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Improving quality of perinatal care through clinical audit

A study from a tertiary hospital in Dar es Salaam, Tanzania

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Abstract

Perinatal audit has been tested and proved an important tool for reduction of perinatal mortality and assessment of quality of perinatal care. At Muhimbili National Hospital (MNH), a tertiary hospital in Dar es salaam, Tanzania we performed a retrospective cross-sectional study using data from an obstetrics database to classify all perinatal deaths during 1999-2003. We also determined the prevalence of anaemia in pregnancy and its impact on perinatal outcome. Furthermore, we conducted a perinatal audit to study potential determinants and causes of perinatal and neonatal deaths and their avoidability. We also assessed the quality of care of patients admitted with eclampsia using a criteria based audit.

Stillbirth, early neonatal and perinatal mortality rates (PMR) were 96, 27 and 124 respectively. A large proportion of foetuses (38%) had no audible foetal heart beat on admission at MNH labour ward and the majority of the neonatal deaths were asphyxiated at delivery. The PMR for multiples and singletons were 269 and 118 respectively resulting in a rate ratio of 2.4 (95%CI: 2.1-2.4).

The prevalence of anaemia and severe anaemia was 68% and 5.8%, respectively. Severity of anaemia increased the risk of preterm delivery with ORs of 1.4, 1.4 and 4.1 for women with mild, moderate and severe anaemia as compared to women with normal haemoglobin levels. The corresponding risks for LBW and VLBW were 1.2, 1.7 and 3.8, and 1.5, 1.9 and 4.2 respectively. The prevalence of preterm delivery and LBW was 17% and 14% respectively.

The hospital-based incidence of eclampsia was 504 per 10,000 women or 5.1 % of all mothers admitted. Suboptimal care were identified on criteria regarding management plan by senior staff, review of the plans by specialist obstetrician, delay on caesarean section, monitoring patients on magnesium sulphate and inadequate use of the laboratory. Two out of three patients requiring operation were not operated within set standards.

Birth asphyxia was the main cause of intrapartum fresh stillbirth (47%) and early neonatal deaths (51%), whereas eclampsia (25%) and preeclampsia (8.3%) were main maternal medical conditions. The majority of stillbirths were fresh, indicating foetal demise during labour or just before delivery.

The audit study identified suboptimal care in about 80% of audited cases out of which about 50% were found to be the likely cause of the adverse perinatal outcome. Inadequate maternal and foetal monitoring during labour were the main suboptimal factors, though delay in referral and operative interventions were also prominent.

Based on these studies, we conclude that:

- The perinatal mortality (PMR) in this study was higher than the national average.

- About one in four perinatal deaths at MNH can be attributed to avoidable factors linked to obstetric care
- Main causes of perinatal and neonatal deaths were intrapartum birth asphyxia, immaturity related and infections Management of patients in labour needs to be improved
- Suboptimal care that is essentially avoidable included: inadequate monitoring of patients during labour, delay of care, e.g. long decision to surgery interval, and delayed referral of patients from primary hospitals
- The prevalence of anaemia in pregnancy was very high; and low birth weight and preterm delivery was independently associated with severity of anaemia
- The prevalence of eclampsia at MNH was high and the case management needs to be improved

Key words. Perinatal mortality, perinatal audit, avoidable factors, anaemia in pregnancy, eclampsia

Abbreviations

ANC	Antenatal care
BWT	Birth weight
CI	Confidence interval
CHF	Community health fund
END	Early neonatal deaths
FIGO	International Federation of Gynaecology and Obstetrics
FSB	Fresh stillborn
GoT	Government of Tanzania
Hb	Haemoglobin
HELLP Syndrome	Haemolysis Elevated Liver Enzymes, Low Platelets Syndrome
HIV	Human Immunodeficiency Virus
LBW	Low birth weight
LND	Late neonatal deaths
LNMP	Last normal menstrual period
MNH	Muhimbili National Hospital
MoH	Ministry of Health
MSB	Macerated stillbirth
NSSF	National social security fund
NMR	Neonatal mortality rate
NHIF	National health insurance fund
OR	Odds ratio
PMR	Perinatal mortality rate
PORALG	Presidents Office, Regional Administration and Local Government
SBR	Stillbirth rate
TRHS	Tanzania reproductive health survey
VLBW	Very low birth weight
WHO	World Health Organization

Glossary

Live birth	The complete expulsion or extraction from its mother of a product of conception, *irrespective* of the duration of the pregnancy, which, after such separation, breathes or shows any other evidence of life, such as beating of the heart, pulsation of the umbilical cord, or definite movement of voluntary muscles, whether or not the umbilical cord has been cut or the placenta is attached; each product of such a birth is considered live born.
Stillbirth or foetal death	Death prior to the complete expulsion or extraction from its mother of a product of conception, irrespective of the duration of pregnancy; after such separation the foetus does not breathe or show any other evidence of life, such as beating of the heart, pulsation of the umbilical cord or definite movement of voluntary muscles.
Total births	Stillbirths + live births
Perinatal mortality rate	[(END + SB)/Total births] x 1000
Early neonatal death rate	(END/Live births) x 1000
Stillbirth rate	(SB/Total births) x 1000
Anaemia in pregnancy (WHO)	Severe: Hb<7.0 g/dL Moderate: 7.0-8.9 g/dL Mild: 9.0-10.9 g/dL
Duration of pregnancy (Gestational age) (WHO)	Preterm: <37 weeks Term: 37-41 weeks Post term: ≥42 weeks
Malaria positive test	Presence of malaria parasites in a thick blood film examined under microscope
Birth weight	Low: <2500 grams Very low: <1500 grams
Apgar score	A system of assessing the general physical condition of a newborn based on a rating of 0, 1, or 2 for five criteria: heart rate, respiration, muscle tone, skin colour, and response to stimuli. The five scores are added together, with a perfect score being 10. *Low Apgar score* = final score<7.

Original papers

This thesis is based on the following papers which will be referred to in the ***text*** by their Roman numerals:

Paper I Kidanto HL, Massawe SN, Nyström L, Lindmark G. Analysis of perinatal mortality at a teaching hospital in Dar es Salaam, Tanzania, 1999-2003. *Afr J Reprod Health 2006*;**10**(2):72-80.

Paper II Kidanto HL, Mogren I, Massawe SN, Lindmark G, Nyström L. Risks for preterm delivery and low birth weight are independently increased by severity of maternal anaemia. *S Afr Med J* 2009;**99**:98-102.

Paper III Kidanto HL, Mogren I, Massawe SN, Lindmark G, Nyström L. Criteria-based audit on management of eclampsia patients at a tertiary hospital in Dar es Salaam, Tanzania. *BMC Pregnancy Childbirth* 2009;**9**:13.

Paper IV Kidanto HL, Mogren I, van Roosmalen J, Thomas AN, Massawe SN, Nyström L, Lindmark G. Introduction of a qualitative perinatal audit at Muhimbili National Hospital, Dar es Salaam, Tanzania. *BMC Pregnancy Childbirth* 2009;**9**:45.

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Contents

Introduction

Global burden of perinatal and neonatal mortality

In developing countries the under-5-year-old children mortality rates have decreased substantially over the past 20 years, However, the perinatal mortality rate (PMR) has not followed the same trend and continues to represent a huge burden and the PMR is five times higher in developing than developed countries (Bhutta et al 2009; Pattison 2003). Each year at least 3.3 million babies are stillborn, more than 4 million die within 28 days of birth, and a further 6.6 million young children die before their fifth birthday (Santon et al 2006; WHO 2006). The overwhelming majority (98%) of stillbirths occur in low and middle-income countries. Although the foetal death (stillbirth) rate has more than halved over the past 30 years, the rate of intrapartum foetal death in babies above 1500 grams is still high and hypoxia is thought to be a factor in 90% of the intrapartum deaths (Bergsjo et al 2003; Pattison 2003). Stillbirths are mostly non-counted in local data collection systems and are also invisible in global policy and programme priorities in many countries (UNICEF 2009; WHO 2005).

The highest PMR are reported from sub-Saharan Africa (about 80 per 1000 births), followed by Asia and Latin America (UNICEF 2008). In sub-Saharan Africa 1.2 million babies die in the first month of life and another million babies are stillborn each year. Tanzania, like other countries in the sub-Saharan region, has a high PMR ranging from 90 to 100 per 1000 births (NBS 2005). In Western Europe neonatal and infant mortality has declined during the last 30 years to 4-6 per 1000 births. The improvement is primarily due to improved socio-economic and living conditions, nutrition of pregnant women and advancements in obstetric and neonatal care. Foetal death in labour is extremely rare in developed countries.

In the UK the confidential inquiry into stillbirths and deaths in infancy focuses on preventable factors in intrapartum related perinatal deaths. The foetuses that die were more likely than the live controls to have had placental abruption, cord prolapse, foetal distress, or an unhealthy placenta (Alessandri et al 2001). The inquiry found that 75% of intrapartum related deaths showed examples of suboptimal intrapartum care which might have contributed to the outcome. Over 90% of these examples were related to failure to recognize a problem, act appropriately, or communicate adequately. A long delay between the onset of foetal compromise and the delivery has been highlighted as a major contribution to intrapartum foetal deaths.

What are underlying causes of perinatal mortality?

Maternal factors

Factors associated with increased risk of a perinatal death include maternal infections, low nutritional status, socio-economic and particularly educational status of the woman, short inter pregnancy interval (<2 years), rural residence , maternal medical conditions (anaemia in pregnancy, preeclampsia, diabetes mellitus and HIV), poor

quality of care provided during pregnancy and after childbirth, prolonged duration of labour and young (<19 years) and higher maternal age (≥35 years) (Hinderaker et al 2003; McClure et al 2009; Watson-Jones et al 2007; Weiner et al 2003). The stillbirth rates have been associated with quality of both antenatal care (ANC) and intrapartum care including monitoring and treatment of risk factors that arise during pregnancy (Di Mario et al 2007). Hence stillbirths, particularly those that occur before labour begins, can be considered a proxy for access to and quality of reproductive health and ANC services (Goldenberg et al 2007). Improving the capacity of ANC services to effectively identify, treat, and monitor conditions like hypertensive disorders, preterm birth, maternal infections like syphilis, and HIV may bring about important reductions in stillbirth rates (Yakoob et al 2009).

Foetal and neonatal factors

Most perinatal and neonatal deaths are related to birth asphyxia, low birth weight (LBW), septicaemia, congenital malformation, preterm deliveries and other miscellaneous conditions (Bhutta et al 2009, Lawn et al 2005).

Preterm babies have an immature immune system, rendering them more susceptible to infections. They are less capable of enduring the mechanical stress of labour, they are less resistant to hypothermia, and their lungs may be immature. All these factors put preterm babies at a much higher risk of perinatal and neonatal death. Systemic infections and urinary tract infections have been associated with preterm delivery and LBW (Bergstrom 2003) and so have nutritional deficiencies and anaemia (Allen 2005).

The frequency distribution of causes of perinatal death differs between low and high income-countries. In the high-income countries, the easily treated conditions are rare, whereas malformations and immaturity related conditions predominate. In low-income settings, the more easily treated conditions like infections and asphyxia related conditions (Figure 1) are more common, and may also indicate problems in the health care system.

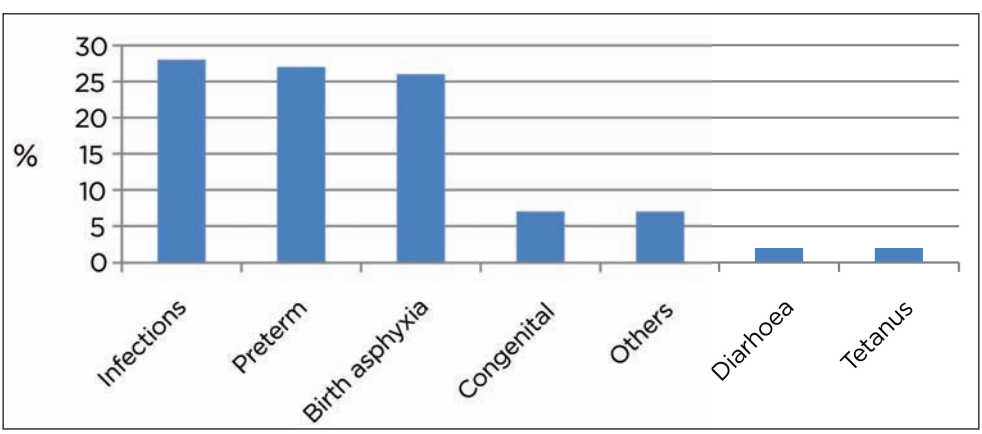


Figure 1. Global estimates of causes of neonatal deaths Source (WHO 2005)

Health care factors

Up to half of the perinatal deaths per year occur as a direct consequence of poorly managed deliveries and there is a wide agreement that stillbirths and neonatal deaths in infants weighing 1500 gram and more are influenced by obstetric care and management of the delivery or a suboptimal health system. Intrapartum asphyxia accounts for both foetal deaths in labour and neonatal deaths (Darmstatadt et al 2009). In developing countries, sub-optimal care has been identified in up to 77% of perinatal deaths in hospital-based studies (De Muylder 1989). This thesis is focused on this weight category.

Wigglesworth (1980) recommended perinatal death analysis by cause and this has been used in the confidential inquiry. Stewart and colleagues (1998) applied this approach for their study of the frequency of asphyxia deaths in relation to time at delivery, They limited their study to babies born with a birth weight of 1500 grams or more and found that twice as many of the babies who died from intrapartum asphyxia had been born between 9pm and 9am, the relative risk was similarly doubled for births in July and August (Stewart et al 1998). However, they did not find higher rates of PMR at the weekend, as found in a previous study (MacFarlane 1978). Although it is tempting to conclude that night staff may be less able to identify and address foetal compromise, further studies are essential before this conclusion is generally accepted. A collaborative perinatal study in the US showed that 57% of term stillbirths were unexplained (Lilien 1970).

Maternal morbidity and perinatal mortality

General overview

Each year, 99% of the estimated 535900 maternal deaths and 98% of the estimated 5.7 million perinatal deaths occur in the developing world. An estimated 42% of the maternal deaths are intrapartum related and are closely related to death of one million babies during labour and 900000 intrapartum neonatal deaths (Lawn 2009). In some areas, a woman is more than 140 times at-risk of dying from a pregnancy related cause as compared to a woman in a developed country. Maternal and perinatal mortality, then, are indicators of a disparity and inequity between rich and poor: generally speaking, the poorer the woman, the less access she has to social, health and nutrition services, and to economic opportunities.

The combined delivery of linked health interventions is a more effective way of achieving common health goals than working independently. Maternal and newborn services potentially can support, and be supported by, such linked interventions. For example, the benefits of combining maternal and newborn services with other interventions, namely those concerned with malaria, nutrition, HIV/AIDS, immunization, child and adolescent and reproductive health are increasingly being seen. Integration may also involve combining prevention and care services. At fixed health facilities, maternal and newborn care is often combined with other services

such as immunization, malaria, HIV/AIDS, growth monitoring, nutritional advice, information on preventive care, child referral (when necessary) and reproductive and sexual health care.

In this thesis we have looked at maternal anaemia and eclampsia as one of maternal medical conditions related to high maternal morbidity and ultimately high perinatal mortality.

Anaemia in pregnancy

The WHO estimated that 55% of all pregnant women living in developing countries and 18% of those in developed countries are anaemic, haemoglobin (Hb) concentration ≤11 g/dL (Rush 2000). It has been shown that anaemia underlies between 8% and 15% of the maternal deaths in developing countries (AbouZahr et al 1991; Guidotti 2000).

Anaemia is a major health problem in Tanzania, especially among young children and pregnant women. In a study done in Dar es Salaam Tanzania, iron deficiency was observed in 86% of anaemic pregnant women (Massawe et al 2002). Other causes of anaemia are malaria which is endemic in most parts of the country as well as dietary deficiencies and parasitic infections.

Although the exact contribution of maternal anaemia to maternal mortality may be unclear (Allen 2000), it is widely recognized as a major determinant of maternal morbidity in developing countries. Urassa and co-workers (1996) found that anaemia was one of the top ten causes of maternal mortality in a community-based case-referent study done in Dar es Salaam, Tanzania. The majority of cases of anaemia are related to iron deficiency, although malaria and hookworm infestation, as well as protein and other micronutrient deficiencies, may play a role also (Guidotti 2000). Iron requirements increase during pregnancy and depletion affects most of the non-supplemented pregnant women, and may lead to anaemia when there is insufficient iron to produce haemoglobin. Obligatory iron loss is 0.2 gram, 0.5 gram is needed to increase the maternal haemoglobin, 0.3 gram is needed for the foetus, and approximately 0.03 gram is needed for the placenta. The total requirement during pregnancy is 1 gram. Due to increased demands during pregnancy supplementation with iron generally is required, especially where diets may be deficient in iron and body stores of iron may be inadequate to meet requirements (Kolsteren et al 1999). Thus, there is a great interest in interventions to improve iron intake and status during pregnancy.

Although it is widely accepted that iron-deficiency anaemia poses an increased risk of complications in pregnancy and maternal and perinatal mortality there is surprisingly little evidence to support this relationship. Lieberman and co-workers (1988) reported that anaemia at the time of delivery was associated with four fold increase in the risk of preterm delivery. However, this finding could not be confirmed by Knottnerus et al (1990) in a hospital based study done in the Netherlands, and

Klebanof et al (1991) in a multi-centre study in the US. Anaemia, which itself can be due to a variety of factors, is just one of several determinants of maternal and perinatal mortality and there is no conclusive evidence of a link between maternal anaemia and LBW or maternal or perinatal mortality (Allen 2000). Moreover, there is little documentation that the health status can be improved by treating anaemia alone. There are no iron-supplementation trials with maternal mortality as outcome measure, and all intervention trials that used perinatal mortality as the outcome were poorly designed or were too small to be conclusive about iron effects (Agarwal et al 1999; Fleming 1989). However, despite the fragmentary nature of the data on the association between maternal anaemia and mortality, some studies have shown a steep rise in maternal mortality with increasing severity of anaemia, especially Hb levels ≤5.0 g/dL (Brabin et al 2001). There is a U-shaped relationship between maternal anaemia and birth weight, because both low and high maternal Hb values are associated with an increased risk of LBW (Scholl et al 2000; Steer 2000). Again, although no causal evidence has been established overall to support or refute the relationship between iron-deficiency anaemia and LBW, the evidence from developing countries, in which iron-deficiency anaemia is common, shows that maternal iron deficiency is positively associated with LBW and poor obstetric outcome (Rasmussen 2001). Some studies have suggested that a relationship exists between maternal anaemia in early pregnancy and increased risk of preterm birth (Klebanoff et al 1991; Zhou et al 1998).

Meta-analyses of iron supplementation trials, conducted under the auspices of the Cochrane collaboration (Cuervo et al 2007), concluded that although iron supplementation significantly reduced the prevalence of low Hb concentration (10.5 g/dL), it had no detectable effect on any other substantive measures of maternal or perinatal outcomes. Although iron reduces maternal anaemia, there is no evidence that iron supplements administered alone or with folate have any effect on birth weight or foetal survival in developed countries. A large iron supplementation trial in Niger showed a significant increase in birth length and Apgar scores and a reduction in the PMR (Preziosi et al 1997). Another interventional study in India by Agarwal et al (2006) demonstrated a reduction in the LBW rate and an increased birth weight of infants born to women who were supplemented with both iron and folate. Increased birth weight, however, was seen only in offspring of women who began supplementation at 16 to 20 weeks' gestation but not in those supplemented after week 20 of gestation. In rural Nepal, Christian et al (2009) showed that iron-folate supplements and multiple micronutrients reduced the prevalence of LBW among pregnant women with 16% and 14% respectively.

Infections may lead to anaemia in several ways. The inflammation induces a sequestration of iron into the reticulo-endothelial system as storage iron. This may be seen as a physiological response impeding the growth of the invading iron-dependent bacteria, but will also lead to a moderate anaemia because of inhibited (iron-insufficient) erythropoiesis. Infections can also lead to a reduction in red cell survival and

bone marrow suppression. HIV infection and tuberculosis often produces anaemia, and is quite common in urban areas like Dar es Salaam. (Wei et al 2004).

Malaria is the major cause of anaemia among pregnant women in many areas of Africa (Steketee et al 1999; Uneke et al 2008), and anaemia may develop through several mechanisms (Shulman et al 2002). First, malaria may lead to massive destruction of red cells and haemolysis. Malaria plasmodia invade erythrocytes, mature and multiply through various stages, which in the end lead to bursting of the invaded erythrocytes and the release of new parasites ready to repeat the cycle. Secondly, malaria disease may also suppress the bone marrow and in this way contribute to anaemia (Shulman et al 2001). A third mechanism for malaria to cause anaemia is hyper-splenism. Chronic malaria often leads to enlargement of the spleen, and if the enlargement is gross, haemolysis may be a result of sequestration of red blood cell by the hyper-active spleen. Malaria affects primigravidae more than multigravidae (Rogerson et al 2007).

Parasite infestation is an important cause of anaemia in many developing countries. In Dar es Salaam, it was shown that 44% of severely anaemic and 17% of moderately anaemic pregnant women had intestinal parasites (Massawe et al 1999).

Tools proven to alleviate anaemia in developing countries other than iron and folate supplementations are:

- Vitamin A supplementation
- Intermittent presumptive malaria prophylaxis
- Use of impregnated bed nets

Hypertensive disorders in pregnancy

Hypertension during pregnancy may either predate the pregnancy or develop during it. Most emphasis is placed on pregnancy-induced hypertension, which is usually defined as hypertension occurring after 20 weeks gestation in a woman with previously normal blood pressure (Magee et al 2008). Beyond that, many subcategories describe the timing and severity of the hypertension. Both the incidence of pregnancy-induced hypertension and mortality due to eclampsia has declined in high-income countries, although higher in low- and middle-income countries, the incidence appear to vary considerably among populations. In high-income countries, more aggressive management, both prenatally and during labor and delivery, is responsible for the decline, but the specific factors leading to decreased incidence are not well understood (Magee et al 2008). Even so, declines in mortality in developed countries have not been as great as for other obstetric emergencies. Pregnancy induced hypertension accompanied by proteinuria is defined as pre-eclampsia, which may lead to eclampsia, signaled by convulsions (but eclampsia may also occur in the absence of preeclampsia). Pre-eclampsia is a major cause of maternal mortality (15–20% in developed countries) and morbidities (acute and long-term), perinatal deaths, preterm birth, and intrauterine growth restriction. Pre-eclampsia is a multisystem disorder of unknown cause that

is unique to human pregnancy. It is characterised by abnormal vascular response to placentation that is associated with increased systemic vascular resistance, enhanced platelet aggregation, activation of the coagulation system, and endothelial cell dysfunction (NHBPEP 2000). The clinical findings of pre-eclampsia can manifest as either a maternal syndrome (hypertension and proteinuria with or without other multisystem abnormalities) or foetal syndrome (foetal growth restriction, reduced amniotic fluid, and abnormal oxygenation) (Sibai 2003). In clinical practice, the maternal syndrome is probably more than one disease with major differences between near-term preeclampsia without demonstrable foetal involvement and pre-eclampsia that is associated with LBW and preterm delivery (Vatten et al 2004). The disorder is heterogeneous for which pathogenesis can differ in women with various risk factors, pathogenesis of pre-eclampsia in nulliparous women may differ to that in women with pre-existing vascular disease, multifoetal gestation, diabetes mellitus, or previous pre-eclampsia. Additionally, the pathophysiology of the disorder leading to onset before 34 weeks gestation could differ to that developing at term, during labor, or postpartum (Hauth et al 2000; Vatten et al 2004).

Pre-eclampsia is a major obstetric problem leading to substantial maternal and perinatal morbidity and mortality worldwide, especially in developing countries. The case fatality rate is assumed to reflect the quality and accessibility of health care: In Africa, the case fatality rate for preeclampsia/eclampsia is estimated at 7-25% (Duley 2003). However, a study done in Sweden found the incidence of eclampsia to be 3.3/10,000 births and there was no maternal mortality; Perinatal mortality rate was 4.7% (Kullberg et al 2002).

Gestational age at time of disease onset, severity of disease, quality of management, and presence or absence of pre-existing medical disorders determine the maternal and perinatal outcome in women with preeclampsia. Women with mild pre-eclampsia developed after 36 weeks' gestation has a lower risk for maternal and perinatal morbidity and mortality (Hauth et al 2000). Women who develop the disorder before 33 weeks gestation with pre-existing medical disorders, and women from developing countries have a higher risk (Ramsay et al 2003; Sibai 2003). Several studies have suggested that women who develop pre-eclampsia are at increased risk of cardiovascular complications later in life. Indeed, many risk factors and pathophysiological abnormalities of pre-eclampsia are similar to those of coronary-artery disease (Haukkamaa et al 2004). Insulin resistance has been suggested as a common factor. Thus, micro vascular dysfunction, which is associated with insulin resistance, could predispose to both coronary heart disease and pre-eclampsia. Pregnancies complicated by pre-eclampsia could identify women at risk of vascular disease in later life and provide the opportunity for lifestyle and risk-factor modification (Sattar et al 2002). Additionally, growth restriction is now recognised as a major risk factor for premature atherosclerosis, according to the so called foetal origins of the adult disease hypothesis. Again, the insulin resistance syndrome seems to be the main pathway through which an adverse intrauterine environment, e.g. growth-restricted

fetuses, or LBW infants in the case of severe pre-eclampsia, negatively affects long term adult health (Hack et al 2002).

Definitions of perinatal and neonatal period

Recognition of stillbirth as a public health concern is hampered by confusion and inconsistent application of definitions. Different definitions are in use in different setting based on different parameters including birth weight (≤350, ≤500, or ≤1000 grams), and body length or gestational age (22-28 weeks). The cut off is generally earlier in high income countries than in low and middle income countries based on standard of viability. For international comparability, The WHO recommends inclusion of all infants born dead and weighing 1000 grams or more at birth (if birth weight is available), or after 28 completed weeks of gestation, or attainment of 35 cm crown heel length (WHO 1977; 1993). Definitions of the perinatal and neonatal period is given in Box 1 and illustrated in Figure 2. In the current study we used 28 weeks of gestations as the start of perinatal period instead of 22 weeks, since this may be more appropriate for low-income countries. However, in the first paper babies weighing ≥500 grams were included in the analysis.

Perinatal deaths include stillbirths and early neonatal deaths. The perinatal mortality *rate* and neonatal mortality *rate* have been defined in the glossary.

Definitions according to ICD-10, 1993

The *perinatal period* commences at the 22 completed weeks (154 days) of gestation (the time when the birth weight is normally 500g), and ends seven completed days after birth.

The *neonatal period* commences at birth and ends 28 completed days after birth. *Neonatal deaths* (deaths among live births during the first 28 completed days of life) may be subdivided into *early neonatal deaths*, occurring during the first seven days of life, *and late neonatal deaths*, occurring after the seventh day but before 28 completed days of life.

Definition according to FIGO and WHO, 1977:

The *perinatal period* is the one extending from the gestational age at which the foetus gains the weight of 1000 g (equivalent to 28 completed weeks of gestation) to the end of the seventh completed day (168 completed hours) of life.

Early *neonatal death* is death of a live-born infant during the first seven days (168 hours) of life.

Late *neonatal death* is the death of a live-born infant after 7 completed days, but before 28 completed days of life.

Box 1. Definitions of neonatal and perinatal death

Pre-pregnancy	Pregnancy		Neonatal/Postnatal		Infancy	Childhood
	Stillbirth		Neonatal death			
	Early	Late	Early	Late		
	22 weeks	28 weeks	1st week	4 weeks	1 year	5 years

Figure 2. Definitions of perinatal and neonatal period

Classification of perinatal deaths

Perinatal deaths are heterogeneous and cause of death and chain of events differ widely. Therefore, for the purpose of identifying specific areas that needs improvements for quality assurance a perinatal death classification that stratifies the perinatal deaths into appropriate groups is important (Korteweg et al 2008; Kristensen 1991). Complications during birth are the main cause of death among almost all infants who were alive when labour started, but were born dead. It is therefore important to know at what point before birth the baby died, so that appropriate intervention can be planned. The proportion of babies that die intrapartum is, therefore, an important indicator enabling health personnel to take the most appropriate measure to prevent such deaths. There are several classification methods of perinatal deaths, however, each has its own deficiencies. In Sudan, El Amin et al (2003) compared the Wigglesworth, Aberdeen and Nordic–Baltic classifications. They noted that necessary information was often not available, giving at least 40% classified as 'unknown' in the Aberdeen classification, whereas the Wigglesworth classification resulted in an even larger group of unspecified asphyxia. They concluded that since classification of perinatal deaths in developing countries is associated with problems regarding application, validity and usefulness, the Nordic–Baltic classification (Box 2) was the most suitable for appropriate stratification using routinely recorded variables and providing categories associated with specific levels. In this thesis classification of perinatal deaths was done by a modified Nordic–Baltic classification (Box2) because we could not ascertain the precise gestational age of the patients as it was mainly relying on the patients remembering the last normal menstrual period. First or second trimester ultrasound scanning was not a routine practice. Thus, we used birth weight, number of foetus, Apgar score and time of death (antepartum, intrapartum and postpartum). Congenital anomalies were not included since they were not properly recorded.

I.	Foetal malformation
II.	Antenatal death, single growth restricted fetus≥28 weeks of gestation
III.	Antenatal death, ≥28 weeks of gestation
IV.	Antenatal death, < 28 weeks of gestation
V.	Antenatal death, multiple pregnancies
VI.	Intrapartum death after admission ≥28 weeks of gestation
VII.	Intrapartum death after admission, <28 weeks of gestation
VIII.	Neonatal death, 28-33 weeks of gestation. Apgar score>6 after 5 minutes
IX.	Neonatal death, 28-33 weeks of gestation. Apgar score<7 after 5 minutes
X.	Neonatal death, >33 weeks of gestation. Apgar score>6 after 5 minutes
XI.	Neonatal death, >33 weeks of gestation. Apgar score<7 after 5 minutes
XII.	Neonatal deaths <28 weeks of pregnancy
XIII.	Unclassified

Box 2. The Nordic-Baltic perinatal death classification

Medical audit

There are many views on how audit should be conducted as there are authors on the subject. The aim of an audit is that, 'it should lead to improvements in patient care, and is perhaps the only aspect on which there is consensus'. Therefore, the principal aim of an audit is to improve the quality of medical care which is similar to quality assurance or total quality management (Mancey-Jones et al 1997). The audit, indeed, aims at improving the quality of health care. Audit is about what is or ought to be the most essential concern of any health professional: to optimize clinical performance and provide the best possible services to patients.

The most commonly quoted *definition of audit* is: "The systematic and critical analysis of the quality of medical care, including the procedures used for diagnosis and treatment, the use of resources and the resulting outcome and quality of life for the patient" (Crombie 1977; Tan et al 1999). The audit involves a criticism of current practice. However, it is not restricted to the technical accuracy of diagnosis or treatment but also involves diverse issues such as for example the timeliness of interventions, the appropriateness of referral, the attitudes of staff, or the information given to the patient. Audit, in other words, crosses professional boundaries and stimulates doctors, nurses, social workers and administrators work side by side to improve the quality of care.

The audit process is generally represented in the form of a closed circle, called the audit cycle (Figure 3). The natural starting point for the audit is to observe and review current practice. This can be done in several ways. The simplest form involves the

review of a single case based on case notes, but the audit may also encompass more complex data collection such as the extraction of information from case notes, routine statistics, specially designed data collection forms or other sources. There is no single best method, each method being suited to certain types of topic and to a particular context. In this thesis, data for audit was obtained by a combination of sources like case notes, the obstetric database and questionnaires. An important step in the audit cycle is to set standards against which the practice can be compared. The final steps of the cycle are to compare current practice to the standards, suggest solutions for the deficiencies identified and implement the changes to improve the delivery of care. Investigations that have been set up just to explore whether the care is adequate or not will in general not bring about change should the care prove not to be adequate (Crombie 1977). The explicit search for solutions for deficiencies identified and the implementation of these solutions is a crucial, although often overlooked step, of the audit process.

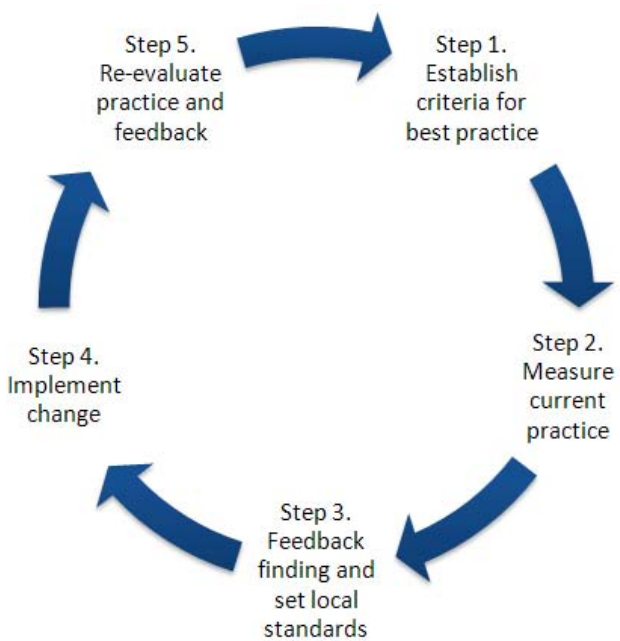


Figure 3. The audit cycle

Criteria-based audit

In a criterion-based audit, agreed standards of care based on explicit criteria are agreed by those involved in the care (Graham et al 2000; Graham 2009). This is clearly distinct from the confidential enquiries where recommendations for improvement are made on the basis of the assessment of "substandard care" but no explicit objec-

tives for change are set. Similarly, other review processes such as the individual case reviews often do not specify clear-cut agreed standards of care. The main hypothesis with criterion-based audits is that the knowledge on not meeting the agreed levels of care will lead to specific changes in clinical practice (Kongnyuy 2009).

Criterion-based audit involves a review process whereby clinicians first agree on a number of explicit and realistic criteria of good quality, adapting external guidelines to take into account the local resource context. Rather than being comprehensive, the list of criteria has to be kept short and simple to apply. Criteria are selected based on their relevance to the audited topic, the strength of the research evidence in their support, their ease of measurement using hospital case notes, and the capacity of the facility in terms of human and other resources. Using the proportions of cases in which the relevant criteria are met as a starting point for discussion, improvements in care are recommended and realistic targets set. Changes in care are suggested and the audit cycle is closed by implementing the changes and re-evaluating practice. Carefully designed criterion-based audit may provide one of the most efficient methods of audit (Kongnyuy 2009; Graham et al 2009). The use of trained non-clinical staff for data collection enables a large number of representative cases to be reviewed. The local staff's involvement in reflecting on their current practice and setting standards is believed to be an effective mechanism for bringing about improvements in care. Even the detailed process of development of criteria may be beneficial, focusing attention on the topic and increasing the sense of ownership of the audit among the clinicians involved. Potential limitations of this approach include the sole reliance on case notes which have to be of sufficient quality, the need for external expertise (for screening case notes and statistical analysis), a tendency to focus mostly on clinical factors and the cost.

Audit of obstetric care in developing countries

Audit of obstetric care has become routine practice in many western countries and the concept of audit is slowly adopted in a number of developing countries. In developing countries there is so far little documented experience with audits of medical care, let alone obstetric care. Applying lessons learned from experiences in western countries may not be straightforward, as developing countries face a number of constraints that may prevent the successful implementation of the audit. Possible constraints to the successful implementation of an audit in developing countries are listed below:

- Scarce resources and inefficiencies in resource allocation in the health sector
- The strong hierarchical structure of the medical profession
- Difficulties to access the scientific literature
- Poor quality of medical case notes
- Limited resources to support audit activities

The magnitude of the resource constraints or inefficiency in resource allocation in the health sector may hamper effective audit. As resources fall under the responsibility of management their shortage can overshadow problems that can readily be addressed by health providers. As a consequence the audit team may fail to address deficiencies in clinical care that fall under their responsibility. The strong hierarchical structure of the medical profession may constrain the peer review process, as not everyone may be invited to express an opinion or take part in proposing solutions. Inadequate access to scientific evidence with an over-reliance on clinical judgment may lead to standards being set on the basis of current rather than best practice, possibly perpetrating inadequate practice. The poor quality of medical case notes may prevent the systematic review of the care given, although a recent review article by Graham (2009) has shown that this may not be the case. Finally, audits are resource intensive, and the limited resources to support audit activities may hamper their sustainability.

Quality of health care and perinatal audit

Quality is the merit of excellence of a thing or activity. In health care it concerns the degree to which the resources correspond with the specified standards. Those standards, if applied are generally expected to lead to the desired result, that is, to improve the outcome or effectiveness of a programme (Roemer 2005). The Donabedian model for assessment of quality of care includes organization, resources, qualification of staff and availability of structured and adequate programs of care (Figure 4). Assessment of quality should ascertain that the care is carried out according to evidence-based guidelines or recommendations.

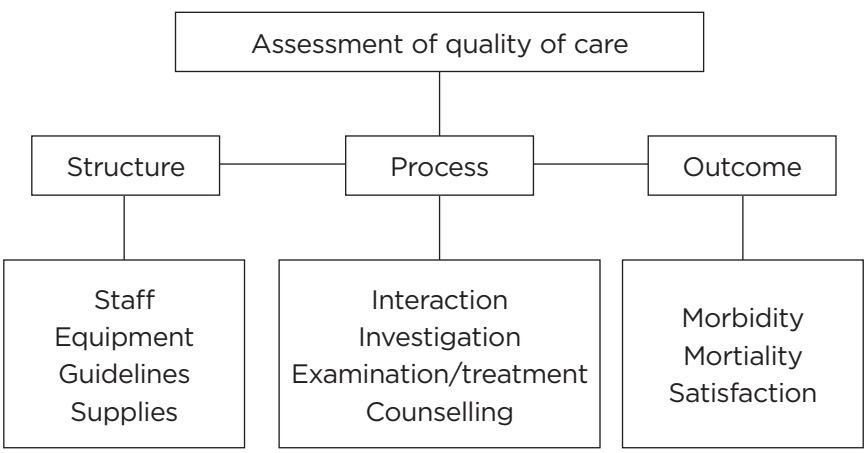


Figure 4. The Donabedian model for assessment of quality of care (Donabedian 1988)

Quality assurance is a process, and to improve the quality repeated measurements constitute the base for the evaluation (Peabody et al 2006) or periodic audit to investigate causes of perinatal mortality and design measures to reduce it (Donabedian 1976). Aspects of the structure, processes, and outcomes of care are selected and systematically evaluated against explicit criteria (Donabedian 2000). Where indicated, changes are implemented at an individual, team, or service level and further monitoring is used to confirm improvement in healthcare delivery (Adey et al 1996; Cruikshank et al 1987). Quality assessment includes both general levels of care as well as adverse events. Indicators must include information about mothers and their newborn and special information in selected cases of special interest. The data collection therefore includes routine registration of basic information as well as more detailed information of complicated events retrieved from medical records (Lindmark et al 2004).

Perinatal morbidity and mortality data, despite their inherent limitations, provide an important base for audit. The most important source for quality improvement activities are routinely collection of information on maternal and perinatal indicators at local and regional level (Carlomagno et al 1988). Analysis and monitoring of data collected on a regular basis in audit meetings avails both the neonatal and obstetric staff the opportunity to examine and critically evaluate patient management and to take appropriate actions wherever possible (De Lange et al 2008). At a higher level, such data help to shape policy and change resource allocation (Lindmark et al 2004). In this thesis an obstetrical database at the maternity ward has been utilized to study trends and magnitude of perinatal mortality. The database has generated monthly reports which have been discussed at meetings conducted in the department.

Possible interventions to reduce perinatal and neonatal mortality

Although no single intervention can prevent perinatal and neonatal deaths two third of newborn deaths in Africa could be avoided if essential interventions already in policy reached 90% of African mothers and newborn by strengthening essential maternal newborn and child health (MNCH) packages along the continuum of care as follows:

*Before conception (*Care of girls and women)*:*

- Increased access and utilization of acceptable family planning methods
- Supplementation of folate to prevent neural tube defects
- Treatment and prevention of sexual transmitted infections (STI) including HIV
- Prevention of female genital mutilation

During pregnancy (ANC package):

- Improved access to quality ANC, with detection and management of risk factors and complications like pre-eclampsia, anaemia, malaria, urinary tract infections (UTI), syphilis screening and treatment, birth preparedness etc
- Tetanus toxoid immunization

During delivery (Skilled maternal and immediate newborn care package):

- Delivery by skilled health attendant
- Clean delivery and avoiding infections of mother and newborn
- Adequate labour monitoring
- Encouragement of supportive companion
- Assistance at birth (including vacuum extraction)
- Early detection, clinical management and referral of maternal and/or foetal complications
- Improve access to both basic and comprehensive emergence obstetric care (EMOC) (Detection and clinical management of obstetric complications, including the provision of instrumental delivery, caesarean section, blood transfusion)

During the neonatal period:

- Improved postnatal and newborn care such as rapid securing of respiration and heart beat of the newborn and avoiding hypothermia
- Nutrition and breast feeding, recommend exclusive breastfeeding
- Community-based case management of pneumonia: Algorithm-based diagnosis and management of pneumonia, including treatment with oral antibiotics
- Emergency neonatal care package: Facility-based clinical care of ill newborns, particularly those with infections, prematurity (e.g. very LBW infants), birth asphyxia

Integrated with other key programs:

- Prevention of mother to child transmission (PMTCT) of HIV and prevention of STI
- Malaria control programmes
- Immunization programmes
- Integrated management of childhood illnesses (IMCI)

Justification of the study

Tanzania, like other countries in sub-Saharan region has a high PMR. The PMR is a key health status indicator which is significantly influenced by the quality of health care (Kongnyuy et al 2008; Manandhar 2004). Perinatal deaths has multi-factorial aetiology, therefore, to address the high perinatal mortality there is a need for careful analysis of contributing factors in order to design appropriate interventions. In a poor resource country like Tanzania assessment of avoidable perinatal deaths (those due to error or omission on the part of the health service) may help to identify the area most likely to bring change and reduction of perinatal deaths.

Objectives

The objective of this thesis is to determine the magnitude of perinatal mortality and engage providers in a clinical audit that aims at addressing the avoidable causes of perinatal mortality as well addressing strategies for intervention to improve the quality of care at Muhimbili National Hospital obstetrical unit. The specific objectives are:

- To estimate the perinatal mortality rate and categorise/classify the perinatal deaths (Paper I)
- To identify the avoidable causes of intrapartum stillbirths and neonatal deaths (Paper III and IV)
- To estimate the prevalence of anaemia at delivery and the impact of the severity of maternal anaemia on different perinatal outcomes (Paper II)
- To examine the quality of care among patients admitted with eclampsia and study the preventable perinatal deaths in this group (Paper III)
- To identify the sub-optimal factors in the perinatal care, that may contribute to intrapartum stillbirths and neonatal deaths of newborn with a birth weight 1500 grams and above (Paper IV)
- To discuss entry points and strategies for interventions (Paper III and IV).

Material and methods

The study area

This study was performed at Muhimbili National Hospital in Dar es Salaam, Tanzania (Figure 5). Dar es Salaam is situated on the east coast of Tanzania and comprise of the municipalities of Ilala, Temeke, and Kinondoni (Figure 6). It is bordered by the Indian Ocean to the east and on all other sides by Coast Region. In 1950s Dar es Salaam had a population of 150,000, while the population according to the 2000 national census is estimated at 2.5 million with an annual growth rate of~5% (NBS 2002), Dar es Salaam is a typical example of the rapid urbanization process that has been taking place in sub-Saharan Africa in recent decades. It is at sea level and the climate is typically tropical with hot weather through the year (ranging from about 26 to 35 degree Centigrade) and two rainy seasons; short rains in November to December and long rains in March to May.

Tanzania (earlier Tanganyika) became independent from British colonial rule in December 1961. One year later, on December 9, 1962, it became a republic, severing all links with the British crown except for its membership in the Commonwealth. In 1964 Tanganyika and Zanzibar joined to form the United Republic of Tanzania.

Many sub-Saharan African countries have been marred with civil war, but Tanzania has been remarkably peaceful in this regard. Tanzania is a large country in east Africa covering 945,000 square kilometres, almost twice as large as France. Currently the population is estimated at 37 million. Health indicators are summarized in Box 3.

Total population	37,627,000
Annual birth	1,403,000
Crude death rate	15/1000
Population growth rate	2.9%
Infant mortality rate	68/1000
Under five mortality rate	112/1000
Neonatal mortality rate	32/1000
Stillbirth rate	29/1000
Contraceptive prevalence rate	20%
Female literacy	60%
Male literacy	69%
Delivery in health facilities	44%
Maternal mortality ratio	578/100000
Delivery by skilled attendant	47%

Box 3. Health indicators for Tanzania. (Source: WHO; TDHS, 2005; www.tanzania.go.tz/statisticsf.html)

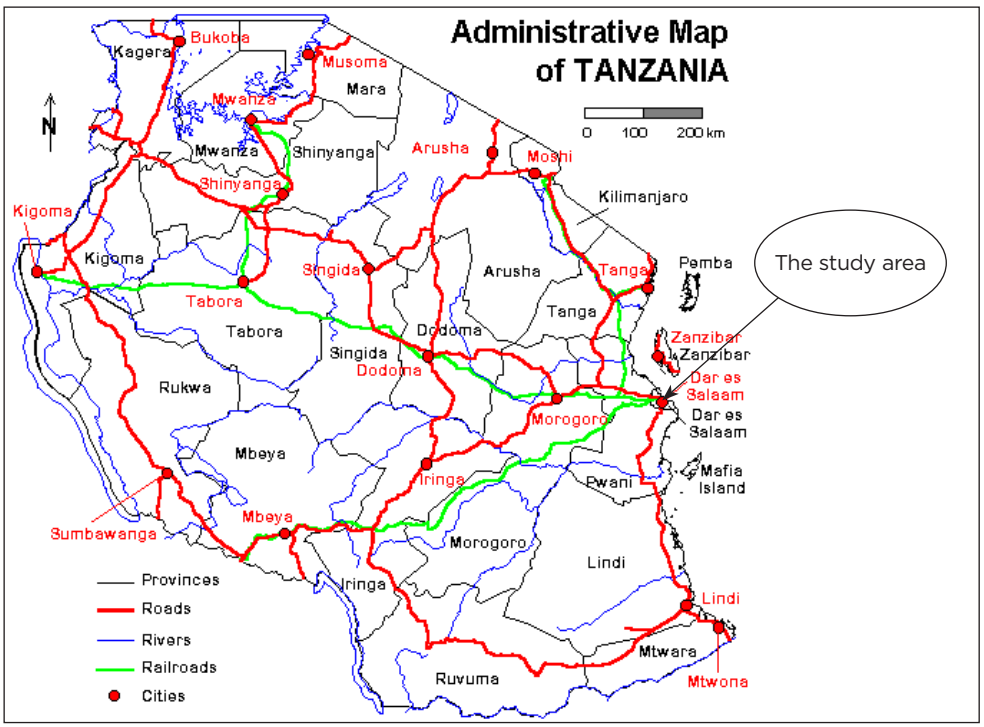


Figure 5. Administrative map of Tanzania

Two third of the population live in rural areas and 56% have access to an improved water source. There are more than 123 ethnic groups with different languages, but most people speak the official language Swahili, and many speak English, the second official language.

The Tanzanian economy depends heavily on agriculture, which accounts for more than 40% of the gross domestic product constitutes 85% of the export, and employs 80% of the work force. The industry traditionally featured the processing of agricultural products and light consumer goods. Minerals also represent major export revenues, and are growing. The booming tourist industry relying on the extraordinary wildlife environment and natural beaches in Tanzania create ten times as great revenue as the minerals.

Health care system

Tanzania has a well developed health care system. The coverage must be regarded as good as nearly 95% of the population is within 10 kilometres of a health facility.

The health service structure is governed by the Ministry of Health, but the services are provided by the government, voluntary agencies, and private companies. The current referral system has a pyramidal pattern which is the cornerstone of the referral

hierarchy (Figure 7), i.e. patients are referred from dispensary and health centres to district and regional hospitals. According to the Ministry of Health estimates, in the year 2006 there were 3565 public health institutions (8 referral/specialized hospitals, 19 regional hospitals, 95 district hospitals, 331 health centres, 3040 dispensaries and 72 training institutions) and in addition, there were 1969 private health institutions (132 hospitals, 150 health centres, 1641 dispensaries and 36 training institutions).

The *village health service* is the lowest level of health care delivery in the country. They essentially provide preventive services that can be offered at home. Usually, each village health post has two village health workers chosen by the village government amongst the villagers and given a short training. The *dispensary services* represent the second level in the health services pyramid. A dispensary serves a population of up to 10,000 people and supervises all the village health posts in its ward. A dispensary may be staffed by a nurse/midwife and a rural medical aide, and usually has a labour room and provide basic essential obstetric services. A *health centre* is expected to cater for 50,000 people, which is approximately the population of the administrative division. Health centres are staffed by clinical officers, nurses and midwives and usually has beds and delivery facilities, including vacuum extraction and intravenous infusion, but not blood transfusion and surgical facilities. Each district is supposed to have a *district hospital* serving 250,000 people and is headed by the district medical officer, who is medical doctor by training or an assistant medical officer. In some districts, a voluntary agency hospital is designated to be a district hospital, and get subventions from the Government on contract terms. The *regional hospital* serves as a referral centre for 4-5 district hospitals and gives specialist services that are not provided at the district hospitals. The *consultant hospitals* are large teaching hospitals with specialist services. At the top of the health pyramid is the Ministry of Health that takes care of referral of patients to hospitals abroad.

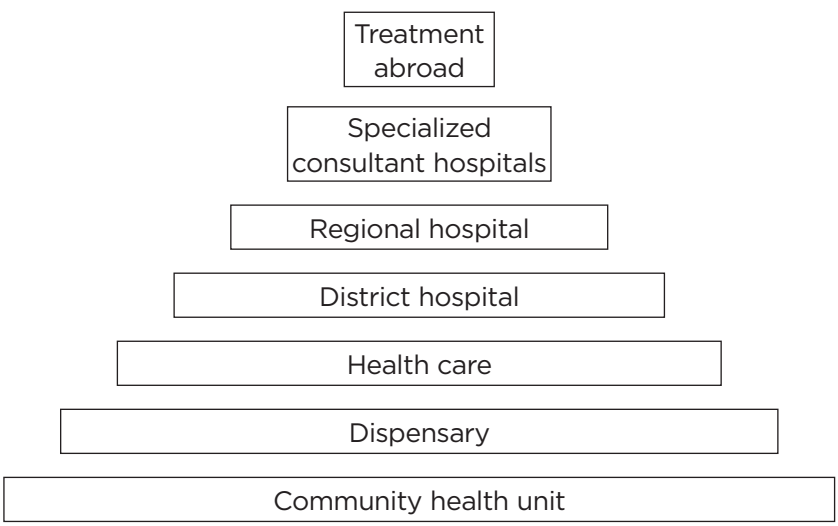


Figure 6. The referral hierarchy

Maternal and perinatal care

It is the policy of Government of Tanzania that medical service for maternity and under five years of age is provided free of charge. The 2004-05 Tanzania demographic health survey (TDHS) data (NBS 2005) showed a rapid decline in the infant mortality. The infant mortality rate in Tanzania was 68 deaths per 1000 live births, down from 99 reported in 1999. During the same period the under-five mortality dropped by 24% from 147 to 112 per 1000 birth. Although infant mortality overall has declined, neonatal mortality (deaths to infants under one month of age) has remained relatively steady since 1996. Half of all infant deaths occur in the first month of life. Neonatal deaths will not decline until more women give birth in functioning health care facilities and with the assistance from trained health professionals.

The national morbidity data shows that malaria, upper respiratory tract infections, diarrhoea and pneumonia are the most common diagnoses at outpatient clinics for both under 5 and older children (NBS, 2005). Malaria is a major public health concern, especially among pregnant women and children under the age of five. In 2006 malaria constituted 44% of morbidity among the under-5 year old children and 34% of the above-5 year old children. The use of mosquito nets, particularly insecticide-treated nets, is a primary health intervention that should reduce the malaria transmission.

Human resources

The health sector in Tanzania is facing a severe shortage of human resources at all levels. There were 29,063 health professionals in public institutions in 2006 while the requirement was 82,277 therefore creating a shortage of staff of 53,214. The retrenchment policy coupled by employment freeze implemented from 1993 to 1999 resulting in a sharp decline in health workforce even as the disease burden increased. During preparation of this thesis the the government has allowed recruitment of new health personel.

Health financing

The government of Tanzania and donors allocation to the health services has doubled from 5.1 to 13.1 billion Tanzanian shillings from 2002/03 to 2007/08 (1US$=1300 shillings) (GoT 2008). It is estimated that donor's contribution constitutes about 40%. The government spend about 13% of their budget in the health sector or 7 US$ per capita (GoT 2008).

Due to multiple areas of priority as compared to available resources the level of finance which the government has been able to provide for its health system has not been sufficient. Therefore, Tanzania initiated *cost-sharing* in public hospitals in 1993 with the intent of reducing the financial gap, improving availability and quality of health services and increasing ownership and community participation. Today all districts have initiated cost-sharing for facilities except for under-five children and maternal and child health (MCH) services (including immunizations and ANC),

tuberculosis, leprosy, paralysis, typhoid, cancer, AIDS and epidemics. Services at all public facilities are still primarily financed by Government and donors through the Ministry of health (MOH), Prime minister's office, regional and local government (PORALG), and municipal council budgets.

In Dar es Salaam there are 28 hospitals (5 owned by government and 23 owned by religious organization, NGOs and private, 29 health centres and 389 dispensaries. There is a gap (deficiency) of 4 hospitals, 24 health centres and 48 dispensaries (Director 2009).

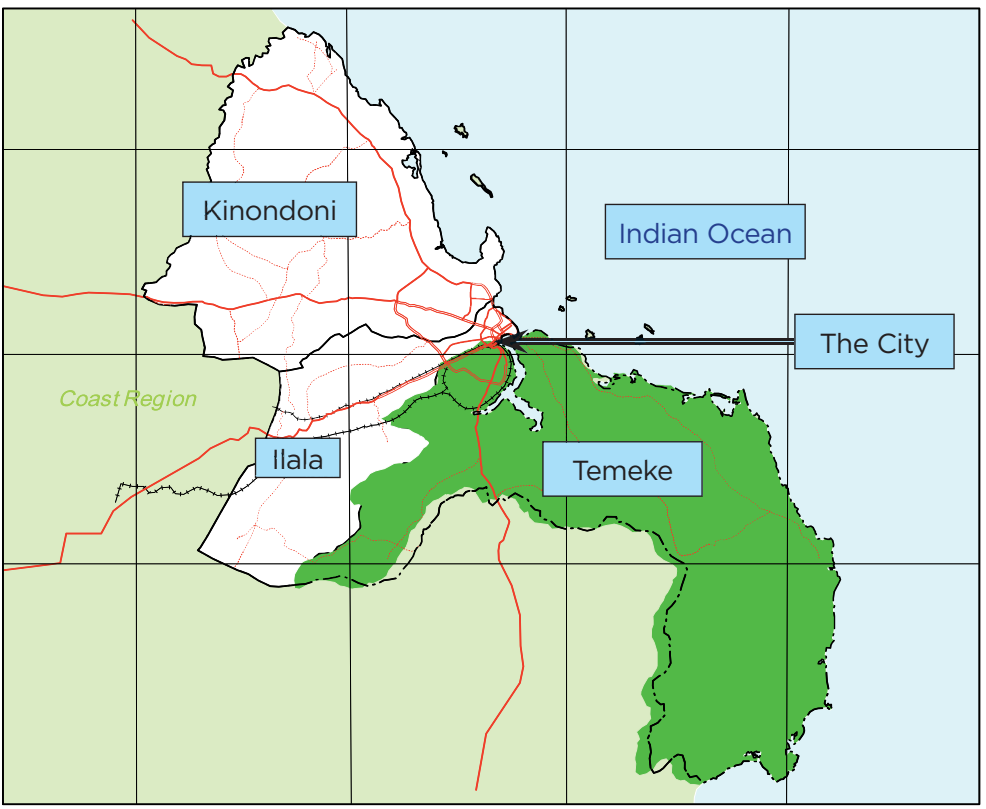


Figure 7. Dar es Salaam

Table 1. Number of government and NGO/private health facilities in Dar es Salaam

Facility	Government	NGO/Private	Total
Hospitals	5	23	28
Health centres	5	24	29
Dispensaries	84	305	389
Total	94	352	446

A nurse attending a pregnant woman at ANC.

Caring for eclampsia patient.

Muhimbili National Hospital (MNH)

The studies have been conducted at Muhimbili National Hospital (MNH), Dar es Salaam, Tanzania, a national tertiary referral institution and a teaching hospital for the Muhimbili University of Health and Allied Sciences (MUHAS).

History

The origins of MNH can be traced back to 1910/20s when it was known as Sewahaji Hospital. In 1956 it was re-named Princess Margaret Hospital. Soon after independence (1961) the name was changed to Muhimbili Hospital and in 1976 it was renamed Muhimbili Medical Centre (MNH 2009).

Muhimbili National Hospital was established by the MNH act of Parliament No. 5 of 2000 by separation of the then Muhimbili Medical Centre into MNH and the Muhimbili University College of Health Sciences (MUCHS) now MUHAS. Separation was effected in November 2004.

The essence of separating MMC and MUCHS was to make MNH more efficient, become an accredited centre of excellence for hospital care in Africa by 2015, provide a conducive teaching environment for training medical and allied health personnel, become a renown centre of medical research in Africa, continuously develop its human resources, achieve financial sustainability and promote the aims of health sector reform by strengthening links with other levels of care in the referral system (MNH 2009).

MNH bed capacity / human resources

MNH has 950 beds and is attended by 1000 to 1200 outpatients per week. It has 2700 employees of which 300 are medical doctors and specialists, 900 registered & enrolled nurses and the rest are supporting operations employees. MNH is organized into seven directorates which are clinical services, nursing services and quality, clinical support services, human resources, finance and planning, technical services, and information and communications technology; it has 25 departments and 106 units (MNH 2009).

The main responsibility of this hospital is to provide tertiary medical services. However, it also provides primary and secondary care mainly for Dar es Salaam districts and the coastal region, but occasionally receives patients from upcountry (Simba et al 2008).

The MNH labour ward

During part of the study period the hospital was undergoing major renovations after long periods of neglect. Economic problems facing the country cut across all levels of services including health services. The MNH labour ward was not spared and lacked may essential resources like drugs and equipments. Delays in operation were a com-

mon phenomenon due to inadequate theatre space. After renovations and introduction of cost sharing the services have improved tremendously.

The labour ward is meant for high risk and complicated deliveries, however, due to poor function of the referral system, 80% of patients are self-referred (Simba et al 2008). This leads to overcrowding, an imbalanced staff patient ratio and overuse of scarce supplies available.

There are three shifts for nurses, each with six midwives. One specialist obstetrician, one consultant obstetrician and one resident (house officer) are on call every day. After a normal uneventful vaginal delivery patients are often observed in hospital for 6-10 hours and the babies also get BCG and polio vaccinations before being discharged. Babies delivered by Caesarean section (C/S) or those with low Apgar score (<7) are admitted to the neonatal ward, which is just one floor up from the labour ward. The unit also admits sick and premature babies from other hospitals.

The neonatal unit

MNH neonatal unit is the only public neonatal ward in Dar es Salaam. It has 130 baby cots (beds) and admits between 12-25 neonates per day. The bed occupancy is between 120%-180%, that means there are between 120-180 neonates in the ward every day which necessitate sharing of beds sometimes. The unit has 2 neonatologist, 4 paediatrician and 6 resident doctors. There are 32 trained nurses, 8 enrolled nurses and 14 ward attendants. There are 3 nursing shifts with 8 nurses each.

The obstetric database

The MNH obstetric database was established in 1998 with financial assistance from Sida/SAREC, and since that time data have been prospectively collected. The main source of data is the midwifery book. All patients admitted to the MNH labour ward bring their antenatal cards which contain summaries of events during ANC. Information from the cards supplemented by interviews of the patients are recorded in the case note on admission. Delivery data, progress of labour, maternal and neonatal outcome are also recorded in the parthogram and case notes. All these information are finally summarized in midwifery book which is the primary data source for the database. The causes of early neonatal deaths based on clinical diagnosis are traced from the neonatal unit records. The neonatal register keeps summaries of the case notes of each neonate. Maternal and neonatal diagnosis is based on doctor's records in the case notes. Data from the midwifery book is then computerized (Figure 8). Validity of data entered in the database is ensured by a data quality control program run weekly and validity check of selected variables. The quality control is done by comparing selected variables e.g. Apgar score, birth weight, mode of deliver, sex of the baby and maternal and foetal outcome(dead or alive) with the actual data in the case notes to countercheck that what is entered by the data clerk is corresponding to the case note. Neonatal deaths reflect only babies born at MNH and admitted to the neonatal unit. Deaths that occurred at home or at other hospitals can't be traced. Article I and II of this thesis utilized data from the database.

The database consists of a data clerk and two research midwives. These staffs have undergone repeated training on data management to ensure continuity of personnel and maintain data quality.

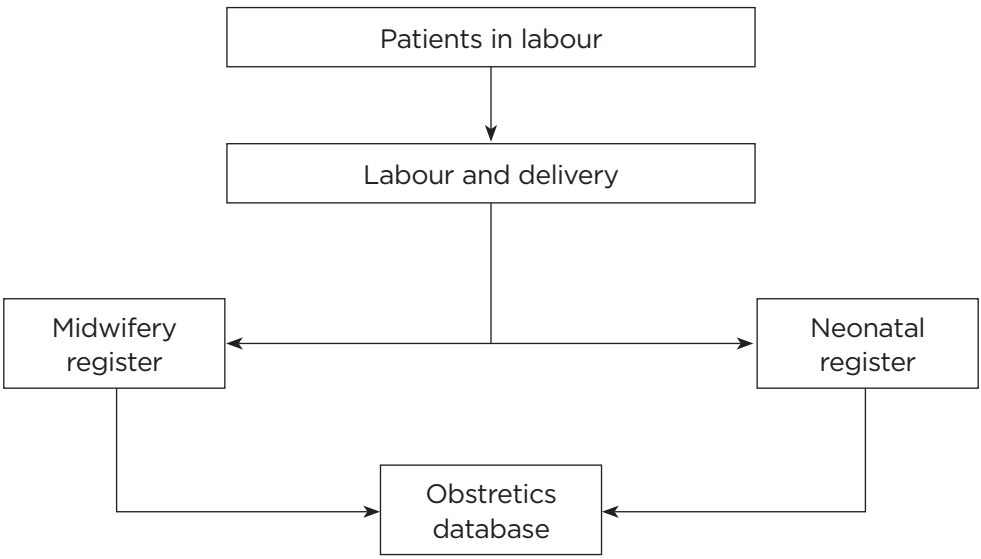
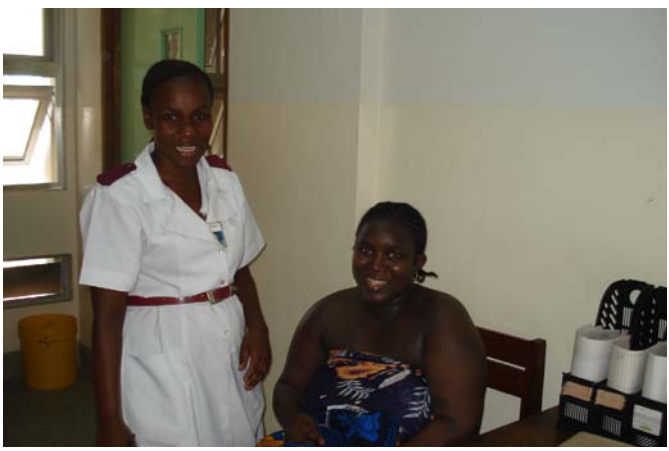


Figure 8. Routine data collection and computerization at MNH labour ward

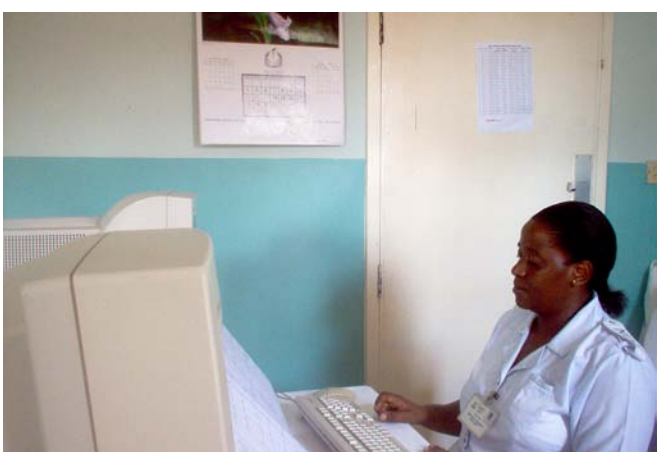
Study design

Research in perinatal mortality and morbidity seeks methods likely to bring about solutions and facilitate change. For this thesis, the perinatal audit process was chosen as a strategy to determine avoidable causes of perinatal mortality and modify certain daily routines that can be shown to contribute to reduction of the PMR. We performed observational studies based on prospectively and retrospectively collected data (Table 2). The obstetric database constituted the base for all studies but had to be supplemented with additional prospective (blood samples for analysis of haemoglobin levels) and retrospective data collection (case notes at obstetric and neonatal ward).

A nurse attending an eclampsia patient.



A happy ending after recovery from eclampsia.



Research nurse entering data in the database.

Study population

The main source of study subjects was the MNH maternity block. This building comprises of the labour ward, a neonatal ward, eclampsia unit and antepartum wards. Patients flow and data collection is summarized in Figure 9.

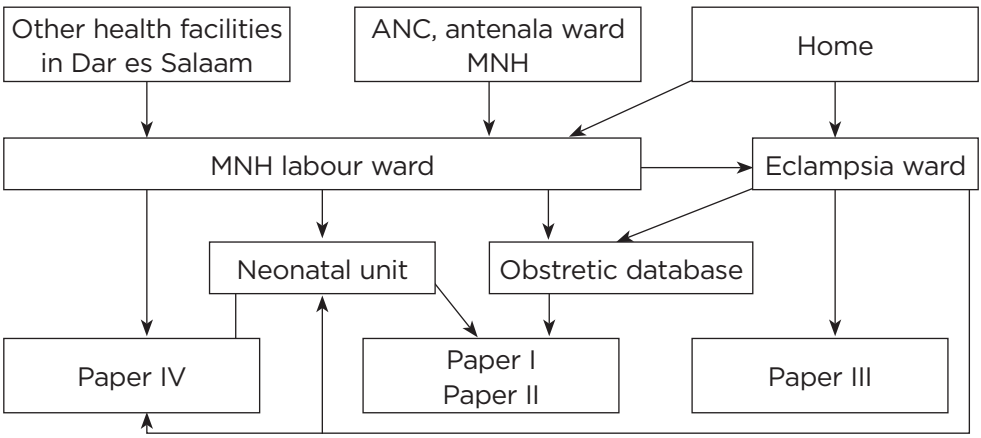


Figure 9. Patient flow and data collection for the studies described in this thesis.

Table 2. Summary of the aims, study period, data collection, study population, additional data source, number of subjects and main outcome measures for the four papers.

Aim	Study period	Data collection	Study population	Additional data sources	Number of subjects	Main outcome measure	Paper
To determine the perinatal mortality rate and categorise/classify the perinatal deaths	1999–2003	Retrospective	All deliveries		77815 deliveries and 9632 perinatal deaths	PMR END rate Stillbirth rate	I
To estimate the prevalence of anaemia at delivery and the impact of the severity of maternal anaemia on different perinatal outcomes	2003–2004	Prospective	All deliveries	Interview of patients and collection of blood samples	1721	Prevalence of anaemia Perinatal outcomes	II
To assess the quality of care among patients admitted with eclampsia and study the preventable perinatal deaths in this group	2005–2006	Retrospective/ prospective	All patients admitted with eclampsia	Case notes and Interviews of relatives	389		III
To identify the sub-optimal factors in the perinatal care, that contributed to perinatal death among babies with a birth weight of 1500 grams and above	2007	Retrospective	Perinatal deaths	Case notes	133		IV

Methods

Estimation of the perinatal mortality rate and classification of perinatal deaths

All perinatal deaths weighing ≥500g and deaths of live born infants occurring in the first week among women delivered at MNH labour ward between January 1999 and December 2003 were included in the study. Data were retrieved from the MNH obstetric database (Figure 8). Neonatal deaths reflect only babies born at MNH and admitted to the neonatal unit, deaths that occurred at home after discharge from the hospital could not be included. A modified Nordic-Baltic classification (Hanne et al 1997) was applied for simplicity. Since it was difficult to ascertain the gestational age, birth weights were used instead. Variables used for classification were time of death (pre-labour, labour or post delivery), Apgar score at 5 minutes, singleton or multiple gestation, and birth weight. Congenital malformations could not be classified since they were not properly recorded. The proportion of perinatal death in each birth weight category was calculated and its contribution to the overall perinatal mortality was determined.

Estimation of prevalence of anaemia in women admitted to the MNH labour ward and estimation of the effect of the severity of anaemia on different perinatal outcomes

Between 15 November 2002 and 15 February 2003 3275 women were delivered at the MNH labour ward. All women that met the inclusion criteria, i.e. attended ANC at least twice, were aged ≥16 years, and had a singleton pregnancy with a complete medical record were prospectively included in the study. Women with multiple gestations, antepartum haemorrhage, a previous history of preterm delivery, or chronic diseases such as tuberculosis, sickle cell anaemia and malignancy, and who were admitted in the second stage of labour or had eclampsia, were excluded to control for confounding factors. Accordingly, 1721 women remained for analysis. All eligible women were informed of the aims of the study and were asked to participate. Women were interviewed in Swahili using a pretested questionnaire to obtain information on socio-economic characteristics, previous pregnancy outcome, iron supplementation, malaria prophylaxis and blood transfusion because of anaemia or treatment for malaria during the current pregnancy and a blood sample was taken.

Anaemia was classified according to the World Health Organization (WHO, 1977) standards (Table 3). The following outcome measures were used: preterm delivery (<37 weeks), Apgar score (<7), stillbirth, early neonatal death, LBW (<2500 g) and very LBW (VLBW) (<1500 g).

Table 3. Classification of anaemia (WHO 1977)

Degree of anaemia	Level of haemoglobin (Hb) g/dL
Normal	≥11.0
Mild	9.0-10.9
Moderate	7.0-8.9
Severe	<7.0

Laboratory test for paper II

Laboratory tests used for the anaemia study were measurement of the level of haemoglobin and a thick blood film for malaria test. Venous blood samples were collected on admission to the labour ward and the haemoglobin level was estimated using a Coulter machine. A thick blood film was also taken, fixed and Giemsa-stained, and malaria parasites were counted under the microscope as a ratio of number of parasites to 200 leucocytes. Measurement of haemoglobin was done by a senior laboratory technician; the Coulter machine was calibrated daily to ensure validity of the results. A new variable (haemoglobin) was therefore created in the database to capture data on haemoglobin that was measured on admission.

Assessment of quality of care among patients admitted with eclampsia. The criteria-based audit

Criteria based audit has been defined as a quality improvement process that seeks to improve patient care and outcome through systematic review of care against explicitly criteria and implementation of change. Aspects of structures, process and outcome of care are selected and systematically evaluated against explicitly criteria. Criteria based audit consists of the following steps: Establish standards of good practice, measure current practice, feedback findings and set local targets, implement changes where required; and re-evaluate practice and feedback.

The *first step* of the criteria-based audit at MNH was a departmental meeting convened in March 2006 to agree on evidence-based criteria on management of eclampsia using the Ministry of Health (MOH) guidelines (MOH 2005), local management guidelines, the WHO manual (Matthai et al 2000) supplemented by the WHO Reproductive Health Library CD-ROM no.8 (WHO 2008), standard textbooks, the Cochrane database and reviews in peer reviewed journals. Participants were all members of the department including doctors and nurses. A list of 14 standards (box 4) was set taking into account the prevailing local setting and available resources. Two workshops were conducted to inform the department members on the standards; each workshop involved 50 participants (doctors, Nurses, and midwives).

The *second step* of the audit was to evaluate the current practice against the agreed criteria/standards. Data were collected by a medical doctor (senior resident) trained for the purpose. Socio-demographic data and events prior to admission like number of fits, previous history of eclampsia or epilepsy were collected by interviewing a relative accompanying the patient using a structured questionnaire. Case files were then collected and reviewed after the patient was discharged to compare the practice against the agreed standards. Information on events during ANC, antepartum and intrapartum period as well as pregnancy outcome was obtained from antenatal cards, case notes and summary. Furthermore, information was collected on gestational age at delivery, number of eclampsia seizures, blood pressure on admission, proteinuria at the antenatal clinic and on admission, gestational age at diagnosis of eclampsia, use of antihypertensive drugs, delivery complications, mode of delivery, Apgar score, birth weight, time interval between admission and delivery, and perinatal and maternal morbidity and mortality.

Mothers were followed up till discharge and all babies referred to the neonatal ward were followed up for seven days to collect data on neonatal outcome and the causes of neonatal deaths. Cause of death was selected from the case notes as recorded by the doctor who certified the death. Post-mortem examination was not performed. The admission book was used to check if all admitted cases were included.

In the *third step* the results of the first audit were presented to members of the department for feedback at a specially convened unit meeting and recommendations for improvement were made.

No.	Standard (criteria)
1	Detailed history and documentation should be made as soon as the patient is admitted.
2	Management plan should be made by senior personnel (senior residents, midwives or registrars).
3	All eclampsia patients should receive $MgSO_4$ as treatment and prophylaxis for further seizures.
4	Treatment of severe hypertension (DBP>110mmHg) with IV medication to all patients with hypertension.
5	All patients' management plans should be reviewed within 2 hours of admission by a specialist obstetrician.
6	All patients should have blood pressure measurement at least every half an hour .
7	Urine analysis for proteinuria should be done within 2 hours of admission.
8	Fluid balance chart should be maintained for 48 hours, in order to monitor urine output and that no patient should be put at risk of fluid imbalance and pulmonary oedema.
9	Deep tendon reflexes should be monitored in all patients treated with magnesium sulphate.
10	Respiration rate should be monitored for 24 hours in all patients treated with magnesium sulphate.
11	Corticosteroids for lung maturation should be given to all preterm cases.
12	Operative delivery (Caesarean section) should be performed within 2 hours of decision.
13	Delivery should be within 24 hours.
14a	Full blood count should be done at least once to all admitted patient.
14b	Renal function test (urea and serum creatinine) should be done at least once to all admitted patient.
14c	The liver enzymes test should be done at least once to all admitted patients.

Box 4. Audit criteria (standards)

The *fourth step* will be to evaluate the practice after implementation of the results and the audit cycle begins again.

Qualitative perinatal audit at MNH to identify preventable causes of intrapartum and early neonatal deaths among babies weighing ≥1500 grams and identifies areas that need improvement to bring change.

Audit procedure

The audit was performed by obstetricians to focus on the care given during labour and delivery from an obstetric perspective. Cases of stillbirth and early neonatal death weighing ≥1500 grams were assessed by an expert panel of two external and one internal auditor. Narratives from the case notes and grading forms were prepared in English by the PhD student and dispatched to the auditors in the Netherlands, Sweden and Tanzania. The auditor from the Netherlands has worked in Tanzania before and has vast experience on African health systems, whereas the auditor from Sweden never has worked in Africa.

The audit protocol was prepared and agreed upon at a perinatal audit workshop convened at the hospital. This workshop was attended by members of the department i.e. nurses, midwives and doctors as well as the auditors. The role of the audit panel members was to identify those situations that were critical and required action. If the required action was not covered by the objective criteria that were formulated beforehand, it was up to the personal judgment of the panel member to assess the adequacy of action taken and to comment on the level of sub-optimality. Suboptimal factors were identified in the antepartum, intrapartum and neonatal periods, and classified in three levels of delay:

- *Maternal/social factors* (Delay related to the patient or relatives)
- *Communication (infrastructure)* (Delay due to transport problem)
- *Care factors* (Delay or lack of appropriate care after reaching the hospital)

The auditors worked independently using a structured assessment protocol and grading form (Appendix 1). The contribution of each suboptimal factor to the fatal outcome was assessed and a final grade was assigned by each auditor. After collating the assessment forms the coordinator (HK) computerized the information.

Data analysis

Epi Info and SPSS were used for data entry and statistical analysis. In the anaemia study Pearson's chi-square test was used to test the difference between two categorical variables.

Logistic regression analysis was performed to estimate the effect of mild, moderate and severe maternal anaemia on various perinatal outcomes (LBW, stillbirth, END and Apgar score) calculating odds ratios (ORs) and their corresponding 95% confidence intervals (CI).

In the perinatal audit degree of agreement between auditors was assessed by the kappa coefficient using the shareware WinPepi. We adopted the Landis and Koch scale (Landis & Koch 1977) i.e. a kappa coefficient of 0-0.20 indicates poor agreement, 0.21-0.40 fair agreement, 0.41-0.60 moderate agreement, 0.61-0.80 good agreement, and 0.81-1 very good agreement.

Ethical consideration

All handling of information regarding the obstetric database including data entry, validity checks, etc. has taken place in the obstetric database room which is always locked and only the database personnel has access to it. The information in the computer cannot be accessed from outside.

In the anaemia study patients were invited to participate in the study and detailed information about the study was provided before an informed consent was given, patients who were found to be anaemic were treated according to the hospitals protocols.

The study protocol including ethical aspects was approved by the research and publication committee of MUHAS. Permission to conduct the study at MNH was granted by the hospital administration.

Results

Magnitude of perinatal mortality

The stillbirth, early neonatal and perinatal mortality rates were 96, 27 and 123 respectively (Table 4). A large proportion (60%) of the intrauterine foetal deaths was admitted in the labour ward without audible foetal heart beat and the majority of the neonatal deaths were asphyxiated at delivery.

Table 4. Perinatal mortality categorized according to a modified Nordic-Baltic classification

Category	**Birth weight (grams)**			**Total**
	<1500 (%)	**1500-2499 (%)**	**≥2500 (%)**	
Number of singleton births:	2374 (3.2)	14441 (19)	58161 (78)	74976
Antepartum stillbirth	1189 (28)	1567 (36)	1574 (36)	4330
Intrapartum stillbirth	476 (18)	658 (25)	1540 (57)	2674
Total	1665 (24)	2225 (32)	3114 (44)	7004
END with Apgar ≤7 at 5 min	361 (25)	424 (30)	645 (45)	1430
END with Apgar ≥7 at 5 min	142 (33)	230 (53)	63 (14)	435
Total	503 (27)	654 (35)	708 (38)	1865
Rate/1000 singleton births				
Stillbirth	701	154	53	93
Early neonatal death	212	45	12	25
Perinatal mortality	913	199	65	118
Number of multiple births	454 (16)	1442 (51)	943 (33)	2839
Antepartum stillbirth	94 (48)	93 (48)	8 (4)	195
Intrapartum stillbirth	96 (32)	142 (48)	60 (20)	298
Total	190 (38)	235 (48)	68 (14)	493
END with Apgar ≤7 at 5 min	99 (55)	56 (31)	26 (14)	181
END with Apgar ≥7 at 5 min	39 (44)	30 (34)	20 (22)	89
Total	138 (51)	86 (32)	46 (17)	270
Rate/1000 multiple births				
Stillbirth	419	163	69	174
Early neonatal death	304	60	47	95
Perinatal mortality	723	223	116	269

Determinants of perinatal mortality

Based on the Nordic-Baltic classification the major causes of neonatal mortality were intrapartum related birth asphyxia (37%) and prematurity (29%) (Figure 10) (Paper I).

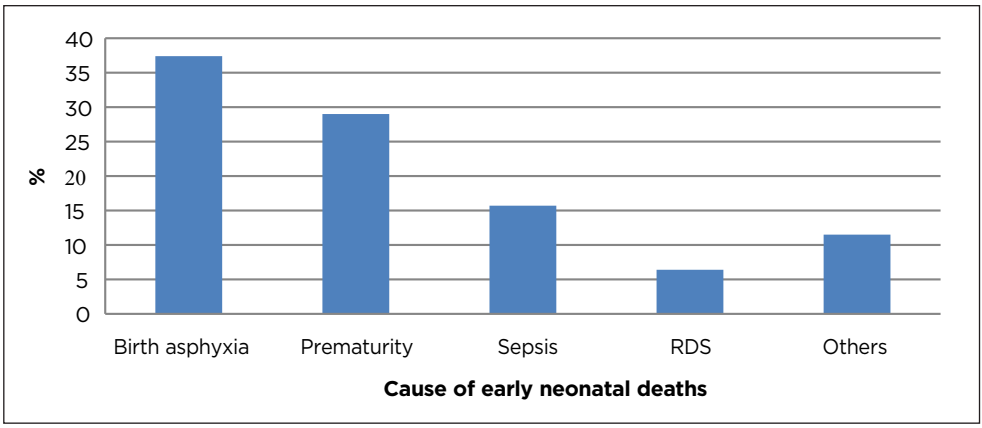


Fig. 10. Causes of neonatal deaths (RDS=Respiratory distress syndrome)

There was an increased risk of perinatal death among LBW babies although there was a significant decrease in the LBW rate during the study period from 19.0% in 1999 to 16.5% in 2003 (Paper I). The decrease in LBW was not followed by a similar trend in PMR. The PMR was very high among babies weighing less than 1500 grams (913/1000 for singleton births and 723/1000 for multiple births). For babies weighing 2500 grams or more it was 65/1000 for singleton births and 116/1000 for multiple births. Analysis of subgroup of perinatal deaths according to the modified Nordic Baltic classification and the birth weight indicated that the relative contribution to the total perinatal mortality of babies weighing 2500 grams or more was 41% and there was an almost equal numbers of both intrapartum and antepartum stillbirths (Figure 11). The majority of neonatal deaths had Apgar score <7 at 5 minutes.

The PMR for multiples and singletons were 289 and 118 respectively resulting in a rate ratio of 2.4 (95%CI: 2.1-2.4). The corresponding figures for intrapartum deaths were 105 and 35.7 respectively resulting in a rate ratio of 2.9 (95%CI: 2.6-3.3) (Paper 1).

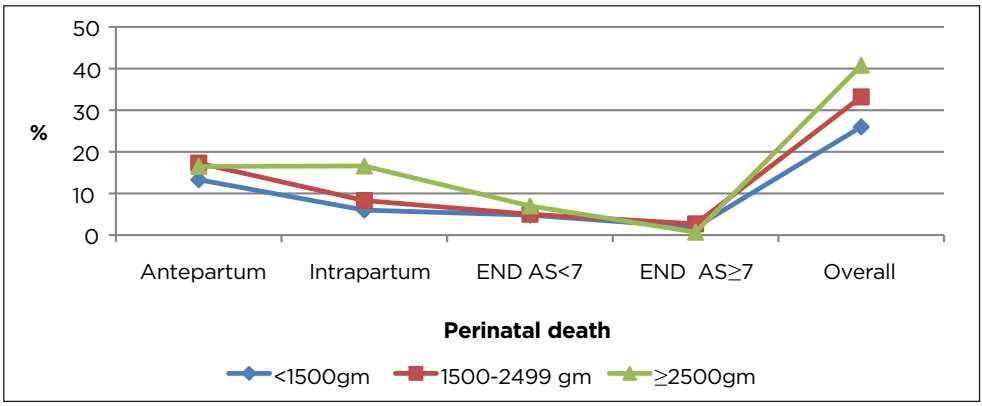


Figure 11. Subgroup of perinatal deaths according to the modified Nordic-Baltic classification by birth weight and their relative contribution to the total perinatal mortality (Antepartum stillbirth, Intrapartum stillbirth, END with Apgar score <7, END with Apgar score ≥7, and Overall perinatal mortality

Maternal morbidity and perinatal outcome

Anaemia during pregnancy and eclampsia were the main maternal medical condition studied. The prevalence of anaemia and severe anaemia was 68% and 5.8%, respectively (Paper II). The hospital-based incidence of eclampsia was 504 per 10,000 women or 5.1% of all mothers admitted (Paper III).

Severity of anaemia increased the risk of preterm delivery with ORs of 1.4, 1.4 and 4.1 for women with mild, moderate and severe anaemia as compared to women with normal haemoglobin levels (Figure 11). The corresponding risks for LBW and VLBW were 1.2, 1.7 and 3.8, and 1.5, 1.9 and 4.2 respectively (Figure 12). The prevalence of preterm delivery and LBW was 17% and 14% respectively.

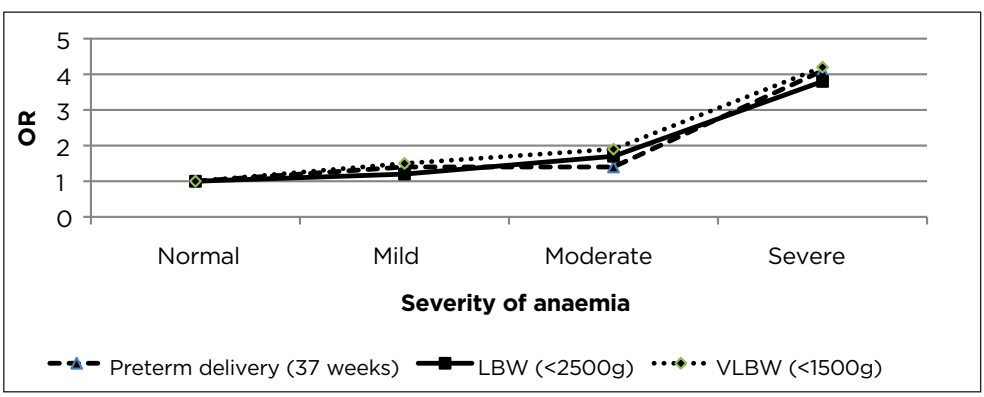


Figure 12. The risk of preterm delivery, low birth weight and very low birth weight by severity of anaemia. (OR = Odd Ratio)

The overall prevalence of positive blood slides for malaria was 6.4% increasing from 5.5% in the non-anaemic group to 6.7%, 5.8% and 11% in the mild, moderate and severe anaemic groups, respectively. One out of four (23%) had a history of at least one malaria episode during the index pregnancy. The prevalence of malaria decreased by increasing age for women≤19, 20-29, 30-39 and ≥40 years from 8.3% to 6.5%, 4.6% and 4.3% respectively.

Criteria-based audit on management of eclampsia was conducted on 389 patients, to assess the quality of care and examine the maternal and perinatal outcome (Paper III). Out of 389 cases of eclampsia studied, 184 (47%), 159 (41%) and 46 (12%) had antepartum, intrapartum and postpartum eclampsia, respectively. Most cases of antepartum eclampsia were preterm (73%) whereas intrapartum (61%) and post-partum (71%) eclampsia more often developed at term. A majority (65%: n=291) were referred from neighbouring municipal hospitals and out of these 26 (8.7%) had already delivered. A median of two seizures had occurred before admission (Range: 1-12). There were 30 maternal deaths and in 40% of them their babies also died. Out of 161 perinatal deaths, 37% were foetal deaths before admission, 16% of the foetal death occurred after admission or during labour, and 29% were early neonatal deaths, 19% were unclassified due to poor documentation.

Suboptimal care were identified on criteria regarding management plan by senior staff, review of the plans by specialist obstetrician, delay on caesarean section, assessment of deep tendon reflexes on patients on magnesium sulphate and laboratory tests. Two out of three patients requiring operation were not operated within set standards, only two patients had deep tendon reflexes assessed. Patients admitted during day time were more likely to be reviewed by specialists than those admitted at night (Paper III).

Avoidable causes of perinatal mortality

Avoidable causes were assessed through a perinatal audit (Paper IV). Perinatal deaths of 133 babies with birth weight 1500 g or more born at MNH from 1st August, 2007 to 31st December, 2007 were audited by three obstetricians, two external and one from MNH. During the study period 3767 births were recorded of which 3449 (91.5%) were live births. There were a total of 120 cases of macerated stillbirth, 120 cases of fresh stillbirth and 65 cases of early neonatal death. Thirteen cases were unclassified, that is in total 318 perinatal deaths. Babies weighing <1500 grams and those with missed values were excluded leaving 133 cases for analysis.

Birth asphyxia was the main cause of intrapartum fresh stillbirth (47%) and early neonatal deaths (51%), whereas eclampsia (25%) and preeclampsia (8.3%) were main maternal medical conditions. Majority of stillbirths were fresh, indicating foetal demise during labour or 12 hours before delivery.

All three auditors identified suboptimal factors in about 80% of audited cases out of which about 50% were found to be the likely cause of the adverse perinatal outcome.

The external auditors associated 60% of the deaths to suboptimal care as compared to 47% for the internal auditor.

Monitoring during labour. In 47%, 41% and 43% of the cases the internal and external auditors assessed poor foetal heart rate monitoring during labour to be indirectly associated with the perinatal death. Parthogram were not properly filled and foetal heart rate monitoring was inadequate.

Delay in providing care. For 23% of patients referred to MNH it took a very long time to reach the hospital. Furthermore, at MNH after making a decision for CS, there were very long intervals between decision and actual procedure. Six patients were delivered vaginally while waiting for Caesarian Section (CS), and instrumental vaginal delivery could have rescued these babies. The auditors suggested more use of vacuum (Ventouse) delivery.

On evaluation of the quality of care, there was a better agreement between the external auditors (κ=0.25) as compared to the external versus internal auditor (κ=0.08-0.19). However, there was a better agreement between external 2 and internal auditor in terms of final grading and contribution of suboptimal factors to adverse outcome (κ=0.31-0.37 and 0.30-0.35 respectively).

Discussion

General discussion

The studies included in this thesis have indicated that perinatal mortality at MNH is very high and suboptimal care contributes significantly on perinatal deaths (Paper I and IV). The PMR was estimated to be 124 per 1000 birth (Paper I), which is higher than the national average (99 per 1000) (NBS 1999). Some smaller community-based studies have reported lower figures (Hinderaker et al 2003; Kitange et al 1994; Mbaruku et al 2009).

In this thesis the most useful part was evaluation through audit the delay in providing care when the patient is already in the hospital. This is because it is within the institution where areas that need change to improve care could easily be identified and immediately designs interventions for implementation. Paper III and IV were audit studies; the former was performed following a criteria-based audit framework (Graham 2009; Kongnyuy 2009) whereas Paper IV was an introduction of qualitative perinatal audit at the hospital.

The causes of perinatal deaths found in studies included in this thesis are consistent with previous studies done in Tanzania (Hinderaker et al 2003; Kitange et al 1994; Mbaruku et al 2009) and the WHO global estimates (WHO 2006). In contrast to more affluent countries, where unavoidable deaths like congenital malformations and extreme preterm birth predominate, in our study intrapartum birth asphyxia and immaturity-related conditions predominated as has been reported in other settings in developing countries (Lawn et al 2009).

The high proportion of stillbirth and neonatal deaths of well formed babies weighing 2500 or more (Paper I) points to poor managed labour as has been shown in other developing countries (Darmstatadt et al 2009), in this material inadequate monitoring of labour was a major suboptimal factor (Paper IV). Complications arising during labour and delivery have been reported elsewhere to be a major contributing factor for intrapartum perinatal death in developing countries (Weiner et al 2003). Appropriate monitoring of labour and delivery and timely action could save majority of these term stillbirths and neonatal deaths (Pattinson et al, 2003). In Paper I, high proportion of antepartum (Stillbirth) (60%) reflects inadequacies in ANC and delayed referrals. However, the finding that about 38% of patients were admitted at MNH without audible foetal heart beat (Paper IV) indicate that at least something could have been done to save some of the remaining 62% of perinatal deaths who arrived at the hospital with foetal heart beats.

We used clinical audit to complement the routinely collected data (Paper III and IV) since audit involves local staff's reflection on their current practice and setting standards for bringing about improvements in care. The value of perinatal audit even in areas with minimum resources has been mentioned in various part of this thesis, for instance, in south western highlands of Tanzania (van Roosmalen 1989). There

are however, diverging opinions about the utility of clinical audit, some report an effect in decreasing risk of perinatal mortality by improving the practice of health care providers (Wagaarachchi et al 2001; Weeks et al 2004; Kongnyuy 2009), while others claim that benefits have never been adequately evaluated (Adey et al 1996).

The high level of suboptimal care and concurrent avoidable perinatal death noted here is similar to previous studies in Africa (El Amin et al 2002) but much higher than that found in European studies (Richardus et al 2003; Saastad et al 2007). We used the term suboptimal care when there was a departure from acceptable evidence based standards. However, suboptimal care does not necessarily lead to a perinatal death, because it can be identified both in cases with good and adverse outcome. In contrast, avoidable factors always refer to their relationship with adverse outcome. About half of the audited deaths were likely to have been due to suboptimal care (Paper IV), and this indicates that changes in the daily routines can bring significant reduction in perinatal mortality in this urban tertiary centre.

Delayed operative delivery, low use of vacuum delivery and delayed referrals were some of the suboptimal factors. During the study periods the hospital was undergoing major renovations and there was only one operating theatre, furthermore, vacuum sets were not available leading to unnecessary caesarean section on cases that could be delivered by vacuum extraction. The audit study (Paper IV) indicates that intra-partum deaths and neonatal deaths could be prevented by up to 64% according to external auditors and by 79% by internal auditor. These figures are much higher as compared to a similar study in Sudan (El Amin et al 2002).

We conducted a perinatal audit in order to identify areas to improve care, however, it may be questioned at this point whether this type of audit improve care on itself. To achieve this, prolonged follow-up studies are necessary to measure the impact like what has been done for ten years in Mozambique (Bugalho et al 1993). This needs resources and may necessitate relinquishing from other quality improvement activities and concentrate on measuring the effect of an audit. However, it is ethical and very important to have continuous quality improvements. This thesis describes the beginning of a continuous process to improve care in a hospital where audit was non-existent. This kind of audit process provides a good start for quality improvement in developing countries like Tanzania. We focused on adverse perinatal outcome and it is imperative that it should be complemented by other quality improvement activities rather than standing alone since it might encourage increased interventions such as caesarean sections.

Audit in poor resource countries like Tanzania is always compromised by the poor quality of information recorded in women's case notes, and by conflict between ideal care and available resources. In this material (Paper III and IV) the poor quality of the patient records including inadequate filling of parthogram has been identified as a problem. Previous study done in the same area had a similar finding (Nyamtema et al 2008). The improvement of recording practices by doctors and nurses is therefore recommended.

Maternal medical condition and perinatal mortality

Anaemia in pregnancy

The prevalence of anaemia and severe anaemia found in this study was high (68% and 5.8% respectively, Paper II). A previous study in the same area indicated that a major proportion of women at reproductive age were anaemic even before entering pregnancy. (Massawe et al 1999; Massawe et al 2002). It is therefore probable that many women were anaemic before their index pregnancy.

Low birth weight is a major contributor to neonatal and post-neonatal mortality. Twenty five million babies a year are born with birth weight below 2500 grams, over 90% of these are born in developing countries where perinatal and infant mortality is already high. We found a significant association of both low birth weight and preterm delivery to the severity of anaemia (Paper II). The LBW rate in this material is (18%), similar to other countries in the region and Asia (George et al 2009). Studies in Tanzania indicate a high prevalence of LBW (10-15%) (Habibu et al 2008; Manji et al 1998; Mwanukuzi et al 1972). PMR among LBW babies was extremely high (Paper I). The high PMR in babies weighing less than 1500 grams in studies included in this thesis is explained by complexity of preterm birth and inability to take care of very premature babies at our neonatal unit. Preterm birth and LBW have been demonstrated elsewhere to contribute significantly to early neonatal deaths. (Cogswell et al 2003; Wilcox et al 1992; Xiong et al 2000).

The association between prematurity and birth weight points to a probable association with small for gestational age (SGA) (George et al 2009; Scanlon et al 2000; Straughn et al 2003). However, the SGA classification is meaningful only when gestational duration has been established by an appropriate method, e.g. gestational age assessed by ultrasound in the second trimester. The other prerequisite for an adequate SGA assessment is reference curves of foetal growth in the population under investigation. There were no such references available for the population in our study. The validity of birth charts is based on reliable estimation of gestational age expressed as completed weeks, in accordance with international recommendations (Kramer et al 2001). This is not the case at MNH since not all women undergo confirmation of gestational age by ultrasound.

Maternal infections during pregnancy are well-known risk factors for preterm labour; appropriate treatment can reduce the adverse effects (Haws et al 2009; Rogerson et al 2007). Infections such as syphilis, HIV and malaria may lead to premature deliveries and therefore LBW (Kusiako et al 2000; Watson-Jones et al 2007). They may contribute into antepartum deaths as has been shown in the previous studies (Axemo 1985; Bergström 2003; Robinson et al 2001).

In addition to a range of micronutrient deficiencies, chronic infections such as HIV have been shown to contribute to the occurrence of anaemia, and C-reactive protein increased in most of the anaemic patients (Fawzi 2007). Penn et al (2006) indicated that women with HIV have a small increased risk of miscarriage, stillbirth, perinatal

and neonatal mortality, intra-uterine growth restriction and LBW babies. In our study area, where anaemia is caused by a combination of factors, HIV is only one of the infections that would impinge on maternal anaemia; consequently, information on HIV serostatus alone is probably of limited value since anaemia can only be expected in a later phase. The strong association shown in this study between anaemia, LBW and preterm delivery demonstrates that maternal anaemia should be seen as an important predictor for increased perinatal risk, although it is not possible to evaluate to what extent this relates to the maternal anaemic condition per se.

Prevention and treatment of both anaemia and infections may prevent a lot of unnecessary perinatal mortality.

Eclampsia

In Paper IV we performed a criteria based audit to evaluate the hospital care of patients with eclampsia in a low-income country, we revealed several suboptimal factors that must be corrected in order to improve maternal and foetal outcomes. The importance of audit and the collection of process indicators were highlighted at the Safe Motherhood Technical Consultation in Colombo in 1997 and criteria-based audit is proven to be a useful tool to measure, improve and monitor the quality of maternity care (Shaw 1990; Wagaarachchi et al 2001; Kongnyuy 2009). It is part of a process for improvement and can empower health workers to conduct their own quality assessments and seek their own solutions that are locally appropriate and internally driven (Wagaarachchi et al 2001).

Eclampsia is such a potentially dangerous condition that is associated with high maternal and foetal morbidity and mortality (Chhabra et al 2007; Weinstein 1982), hence, a specialist assessment of all patients is mandatory irrespective of their condition on admission. Furthermore, adequate use of the laboratory might help to early diagnosis of conditions with serious morbidity and mortality such as the HELLP syndrome (Wightman et al 1978). Pregnant women in Tanzania have free medical care; therefore, there is no cost for laboratory test. Lack of using the laboratory may reflect the inadequacy of current protocols or lack of knowledge among health care providers on the pathophysiology of eclampsia.

Magnesium toxicity may result in coma, cardiac or respiratory arrest (Yucesoy et al 2005). Therefore close monitoring of patients on magnesium treatment is mandatory. Inadequate monitoring of deep tendon reflexes found in Paper III might have been due to lack of coordination between doctors and nurses or lack of documentation.

Preterm delivery and LBW are well known major causes of perinatal mortality among preeclampsia/eclampsia patients (Goldenberg et al 2008; Gul et al 2005). The high prevalence of LBW (51%) found in the eclampsia study is coherent with other reports (Igberase et al 2006). Therefore whenever indicated patient with premature labour should receive corticosteroids for foetal lung maturity.

Methodological considerations

Choice of the study area and the study population

Muhimbili National Hospital is the only tertiary public hospital in a city of more than 3 million inhabitants. The hospital's main responsibility is to provide tertiary medical services. However, due to inadequate health facilities in the city, the hospital also offers secondary and occasionally primary care services. The three public municipal hospitals in Dar es Salaam are small and do not have a 24 hours comprehensive emergence obstetric care. Therefore, majority of patients are treated at MNH. We consider our study representative of the population of Dar es Salaam since 80% of obstetrics patients come straight from home and have essentially normal delivery (MNH obstetric database). Presence of a well established electronic database at MNH was an added advantage and it was mainly used in Paper I and II of this thesis. A pervious study done in the same hospital indicated that apart from patients referred from municipal hospitals, 72% of the patients attended at MNH were self referral and 70% required admission (Simba et al 2008), and out of this 67% required surgical intervention with obstetrical conditions being more prominent (25%).

Measurement of haemoglobin and malaria test

The cross-sectional anaemia study (Paper II) was conducted in an area with a known high prevalence of anaemia during pregnancy (Massawe et al 2002), which we consider an advantage concerning the research objective.

The definition of anaemia has been much debated. However, in study II we used the WHO criteria for pregnant women that define anaemia as Hb below 11.0 g/dL, and severe anaemia as Hb under 7.0 g/dL (WHO 1992). In a normal pregnancy, the physiological expansion of the plasma volume leads to a decreasing Hb in the first and second trimesters and increases a little in the last trimester, giving the characteristic U-shaped curve throughout pregnancy (Koller 1982). We measured the maternal haemoglobin at delivery, at the end of the third trimester in most cases. This was to ensure quality of data and standardize the measurement since women included in the study had attended various ANC clinics using different methods of haemoglobin measurement; furthermore, some women had never had haemoglobin measurements during the current pregnancy. Therefore, for the purpose of the study, a new variable 'haemoglobin' was created in the obstetrics database to capture data on the level of haemoglobin.

Laboratory tests

Venous blood samples were collected on admission to MNH, and the haemoglobin level was estimated using a Coulter machine. Measurement of haemoglobin was done by a senior laboratory technician; the Coulter machine was calibrated daily to ensure validity of the results. A thick blood film for *malaria parasite* examination was also taken, fixed and Giemsa-stained, and malaria parasites were counted under

the microscope as a ratio of number of parasites to 200 leucocytes. This is a semi-quantitative measure, and will be sensitive to changes in the total number of white blood cells, e.g. during a bacterial infection (Cheesbrough 1999). Interpretation of the blood slide results may be difficult in a population of partially immune subjects, and its predictive value for malaria disease may be rather low (Delley et al 2000; Kilian et al 2000). Thus, the inference we can make is only on the association between anaemia and a positive *blood slide,* not the actual association between anaemia and *malaria disease*.

Although the study area was endemic for malaria, only 6.4% of the pregnant women had peripheral malaria; and the fact that 1 in 4 women had a positive history of treatment for malaria during their current pregnancy confirms that a thick blood film is not always a reliable test for malaria in pregnancy. The low laboratory figure may be attributed either to intermittent presumptive prophylaxis (Brentlinger et al 2007) or placental localization of the parasites, which we did not investigate. The mechanism that causes malaria serious effects in pregnancy have not yet been fully established (Cot et al 2003). However, it appears probable that a major factor is the severe anaemia caused by malarial parasitaemia. Previous studies have indicated that malaria increases the risk of preterm birth, and 25% of the babies born are also anaemic (Kasumba et al 2000). Placental malarial infestation may lead to severe intra-uterine growth restriction of the foetus, which in turn predisposes to preterm birth.

Perinatal audit

The methodology used in Paper IV had the advantage that the auditors included both a local obstetrician and two external auditors. One of the external auditors had vast experience of obstetric practice in Africa and the other obstetrician had not practiced in Africa. We consider that this combination of auditors added strength to our study and might have minimized bias in the total assessment. The internal auditor was an obstetrician working in the same hospital which might have made her less critical, but she also had the advantage of knowledge of the working environment. It was more common that the external auditors considered that the clinical action was delayed than the internal auditor did so; a similar finding to a study in Sudan (El Amin et al 2002).

Grading of suboptimal care into three levels of delay (delay in recognition of a problem 'community' and seek care), delay to reach health facility 'infrastructure' and delay to receive quality care in the facility) enabled us to pinpoint areas related to suboptimal care after the patient has arrived in the hospital. We further associated suboptimal care to cause of the adverse outcome (as unlikely, possibly or a likely cause of the adverse perinatal outcome). This methodological approach enabled us to detect areas which needed improvements to reduce perinatal mortality (Paper IV). The evaluation of the cases and grading depended greatly on the individual auditors experience as reflected by fair to poor agreement among auditors. The external auditors were more critical than the internal auditor. It could be questioned whether external auditors should always be invited in this kind of audit, however,

for this particular study it was necessary because it was the introduction of audits in this hospital with very high perinatal mortality, therefore, it was as well a capacity building process.

We prepared case narratives and dispatched them to the auditors. However, it is obvious that it is not possible in a busy labour ward like MNH to prepare case notes of all cases for audit, but a good way is to give the task to one of the junior doctors to prepare case stories for assessment e.g. 2-3 cases a week that can be presented and assessed at the weekly meeting. One can alternate between types of cases as the senior obstetrician decides. In general practice it is not the main aim to get statistics of the sort we have in a paper, so there is no need to assess all cases as long as all types of complications are represented.

Conclusions

Based on these studies, we conclude that:

- The perinatal mortality (PMR) in this study was higher than the national average
- About one in four perinatal deaths at MNH can be attributed to avoidable factors linked to obstetric care
- Main causes of perinatal and neonatal deaths were birth asphyxia, and immaturity related and infection
- Suboptimal care that is essentially avoidable included: inadequate monitoring of patients during labour, delay of care, e.g. long decision to surgery interval, and delayed referral of patients from primary hospitals
- The prevalence of anaemia in pregnancy was very high; and low birth weight and preterm delivery was independently associated with severity of anaemia
- The prevalence of eclampsia at MNH was high and the case management needs to be improved

Recommendations

In the prevention of perinatal deaths significant areas remain for health care improvements and this thesis highlights the importance of care during labour and delivery. Therefore the most important policies to implement in the future are:

- Adequate foetal and maternal monitoring during labour
- Shortening the interval between decision and caesarean section
- Management of eclampsia patients needs more involvements of specialist obstetrician and proper monitoring of the mother and the baby
- Performing instrumental vaginal delivery when indicated
- Reducing prolonged labour at MNH as well as in referring hospitals and promote prompt hospital transfer after decision to refer

Intervention

For intervention purposes the following steps have been taken to improve the perinatal outcome. These steps will be followed by data collection to assess the impact:

- Continued medical education by re-training the midwife and doctors on the use of parthogram and interpretation of abnormal parthogram findings (Two trainings have been conducted with 60 participants each). This will improve monitoring during labour
- For more involvement of obstetrician on the management of patients in the labour ward and eclampsia room, an obstetrician on call is relieved from other duties while on call, a room has been prepared for the obstetrician to spend night at the hospital, and the hospital has provided a mobile phone for obstetrician on call for easy consultation with junior doctors and colleagues
- Management protocols for eclampsia and other obstetrics emergences have been prepared and displayed in the wards notice boards
- New sets (5 sets) of vacuum (ventouse) and Doppler have been purchased for assisted deliveries and assessment of foetal heart beats
- Nurses/midwives working in the labour ward have stated routine continued medical education every morning once a week
- A decision operation interval is checked by record tracing of the patient from the labour ward to theatre. (A log book has been opened for this purpose to identify areas of delay)
- Training midwives/doctors on helping the baby to breath has been introduced (One training has been conducted)
- The administration has been in contact with the municipal hospitals to streamline referrals so that there are no delays
- Regular perinatal audits have been introduced

The researcher

A young man born a couple of years ago at the foot of Kilimanjaro and Pare mountains in north eastern Tanzania. During my childhood I really loved to see medical personnel on their white coats though I was afraid of injection.

Soon after completing secondary education I joined the compulsory military service for one year, after that I joined an accountancy school to accomplish my parents wish. However, this could not last more than a year because my interest was to be a medical doctor rather than an accountant.

I started my long journey to be a medical doctor at 1987 in Marmara University, Turkey. After completion of my MD degree I joined the department of medicine in the same University wishing to be an internist, but this dream ended prematurely (one year) after discovering that patient satisfaction in this speciality was very low since many patients had chronic diseases that were rarely curable. My wish was to pursue a speciality that would have higher patient satisfaction. I then joined the University of Dar es Salaam in 1996 to pursue a masters degree of medicine in obstetrics and gynaecology.

After graduation I joined the Muhimbili National Hospital, a teaching hospital for Muhimbili University of Health Sciences as a specialist cum lecturer. During this time I was appointed to head the obstetric database and as a consultant for the eclampsia ward. I was responsible for production, preparation and distribution of monthly, quarterly, half and annually maternity ward reports as well as overseeing the management of eclampsia patients. It was this time when I realised that perinatal mortality was a major problem in the hospital and I decided that something has to be done.

After discussion with Professor Siriel Massawe the head of the reproductive health project and the Swedish collaborators that were supporting the database project, I was advised to introduce perinatal audits so that we can determine the magnitude of the problem and study the underlying avoidable causes that can be rectified to reduce perinatal mortality.

My PhD journey began way back in year 2003 when I was given an opportunity to attend a field research methods course in Umea. This course gave me an insight on research, that was when I was prompted to ask Professor Siriel Massawe and Gunilla Lindmark and Lennarth Nystrom to consider me for PhD studies. I was registered in 2007.

Since I joined the PhD program, a lot has changed; I have been involved in many activities related to prevention of stillbirth and early neonatal deaths in my country. I have a better understanding of the determinants of stillbirth and neonatal deaths and I am now a national trainer for helping the baby to breath, a program run by the Ministry of Health in collaboration with the American paediatrics association. I feel proud to be part of this crusade.

To reach where I am now was a collective effort of many individuals as acknowledged below.

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Appendix 1. Perinatal audit form for identification of sub optimal factors and grading

Level of delay	1=Maternal/social (Community level)	
	2=Infrastructure/communication	
	3=Care	
	4=Infrastructure and care	
	5=All of above	
	6=No delay	
Contribution of the suboptimal care to the foetal death	1=Unlikely	
	2=Possibly	
	3=Likely	
Final grading	**Grade 0** No suboptimal care has-been identified	
	Grade I Suboptimal care has been identified, but unlikely to have contributed to the fatal outcome and different management would have made no difference to the outcome	
	Grade II Suboptimal care has been identified and might have contributed to the fatal outcome. Different management might have made a difference to the outcome.	
	Grade III Suboptimal care has been identified and is likely to have contributed to the fatal outcome. Different management would reasonably be expected to have made a difference to the outcome. A clearly avoidable factor implying that any adverse outcome could have been prevented.	
Overall suboptimal graded 0, I, II or III according to above definition		
Do you think there was sufficient information available to assign a final grade in this case	1=Yes 2=No	
Do you consider likely that this death was preventable?	1=Yes 2=No	
Signature of the author.....	Date.....	