate the transfer process made by the different transfer teams, from excellent to poor. I analysed the characteristics of the poor transfer process ratings as assessed by the different clinicians to see if there were any common adverse events that determined the poor rating.

Twenty-two infants (23%) were given a poor rating and table 3.18 shows a trend of adverse events that were frequently associated with the rating score. All the transport teams (3/3) that had the infant's endotracheal tubes dislodged on arrival at the receiving hospital, as an adverse event, were given a poor rating by the receiving clinician. The majority of infants (80%) who arrived hypothermic at the receiving hospital, had their transport team rated poorly, followed by bradycardia and hypoglycaemia (71% and 61% respectively).

Infants transported by the provincial ambulance services (GEMS) had a significantly higher number of infants with a poor rating (16/33), compared to the other transport teams (6/63), OR 8.94, 95% CI (2.72 – 30.76), p < 0.001.

Table 3.18 Infants with a poor rating of the transfer process (N=22)

Item identified/Adverse event	**Total number experiencing the event**	**Number rated poor**	**Percentage (%)**
Dislodged Endotracheal Tube	3	3	100
Hypothermia	20	16	80
Bradycardia	7	5	71
Hypoglycaemia	13	8	61
Acidosis	21	7	33

3.13.1 Summary of clinical adverse events on infants on arrival at the receiving hospital

The audit revealed 123 physiological adverse events, both major and minor. This meant that, on average, retrieved infants suffered at least more than one adverse event at the time of arrival at the receiving hospital.

Table 3.19 Summary of adverse clinical physiological parameters on admission to the receiving hospital

Adverse Event	Number of infants (N=96)	Percentage (%)
Acidosis (pH < 7.25)	21/52*	40
Hypotonia	31	32
Hypoxia (oxygen sats <85%)	21	22
Hypothermia (Temp <36°C)	20	21
Cyanosis	18	19
Hypotension (mean BP < -2sd)	7/36*	19
Hypoglycaemia (glucose <2.5mmol/l)	13	14
Dislodged ETT	3/32*	9
Bradycardia (HR < 100b/min)	7	7

* Denominator indicates number of infants undergoing procedure

3.13.2 Comparison between public and private companies of clinical adverse events experienced by the transported infants.

A direct comparison of adverse events experienced by infants on arrival at the receiving hospital between the private and public ambulance services is presented in table 3.20. Overall, 33/96 (34%) were undertaken by the public service while 61/96 (64%) were done by the private ambulance teams.

When the number of adverse events per patient was used as a way of comparing the provincial and the private ambulance services, the score was 2.4 events per patient vs. 1.0 event per patient respectively. A detailed analysis done showed that documented hypothermia and hypoglycaemia significantly depended on the transport team used to transport the infant with more episodes occurring on infants transported by the public transport team, p-value 0.001 and 0.03 respectively (table 3.21).

Table 3.20 Comparison of the number of adverse events documented on infants between the private and public transport teams.

Adverse event	Total number of adverse events	Private Ambulance companies N (%)	GEMS (Public ambulance service) N (%)
Hypotonia	31	13 (42)	18 (58)
Poor rating by receiving clinician	22	6 (27)	16 (73)
Hypothermia	20	5 (25)	15 (75)
Acidosis	21	15 (71)	6 (29)
Hypoxia	18	9 (50)	9 (50)
Hypoglycaemia	13	4 (31)	9 (69)
Hypotension	7	6 (86)	1 (14)
Bradycardia	7	4 (57)	3 (43)
Gasping	4	2 (50)	2 (50)
Total	**143**	**64 (45%)**	**79 (55%)**

Table 3.21 Comparison of physiological parameters of infants transported by the two ambulance groups on arrival at the referral hospital

Physiological parameter	Ambulance Group	Total number (N)	Mean	Std. Deviation (SD)	P-value
Heart rate	Public	33	131.24	32.59	0.160
	Private	63	140.25	27.91	
Mean Blood Pressure	Public	5	40.00	24.25	0.089
	Private	32	53.56	14.76	
pH	Public	15	7.19	0.25	0.126
	Private	37	7.28	0.16	
Oxygen saturations	Public	33	84.36	22.22	0.217
	Private	63	89.53	17.70	
Temperature	Public	33	35.62	1.53	**0.001**
	Private	63	36.53	0.98	
Blood glucose	Public	33	4.27	2.71	**0.027**
	Private	63	6.70	5.87	

Abbreviations: GEMS – Gauteng Emergency Medical Services

3.14 Predictors of mortality

Infants who presented with hypoxia (oxygen sats <85%) on admission had a statistically significantly higher risk of death before 48 hours compared to infants who had no hypoxia (28% vs. 1%, OR=29.6, 95% CI 3.31-264.0, p<0.001). Infants who were admitted with bradycardia (heart rate <100 beats/min) and those who had hypothermia (temperature < 36°C) also had a statistically significant association with death outcome before 48 hours with OR 38.22, 95% CI (4.42 – 421), p<0.001 and OR = 6.08 95% CI (1.01 – 39), p=0.03 respectively (table 3.22). Infants who had a poor rating by the receiving clinician were ten times more likely to die before 48 hours when compared to infants without a poor rating on admission, OR = 10.59, 95% CI (1.60 – 87.36), p-value = 0.006.

There was no statistically significant relationship between infants who died before 48 hours and birth weight (p=0.56), admission blood glucose (p=0.76), transport team used (p=0.12), referring health institution (p=0.53), clinical diagnosis of the patient (p=0.41), acidosis on admission (p=0.16) or hypoxaemia on admission (p=0.06).

Table 3.22 Probability of death related to the presence of adverse physiological parameters

Clinical Parameter	Total (N)	Death < 48 hrs	Alive at 48 hrs	Odds ratio	95% CI †	p-value
Hypoxia	21	6	15	**29.6**	3.31-264	**< 0.001**
Muscle tone						
- Low	35	6	25	Undefined		0.003
Heart rate						
- Bradycardia (HR< 100 b/min)	7	4	3	**38.22**	4.42 - 421	**0.003**
- Tachycardia (HR> 180 b/min)	2	0	2	0.00	0.00 - 62.93	0.85
- Normal (HR 100b –180b/min)	87	3	84	0.04	0.01 - 0.33	0.001
Temperature						
- Hypothermia (Temp<36°C)	20	4	16	**6.08**	1.01 - 39	**0.03**
- Hyperthermia (Temp >38°C)	4	0	4	0.00	0.00 - 23.91	0.73
Acid-Base Status						
- Acidosis (pH<7.25)	21	4	17	2.75	0.45 - 17.91	0.19
- Alkalosis (pH>7.45)	3	0	3	0.00	0.00 - 20.25	0.67
Blood Glucose						
- Hypoglycaemia (HGT <2.5mmol/l)	13	1	12	1.07	Undefined	0.65
- Hyperglycaemia (HGT >8mmol/l)	14	2	12	2.57	0.30 - 17.92	0.26
- Normoglycaemia	69	4	65	0.49	0.08 - 3.03	0.30
Blood Pressure						
- *Hypotension (Mean BP < -2sd)	7	4	3	**14.67**	1.64 - 165.8	**0.008**
Rating score for the transfer						
- Poor	22	5	17	**10.59**	1.60 - 87.36	**0.006**
- Other rating	74	2	72	0.09	0.01 - 0.62	0.006

* N=36 – Total number of infants undergoing the procedure.

† CI – Wide confidence interval values were noted due to a small study number.

Chapter 4: Discussion

4.1 Summary of findings

Newborn infants aged less than 24 hours (55%), of low birth weight (73%) and mostly preterm (67%), were the main group of infants that were transported within the neonatal period in this study. Most of the transfers were inter-hospital transfers (57%) owing to the nature of services rendered within the three academic hospitals. The provincial ambulance service exclusively transferred infants between MOUs and the hospitals, with almost all inter-hospital transfers performed by privately run ambulance teams.

Transport teams comprised only of paramedics team in the vast majority of cases which was in keeping with trends in other resource poor settings where paramedics form the core of retrieval teams (24;27). By far the most common indication for transferring neonates between the facilities was respiratory problems.

The clinical outcomes of transported infants was disappointing, at best - with over 140 adverse clinical events being recorded on arrival at the receiving hospital and a high mortality rate at 48 hours of 7%. This represents a minimum mortality estimate for the transported group of infants.

4.2 Who gets transferred?

A fifth of all the infant transfers were between the three academic hospitals of the University of Witwatersrand's teaching complex. This group of infants were requiring Intensive Care Unit in a third of cases and almost half of them were admitted to a high care ward. Infants from Midwife

Obstetric Units were admitted mainly at the Johannesburg and Chris Hani Baragwanath hospitals.

Outside of the three academic hospitals, patients were referred from across the Gauteng province and also from the North West province. Due to problems of bed shortages across the different provinces, patients were received from hospitals that fell outside the catchment area designated for the individual hospitals. This trend is not peculiar to South Africa, but is well recognised phenomenon even in the resource-rich countries owing to the regionalization of the intensive care facilities (1;28). Within resource rich settings, there are often well organised systems for undertaking retrievals between the different hospitals as well as the utilisation of dedicated retrieval teams. This is clearly lacking in our setting and individual clinicians at the referring hospital are tasked to organise all the transfer arrangements (1;28).

Over half the neonates transferred were less than 24-hours old, mostly being transferred from MOUs. This finding was in keeping with the protocols for midwives working at clinics and MOUs which are compiled by the provincial health department's mother and child directorate. The protocols differ from one unit to the other but have the same underlying principles, i.e. infants of low birth weight (<2500g), LGA infants (>4000g) or those that are sick (e.g. respiratory distress, perinatal asphyxia or dysmorphic infants etc.), were to be transferred to the nearest neonatal unit for assessment and possible admission (29).

South Africa has a primary health care based strategy in place whereby most basic health services are decentralised to primary health care clinics and only serious or complicated cases are transferred to secondary or district hospitals (29). As part of this plan, uncomplicated obstetric patients are usually managed in primary health care facilities, commonly known as

Community Health Care centres that have midwife-led MOUs. These units are responsible for the management of low risk pregnancy patients from the time of booking in the antenatal period through to delivery and the postnatal care including postnatal contraception and basic neonatal care (29).

Due to the fact that these units are based in the community and are easily accessible to members of the community, they occasionally find themselves dealing with unexpected deliveries of high risk pregnancies at their facilities. These situations arise not by choice but either due to the unavailability of ambulances to transport the patients to nearest hospital timeously or some patients presenting in advanced labour and delivering imminently, which is inevitable. Preterm and low birth weight infants delivered at these facilities are then transferred to the nearest neonatal unit for further management, but unfortunately long delays often result whilst nursing staff try to mobilise emergency medical transport units to transfer these infants to hospital.

This situation sharply contrasts with the setup that currently exists in resource-rich countries where almost all obstetric deliveries are done in hospitals (with the exception of midwife led home deliveries) and only neonates requiring intensive care are transferred to other NICUs by dedicated transport teams (2-4).

Inter-hospital admissions, on the other hand, were mostly for infants older than 24-hours because most of the hospitals have monitoring facilities. Infants were therefore transferred once they required an intensive care admission or paediatric sub-specialist care at tertiary centres. This trend is similar to the retrieval trends elsewhere in the world especially in resource rich countries, where infants are transferred to other critical care facilities with available intensive care beds (2;3).

Respiratory problems of the newborn period were the commonest indication to transfer infants between the facilities. These included a variety of diagnoses causing respiratory distress in the newborn period, i.e. respiratory distress syndrome, meconium aspiration syndrome and pneumonia. There was a tendency for referring centres to label all low birth weight infants with respiratory difficulty as having respiratory distress syndrome and in doing so overestimating the actual number of infants with the diagnosis of respiratory distress syndrome.

Infants referred for sub-specialist care included referrals for paediatric surgical care and infants with cardiac problems referred for management by paediatric cardiologists. In most countries, including South Africa, these specialised services are limited to tertiary academic centres and infants requiring these services are therefore transferred to the dedicated hospitals within the region (24).

4.3 Quality of Transport Services

4.3.1. Transport services for neonates and team composition

This audit revealed that two parallel transport services exist for transporting neonates within the public sector in the Johannesburg metropolitan area. One transport system services infants referred from MOUs to hospital, and are almost exclusively rendered by the provincial emergency services (i.e. GEMS), which mainly provides a Basic Life Support level intervention service. The second transport service is for infants transferred between hospitals, most of whom required high care or intensive care in transit, and this service was predominantly delivered by private ambulance services on behalf of the provincial health department and is predominantly an Advanced Life Support level service.

The transport of neonates and infants was almost exclusively undertaken by a paramedic only team (92%) irrespective of how critical the infant's condition was, or the distance between the hospitals. Only 3% of all retrievals were undertaken by a doctor/paramedic team, which is in sharp contrast to the international trends, where the clinical status on the neonate determines the composition of the transport team to be utilized for the transfer (3; 10). Transport teams in USA and Canada have a well-developed network of neonatal transport personnel that includes Advanced Neonatal Nurse Practitioners (ANNPs) and doctors who are well trained in handling transfers of sick neonates between the different hospitals (3; 4; 5; 8). Europe on the other hand was slow in developing such networks and personnel but currently the use of ANNP led transfers has gained significant momentum especially in the United Kingdom where such transfers have been shown to be more practical and safe (10). As such, the composition of the transport team depends largely on the availability of personnel (either doctor or ANNP) as well as the underlying condition of the neonate to be transported and in some cases it would depend on the scoring system used prior to the transfer of the patient (14; 15), but never a paramedic only team for critically ill infants.

It was, however, difficult to compare and contrast service rendered by the two transport teams (i.e. private and public transport teams), as they managed infants with different medical profiles requiring different levels of clinical interventions in transit. There are currently no agreed standards of the level of clinical care that should be rendered to sick infants in transit (1). The absence of an internationally recognised scoring system for outcomes of transported infants makes it difficult to benchmark a service rendered by a transport team (1). If the parameters that have been utilised by other transport teams elsewhere, especially the Children's Acute Transport Service team in London, are used, one would have to characterise the service provided to local sick infants in transit as 'sub-optimal and a health risk' (1).

Infants retrieved using the provincial ambulance service teams were twice more likely to suffer adverse events compared to the private retrieval teams when one looked at the number of adverse events per infant (2.4 vs. 1.0 adverse events, respectively), but the clinical profile of these patients differed significantly and it was therefore difficult to compare and contrast their quality of service based on the number of adverse events documented. The private ambulance retrieval teams had a number of preventable adverse events that the infants suffered on arrival at the receiving hospital, which was disappointing considering the amount of money spent on financially remunerating such units.

The absence of dedicated retrieval teams within the Johannesburg Metropolitan area and other similar metropolitan areas will continue to hinder advances in the care for sick neonates and infants in transit and their clinical outcomes in intensive care will also be severely adversely affected (5). Heatherill et al showed conclusively that by utilising dedicated retrieval teams for admissions to the paediatric intensive care unit at Red Cross Children's Hospital, they recorded zero clinical adverse events compared to non-specialised retrieval teams utilising only paramedic staff (27).

One should, nevertheless, commend the work done by paramedic staff on a daily basis as they are the core staff for transporting sick infants across the country, but they should be supported by all means possible with further training of their personnel and with technical support whilst working towards having dedicated retrieval teams for intensive care unit transfers.

Some of the issues that have been highlighted by this audit are the lack of clinical skills of personnel required to stabilise neonates prior to transfer, such as the insertion of intravenous lines for newborn fluid management, temperature management measures for infants in transit as well as updating of resuscitation skills. Hadley et al noted from his audit in Durban, almost a decade ago, that simple measures like managing fluid requirements of infants, keeping infants warm in transit and insertion of nasogastric tube neonates requiring surgical care, were some of the issues that needed to be improved upon rather than investing on high technology (24), and this still remains true today.

Utilising advanced neonatal nurse practitioners to help paramedic staff for retrievals might be a practical and cost effective measure in future to try and optimise the quality of service for critically ill infants in transit (10). Advanced neonatal nurse practitioners are a group of trained neonatal intensive care nurses who have experience in NICU, who then undergo special training to update their clinical skills in interventions such as endotracheal intubation and transportation of sick infants (3;10). A study done by Leslie et al in 2003 in the United Kingdom which compared retrievals undertaken by advanced neonatal nurse practitioners and doctor led teams, showed no statistically significant difference when compared to the measured outcomes of transit time, interventions undertaken during stabilisation and physiological variables measured. There was significantly better temperature control of infants on arrival at the receiving hospital as well as superior oxygen saturations for ANNP led retrieval teams compared to doctor led retrievals (10).

In our current setting, one would need to aggressively motivate health authorities and also provide good incentives and training for ICU trained nurses to attract and retain them as transport nurses; bearing in mind that NICU trained nurses are a rare commodity.

4.3.2 Reasons for a poor rating of ambulance services

Provincial ambulance teams were rated more poorly compared to the other retrieval teams, which was disappointing but not unexpected. When one considers the type of patients that were retrieved by the provincial ambulance team were mainly those transferred from clinics and MOUs where little or no pre-transfer stabilisation occurs and hence make these infants more unstable during the transfer process. This often resulted in poor outcomes in the infants on arrival at the receiving hospital. On the other hand, private ambulance teams transferred infants between hospitals after they have been stabilised by the referring hospital doctors. This complicated comparisons between the two retrieval teams as they did not have similar groups of patients. Nevertheless, private ambulance services had on average an infant experiencing at least one adverse event per retrieval, which also raises questions about the quality of care that these units provide to patients.

Other issues that were identified for the poor rating:

- Lack of proper transport equipment especially incubators to safely transport neonates from one health facility to the other. Some infants were brought to hospital on their mother's lap and in some instances in boxes. (This was an added comment on one of the questionnaires). Sontheimer et al. reported in 2004 on Kangaroo Mother Care neonatal transfers of stable preterm and term infants and their preliminary results suggested no compromise in physiologic stability.(30). Further studies are however required to ascertain the safety of Kangaroo Mother Care transfers of ventilated and unstable infants.(30).
- There was an absence of any pre-transfer stabilisation process when patients are transferred from one facility to the other. Dedicated retrieval units in other centres spend a significant amount of time stabilising sick infants prior to transfer as this is

crucial to achieving good clinical outcomes, as well as less adverse events en-route (1; 5; 8; 27). As a result, infants suffer from unnecessary and preventable clinical adverse events such as hypoglycaemia on arrival at the receiving hospital if no stabilisation of the infant occurred.

- Ambulances sometimes lacked essential equipment in transit such as proper oxygen facilities or they ran out of oxygen from the cylinders in transit resulting in infants not getting the required amount of oxygen in transit and thus arriving at the receiving hospital hypoxic. (This was also a comment on some of the questionnaires, where paramedic staff brought an infant to the ward with empty oxygen cylinders).

Within the Johannesburg Metropolitan region there are no dedicated ambulances for transferring newborn infants between the different health facilities. This meant that critically ill infants had to wait for the next available ambulance which often resulted in long delays. This undue delay may invariably lead to further deterioration of the clinical state of the infants (1;6). Unfortunately I could not document the waiting times for ambulance at the different referring health institutions because it was too difficult to co-ordinate the study across multiple sites while being a sole researcher in the project. This, however, presents an opportunity for additional research. It may be worthwhile to study the waiting times as well as the pre-transfer stabilisation process for infants at the different health institutions and to compare these in different provinces in order to fully quantify the magnitude of the problem.

4.3.3. Adverse events commonly experienced by transported infants on arrival at the receiving hospital.

4.3.1 Clinical Adverse events

A number of clinical adverse events were documented when infants arrived at the receiving hospital. The common clinical adverse events documented were acidosis, hypothermia, cyanosis, hypoxia and hypoglycaemia. I also documented 31 infants with hypotonia on arrival at the receiving hospital, but this clinical sign is not a reliable marker of the efficiency of the transport process as it could reflect the degree of prematurity of the infant or effects of the underlying disease or medication given, and hence the finding should be interpreted with caution.

- **Acidosis**

This audit revealed that 21 infants presented with acidosis of varying types. A number of intrinsic and extrinsic factors influence blood gas analysis results, like the presence or absence of hypothermia where it can cause or even worsen the underlying acidosis (30). Studies have also shown that hypothermia inhibits the production of surfactant from the alveoli and hence worsen respiratory distress syndrome and atelectasis which might result in respiratory or mixed acidosis picture on blood gas analysis (31).

- **Hypothermia**

The fact that a fifth of infants were hypothermic on arrival at the receiving hospital, clearly demonstrated the lack of understanding of the special needs of neonates in transit by the transport teams as well as the referring clinicians. Referring clinicians also did not pay enough attention on ensuring that the retrieval teams had appropriate equipment, such as transport incubators, conveniently turning a blind eye to such unacceptable practices.

Several studies have demonstrated conclusively that hypothermia is an independent predictor of mortality in neonates (32). Mortality was observed to be significantly higher by Gunn *et al* in babies of all birth weight groups whose core temperature fell below the optimal temperature for survival (36 to 37 degrees Celsius) (31). Similarly, hypothermic infants in our audit had a six-fold increased risk of dying compared to infants who had a normal temperature on arrival. Lack of proper transport equipment (e.g. transport incubators) for infants has been cited to be one the main causes of this adverse outcome. If I had followed up the infants to discharge or death (rather than for 48 hours only), it may have revealed more infants with an unfavourable outcome including a higher mortality compared to inborn infants (32).

- **Hypoxia**

The third most common adverse event noted on arrival at the receiving hospital was hypoxia. These infants arrived with oxygen saturations below 85%, and may or may not have had cyanosis as well. Five percent of infants retrieved by the provincial services transport team did not receive oxygen in transit where it was clinically indicated. This number could seem small statistically, but is one of the simplest interventions to undertake in transit and the benefits derived are immense. On the other hand, infants retrieved by private ambulance teams had a severe underlying respiratory pathology as a cause for hypoxia rather that some technical fault or omission.

Infants who presented with hypoxia on arrival at the receiving hospital were almost 30 times more likely to die before 48 hours compared to infants with normal oxygen saturations. Heatherill et al found that 26% of all non-surviving infants had hypoxia compared to 86% from our audit. Although our numbers were smaller than the Cape Town audit, this adverse clinical event could potentially be a better indicator for assessing the need for ICU rather than assessing survival, when developing a scoring system for transported infants (27).

- **Hypoglycaemia**

The study documented hypoglycaemia in 13 infants on arrival at the receiving hospital. This occurred twice as often compared to a similar audit by Heatherill et al*,* who documented only 6% of infants with hypoglycaemia (27). Infants who arrived without a drip were statistically significantly more likely to suffer from hypoglycaemia than infants with a drip. However there was no statistically significant association with death before 48 hours. The devastating effects of hypoglycaemia on neonates are well described, including brain injury (33). The effects of hyperglycaemia on the other hand have recently come under a spotlight as well as many intensive care units now strive to have tighter control of the hyperglycaemia in a bid to prevent sepsis in ICU (34). A total of 14 infants were documented to have hyperglycaemia from our audit of whom two died in the first 48 hours.

- **Cardiac instability**

Measures for cardiac instability on arrival of infants included bradycardia and hypotension. Just over a third of infants (37%) had a blood pressure measured on arrival at the receiving hospital, and these were mainly infants admitted to intensive care or high care wards. This finding suggests that the clinical assessment of infants on arrival – whether outborn and inborn infants - is substandard at the very least, since the majority of infants do not have a blood pressure measurement at all unless they require intensive care. How this practice has gone unchallenged for all this time is perplexing. It has seemingly become a norm that only infants who have deteriorated to an extent of needing intensive care will have a blood pressure measured on them instead of doing it as part of routine practice and even in transit. Our audit clearly identified hypotension as a predictor of mortality at 48 hours.

4.3.2. Critical Adverse events

Adverse critical events experienced by infants on arrival at the receiving hospital included a dislodged endotracheal tube requiring immediate re-intubation, and infants who required immediate resuscitation and/or cardiopulmonary resuscitation. All infants who required immediate re-intubation were still alive at 48 hours, but only one of the four infants who were gasping on arrival and required resuscitation, survived to 48 hours.

One can debate the reasons why an unstable infant was transferred, but the current approach used by paramedic personnel especially from MOUs is that of 'scoop and go'. The American Academy of Paediatrics states that "a transport team must be able to rapidly deliver intensive care management from the bedside at the referring hospital and maintain that level of care throughout the journey until the infant is handed over to the intensive care unit staff"(8). If this principle was the reference standard used to benchmark health care service, our documented practice would be considered to be grossly substandard.

4.4. Mortality

Mortality in this audit was 7%. Further analysis of the deaths revealed that all but one of the infants retrieved were of a viable gestational age (>28 weeks gestation) and birth weight (>1000g), based on local standards of care. This mortality rate in the first 48 hours after admission to the receiving hospital does not consider the final outcome of the infant as some infants demised after 48 hours of admission. It was difficult to specifically ascertain whether the deaths were solely due to sub-optimal care of the infant in transit or due to the underlying disease. To do this would require comparison of outcomes of inborn vs. outborn infants and the details of physiological parameters in transit. Neither of these data was available.

All but one of the non-survivors had more than one clinical adverse event at the time of arrival at the receiving hospital. It was difficult to predict if the deaths would have occurred had extra care been taken in transit. Using dedicated transport teams for retrievals markedly improves outcome of infants on arrival at the receiving hospital (27). This makes a strong case for using dedicated transport teams when transporting sick young infants between health facilities in order to achieve good clinical outcomes for transported infants irrespective of maternal social circumstances (1; 2; 5; 27).

4.5 Predictors of Mortality

A number of negative clinical physiological parameters were identified on arrival at the receiving hospital that positively predicted mortality outcome - including hypoxia, bradycardia, hypotension and hypothermia. Infants who presented with a bradycardia at the receiving hospital were 38 times more likely to die within 48 hours of admission to the hospital, followed by hypoxia (OR 29.6), bradycardia (OR 14.67), a poor clinician rating (OR 10.59) and hypothermia (OR 6.08).

Some adverse events, though not positive predictors of mortality in our audit, do cause significant morbidity in sick young infants and thus should be prevented at all costs. These include hypoglycaemia and acidosis (14,32). There are other important parameters that could influence clinical outcomes of transported infants as evaluated by the Mortality Index of Transported Infants scoring system (i.e. MINT score) (14). These parameters include birth weight of the infant, gestational age and presence or absence of congenital abnormalities amongst others, as they have been shown to influence the outcomes of infants in intensive care units (14-17). This audit failed to show a statistically significant relationship for these indicators with death probably because the sample size was small.

It was quiet interesting that poor rating for the transfer process was a predictor of mortality since this was based on the individual clinician or nurses assessment of the transfer process. One would however need to explore this in a greater detail in a qualitative review, as to what different nurses and doctors use as a benchmark for the quality of a transfer process.

4.6 Study limitations

The study design was cross-sectional and depended on reporting by the receiving clinician or a nursing sister which may have imposed some observer bias.

Sampling was convenience based rather than consecutive as some of the retrieved infants did not have the required clinical parameters documented immediately after arrival at the receiving hospital (i.e. within half-hour of arrival at the receiving hospital) and hence these infants were excluded.

I relied heavily on the assistance and cooperation of busy nursing and medical staff to complete arrival data forms, since I could not be at all the data collection points when a new infant arrived. This obviously may have influenced the completeness and/or accuracy of data collection. This also restricted the total number of infants that were recruited for the study and therefore influenced statistical outcomes.

The sample size was smaller than initially anticipated which increased the chance of a type II error for some of the statistical analyses. Wide confidence intervals were observed when doing univariate statistical analysis due to small sample size.

This research project had originally proposed to study a number of other important aspects of neonatal transport that I could not add or complete, such as the condition of ambulances and their equipment and the skills and training of paramedic transport personnel, owing to time constraints. The availability of this type of data would have increased my ability to critically interpret the available data.

Another limitation was the difficulty I experienced with regard to accessing data of the infant at the time of referral, and also the waiting time prior to referral. I was therefore not be able to conclusively determine if any parameters changed whilst in transit and whether the change was due to transport mishaps or due to the underlying medical condition.

4.7 Conclusions

- Transport of sick newborn infants within the Johannesburg Metropolitan area like other resource poor settings remains risky and uncoordinated, as evidenced by the number of adverse events that were documented on arrival at the receiving hospital.

- A number of physiological adverse events were documented that positively predicted mortality at 48 hours for transported infants which included hypoxia, hypothermia amongst others.

- A lack of appreciation of the special needs of transported sick young infants such as the importance of temperature control, supplemental oxygen therapy and glucose control mechanisms resulted in a high morbidity and mortality.

- Retrieved infants had poor outcomes as a result of the lack of dedicated neonatal/paediatric transport teams. Proper training of personnel as well as proper pre-transfer stabilisation of infants are priority interventions needed.

- Infants retrieved using public transport teams had a higher rate of adverse events documented compared to the private retrieval teams, although they dealt with different patient clinical acuity profiles.

4.8 Recommendations

- The Gauteng Health Department should strive to establish dedicated transport teams for infants within the Johannesburg Metropolitan region since this has been shown to significantly improve the clinical outcomes of transported infants in intensive care units in other settings.
- Special training of the current paramedic staff on important issues to consider in transit when transporting sick young infants e.g. fluid and temperature management in transit as well as basic non-invasive ventilatory support for infants etc. still remains a key intervention in the short term as was suggested a decade ago.(22)

- Utilising transport teams led by neonatal trained nurses with vast experience in managing sick newborn infants might be critical in addressing the current need for skilled transport team personnel, similar to the Advanced Neonatal Nurse Practitioner type personnel used in the resource rich countries. This should be a long-term goal for the department of health in Gauteng.

- Major funding from both the national and provincial health departments is needed to establish and sustain transport team networks for them to be able to function optimally.

- Centralisation of intensive care beds allocations within the metropolitan regions is required in the mid to long-term period, so that the sickest patients are prioritised with intensive care bed allocation. This will ensure that an appropriate retrieval unit is dispatched for the infant in order to address the inequities that currently exist with bed allocations in intensive care units for sick neonates.

- Clinical assessment of infants in High Care should also be improved upon and as a routine should include a blood pressure measurement on all infants on arrival, not only those who require Intensive Care Unit care.

- Infants (especially from MOU or clinics) with difficult intravenous access should at least be given the first feed prior to transfer, if not clinically contraindicated, as feeding or intravenous fluid administration significantly reduced hypoglycaemic episodes on infants on admission.

- Further research is required about the value of using Kangaroo Mother Care during the transport of stable and sick newborn infants as a means of ensuring clinical stability for infants in transit especially in resource poor settings.

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Appendix A – Information sheet

Information Leaflet for prospective study

Research Project: The Quality of Neonatal inter-facility transport systems within the Johannesburg Metropolitan region.

Good day, my name is Dr M. D. Thwala (Paediatric Registrar) from the University of Witwatersrand medical school, Division of Community Paediatrics.
I would like you to consider enrolling your baby to this research study titled, the quality of Neonatal Inter-facility transport systems within the Johannesburg Metropolitan region.
Before agreeing to participate, it is important that you understand the purpose of the study, the study procedures, benefits, risks, discomforts, and precautions as well as the alternative procedures that are available to you, and your right to withdraw from the study at any time. If you have any questions, do not hesitate to ask me. You should not agree to take part unless you are satisfied about all the procedures involved. If you decide to take part in this study, you will be asked to sign this document to confirm that you understand the study. You will be given a copy to keep.

The purpose of the study is to look at how babies are transported in Johannesburg and the condition in which they are transferred to hospital and the general use of transport facilities from the MOUs. We will only review basic clinical observations on the medical records of babies when they are referred to hospital. There will be no testing done only for the purposes of the study and hence the study does not pose any risk to your baby. There are no financial incentives to be received from doing the study.

There are no benefits to you or your child for being in this study. But the study will have great benefits towards understanding transport of neonates in Johannesburg and will lead to improvements of the system of transporting babies in future. The study will be undertaken at five different surrounding MOUs. All babies that have been transferred from MOUs to any of the three academic complex hospitals (i.e. Chris Hani Baragwanath, Coronation and Johannesburg General hospitals) are enrolled.

Participation in the study is completely voluntary and your refusal to enroll your baby in the study will not affect the quality of treatment that your baby receives from the hospital.
You may withdraw your consent at any time during the study should you decide to do so.

All information obtained will be kept strictly confidential by the researchers and any patient identifiable information will be kept under lock and key to be used solely for the purpose of follow up of patients.

This clinical study protocol has been submitted to the University of the Witwatersrand, Human Research Ethics Committee (Medical) and a written approval has been granted by this committee.

If you require any other source of additional information regarding your rights and that of your child, please contact Prof Cleaton-Jones, Chairperson of the University of Witwatersrand Human Research Ethics Committee (Medical) on 011 717 2229.

For any other questions regarding the study, please feel free to ask me anytime, my contact numbers are 082 3802 816 (24hours) or 011 481 5196 (office hours).

Appendix B - INFORMED CONSENT FOR PARENTS/LEGAL GUARDIANS

I have been provided with a copy of the participant information leaflet and consent regarding clinical study, The quality of Neonatal Inter-facility Transport systems within the Johannesburg Metropolitan region. The risks, benefits and purpose of the study have been fully explained to me.

- I have been given the opportunity to ask any questions concerning the study.
- It has been explained to me that I will be free to withdraw my child from the study at any time, without any disadvantage to future care.
- I have understood everything that has been explained to me and I consent for my child to participate in this clinical study.

PARENT/LEGAL GUARDIAN:

____

Printed Name Signature / Mark or Thumbprint Date and Time

STUDY DOCTOR:

____

Printed Name Signature Date and Time

TRANSLATOR/OTHER PERSON EXPLAINING INFORMED CONSENT:……………………………………(DESIGNATION):

____

Printed Name Signature Date and Time

WITNESS (If applicable)**:**

____

Printed Name Signature Date and Time

Appendix C

New transfer arrival form

Dear colleague:

- The Department of Community Paediatrics is undertaking research into neonatal interfacility transport in order to improve the clinical state in which babies arrive at the receiving hospitals.
- We will be grateful if each receiving doctor (intern/ medical officer/ registrar) would complete the questionnaire.
- If a doctor is not available when the baby arrives, the sister can complete the form.
- This project has been approved by the Wits Human Research Ethics Committee (Medical).
- Confidentiality of patient information will be maintained by the researchers.
- All completed forms will be collected by the researcher (Dr M.D. Thwala).

A. Patient Details

Initials: __________
Hospital Number: ____________
Date of Birth: /_____/2007

Please circle the appropriate response(s)

B. Referral Details

Name	Question	Codes
H001	Name of receiving Hospital	1=Chris Hani Baragwanath 2= Coronation 3=Johannesburg General
H002	Referring Health institution	1=MOU 2=Hospital Name...
H003	Ambulance company	1=Provincial 2=Clinix 3=Intercity 4=ER24 5=Netcare 6=Other..................................(specify)
H004	Diagnosis/Reason for referral *(mark all appropriate answers)*	1=Hyaline Membrane Disease 2=Meconium Aspiration 3=Pneumonia 4=Neonatal Sepsis 5=Surgical (detail: ....) 6=Low birth weight 7=Birth Asphyxia 8=Other.............................(specify)
H005	Gestational Age (estimate)	.... weeks
H006	Weight	_ _ _ _kg
H007	Ward admitted to	1=NICU 2=High Care /Transitional care 3=Neonatal ward 4=Surgical ward 5=Other..........................(specify)
H008	Date of Admission	/ /2007
H009	Who brought the baby to hospital	1= Paramedic 2= Nurse 3= Doctor 4= Driver only 5= Don't know

C. **Condition of the baby on arrival**

Name	Question	Codes	
H101	General appearance	1=Blue/Cyanosed 2=Pink in room air 3=Gasping 4=Apnoeic	
H102	Muscle Tone	1=Lethargic/Floppy	2=Vigorous
H103	Oxygen Saturation on arrival (%)		
H104	Heart Rate (rate /min)		
H105	Axillary Temperature (˚C)		
H106	HGT/ Blood glucose (mmol/l)		
H107	Systemic Blood Pressure (if available)	_ _ _/_ _ _	
H108	Arterial Blood Gas (within ½ hour if available)	pH= pCO2= mmHg pO2= mmHg BE=	

D. **En-Route Interventions**

Name	Question	Codes
H201	Intubated	1=Yes 2=No
H201.1	If yes, mode of ventilation	1=Ventilated (ventilator) 2=Nasal CPAP 3=Manual bagging 4= Other……………….(specify)
H202	Oxygen Administered	1= Yes 2=No 3=Not indicated
H202.1	Method of oxygen administration	1=Head Box 2= Polymask 3=Facemask 4=Nasal Prongs 5=Other…………….(specify)
H203	Inotropes	1=Yes 2=No
H204	Intravenous line in situ	1=Yes 2=No
H205	Type of fluid infused	1=Non-K 2=Neonatalyte 3=5% Cocktail 4=Other……………….(specify)
H206	Was baby fed prior to arrival	1=Yes 2=No 3=Do not know

E. **Transfer outcome**

Name	Question	Codes
H301	Rate the overall condition of the transfer (based on the baby's condition)	1=Excellent 2=Good 3=Satisfactory 4=Poor
H302	Outcome (leave blank for the researcher to fill)	Death within 48 hours 1=Yes 2=No Ward baby admitted to 1= NICU 2=Neonatal ward 3=surgical ward 4=other (specify)

Appendix D Wits Ethics clearance form

UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG

Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Thawala

CLEARANCE CERTIFICATE **PROTOCOL NUMBER M070910**

PROJECT The Quality of Neonatal Inter-Facility Transport Systems within the Johannesburg Metropolitan Area

INVESTIGATORS Dr MD Thawala

DEPARTMENT Department Paediatrics

DATE CONSIDERED 07.09.28

DECISION OF THE COMMITTEE* APPROVED UNCONDITIONALLY*

Unless otherwise specified this ethical clearance is valid for 5 years and may be renewed upon application.

DATE 07.10.30 **CHAIRPERSON** ....
(Professors PE Cleaton-Jones, A Dhai, M Vorster, C Feldman, A Woodiwiss)

*Guidelines for written 'informed consent' attached where applicable

cc: Supervisor : Dr RM Mphahlele

DECLARATION OF INVESTIGATOR(S)

To be completed in duplicate and ONE COPY returned to the Secretary at Room 10005, 10th Floor, Senate House, University.
I/We fully understand the conditions under which I am/we are authorized to carry out the abovementioned research and I/we guarantee to ensure compliance with these conditions. Should any departure to be contemplated from the research procedure as approved I/we undertake to resubmit the protocol to the Committee. **I agree to a completion of a yearly progress report.**

PLEASE QUOTE THE PROTOCOL NUMBER IN ALL ENQUIRIES