NEONATAL MORTALITY AT LERATONG HOSPITAL

Jean-Claude Moundzika-Kibamba

Student number: 395732

A research report is submitted to the Faculty of Health Sciences, University of the Witwatersrand, Johannesburg, in partial fulfilment of the requirements for the degree

of

Master of Sciences in Child Health

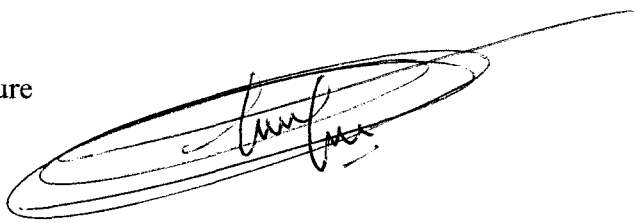
Johannesburg, 2016

DECLARATION

I, Jean-Claude Moundzika-Kibamba declare that this research report is my own work.

It is being submitted for the degree of Master of Sciences in Child Health at the University of the Witwatersrand, Johannesburg.

It has not been submitted before for any degree or examination at this or any other University.

Signature 

Date: 4th February 2016

DEDICATION

To God the Father Almighty

For nothing is impossible to Him.

I am grateful for who God is in my life and for what He has done.

Affectionately to my wonderful wife Roselyne:

You are the gift of God in my life. I thank you for the blessings which I have received through you.

I am grateful for your support and encouragement.

May this work give you joy to see this dream come to pass.

To my children Claude-Mary, Mathurin and Nathan:

Sharing this moment with you is what my heart desires so you may be brave and strong for every challenge, obstacle, and difficulty that you will overcome with God's presence.

In memory of my parents:

Marie Malongo

Albert Moundzika-Kibamba

ABSTRACT

Background: Leratong Hospital is a regional hospital in the West Rand of Johannesburg, South Africa. Statistics from maternity in 2008 showed high utilisation rates for delivery services at Leratong but a study on neonatal mortality was not yet done. It was therefore essential to measure and analyse the causes of newborn deaths so as to have policies to advance neonatal care.

Objectives: To determine the neonatal mortality rate (NMR), the major neonatal causes of death and the occurrence of avoidable health factors.

Methods: This was a prospective review of the clinical records of the 46 neonates who died within the 3 month period (15th April 2013 to the 15th July 2013). Data was obtained from neonatal admission and death registers. Information on the number of live births was obtained from labour ward registers. Delegation books for nurses were checked to determine the number of nursing staff per shift as well as their allocation in different rooms. Neonate's age, birth weight, gender, race, place of origin, reason for admission and cause of death, were analysed. Health factors examined were access to high care services and to the neonatal ICU, number of staff on duty and the use of treatment guidelines. Questionnaires were used to collect information, and the consent to use clinical records was obtained from the mothers. Descriptive statistics were used to describe the frequencies and percentages of variables. Logistic regression of variables was applied to predict mortality.

Results: The overall neonatal mortality rate at Leratong Hospital was lower than the rates found in South Africa and other studies in sub-Saharan Africa. Almost 37% of neonates died within 24 hours of admission. The three most common causes of death were: prematurity (39%), perinatal asphyxia (26%) and infection (20%). More than sixty per cent of deaths occurred in the admission room. Three-quarters of neonates who died (74%) were low birth weight neonates. A critical staff shortage (nurse: neonate ratio≥ 1:10) was the most common modifiable factor (63% of deaths). Thirty seven per cent of neonates were denied access to ICU. The significant predictors of neonatal death were being born preterm (OR: 3.1, 95% CI 1.7-6.0), extremely low birth weight (OR: 27.5, 95% CI 8.2-92.6), very low birth weight (OR: 5.0, 95% CI 2.1-12.3) and birth by caesarean section (OR: 3.2, 95% CI 1.6-6.2).

Conclusions: The study found the neonatal mortality rate at Leratong Hospital in 2013 to be lower than rates recorded in South Africa. Our results showed that the most common causes of neonatal mortality were similar to those in other hospitals in sub-Saharan Africa and in South Africa. A high number of neonatal deaths were avoidable by providing high care services (including NCPAP and surfactant) and adequate number of nurses trained in newborn care in the admission room, improving access to neonatal ICU, early detection of perinatal asphyxia and improved neonatal resuscitation, and the supervision of medical doctors.

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Lastly but not the least, my high regard is sent to the statistician Cornelius Nattey for his assistance in the data analysis.

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NOMENCLATURE

- Live birth: birth of an infant who shows postnatal evidence of life.
- Birth weight: weight of an infant at birth.
- Low birth weight: birth weight less than 2500g regardless of gestational age.
- Very low birth weight: birth weight less than 1500g.
- Extremely low birth weight: birth weight less than 1000g.
- Preterm: infant born alive before 37 weeks of gestation. Based on gestational age, preterm birth is divided into: extremely preterm (<28 weeks), very preterm (28- 32 weeks) and moderate to late preterm (32- 37 weeks).
- Prematurity- related death: death of a preterm due to complications of its immaturity (e.g. extreme multi-organ immaturity, respiratory distress syndrome, intraventricular haemorrhage).
- Perinatal asphyxia: asphyxia of the newborn during labour, delivery, or immediate postnatal period. Complications of perinatal asphyxia include: hypoxic ischaemic encephalopathy, meconium aspiration, persistent pulmonary hypertension of the newborn.
- Neonatal sepsis: bacterial infection in the blood of the neonate. The clinical presentation is often non-specific. Neonatal sepsis is divided into: early- onset (infection occurring in the first 5 days of life) and late- onset (infection occurring after 5 days of life).
- Congenital abnormalities: Structural or functional anomalies that occur during intrauterine life and can be identified prenatally, at birth or later in life.
- Neonatal period: commences at birth and ends 28 completed days after birth.
- Neonatal mortality rate (NMR): number of neonatal deaths per 1000 live births. NMR is divided into early (ENMR) and late neonatal deaths (LNMR).

- Early neonatal mortality rate (ENMR): neonatal deaths 0-7 days per 1000 live births.
- Late neonatal mortality rate (LNMR): neonatal deaths 8-27 days per 1000 live births.
- Perinatal care index: calculated as perinatal rate divided by low birth weight rate. It is a measure of the quality of care; the higher the index the poorer the care. The index should be below 1 for community health centres and below 2 for all hospitals.

  Pattinson RC, editor. Saving Babies Report 2008-2009
- The perinatal period: begins at 22 completed weeks (154 days) gestation and lasts seven days after birth.

  International Statistical Classification of Diseases and Health Problems, Tenth Revision. 1992
- Perinatal mortality rate (PMR): stillbirths and deaths in the first week of life per 1000 live births.
- Primary cause of death: condition that initiated the chain of events leading to the infant's death e.g. immaturity.
- Final cause of death: final event that claims the infant's life e.g. sepsis.

ABBREVIATIONS

APH: Antepartum haemorrhage

ELBW: Extremely low birth weight

FA: Foetal abnormalities

HT: Hypertension

Inf.: Infections

IPA+T: Intra-partum asphyxia and birth trauma

IUGR: Intra-uterine growth retardation

LBW: Low birth weight

MD: Pre-existing medical conditions

MDG: Millennium development goal

NCPAP: Nasal continuous positive airway pressure

PMR: Perinatal mortality rate

PPIP: Perinatal problem identification programme

SAPA: South African Paediatric Association

SD: Standard deviation

SGA: Small for gestational age

SPTB: Spontaneous preterm birth

VLBW: Very low birth weight

WHO: World Health Organization

CHAPTER 1

1.0 INTRODUCTION

Each year there are an estimated 3.6 million neonatal deaths globally [1]. These deaths are mostly in low-income countries, but neonatal mortality and morbidity is also a problem in high-income countries [1, 2]. Almost 41% of the 9.7 million deaths occurring in children under the age of five happen in sub-Saharan Africa [3]. Over 70 neonates die daily at hospitals and clinics in South Africa [4].

Information on the cause of death is lacking for 98% of the world's 4 million neonatal deaths that occur in countries with inadequate vital registration [5]. South Africa is one of the few developing countries to have a national confidential inquiry into maternal deaths, with 164 health facilities obtaining audit data for stillbirths and neonatal deaths [6]. Deaths during the first seven days of life account for 88 % of South African neonatal deaths [4].

In a Lancet article [5] based on data from 193 countries, the major causes of neonatal deaths in the year 2008, were estimated to be preterm birth complications (12%), birth asphyxia (9%), sepsis (6%) and pneumonia (4%). In addition, it highlights the lack of reliable data on the causes of death in the settings in which most neonatal deaths occur.

Ngoc *et al* [7], found that prematurity was the main cause (62%) of early neonatal deaths in six WHO collaborating centres in Argentina, Egypt, India, Peru, Viet Nam and South Africa. They also found that maternal health contributes to neonatal outcomes. Spontaneous preterm delivery (29%) and hypertensive disorders (24%) were the most common obstetric events leading to perinatal deaths. Velaphi *et al* [8], at Chris Hani Baragwanath Academic Hospital

reported that the survival rates were lower at 26 weeks' gestational age (38%), than at 27 and 28 weeks' gestational age (50% and 65% respectively).

In South Africa, preterm deaths represent more than 36% of neonatal deaths, followed by perinatal asphyxia (32%) and infections (14%) [9-10].

Poor survival in neonates admitted to Chris Hani Baragwanath Academic Hospital was linked to premature birth in association with very low birth weight, but was also related to limited resources, especially the lack of mechanical ventilation [8]. The Saving Babies Report 2006 [9] also found that most avoidable factors were health system-related. These include the unavailability of health services and the lack or poor implementation of programmes and protocols for pregnant women and newborns. Over a 6-year audit at Frontier Hospital, Queenstown in South Africa, Patrick [11] reported that medical personnel-related avoidable factors occurred in about 50% of perinatal and neonatal deaths.

The World Health Organization had set a target to reduce the child mortality (under 5 years) rate by two-thirds by the year 2015 (Millennium Development Goals: MDG-4) [12-13]. However, South Africa has not achieved this goal. Therefore, it is important to measure the neonatal health outcomes.

Newborns are still dying around the world and the majority of which happens in sub-Saharan Africa. In order to reduce under-5 mortality and especially neonatal mortality, many audits have been done in the areas of mortality rates, where and why newborns died, and what actions are needed to improve their survival.

1.1 Newborn deaths in the World

Of the 130 million babies born every year, about 4 million die in the first 4 weeks of life - the neonatal period [14, 15].

In an updated systematic analysis for 2010 with time trends since 2000, Liu *et al.* found that of 7.6 million deaths in children younger than 5 years in 2010, 40.3% (3.072 million) occurred in neonates. In 2013, 2.8 million neonates died within the first month of life, which represents about 44% of all under-five deaths. While, the number of neonatal deaths has declined, progress has been slower than for the overall under-five mortality rate [16].

Preterm birth complications (14.1%; 1.078 million), intra-partum related complications (9.4%; 0.717 million), and sepsis or meningitis (5.2%; 0.393 million) were the leading causes of neonatal death [17].

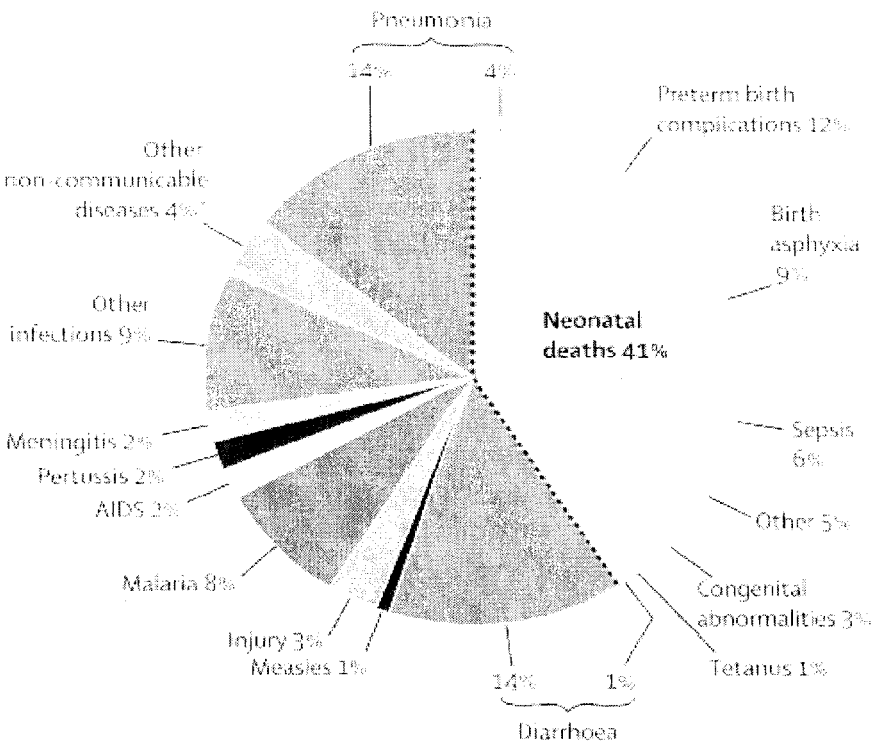

Figure 1.1.1 Global causes of deaths separated into deaths of neonates aged 0-27 days and children aged 1-59 months [5]

Worldwide the number of newborns who die every day is still high. Zupan *et al* [15] have reported that three-quarters of neonatal deaths happen in the first week after birth. Furthermore, information on the causes of deaths is reliable in countries with adequate vital registration. Owing to inadequate vital registration data in some countries with high mortality, estimation using the multi-cause model for neonatal deaths is the only option [14, 18].

It is estimated that 18 million newborns have a low birth weight (birth weight <2500g) every year - half in South Asia [19]. In addition low birth weight is an important population indicator for tracking neonatal health and includes neonates born preterm (<37 completed

weeks of gestation) and neonates with intrauterine growth restriction [20]. The primary causes of low birth weight are preterm birth, intra-uterine growth retardation (IUGR) or the combination of the two [14, 21].

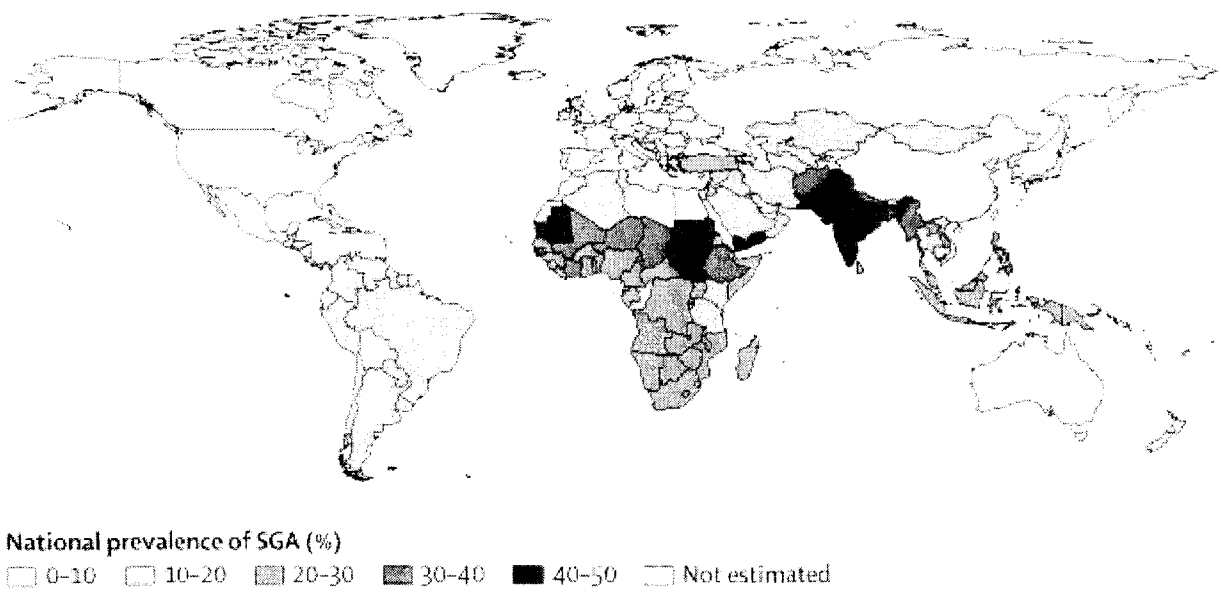

Figure 1.1.2 Estimated prevalence of small for gestational age (SGA) births in 138 low-income and middle-income countries for the year 2010 [22]

Analysing the mortality risk in preterm and small-for-gestational-age newborns in low-income and middle-income countries, Katz *et al.* reported that neonatal mortality rates and relative risks increased with decreasing gestational age across studies and regions [23].

Action was needed in reducing deaths in the first week of life in order to achieve the MDG-4.

1.2 Situation of newborn deaths in sub-Saharan Africa

Nearly 4.7 million mothers, newborns, and children die each year in sub-Saharan Africa: 265,000 mothers die due to complications of pregnancy and childbirth [24]; and 1,208,000 babies die before they reach one month of age [25]. However, the causes of deaths vary between and within countries.

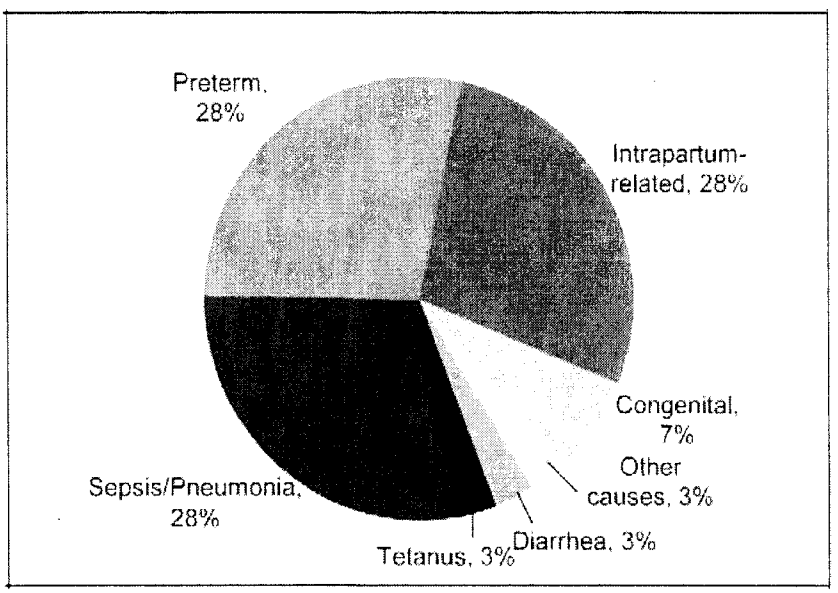

Figure 1.2.1 Causes of newborn deaths in sub-Saharan Africa [26]

In 2010, an estimated 43.3 million newborns (36% of live births) were either preterm or small for gestational age, or both in countries of low and middle income (Figure 1.2.2) [22]. Of 18 million low-birth weight newborns, 59% were term but small for gestational age (SGA), whereas 41% were preterm (16% preterm-SGA, 25% preterm and appropriate size for gestational age (AGA)) [22].

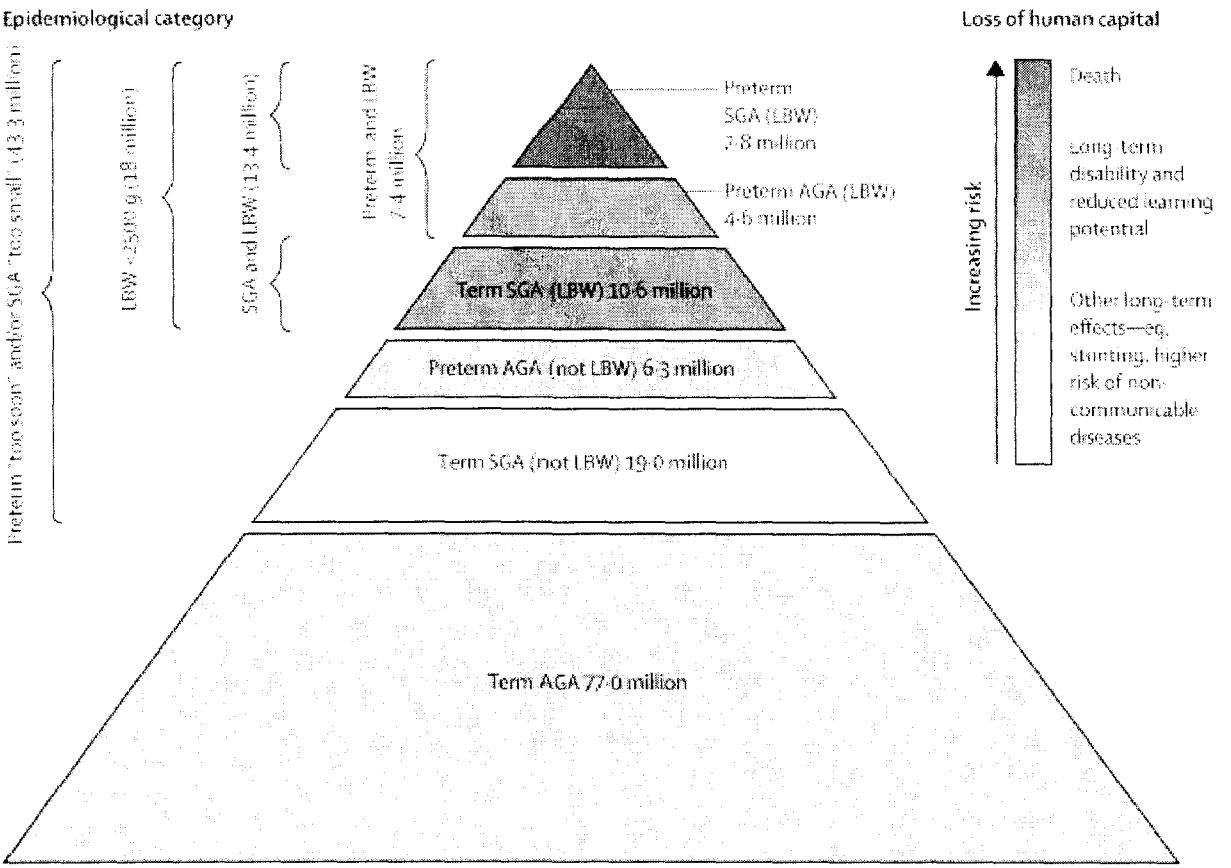

Figure 1.2.2 Public health implications of the burden of preterm and SGA births for 120 million births in countries of low and middle income [22]

AGA= appropriate for gestational age. SGA= small for gestational age. LBW= low birth weight

In sub-Saharan Africa, although preterm birth rates were similar to those in South Asia, the rate of low birth weight newborns was lower (14%) and preterm birth made a relatively larger contribution to the low birth weight metric (57% preterm birth *vs.* 43% term-SGA) [22].

Some countries have already reached or surpassed the MDG-4 target (67 % reduction): Cape Verde, Eritrea, Mauritius, Seychelles, Botswana, Malawi, Liberia, Tanzania, Ethiopia, and Niger [24, 27].

Newborn deaths are not only due to direct causes, but also due to local factors.
In a recent study that assessed the interventions which are effective in reducing intra-partum-related neonatal deaths in low- and middle-income countries, Wall *et al* [28] concluded that the coverage of effective interventions is low and many opportunities are missed to provide quality care within existing health systems. In addition, recent health services assessments found only 15% of hospitals equipped to provide basic neonatal resuscitation in sub-Saharan Africa [28].

Call for actions to improve newborn survival has been at the centre of many studies. One of the most effective interventions is to ensure sufficient human resources. However, globally the workforce for health is in crisis [29, 30]. Chen *et al* [30] advised the need for personnel planning and management system that ensures satisfactory terms of employment, appropriate training, supportive supervision, and career pathways as a way to address the lack of skilled health professionals and supportive supervision which are among the reasons for poor resources.

1.3 Newborn deaths in South Africa

South Africa has an unacceptably high infant mortality rate, with neonatal deaths accounting for 35-40% of all deaths of children younger than 5 years [31 - 33]. Important reduction had occurred in neonatal mortality, which was at a rate of 15 per 1000 live births in 2013, although the rate was higher in comparison with other countries of similar socioeconomic status [34]. South Africa is also one of the countries which have not reached the Millennium Development Goal's 2015 deadline to reduce child mortality by two-thirds [31].

Trends in neonatal mortality rates in South Africa have shown little improvement [35-39]. However, the 2013/2014 inpatient ENMR was 10.1 per 1000 live births, a marginal decrease from 10.2 per 1000 live births in 2012/2013 [38].

According to the Saving Babies report (2012-2013), there were 1,412,355 births in the public sector, of which 14576 were early neonatal deaths [40].
Deaths during the first seven days of life account for 88 % of South African neonatal deaths [4]. Prematurity related neonatal deaths is more common in the 500g or more group but hypoxia related deaths is more common in the 1000g and above group [10, 41].

Pattinson in 2003 using PPIP, reported that out of the 8085 perinatal deaths of newborns weighing 1000g or more, the low birth weight rate (LBWR) was high in all groups, but especially in the metropolitan group (19.69%), followed by the city and town group (16.5%) and the rural group (13.09%) [42].

In the Eighth and Ninth reports on perinatal care [40, 41], health care provider related factors accounted for 44% of early neonatal deaths due to hypoxia, and merely 19% of early newborn deaths due to prematurity.

In the same reports on perinatal care [40, 41], administrative problems contributed to 17% of deaths due to hypoxia, and to 22% of fatalities due to prematurity.

1.4. Leratong Hospital profile

Leratong Hospital is a public-sector regional hospital in the West Rand region of Gauteng that renders secondary level health services. It is a referral centre for two district hospitals (Dr Yusuf Dadoo Hospital and Carltonville Hospital), for 41 primary health care clinics and 2 Maternal Obstetric Units (Mohlakeng and Bekkersdal), and for private hospitals and general practitioners in the region.

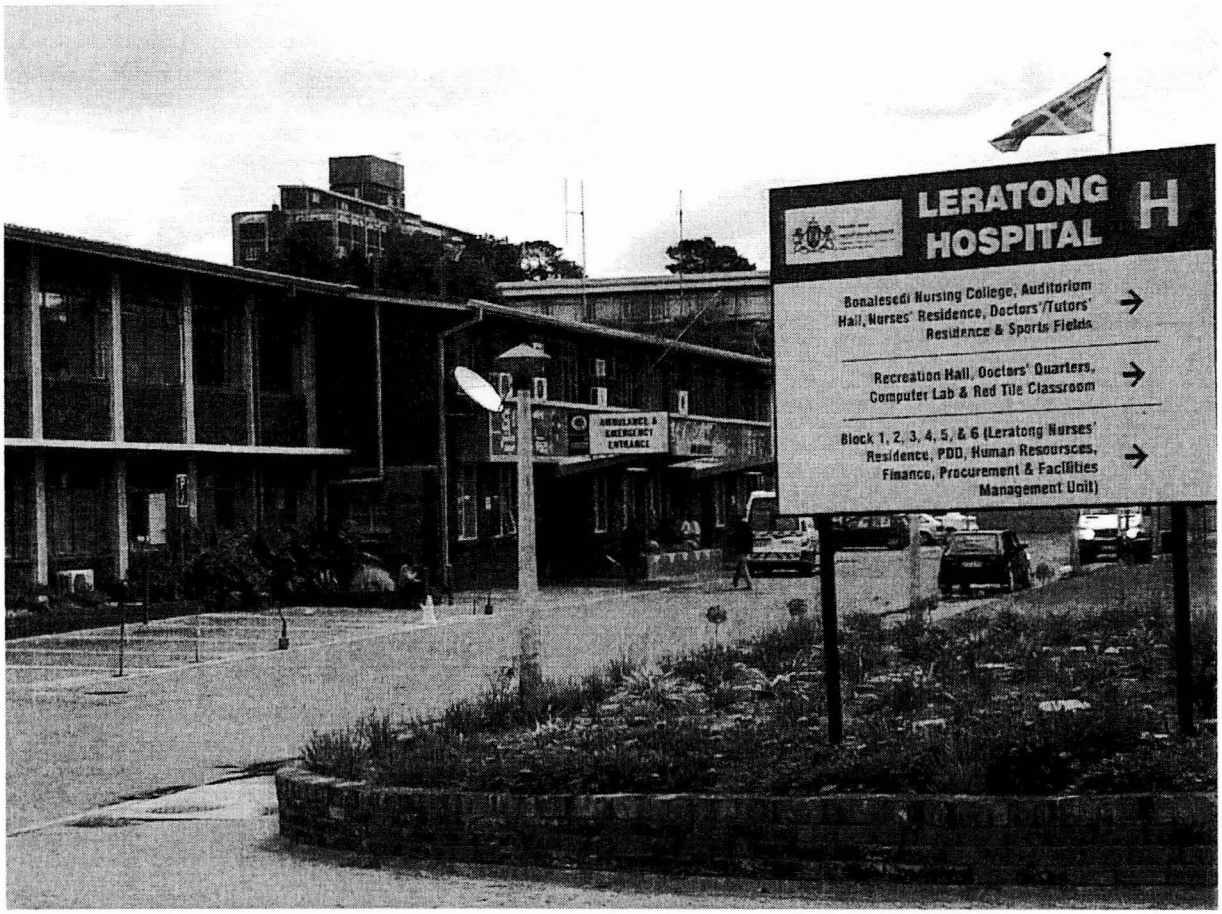

Figure 1.4.1: Leratong Hospital

The hospital is a site for PPIP and Child PIP.

Neonatal care that is delivered in this hospital includes: General care (GC), Intermediate care (IC), Kangaroo Mother Care (KMC), High care (HC) and Intensive care (ICU).

The neonatal unit was designed to admit 37 neonates, but during the study period it accommodated an average of 55 neonates per day for the whole 3 months.

The Neonatal Intensive Care unit (NICU), which has four beds and two ventilators, has been operational since 2000.

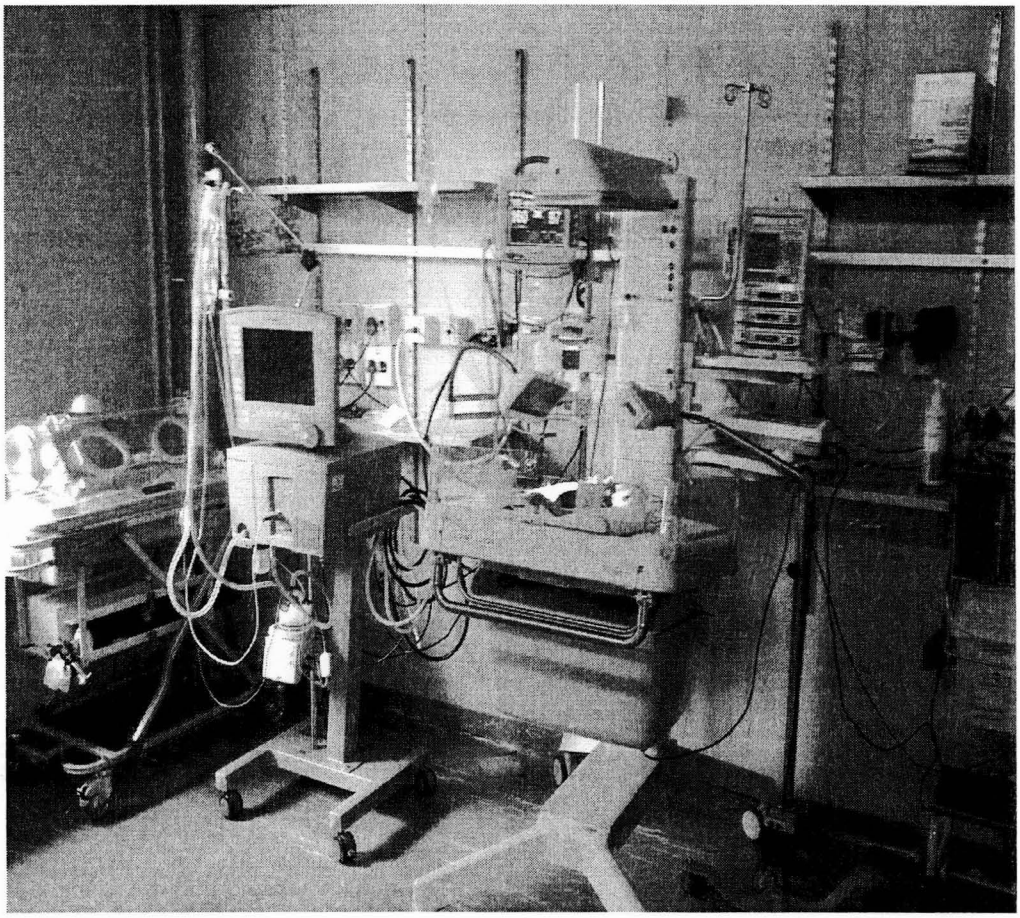

Figure 1.4.2 Neonatal ICU

The Kangaroo Mother Care (KMC) unit was opened in 2005 and can accommodate nine newborns with their mothers.

The admission room has ten beds, but it admitted an average of sixteen newborns per day during the study.

In 2009, another room (low care) was opened to deal with stable newborns. It has nine incubators and eight cribs.

The mixed room admits neonates from home and also serves for isolation of suspected or confirmed septic neonates. It has six approved beds, but an average of nine neonates admitted per day.

The medical personnel comprised a Principal Paediatrician (Head of the Department), a junior qualified paediatrician who resigned before the study, two medical officers caring for the neonatal ward, and one medical officer for neonatal intensive care unit and kangaroo mother care unit. After a three-month rotation in the neonatal wards, the medical officers then move to another paediatric ward. Two interns spend one-month in the neonatal ward before they move to another paediatric ward.

The nursing personnel in neonatal wards per shift included an area manager, two senior professional nurses, two professional nurses, and four staff nurses. The nurse to neonate ratio was one Nurse to eight neonates in the General Care and Intermediate Care, one Nurse to nine neonates in KMC, and in NICU there was one Nurse to two neonates.

There were no national guidelines on the staff norms for newborn services. However, the norms and standards for newborn services in Limpopo which were based on the document "Health Plan for Neonatal Care" produced by the 1997 Perinatal Priorities Conference, and which were broadly used, recommended the nurses per shift as follows: Professional nurse (PN) with NICU training in charge, 1 PN per 3 High Care newborns, 1 nurse per 6 newborns in Intermediate Care and KMC [13].

The unit lacked sufficient neonatal equipment including cardiac monitors, oxygen saturation monitors, infusion pumps, cribs, incubators, nasal continuous positive airway pressure (CPAP machines), and ventilators.

Data for Leratong Hospital for 2008 showed that 6847 newborns weighing more than 1000g were delivered; 6743 were live births and 104 were still born. The Perinatal Mortality Rate (PMR) was 23.22 per 1000 live births; the Early Neonatal Mortality Rate (ENMR) was 8.15 per 1000 live births which was similar to the national ENMR (8.9/1000) and the Neonatal Mortality Rate (NMR) was18 per 1000 live births.

Statistics from Leratong maternity in 2008 showed high utilisation rates for delivery services, but a study on neonatal mortality has not yet been done.

1.5 Overall aims of the study

The aims were to describe the causes of neonatal deaths and to identify health services factors associated with neonatal deaths at Leratong Hospital during the period from the 15th April 2013 to the 15th July 2013.

1.6 Objectives

The objectives of the study were divided into primary and secondary.

1.6.1 Primary objectives:

- To determine the neonatal mortality rate at Leratong Hospital.
- To determine the major causes of neonatal deaths.

1.6.2 Secondary objectives:

- To describe the demographics of all neonates (0 to 28 days of life) who died within the study period.
- To identify health service factors associated with these deaths.

CHAPTER 2

2.0 MATERIALS AND METHODS

2.1 Study design:

A prospective descriptive study was conducted over a 3 month-period (from the 15th April 2013 to the 15th July 2013), which reviewed the clinical records of neonates who died at Leratong Hospital. Data on the number of deaths (which was used as numerator for determining the neonatal mortality rate) was obtained from the neonatal admission and death registers, as well as paediatric outpatient and emergency areas, labour ward and casualty registers. The number of live births (which served as denominator during the study period) was obtained from labour ward registers. Inborn mortality rate was calculated from the deaths and births at Leratong only and not included the other hospitals. For NMR, the denominator reflected live births for the West Rand region. The major causes of neonatal deaths were categorised using the Saving Babies 2008-2009 classification [35]. Structured questionnaires were used to collect information on: demographic status, maternal information, birth history, causes of death and health services identifiable factors which included missed opportunities for good care (e.g. absence of neonatal ICU bed) and examples of substandard care (e.g. not following treatment guidelines).

2.1.1 Population:

All neonates born and/or admitted to Leratong Hospital (NICU, neonatal unit, or KMC) from the 15th of April 2013 to 15th of July 2013.

2.1.2 Sample:

All neonates who died at Leratong Hospital (NICU, neonatal unit, or KMC) from the 15th of April 2013 to the 15th of July 2013.

2.1.3 Site:

The study was conducted in the Neonatal Unit at Leratong Hospital.

2.1.4 Inclusion criteria:

- All neonates who died at Leratong Hospital during the study period.
- Neonates born before arrival and outside Leratong Hospital.

2.1.5 Exclusion criteria:

- Neonates whose mothers did not give consent.
- Patients where records could not be traced.

2.1.6 Data collection tools:

Questionnaires were designed and used to collect data:

Data capture sheet (Appendix A) had a study number and the file number. It contained the information on: neonate, mother, delivery, admission, record keeping, cause of death, health modifiable factors, and duration of stay.

Information on data capture sheets was based on data collected using PPIP, Child PIP data on neonatal deaths, and the Chris Hani Baragwanath Academic Hospital Neonatal admission form.

The nurse per shift sheet (Appendix B) was used to have the number of the nursing staff in the neonatal unit for both day and night shifts.

The neonate per shift sheet (Appendix C) was designed to collect the number of neonates present in the neonatal unit during day and night shifts.

An equipment check list (Appendix D) was used every Wednesday to check the working condition of the available equipment.

The consent form to use clinical information (Appendix E) was a modified version of the Chris Hani Baragwanath Academic Hospital Neonatal Unit version [43].

2.2 Study procedures

The study was a prospective review of the clinical records of all neonates who died within the 3 month-period at Leratong Hospital. Data was obtained from neonatal admission and death registers. For neonates who died in Paediatric Outpatient and Emergency areas, labour ward and Casualty, information was obtained from respective registers. A study number was used instead of names on all forms, and identifiers were kept separately. Information obtained from the registers remained confidential. From Monday to Friday, the researcher stayed after hours to check the registers for all new deaths. For neonates who died during the night, the researcher checked registers in the morning, and for those that died during the weekend when he was not on duty, registers were reviewed on Monday. Information on the number of live births during the study period was obtained from labour ward registers and West Rand District [45]. Delegation books for nurses were checked to determine the number of nursing staff per shift, as well as their allocation in different rooms.

All the information was captured on a data capture sheet with parameters on the mother, neonate, and staffing.

In the absence of national neonatal care guidelines, the following guidelines were used:

- The South African Paediatric Association (SAPA): Neonatal Resuscitation,
- Limpopo Initiative for Newborn Care (LINC): Norms and standards for Newborn Services, as well as
- Chris Hani Baragwanath Academic Hospital Neonatal Protocols,
- Kangaroo Mother Care standard policy and
- National PMTCT guidelines.

The quality of neonatal care was assessed using the following criteria [9]:

- Staffing (availability of doctors and nurses),
- Critical equipment items (CPAP devices, ventilators, resuscitation bag, laryngoscope, cardiac monitor, gases machine, and pulse oximetry),
- Drugs used (Penicillin G/ Ampicillin, Gentamicin/ Amikacin, and Nuelin), and
- Referral to neonatal ICU/tertiary hospital.

For each cause of death, the following health services factors were examined:

- Facilities: Presence/absence and availability of the CPAP, ventilators.
- Human resources: number and experience of doctors and nurses on duty, and
- Health care provider: appropriate/inappropriate use of drugs, adequate/inadequate record keeping.

Health services identifiable factors are defined as conditions where deaths could be avoided through the actions of the health system and included: Health care workers and administrative factors.

In this study, health care worker is a person who renders neonatal services (doctors and nurses).

Junior medical doctors (JMO) included community service doctors and medical officers of less than 5 years of work experience. They received basic neonatal resuscitation training.

On the other hand senior medical officers (SMO) had more than 5 years of work experience and were trained in basic and advance neonatal resuscitation.

Nursing personnel included: neonatal trained professional nurses and staff nurses.

Administrative factors [41] are those directly influenced by the health system and included staff and facilities.

2.3 Statistical analysis:

Data was entered into an MS Excel (2007) spread sheet and statistical analysis was done using the Epi Info software programme (Centres for Disease Control and Prevention, CDC, USA).

Continuous variables (e.g. weight) were expressed as mean (standard deviation) or median (interquartile range), while categorical variables (e.g. male or female for the variable sex) were summarised using frequencies and percentages.

Logistic regression was conducted on a univariate level to identify the predictors of neonatal death. Variables with significant (p-value of 0.05) prediction of death were then entered into a

multiple logistic regression analysis. Results were expressed as odds ratios (OR) with corresponding *p*-values and 95% confidence intervals.

2.4 Ethical considerations:

Permission was granted by the Gauteng Health (Director, West Rand District Council) to conduct the study, and the hospital management authorized the use of registers to collect information.

Consent to use clinical records, was obtained from the mothers.

The Human Research Ethics Committee (Medical) of the University of the Witwatersrand (Clearance Certificate: M120867) approved the study.

CHAPTER 3

3.0 RESULTS

3.1. Characteristics of the inborn neonates

There were 1962 total live births at Leratong Hospital during the study period 15th of April 2013 to the 15th of July 2013. Sixty two per cent (62.5%) of the newborns were delivered by normal vaginal delivery, and most newborns were black (99.2%).

Most neonates (83.2%) had a birth weight above 2500g, with two hundred and ninety three neonates (15%) classified as low birth weight (LBW), twenty nine (1.5%) were very low birth weight (VLBW), and seven (0.3%) had extremely low birth weight (ELBW). Similar numbers were found for gestational age (Table 3.1.1).

Table 3.1.1 Characteristics of the inborn neonates

Characteristic	n	%
Total deliveries	1962	
Gender		
• Male	977	49.8
• Female	985	50.2
Race		
• **Black**	**1946**	**99.2**
• Indian	10	0.5
• White	6	0.3
Month of delivery		
• April (15- 30)	364	18.5
• May	662	33.8
• June	654	33.3
• July (1- 15)	282	14.4
Mode of delivery		
• **Normal vaginal delivery**	**1227**	**62.5**
• Caesarean section	735	37.5
Gestational age		
• < 28 weeks	7	0.3
• 28- 32 weeks	29	1.5
• 32- 36 weeks	293	15
• >37weeks	**1633**	**83.2**
Birth weight		
• 500- 999g	7	0.3
• 1000- 1499g	29	1.5
• 1500- 2499	293	15
• >2500g	**1633**	**83.2**

3.2 Characteristics and other information for admitted neonates

There were 380 admissions to the neonatal unit of which 256 (67.4%) were inborn patients.

A third of the total admissions came from home (110 neonates), or from another facility (14 neonates). There were 196 (51.6%) term neonates. Eighty per cent of all neonates were delivered by normal vaginal delivery. Fifty per cent of the patients were low birth weight. About half the neonates were admitted to the unit for less than 7 days (Table 3.2.1).

Table 3.2.1 Admissions and deaths per category

Description	Admissions n=380	Deaths n=46	Deaths per category (%)
Place of origin			
• **Leratong (inborn)**	**256**	**35**	13.7
• **Home**	**110**	5	4.5
• Dr Yusuf Dadoo	8	3	**37.5**
• Carletonville	3	2	**66.7**
• Private	2	-	
• CH Baragwanath	1	1	**100**
Gender			
• Male	**202**	22	10.9
• Female	178	**24**	13.5
Gestational age			
• Term	196	13	6.6
• **Preterm (<37 weeks)**	184	**33**	**17.9**
○ <28 weeks	15	10	**66.7**
○ 28- 32 weeks	41	11	26.8
○ 32- 36 weeks	128	12	9.4
Mode of delivery			
• **Normal vaginal**	**306**	**27**	8.8
• Caesarean section	74	19	**25.7**
Birth weight			
500- 999g	15	10	**66.7**
1000- 1499g	41	11	**26.8**
1500-2499g	132	13	9.8
>2500g	**192**	12	6.2
Duration of stay			
<1 day	37	**19**	**51.3**
1-3 days	71	8	11.3
4-7 days	101	11	10.9
8- 28 days	**171**	8	4.7

3.3 Neonatal mortality

Of the total number of admissions, the main reasons for admissions were prematurity-related diseases (37.9%), perinatal asphyxia (26.8%), and neonatal jaundice requiring phototherapy (12.6%), infections (10%), and congenital abnormalities (1.1%) (Table 3.3.1)

Table 3.3.1 Reasons for admissions and deaths

Description	**Admissions**		**Deaths**		**Deaths per**
	n=380	%	n=46	%	**category** (%)
Prematurity- related	**144**	**37.9**	**18**	**39.1**	12.5
Perinatal asphyxia	**102**	**26.8**	**12**	**26.1**	11.8
Neonatal jaundice	48	12.6	-		-
Infections	38	10	**9**	**19.6**	**23.7**
Congenital abnormalities	4	1.1	4	8.7	**100**
Other	44	11.6	3	6.5	6.8
Total	380	100	46	100	

A total of 46 neonates died (12.1% of total admissions) during the study period (Table 3.2.1). The highest number of deaths was in neonates born at Leratong Hospital (76%). Forty one per cent (41.3%) of them died within 24 hours of admission. Their mean age was 5 days (sd ± 5.8 days).

Of the total deaths, twenty eight per cent (28%) of patients that died were between 1500-2499g, followed by 26% in the 2500g weight category, and a quarter of the deaths were in the category of neonates weighing <999g. Their mean weight was 1824.5g (sd ± 29).

Seventy four per cent of deaths were early neonatal deaths with the higher proportion occurring in the group of neonates with a weight >1500g. Their mean stay was 113.6 hours (sd ± 19) (Table 3.3.2).

In the death per category, seventeen per cent deaths were in the premature, a quarter of deaths were delivered by caesarean section, sixty six per cent neonates were in the 500- 999g, and half of the neonates died in the category of those admitted for less than a day (Table 3.2.1).

Table 3.3.2 Deaths in each birth weight category

Weight	**Births** n=380	**Deaths** (n=46)		**Death per category (%)**
		END n=34	**LND** n=12	
500-999g (ELBW)	15	8	2	**66.7**
1000-1499g (VLBW)	41	7	**4**	26.8
1500-2499g (LBW)	132	**9**	**4**	9.8
>2500g	192	10	2	6.2

Mortality was higher (63%) in the admission room (Room 1), followed by the Neonatal ICU (15.2%), and labour ward (10.9%).

Table 3.3.3 Place of death and nurse: neonate ratio

Place of death	**Deaths** n=46	%	**Nurse: neonate ratio**
Neonatal admissions*	**29**	**63**	**≥1: 10**
NICU	7	15.2	1: 2
Labour ward	5	10.9	1: 4
Mixed neonates #	4	8.7	1: 10
Low care ¥	1	2.2	1: 8
Total	46	100	

* Admission room for all neonates from Leratong labour ward and theatre, as well as those transferred in from other hospitals

Admits neonates from home and isolation room

¥ Low care (stable neonates and awaiting weight gain)

3.4 Mortality rates

The inborn mortality rate at Leratong Hospital during the study period was 17.8/1000 live births, with the early neonatal mortality rate (ENMR) at 14.8/1000 live births, and the late neonatal mortality rate (LNMR) was 3.0/1000 live births.

NMR during the study was 15.5/1000 live births.

NMR at Leratong Hospital for the year 2013, was 13.7/1000 live births.

3.5 Causes of deaths

Prematurity-related (39%), perinatal asphyxia (26%), infection (20%), congenital abnormalities (9%), and other (6%) were the most common causes of death (Figure 3.5.1 and Table 3.5.1).

Two thirds of the 20% of deaths due to infections were attributed to late onset sepsis. Four were culture positive with the most common organism being *Coagulase Negative Staphylococcus* (2) which is usually considered a contaminant, followed by *Klebsiella Peumoniae* (1), and *E.Coli* (1). Thirty three per cent were culture negative, but the clinical parameters were suggestive of sepsis (low white cell count, low platelets and raised C-reactive protein).

In 4 neonates, congenital abnormalities were noticed. One had a diagnosis of Down syndrome, and subsequently died from prematurity-related cause. The 3 cases of gross abnormalities incompatible with life, that were associated with death included an infant with malformed

head and limbs, anencephaly associated with club feet and absent hands, and ectopia cordis. These infants were not resuscitated or offered life-sustaining support.

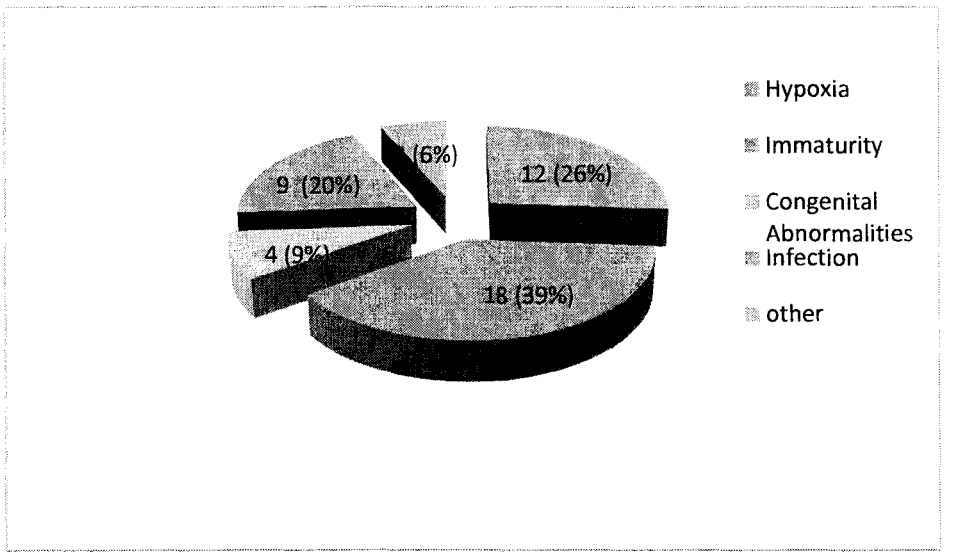

Figure 3.5.1 Causes of deaths at Leratong Hospital during the study period

Table 3.5.1 Details of the causes of deaths

Description	**Deaths**	
	n=46	% of group
Prematurity-related	**18**	
• **Extreme multi-organ immaturity**	**9**	**50**
• Respiratory distress syndrome	6	33.3
• Pulmonary haemorrhage	2	11.1
• Intraventricular haemorrhage (grade III/IV)	1	5.6
Perinatal asphyxia	**12**	
• **Hypoxic ischaemic encephalopathy (stage II/III)**	**10**	**83.3**
• Persistent pulmonary hypertension of the newborn (PPHN)	2	16.7
Infection	**9**	
• **Sepsis** (2 contaminants with *Coagulase Negative Staphylococcus* /laboratory or clinical suspicion)	**7**	**77.8**
• Nosocomial infection (*Klebsiella Pneumonia*)	1	11.1
• Meningitis (*E.Coli*)	1	11.1
Congenital abnormalities	**4**	
• **Gross congenital abnormalities**	**3**	**75**
• Down syndrome	1	25
Other	**3**	
• Aspiration pneumonia	1	33.3
• Other	2	66.7

3.6 Health services factors associated with death

Insufficient number of nursing staff was the first most common identifiable factor associated with the death of a neonate in our unit, followed by limited medical staff, and lastly inadequate facilities.

3.6.1 Health care worker related factors

In two-thirds of deaths (63%) the nurse and neonate ratio was more than one to ten. In addition during day and night shifts, there was an average of one neonatal trained professional nurse in the admission room (Table 3.3.3).

The study also found a limited number of medical staff per call (1 medical doctor with 1 intern) on both week days and weekends in 19.6% of deaths. The reasons cited for medical personnel associated factors were:

- Doctor was busy in NICU: 1
- Neonates deteriorated and doctor was called too late: 2
- Neonates were not seen on time by doctor: 3
- Neonates had infection but blood culture was not checked: 3

Junior medical officers (JMO) and senior medical officers (SMO) attended to the majority of neonates who died: 47.8% and 45.7% respectively.

The unit's treatment guidelines were followed in most of the neonates that died (82.6%) and drugs were also appropriately prescribed (74%).

Forty per cent of the blood results were checked. In the remaining sixty per cent, blood results were not in the file at the time of death. For example: electrolyte imbalance which could have been corrected, and a blood culture sensitivity which could have influenced the choice of the antibiotic (Table 3.6.1).

Table 3.6.1 Medical-provider associated factors

Description	**Deaths**	
	n=46	%
Neonates seen by a consultant during hospitalization	8	17.4
Health worker who attended to neonate at the time of death:		
• JMO	22	47.8
• SMO	21	45.7
• Nursing Sister	3	6.5
Guidelines observed	38	82.6
Results checked	19	41.3
Drugs prescribed appropriately	34	74

3.6.2 Administrative related factors associated with deaths

The most common identifiable administrative factors related to death were insufficient number of staff, lack of ICU bed, and inadequate facilities.

Table 3.6.2 Common administrative factors

Administrative problems	n	%
Inadequate facilities/equipment in neonatal unit/nursery	2	4.3
No accessible neonatal ICU bed with ventilator	17	37
Lack of adequate neonatal transport	2	4.3
Insufficient nurses on duty to manage the patient adequately	29	63
Insufficient doctors available to manage the patient	9	19.6
Personnel too junior to manage the patient	22	47.8

3.7 Logistic regression analysis of predictors of mortality

At the univariate level, 4 factors were linked to neonatal death, namely preterm delivery (OR: 3.1; 95% CI: 1.7- 6.0), extremely low birth weight (OR: 27.5; 95% CI: 8.2- 92.6), very low birth weight (OR: 5.0; 95% CI: 2.1- 12.3), and caesarean section (OR: 3.2; 95% CI: 1.6- 6.2).

In the multivariate model, the most important predictors of mortality were birth weight (OR: 27.3; 95% CI: 7.9- 94.3), and caesarean section (OR: 3.3; 95% CI: 1.6- 6.8) (Table 3.7.1).

Table 3.7.1 Logistic regression analysis of predictors of mortality

	Univariate			Multivariate		
Variable	Unadjusted Odds ratio	95% CI	P value	Adjusted Odds ratio	95% CI	P value
Gender						
Male	1					
Female	1.2	0.6- 2.2	0.541			
Gestation age						
Term	1					
Preterm	**3.1**	**1.7- 6.0**	**0.001**			
Delivery						
Normal vaginal	1					
Caesarean	**3.2**	**1.6- 6.2**	**0.001**	**3.3**	**1.6- 6.8**	**0.000**
Birth weight						
>2500g	1					
500-999g	**27.5**	**8.2- 92.6**	**0.000**	**27.3**	**7.9- 94.3**	**0.000**
1000-1499g	**5.0**	**2.1- 12.3**	**0.000**	**4.6**	**1.9- 11.5**	**0.001**
1500-2499g	1.4	0.6 -3.1	0.443	1.2	0.5- 2.7	0.709
Diagnosis						
Prematurity	1.3	0.5- 3.7	0.600			
Hypoxia	0.9	0.3- 2.7	0.823			
Jaundice	0.1	0.0- 1.3	0.079			
Infection	1 (omitted)					
Congenital abn*	1 (empty)					
Other	1 (empty)					
Room						
NICU	1 (omitted)					
Room 1	0.8	0.3- 2.0	0.675			
Room 2	0.2	0.0- 0.8	0.020			
Room 13	0.1	0.0- 0.9	0.043			
KMC	1 (empty)					
Labour ward	1 (empty)					
Senior supervision						
Supervised	1 (omitted)					
Not supervised	0.8	0.3- 1.9	0.593			
Admission time						
Day	1					
Night	1.7	0.9- 3.2	0.089			
Duration of stay						
<1 day	1(omitted)					
1-3 days	0.2	0.1- 0.5	0.001			
4-7 days	0.2	0.1- 0.4	0.000			
8-28 days	0.1	0.0- 0.2	0.000			

*congenital abnormality

CHAPTER 4

4.0 DISCUSSION AND CONCLUSIONS

4.1 Discussion

This prospective study provided the causes of neonatal deaths as well as health factors which should be addressed to avoid these deaths.

The overall neonatal mortality rate at Leratong Hospital in the year 2013, was lower than the rates found in other studies in sub-Saharan Africa [26, 31, 35, and 36] and in South Africa (15/1000 live births in 2013) [32- 34]. The neonatal mortality rate (NMR) was 13.7/1000 live births, which was similar to the NMR at Central and Eastern Tshwane district (13.6/1 000 live births) in 2011[44], but it was higher compared to the rate in the West Rand region (8/1000 live births).

The deaths in the region for 2013, were 128 of which three-quarters were reported at Leratong Hospital (98/128; 76.6%), sixteen at Dr Yusuf Dadoo Hospital, thirteen at Carletonville Hospital and one death at Bekkersdal West CHC [45].

All neonatal admissions were mostly inborn neonates and inter-hospital referrals compared to those who came from home. The total live births in facility in the West Rand region for 2013, were 16150 of which 813 (5%) were admitted in a neonatal ICU. Forty four per cent of live births occurred at Leratong Hospital (7154 live births), followed by Dr Yusuf Dadoo Hospital (4256 live births), Carletonville Hospital (2434 live births), Bekkersdal West CHC (931 live births), Mohlakeng CHC (748 live births) and Khutsong CHC (627 live births) [45].

The demographic information of neonates who died showed that the mean age was 5 days. There was a predominance of female neonates as opposed to male in all admissions, which was contrary to male predominance for both admissions and deaths in the results by Hoque [10]. Similarly, low birth weight of neonates (<2500g) accounted for higher rates of admissions and deaths in both studies.

Our results revealed that the most common causes of neonatal mortality were prematurity-related, perinatal asphyxia, infection and congenital abnormalities and were in keeping with the literature [1, 2, 5, 9, 10, 35 and 40]. Prematurity and asphyxia represent more than 65% of all admissions and deaths, like in the sixth, seventh and ninth Saving Babies' Reports [9, 35, and 40].

As expected the period of death was no different to previous studies [4, 7, 31], in that most of our neonates died within their first 7 days of life (17.3/1000 live births), and in 37% of cases death occurred within 24 hours of admission similar to that reported by Zupan *et al* [15] and by Statistics South Africa in 2015 [46]. Although the duration of the research was 3 months, it was sufficient enough to conclude that many neonates still died in one of the regional hospital in South Africa [35].

With regard to the gestational age, preterm birth was the highest reason for admission (54.4%) and mortality (39%). We also found that premature and low birth weight neonates had a high mortality which was likened to the Hoque and Katz studies [10, 23]. Low birth weight neonates represented nearly 74% of our deaths, identical to what was seen in many developing countries with limited resources [14, 18, and 21]. In China, the incidence of low birth weight has increased [47].

On a univariate logistic regression analysis, preterm delivery, extremely low birth weight and very low birth weight, were the significant predictors of death. Similar results were found in a rural hospital in Kwa-Zulu Natal [10], and in both reports at Charlotte Maxeke Johannesburg Academic Hospital [48, 49], where the main determinants of survival were birth weight and gestational age.

The survival of neonates weighing less than 1000g was near zero. Of the 10 neonates with less than 1000g birth weight, 66.7% died within the first 7 days of life. The survival rate was poorer than 34% reported at Chris Hani Baragwanath Academic Hospital [8] and 34.9% at Charlotte Maxeke Johannesburg Academic [48], which are both tertiary hospitals in Johannesburg; but comparable to 5% recorded in KwaZulu-Natal [10].

Because of limited resources in our hospital, extremely low birth weight neonates were not given high care support, hence they did not qualify for ICU, neither were they given surfactant nor put on nasal continuous positive airway pressure (NCPAP). Unofficially the cut off birth weight used was 1000g for these life-sustaining measures.

In a retrospective study at Charlotte Maxeke Johannesburg Academic Hospital, Ballot *et al* found that the survival was related to birth weight. The survival of neonates below 1001g was 34.9% compared to 85.9% for those between 1001 and 1500g at birth. They advised that NCPAP with surfactant should be offered to neonates from 750g [48].

In another research, Kalimba reviewed 382 neonates with a birth weight of $\leq$ 900g who were not offered conventional mechanical ventilation. Their survival rate was 26.5%, and no neonate weighing < 600g survived [49].

Unlike in the previous study in the same neonatal unit, which demonstrated the impact of NCPAP and surfactant in the survival of the ELBW, Kalimba's study did not show a positive outcome as it was done in an earlier time period to Ballot *et al*, where very few ELBW neonates were offered NCPAP.

Several interventions have been shown to improve the survival of these neonates and they include among others: antenatal steroids, NCPAP, surfactant replacement, kangaroo mother care (KMC) and improved neonatal resuscitation.

Firstly, studies had shown the efficacy of antenatal steroids in the reduction of the incidence of respiratory distress syndrome and the neonatal deaths [50, 37, and 51]. Sixty three per cent of mothers admitted at Leratong hospital before 34 weeks of gestation, received 2 doses of antenatal steroids.

Another intervention is nasal continuous positive airway pressure, if used early rather than later has been shown to reduce mortality by 35% to 50%, and also reduces the need for intubation for mechanical ventilation [37, 49, 52, 53, and 54]. Smith in Western Cape had comparable results over a period of 10 years [55].

ELBW neonates in our unit were not eligible for mechanical ventilation or NCAP due to resource constraints. These neonates were nursed in intermediate neonatal care rooms. However, as a strategy the unit policy could be changed so as to offer 900g and above NCPAP with early selective surfactant. An audit can be carried out to see the impact this has on

mortality and morbidity and then be further decreased to 800g. Management and hospital staff need to be engaged in order to impact change.

Finally, Kangaroo mother care is a simple intervention for caring for stable premature neonates as they approach discharge [56]. We registered no death in KMC, which was opened to accommodate stable premature newborns.

These neonatal interventions existed in our unit but their coverage was low, in contrast to high coverage in the United States and United Kingdom [57].

Perinatal asphyxia was the second most important cause of neonatal admissions and mortality with 26.8% and 26% respectively. In fifty eight per cent, labour- related asphyxia was the cause of death in >2500g neonates.

In our study, 95.6% of neonates were delivered in the health facility and was consistent with the Gauteng province's delivery rate of 97% in 2008/2009 [58]. In the Annual report 2013 [59], the Gauteng Department of Health noted an increased in the number of deliveries in facilities. This might reflect normal population growth or indicate that more individuals perceive the benefits of delivering babies in a health facility with the attention of a skilled health worker, the report said [38, 59]. Yet, we registered many deaths due to asphyxia.

Furthermore training in neonatal resuscitation can reduce deaths in newborns with intra-partum asphyxia by 30% and early deaths by 38%, but alone cannot improve the outcome of these asphyxiated newborns [28, 37, 56, and 60]. Neonatal resuscitation training was offered

at Leratong hospital every 4 months over the past 5 years and most midwifes in labour ward and paediatric doctors were trained in basic neonatal resuscitation.

In labour ward, equipment to detect foetal distress was not always readily available, and if detected the time to deliver the newborns might be inadequate. Out of 16 caesarean sections performed on neonates more than 1000g, 12 neonates (75%) had a low Apgar score (< 5/10) at 1 minute which could be attributed to inappropriate management during labour.

For example, there was a delay in the transfer of women at term in labour with a diagnosis of foetal distress from the district hospitals to Leratong hospital. Even when foetal distress was recognised in labour ward, some women were pushing on an incompletely dilated cervix, and the time to perform a caesarean section was inadequate due to sometimes insufficient number of anaesthetic doctors and delayed transfer to theatre.

On the multivariate model, the study found that caesarean section was an important predictor of death. Surprisingly, the finding was contrary to other data [10, 48 and 49] which reported that delivery by caesarean section improved the chance of survival than neonates born by normal vaginal delivery. A possible reason for the differences was the lack of information on the decision-to-delivery interval (DDI) for emergency caesarean sections at Leratong Hospital, and was not analysed in this study.

In an audit conducted by O'Dwyer in a busy urban obstetric unit in Cape Town which reviewed 110 emergency caesarean sections and in another study led by Chukwudi who looked at 352 emergency caesarean sections in a tertiary institution in Nigeria, the mean decision-to-delivery interval was 64 minutes and 106 minutes respectively. The authors found that a decision-to-delivery interval of 30 minutes or less which is recommended in anticipating

beneficial effect on neonatal outcomes may not be achieved in all emergency caesarean sections [61, 62]. Therefore, a larger study would be necessary to determine whether the decision-to-delivery interval is critical in emergency caesarean section at Leratong Hospital.

In most cases, midwives did not use the partogram to detect foetal distress; instead 1-2 cardiotocogram machines were used for the whole labour ward.

Antenatal and intra-partum management of high risk pregnancies, early transfer to high level of care, active monitoring of labour, resuscitation at the time of birth and continuum of care in the neonatal unit are important steps to reduce high mortality related to perinatal asphyxia. This can be achieved with weekly morbidity and mortality meeting involving the neonatal unit, maternity, department of anaesthesia, theatre and porters, which will help identify these avoidable and preventable factors.

The success of these meetings depends on the commitment of all involved in the care of the pregnant women and that of their newborns. At the time of this study, there was a poor communication and collaboration between the paediatric and the obstetric and gynaecologic departments.

Neonatal infection although the fourth cause of admission (10%), represented the third cause of death (20%) at Leratong Hospital. This was comparable to the mortality rate due to sepsis (20.8%) in the Johannesburg Hospital neonatal unit in 2003 [63]. Among deaths related to infection, sepsis accounted for almost 78% of deaths. Bryce *et al* noted that preventing neonatal infection is complex [64, 65].

In labour ward and theatre, prevention of neonatal sepsis was done using sterile equipment for umbilical cord care. The transfer of the admitted neonates was done in the transport incubator.

Nevertheless in the neonatal ward, there was a major challenge to the prevention of neonatal sepsis. For example, neonates shared the same overhead heated bed (radiant warmer) or neonates with sepsis and were not cohorted. Thus, there was no space for isolation. Sometimes antiseptic and disinfectant were not used by the staff before and after handling an infant. The adherence to infection prevention control measures was not consistent.

By addressing the high number of neonates and the number of staff to nurse them, as well as the hand washing practices it might be possible to prevent nosocomial infection in the unit.

Lastly, congenital abnormalities had a lower hospitalization rate (1.1%), but the mortality rate (9%) was identical to that in KwaZulu-Natal (9%) [10]. It was lower than the Steve Biko Academic Hospital rate (17.6%) [44]. High risk pregnancies were referred to tertiary hospital, but no such cases were reported during this study. Therefore, research may be done to determine mortality due to congenital abnormalities in the institution.

The high neonatal mortality observed in our results was also related to some local factors in the health system and were seen in other reports [9, 10, 28-30, 37, 41, 44, 66].

The study identified insufficient number of personnel and inadequate neonatal facilities as the main administrative problems associated with deaths (37%).

Most deaths (63%) occurred in the admission room (Room 1) than in neonatal ICU (15%), and yet it was where the nurse ratio was the most poor (ratio nurse: neonate is $\geq$1:10). In the absence of staff norms, understaffing had been the norm in contrast with the Health Plan for Neonatal Care [13] which recommended 1 professional nurse per 3 high care neonates. For many years the status of the admission room had been unclear. The Gauteng Provincial Health did not recognize it as high care area, hence negatively affecting the recruitment of trained

nurses in newborn care. The work load coupled with shortage of trained nurses during day and night shifts were a major challenge to improve newborn survival.

Medical staff shortage was another challenge in our department. Each call had insufficient doctors to cover both areas which were the neonatal ward and paediatric wards. They were consequently not able to deal with problems which aroused at the same time. During their calls, junior medical doctors (community service doctors) were not supervised.

A significant number of neonates, who died were not seen by a consultant during their hospitalization. One of the given reasons was that there was only one consultant in the unit. Although the Saving Babies report 2008-2009 [35] recommended that a regional consultant must do clinical teaching ward rounds with all the staff working in the neonatal unit, such a programme was not a routine in the unit. In fifty eight per cent of the neonates, results were not checked which could have changed their management. However, the logistic regression analysis did not find the lack of supervision of medical doctors by the consultant to be a predictor of death.

The regional outreach consultant programme from Rahima Moosa Mother and Children Hospital was an effective model of on-site training and supervision of medical doctors in the unit. Each month and on an agreed date, a consultant participated in service training where infants were discussed and the transfers of those requiring tertiary care to the academic hospital were arranged. Unfortunately at the time of this work, the outreach programme had stopped for unknown reasons.

4.2 CONCLUSIONS

The study found the neonatal mortality rate at Leratong Hospital to be lower than rates recorded in South Africa. Our results revealed that the most common causes of neonatal admissions and mortality were similar to those in other hospitals. Most neonates died within 7 days of life as reported in the literature. Preterm delivery, low birth weight and caesarean section were major predictors of death. A high number of neonatal deaths were avoidable by providing high care services (including NCPAP and surfactant) and adequate number of trained nurses in newborn care in the admission room, improving access to neonatal ICU, early detection of perinatal asphyxia and improved neonatal resuscitation, and the supervision of medical doctors.

4.3 RECOMMENDATIONS

4.3.1 Recommendations for clinical practice

The implementation of the following recommendations would significantly reduce neonatal deaths in the unit.

4.3.1. Administrative problems:

4.3.1.1 Facilities:

- The status of the admission room (Room 1) must be changed to high care
- Increase the number of beds available
- Provision of high care services including NCPAP must be available in the admission room and increase the number of NCPAP
- Improved access to neonatal ICU:
    - all neonates in need of intensive care regardless of their origin
    - neonate's birth weight to be considered even if it drops to <1000g
    - cut off neonate's weight to be at least 900g
    - Use NCPAP with surfactant to neonates from 900g
- Improved the quality of intra-partum care by early detection of perinatal asphyxia:
    - Partogram to be used for each woman in labour
    - Cardiotocogram machine readily available
- Build a mother lodger facility so that mothers can help with feeding, washing newborns and changing of diapers.

4.3.1.1 Personnel:

- Increase number of consultants
- Adequate number of medical staff on call: ideal of 2 medical officers every day.
- Skilled and trained medical staff who can deal with neonatal emergencies.
- Adequate number of neonatal trained nursing staff to care for these newborns.
- Norms specified (Saving Babies 2003-2005) must be followed
- Outreach programmes should continue

4.3.2. Health care provider problems must be addressed

- Consultants must do clinical teaching ward rounds with all staff (nurses and doctors)
- Delays in attending newborns must be reduced
- All investigation results must be checked
- Use of partogram by midwives in labour ward must be mandatory
- Hand washing practices must be emphasised

4.3.2 Recommendations for research

- Impact of NCPAP with early selective surfactant in the management of 900g and above neonates
- Determine whether the decision-to-delivery interval is critical in emergency caesarean section at Leratong Hospital
- Determine mortality due to congenital abnormalities in the institution

4.3.3 Recommendations for policy

- The unit policy could be changed so as to offer 900g and above NCPAP with early selective surfactant
- The partogram must be used on every woman in labour

4.4 STRENGTHS AND LIMITATIONS OF THE STUDY

4.4.1 Strengths

- Data was prospective and it was possible to assess data accurately
- The study identified problems in the management of the sick newborn in our unit, and provided evidence for change

4.4.2 Limitations

The limitations of this study were:

- The short period of data collection for analysis
- The sample size was small

APPENDICES

APPENDIX A: Data capture sheet

Confidential document

Study number: _____ File number: _____ Date: _____

1. Infant details:

- Age: _____ Gender: M/F. Race: B/W/C

2. Mother details

- Age: _____yrs. Antenatal visit/s? Y/N Blood group and Rhesus: _____
- WR: Negative/Positive/Unknown. HIV: Negative/Positive/Unknown. If HIV positive, HAART? Y/N

3. Delivery

- Date of birth: _____Time of birth: _____Place of birth: _____Other hospital: _____Home/Other
- Gestational age: _____weeks (Premature/term)
- Mode of delivery:
    - Vaginal (vertex/breech/vacuum/forceps) or Caesarean section
- Birth weight: _____ grams. Head circumference: _____ cm. Length: _____ cm
- Apgar: 1 min: _____ 5 min: _____ 10 min: _____
- Resuscitation at birth?

- No/Yes: Via mask/Via ET tube/Time to spontaneous respiration: _____min

4. Admission

4.1. Date of admission: _____Time of admission: _____ Place of origin (mark with X):

Labour ward ( ), Ward 6 ( ), Theatre ( ), Casualty ( ), Home ( ), Transfer ( ) from

_____

4.2 What was the reason for admission (circle)?

Prematurity-related (*extreme multi-organ immaturity, respiratory distress syndrome, necrotizing enterocolitis, pulmonary haemorrhage, other, intraventricular haemorrhage, not specified*), **Hypoxia** (*hypoxic ischaemic encephalopathy, Meconium aspiration, other, persistent foetal circulation, not specified*), **Infection** (*septicaemia, pneumonia, HIV infection, Nosocomial infection, congenital infection, other, congenital syphilis, meningitis, group B streptococcal infection, tetanus,*

not specified), **Congenital abnormalities** (*other, chromosomal abnormality, respiratory, CNS, CVS, renal, not specified*),

Other conditions (*sudden infant death syndrome=SIDS, aspiration pneumonia, hypothermia, haemorrhagic disease of newborn, hydrops- non-immune, isoimmunisation, hypovolaemic shock, not specified*), **Unknown cause of death**, **Trauma** (*other, subaponeurotic haemorrhage*), **other**

4.3. Were there abnormal investigations during illness that caused or contributed to death?

- No/ If Yes, tick relevant box/es

Investigations	N	↓	↑	Treatme t guidelines followed	Health factors code	Other comments
WCC						
Haemoglobin						
Platelets						
CRP						
Bilirubin						
Sodium						
Potassium						
$C0_2$						
Urea						
Creatinine						
Glucose						
Blood culture						
CSF						
Radiological						
Others						

Treatment guidelines coding: Y=Followed, N=Not followed

Health modifiable factors coding: 1= Result not checked, 2= Not collected, 3= Not ready, 4= Not found, 5= Laboratory phoned the ward but result not in the file, 6= Did not change treatment accordingly

5. Record keeping

- Adequate (most of the above information available)/Inadequate (incomplete notes, incomplete charting by sister)

6. Cause of death

6.1 Date of death: _____Time of death (circle): _____ day/night/weekend/public holiday

6.2. Where did death occur? NICU/ Room 1/ Room 2/ Room 13/ KMC

6.3. What was the final cause of death? (circle) (saving babies 2008-9)

- **Prematurity-related**: *extreme multi-organ immaturity, respiratory distress syndrome, necrotizing enterocolitis, pulmonary haemorrhage, other, intraventricular haemorrhage, not specified.*
- **Hypoxia**: *hypoxic ischaemic encephalopathy, Meconium aspiration, other, persistent fetal circulation, not specified.*
- **Infection**: *septicaemia, pneumonia, HIV infection, Nosocomial infection, congenital infection, other, congenital syphilis, meningitis, group B streptococcal infection, tetanus, not specified.*
- **Congenital abnormalities**: *other, chromosomal abnormality, respiratory, CNS, CVS, renal, not specified.*
- **Other conditions**: *sudden infant death syndrome (SIDS), aspiration pneumonia, hypothermia, haemorrhagic disease of newborn, hydrops- non-immune, isoimmunisation, hypovolaemic shock, not specified.*

- **Unknown cause of death**
- **Trauma**: *other, subaponeurotic haemorrhage.*
- **Other**:

7. Health modifiable factors

7.1 Facilities:

7.1.1. ICU bed:

- Did infant require an ICU bed? Y/N
- If yes, did infant die because of lack of ICU bed? Y/N
- If yes, why was ICU bed not offered? Not available/ no nursing staff/ no equipment/ not meet ICU criteria (< 1 kg, severe asphyxia, congenital abnormalities like anencephaly)
- Was an attempt made to transfer infant to outside hospital? Y/N
- If yes, why not transferred? No bed available/ no transport/ died before transport arrived.
- Comments:

7.1.2. CPAP:

- Did infant require CPAP? Y/N
- If yes, did infant get CPAP? Y/N
- Did infant die because of lack of availability of CPAP? Y/N
- If yes, why was CPAP not offered? Not available/ no nursing staff/ nurse refused to use CPAP in room 1

- Comments:

7.2. Staff and supervision:

- Who attended to the infant at the time of death? Consultant/ senior medical officer/ Junior medical officer
- Was infant seen by consultant during hospitalization or when deteriorated? Y/N
- If not, why infant not seen by consultant? admitted and die during weekend/ not called/ did not do round/ did not respond
- Was infant seen by doctor during the last 24 hours or since deteriorated? Y/N
- If not, why? staff shortage/ not red flagged/ was not called on time/ did not respond on time/ came too late
- Did infant require closed monitoring? Y/N
- If yes, why infant not monitored closely? not red flagged/ not enough nurses
- What was the nurse/infant ratio in the room at the time of death? _____

7.3. Treatment guidelines:

- Was death related to non-adherence to treatment guidelines? Y/N
- If yes, which guideline was not followed? surfactant/ incorrect drugs
- According to guidelines, was drug indicated? Y/N
- If yes, was it prescribed? Y/N. If yes, which drug/s_____

- If prescribed, was it appropriate? Y/N
- If inappropriate, why? Incorrect dose/ sensitivity not tested/ incorrect duration/ no drug level done

7.4. Other

8. Underlying condition? N/Y e.g. cardiac, malformation

9. Duration of stay: Hours_____ / Days_____

APPENDIX B: Nurses per shift

Table B1: Number of nurses per shift

Month:	NICU		Room 1		Room 2		Room 13		KMC		Comments
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night	
1											
2											
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Appendix C: Neonates per shift

Table C1: Number of neonates per shift

Month:	NICU		Room 1		Room 2		Room 13		KMC		Total	Comment
	Day	Night	Day	Night	Day	Night	Day	Night	Day	Night		
1												
2												
3												
4												
5												
6												
7												
8												
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31												

APPENDIX D: Equipment check list

Table D1: Equipment check list for the last 3 months

Date	NICU	Room 1	Room 2	Room 13	KMC	Comments
	V: 6 C: 4 R: 7 L: 2 CM: 7 G:1	R: 2 L:1 P:1	R: 0 L: 0 P: 0	R: 0 L: 1 P: 0	R: 1 L: 1 P:1	
Wed 5/9 9h00	V: C: R: L: CM: G:	R: L: P:	R: L: P:	R: L: P:	R: L: P:	
Wed 12 9h00	V: C: R: L: CM: G:	R: L: P:	R: L: P:	R: L: P:	R: L: P:	
Wed 19 9h00	V: C: R: L: CM: G:	R: L: P:	R: L: P:	R: L: P:	R: L: P:	
Wed 26 9h00	V: C: R: L: CM: G:	R: L: P:	R: L: P:	R: L: P:	R: L: P:	
Wed 3/10 9h00	V: C: R: L: CM: G:	R: L: P:	R: L: P:	R: L: P:	R: L: P:	
Wed 10 9h00	V: C: R: L: CM: G:	R: L: P:	R: L: P:	R: L: P:	R: L: P:	

Wed 17 9h00	V: C: R: L: CM: G:	R: L: P:	R: L: P:	R: L: P:	R: L: P:	
Wed 24 9h00	V: C: R: L: CM: G:	R: L: P:	R: L: P:	R: L: P:	R: L: P:	
Wed 31 9h00	V: C: R: L: CM: G:	R: L: P:	R: L: P:	R: L: P:	R: L: P:	
Wed 7/11 9h00	V: C: R: L: CM: G:	R: L: P:	R: L: P:	R: L: P:	R: L: P:	
Wed 14 9h00	V: C: R: L: CM: G:	R: L: P:	R: L: P:	R: L: P:	R: L: P:	
Wed 21 9h00	V: C: R: L: CM: G:	R: L: P:	R: L: P:	R: L: P:	R: L: P:	

Coding: V=ventilator, C=CPAP, R=resuscitation bag, L=laryngoscope, CM=cardiac monitor, G=gases machine, P=pulse oximetry. For each item: number of working item will be given next to the code.

LERATONG HOSPITAL NEONATAL UNIT

CONSENT FORM: USE OF CLINICAL INFORMATION

This document must be explained to the parent/guardian by a member of the clinical staff and a copy of the signed document is to be given to the parent/family member/guardian.

Dear Mother,

Your baby is admitted to the Neonatal Unit at Leratong Hospital for treatment. The Hospital not only renders treatment but is also involved in conducting research aimed at improving the quality of care we deliver. From time to time such research involves the use of patient's records from which information is extracted. The use of such information is subject to:

- Approval from the Committee for Research on Human Subjects of the University of the Witwatersrand
- Anonymity e.g. the identity of the baby from whose file information is extracted is never revealed to anyone but the researcher unless specific consent is obtained to do so.

Whilst we are not currently involved in research that requires us to use any information now, this may change in the future when you or your child are already discharged. We would like to obtain your consent to use information from your file and baby's file for the purpose of research, subject to the aforementioned conditions. If you choose not to give consent, this will not compromise your child's treatment in any way. If at any time you choose to withdraw consent you are free to do so and you or your child will not be prejudiced in any way.

Should you wish to contact us at any stage regarding this consent, contact Leratong Hospital Neonatal Unit at

(011) 411 3629 or 3680.

A.

I.....hereby give consent for my and my child's records to be used as per the abovementioned conditions for the purposes of research.

Mother: ..... Date: .....

Witness: ..... Date: .....

B.

I.....do not give consent for my and my child's records to be used.

Mother: ..... Date: .....

Witness: ..... Date: .....

This document is a modified version of the original (Chris Hani Baragwanath Hospital Neonatal Unit)

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UNIVERSITY OF THE WITWATERSRAND, JOHANNESBURG
Division of the Deputy Registrar (Research)

HUMAN RESEARCH ETHICS COMMITTEE (MEDICAL)
R14/49 Dr JC Moundzika-Kibamba

CLEARANCE CERTIFICATE	M120867
PROJECT	Neonatal Mortality at Leratong Hospital
INVESTIGATORS	Dr JC Moundzika-Kibamba.
DEPARTMENT	Department of Paediatrics & Child Health
DATE CONSIDERED	31/08/2012
DECISION OF THE COMMITTEE*	Approved unconditionally

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

DATE 31/08/2012 CHAIRPERSON .....
(Professor PE Cleaton-Jones)

*Guidelines for written 'informed consent' attached where applicable
cc: Supervisor Dr Firdose Nakwa

DECLARATION OF INVESTIGATOR(S)
To be completed in duplicate and **ONE COPY** returned to the Secretary at Room 10004, 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

GAUTENG PROVINCE
HEALTH
REPUBLIC OF SOUTH AFRICA

Enquiries: Dr Shaikh G K
Tel: 0828571925
Fax: 0866004183

TO : **Dr Jean Claude Moundzika-Kibamba**
Division of Community Paediatrics
University of Witswatersrand

FROM : **Ms Puleng Muso**
Director, West Rand District Council

DATE : **11th February, 2013**

PERMISSION TO CONDUCT RESEARCH IN WEST RAND DISTRICT.

Your correspondence on the above matter refers.

Thank you for your request to conduct research in Leratong hospital.
Permission is hereby granted to you to conduct research in Leratong hospital. You are requested that you conduct your research with the permission of the CEO of the institution, and the knowledge of the HOD of Paediatrics department.

I am anticipating that you will share your findings and recommendations with the district in order to improve service delivery to the people of West Rand.

Yours,

MS PULENG MUSO

GAUTENG PROVINCE
REPUBLIC OF SOUTH AFRICA

Leratong Hospital
Private Bag X2078
KRUGERSDORP
1740

Enquiries: Mr G J Dube
Tel: (011)411-3531
Fax: (011)410-8421
Email: GreyD@gpg.gov.za

Dr J C Moundzika-Kibamba
Paediatrics Department
Leratong Hospital

REQUEST TO CONDUCT RESEARCH : STUDY ON THE NEONATAL MORTALITY AT LERATONG HOSPITAL

Permission has been granted to conduct research study entitled Neonatal Mortality at Leratong Hospital based on the conditions indicated from policy planning and research department (provided final approval is granted by Gauteng Department of Health and Social Development).

It would be appreciated if you could share your results of the research with the Management of Leratong Hospital.

Thank you for showing interest in our Institution.

Kind regards

CHIEF EXECUTIVE OFFICER
/jve
2012/07/24