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Maternal Health and Pregnancy Outcomes in Rural Malawi

University of Tampere
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Maternal Health and Pregnancy Outcomes in Rural Malawi
To the people of Lungwena
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LIST OF ORIGINAL COMMUNICATIONS

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


## ABBREVIATIONS

<table>
<thead>
<tr>
<th>Abbreviation</th>
<th>Definition</th>
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<tbody>
<tr>
<td>CI</td>
<td>Confidence interval</td>
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<tr>
<td>ELISA</td>
<td>Enzyme-linked immunosorbent assay</td>
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<tr>
<td>HIV</td>
<td>Human immunodeficiency virus</td>
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<td>MUAC</td>
<td>Mid-upper-arm circumference</td>
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<tr>
<td>OR</td>
<td>Odds ratio</td>
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<tr>
<td>MMR</td>
<td>Maternal mortality ratio</td>
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<tr>
<td>NMR</td>
<td>Neonatal mortality rate</td>
</tr>
<tr>
<td>PCV</td>
<td>Packed cell volume</td>
</tr>
<tr>
<td>PMR</td>
<td>Perinatal mortality rate</td>
</tr>
<tr>
<td>RPR</td>
<td>Rapid plasma reagin</td>
</tr>
<tr>
<td>RR</td>
<td>Relative risk</td>
</tr>
<tr>
<td>SD</td>
<td>Standard deviation of the mean</td>
</tr>
<tr>
<td>SFD</td>
<td>Symphysis-fundus distance</td>
</tr>
<tr>
<td>SP</td>
<td>Sulphadoxine-pyrimethamine</td>
</tr>
<tr>
<td>TPHA</td>
<td>Treponema Pallidum Haemaglutination assay</td>
</tr>
<tr>
<td>UNICEF</td>
<td>United Nations Children’s Fund</td>
</tr>
<tr>
<td>WHO</td>
<td>World Health Organization</td>
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<tr>
<td>WDPZ</td>
<td>Weight for duration of pregnancy Z-score</td>
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</table>
## DEFINITIONS

<table>
<thead>
<tr>
<th>Term</th>
<th>Description</th>
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<tbody>
<tr>
<td>Antenatal</td>
<td>Period of pregnancy from conception to the onset of labour</td>
</tr>
<tr>
<td>Gestational age</td>
<td>The duration of gestation is measured from the first day of the last normal menstrual period. Gestational age is expressed in completed weeks</td>
</tr>
<tr>
<td>Low-birth weight</td>
<td>Birth weight less than 2500 grams</td>
</tr>
<tr>
<td>Low-income countries</td>
<td>The term low-income countries is used synonymously with the term developing countries, and includes 130 countries according to the United Nations Development Programme (UNDP) classification of 1996. All African states are labelled low-income countries (UNDP 1996)</td>
</tr>
<tr>
<td>Maternal death</td>
<td>Death of woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes</td>
</tr>
<tr>
<td>Maternal mortality ratio</td>
<td>Number of pregnancy related deaths per 100,000 live births</td>
</tr>
<tr>
<td>Neonatal period</td>
<td>A period from birth to the 28\textsuperscript{th} day of life of a baby</td>
</tr>
<tr>
<td>Neonatal mortality rate</td>
<td>The number of deaths of the babies within the first 28 days of life per 1,000 live born babies</td>
</tr>
<tr>
<td>Newborn weight</td>
<td>Weight of newborn baby measured before the age of seven days</td>
</tr>
<tr>
<td>Perinatal mortality rate</td>
<td>The number of stillbirths after 22 weeks of gestation, or deaths of newborns during the first 7 days of extrauterine life per 1,000 births</td>
</tr>
<tr>
<td>Perinatal period</td>
<td>A period from 22 completed gestation weeks to seven completed days of life of a foetus/baby</td>
</tr>
<tr>
<td>Preterm</td>
<td>Gestational age of less than 37 completed weeks</td>
</tr>
<tr>
<td>Sub-Saharan Africa</td>
<td>39 mainland countries of the continent south of the Sahara (thus excluding Western Sahara, Morocco, Algeria, Tunisia, Libya and Egypt). This term is used interchangeably with the term “Africa”</td>
</tr>
</tbody>
</table>
1. INTRODUCTION

Maternal and child health has globally been of great concern for a long time. For approximately two decades i.e. since the historical meeting in Alma-Ata, many countries have even prioritized women and children in their national health strategies (WHO 1988, Meyer 1992). Concomitantly, the average health development among these target groups and the general population has become more favourable. Thus, the worldwide average for under-five and infant mortality rates has decreased between 1960 and 1997 from 192 to 87 and from 124 to 59 deaths per 1,000 live births, respectively. Between 1955 and 1995 life expectancy at birth increased from 48 years to 65 years (UNICEF 1998, WHO 1998).

Despite the positive global trend in health development the progress has been slow or even non-existent in most low-income countries. The situation is especially alarming among pregnant women and newborn children. Even today, as many as 600,000 women each year - more than one woman per minute - die from complications related to pregnancy and childbirth. Ninety-eight per cent of these women are from low-income countries (Ahmad 1999). Moreover, the average perinatal and neonatal mortality rate in low-income countries stands at 57 deaths per 1,000 births and 36 deaths per 1,000 live births, respectively. These rates are approximately ten times higher than those in industrialised countries (WHO 1998).

Traditional health interventions to improve maternal and newborn health in low-income countries have laid great emphasis on antenatal care, whereas less attention has been given to improvement in delivery services (Weil and Fernandez 1999). The primary rationale for such strategies has been to screen for individuals that possess certain risk factors and who thus form a target group for specific interventions. Most antenatal programmes in low-income countries have, however, been largely copied from developed countries, without testing their true potential to reduce adverse pregnancy outcomes in the new settings (Villar and Bergsjo 1997). Because of the minimal reduction in maternal and newborn mortality, the role of antenatal care in low-income countries has been increasingly questioned (McDonagh 1996, Brouwere 1998, Derveeuw et al. 1999, Weil and Fernandez 1999).

At present, little community-based information is available on the characteristics and patterns of maternal and newborn health in low-income countries (Barros et al. 1987, Gray et al. 1991, Rooney 1992, Fikree and Gray 1996, McDonagh 1996, Bergsjo and Villar 1997, Villar and Bergsjo 1997, Nielsen 1998, Wessel 1998, Osman 2000). Therefore, it is also difficult to assess the benefits of antenatal care in these circumstances. The present research was designed to describe and analyse the health situation of pregnant women and newborn children in rural Malawi. Of special interest was to identify the associations between different antenatal factors and adverse pregnancy outcome and in doing so to evaluate the Malawian antenatal care procedures at community level.
The present study focuses on socio-economic situation of pregnant women, maternal health and pregnancy outcome in rural Malawi. The study was carried out at primary health care level where medical resources were limited. In such circumstances, community level cohort studies provide the most reliable information. This design minimizes selection bias and many other potential sources of error that easily confound hospital-based and retrospective study designs.

Before the present study approximately ten larger prospective studies on maternal health and pregnancy outcome have been published from sub-Saharan Africa (table 1). Whereas all of these studies have provided some data on maternal and newborn health in general many of them have primarily focused on more specific topic. These topics include malaria (McDermott et al. 1993), adolescent pregnancies (Brabin et al. 1998), maternal genital or infectious diseases (Wessel 1998, Osman 2000), foetal growth or maternal anthropometry (Möller et al. 1989a and b, Pelletier et al. 1995, Osman 2000). The present study provides data from one of the first rural mother-child cohorts in Malawi.

Because maternal and child health services form one element of primary health care, this review will first provide a historical perspective of primary health care. Thereafter maternal and newborn health will be reviewed in relation to the most common adverse pregnancy outcomes both from the maternal and the newborn perspectives. The last chapter of this review will concentrate on the philosophy of antenatal care as well as its potential to eliminate or alleviate adverse pregnancy outcomes. At the end, some unanswered questions will be highlighted which formed the basis of the present study. Whereas the literature arising from the specific topics of the current studies are reviewed in more detail in the discussion section, the scope of the present literature review will be restricted to the main characteristics of maternal and newborn health and the means to improve it in low-income countries.

### Table 1. List of published community-based, prospective studies on maternal health and pregnancy outcomes in sub-Saharan Africa.

<table>
<thead>
<tr>
<th>Place and time the study has been carried out</th>
<th>Reference</th>
</tr>
</thead>
<tbody>
<tr>
<td>Machacos, Kenya 1975-78</td>
<td>Voorhoeve et al. 1979</td>
</tr>
<tr>
<td>Farafenni area, Gambia 1982-1983</td>
<td>Greenwood et al. 1987</td>
</tr>
<tr>
<td>Ilula, Tanzania 1983-85</td>
<td>Möller et al. 1989 a and b</td>
</tr>
<tr>
<td>Mangochi District, Malawi 1987-1990</td>
<td>McDermott et al. 1993</td>
</tr>
<tr>
<td>89 villages in northern Malawi 1986-1989</td>
<td>Pelletier et al. 1995</td>
</tr>
<tr>
<td>Kwimba District, Tanzania 1990</td>
<td>Walraven et al. 1995a</td>
</tr>
<tr>
<td>Chikwawa District, Malawi 1993-1994</td>
<td>Brabin et al. 1998</td>
</tr>
<tr>
<td>Embu District, Kenya</td>
<td>Ngare and Neumann 1998</td>
</tr>
</tbody>
</table>
2.1 Historical perspective of primary health care

The global development of health policy emphasising primary health care has its roots in the period after the Second World War. At the time the European colonial system collapsed and colonies in Africa and Asia got their independence one by one. The health care systems of previous colonial countries were underdeveloped. Because of insufficient financial means as well as lack of know-how, new national governments were unable to raise the health care systems to the level of the industrialised nations. Undoubtedly, development took place and new hospitals and health stations were established with support from Christian missionaries or the European governments who felt responsible for their previous colonial societies. However, these health care systems concentrated mainly on curative medical care and lacked major public health implication (King 1966, Juva 1994).

The shock of the Second World War led people in northern countries to wish for improved collective strategies to avoid war and increase the ability for joint efforts that would improve the quality of life of people all over the world. As a response to this, in the 1950s, many departments of community medicine were established and primary health centres were built in some countries. By necessity, the health authors started to look not only at the causes of diseases but also the causes of health of people and this development also forced health workers to look outside the hospitals at the reality of the people’s environment.

Unfortunately, these early attempts at new approaches to health faced difficulties. One of the obstacles laid in the lack of intersectoral and interprofessional co-operation for health. Another reason was the rapid development of curative medicine in the 1950s and 1960s. Both clinical investigation and treatment took tremendous strides forward and the broader public health issues were pushed aside by politicians (King 1966, Hellberg and Mäkelä 1994).

A policy shift became evident in the early 1970s’ when the Director General of WHO gave several reports on the world health situation that pointed out the disparities in stages of development of both health services and peoples’ health between countries. Especially in low-income countries, much of the rural population lacked proper access to health services (Hellberg and Mäkelä 1994). According to these reports, better equity was the target and the concept of “health for all by the year 2000” was expressed by World Health Assembly in 1977. An international primary health care conference held in Alma-Ata endorsed it in 1978 and promoted primary health care as the principal means to realize it. Thereafter, individual countries have developed national modifications from this agenda when creating their health care systems (WHO 1978, Tarimo 1991, Hellberg and Mäkelä 1994).

The concept of primary health care rests on three fundamental pillars including equity for all, community involvement and intersectoral coordination. On a more specific level, eight elements have been said to make up primary health care, table 2 (Hart et al. 1990, Tarimo 1991, Hellberg and Mäkelä 1994). Out of these components of primary health care the present study will cover some aspects of maternal and child health care as well as components of nutrition, water and sanitation, immunisation and endemic diseases from the point of view of pregnant women.

Table 2. The eight elements of primary health care
(Tarimo 1991).

<table>
<thead>
<tr>
<th>Health education</th>
<th>Promotion of food supply and proper nutrition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Safe water and basic sanitation</td>
<td>Maternal and child health care</td>
</tr>
<tr>
<td>Immunisation</td>
<td>Prevention and control of locally endemic diseases</td>
</tr>
<tr>
<td>Treatment of common diseases and injuries</td>
<td>Provision of essential drugs</td>
</tr>
</tbody>
</table>
2.2 Maternal and newborn health in setting of low-income countries

2.2.1 The relationship between maternal, perinatal and neonatal health

In medical terminology maternal health is almost exclusively understood as pregnancy related health. In contrast the concept perinatal alludes neither to the foetus nor to the pregnant women. However, the use of the term perinatal has been criticized because more attention has been given to foetal or infant events than to the maternal side and, for example, maternal mortality is rarely included in the scope of perinatal medicine (Bergström 1991). All in all the deaths and diseases of infants during perinatal and neonatal period are strongly associated with maternal biological characteristics and with problems during pregnancy and childbirth. Since maternal and perinatal health problems are closely linked, the major risk factors for disease and death among mothers and their newborns are the same and efforts to improve the health of either pregnant women or the newborn have synergistic effects on the health of the other (Baird 1969, Bhatia 1989, Bergström 1994b, Walsh et al. 1994).

2.2.2 Maternal health

Three different types of indicators have often been used to describe maternal health in low-income countries. These are maternal mortality, morbidity for selected illnesses and nutritional status during pregnancy (Koblinsky et al. 1993, Merchant and Kurz 1993, Bergström 1994a).

Levels of maternal mortality in industrialized and developing countries show greater disparity than any other public health indicator. Whereas the figures in industrialized countries are generally in the range of 10-15 deaths per 100,000 live births, in low-income countries they are in the range of 200-1,000 or more (AbouZahr et al. 1996). The highest overall maternal mortality ratios occur in Africa, especially in the sub-Saharan region where the figures in some places rise as high as 1,100 deaths per 100,000 live births (AbouZahr et al. 1996, WHO 1999). The direct causes of maternal deaths are the same around the world. About three quarters of these have been attributed to haemorrhage, sepsis, eclampsia, obstructed labour and abortion complications. The remaining include complications of pre-existing illness such as diabetes and cardiovascular diseases or such conditions as hepatitis, anaemia, or latent infections e.g. tuberculosis, malaria, sexually transmitted and other genital infections that can become active during pregnancy (Walsh et al. 1994, AbouZahr 1996).

It has been estimated that for each maternal death there are about 30 cases of severe maternal disability or morbidity as a result of complications. Maternal morbidity could be measured in two ways: Firstly maternal disease might be diagnosed clinically as diseases occurring during pregnancy or the puerperal period. Secondly maternal health is necessarily reflected in its dependent passenger, the foetus. Maternal diseases show wide variation comprising in low-income countries diseases like cerebral malaria, severe anaemia, tuberculosis, nutritional deficiency related conditions, HIV-related conditions and complications arising from illicit abortion. Some devastating consequences of complicated pregnancies and deliveries include chronic conditions like fistulae or tubal sterility after postpartum endometritis-myometritis (Koblinsky et al. 1993, Bergström 1994a). The relevant indicators of the passenger expression of maternal morbidity are for example prevalence of preterm births and infants with low birthweight as well as stillbirth, perinatal and neonatal mortality rates (Bergström 1994a, Walsh et al. 1994).

Nutritional status of woman before and during pregnancy is a fundamental determinant of foetal growth, birthweight and
infant morbidity as well as of women’s health, productivity and caring capacity (Merchant and Kurz 1993, WHO 1995a). In low-income countries, maternal malnutrition is frequently combined with infectious and other diseases which both contribute to the poor health of the mother and child (Tomkins and Watson 1989). Malnutrition, on the other hand, can be seen as a contributing factor for all main causes of maternal deaths. Thus, anaemia has been associated to a quarter of deaths from haemorrhage. Childhood stunting reduces maternal stature which increases the risk of obstructed labour. The inter-relationship between malnutrition and infection is well known and maternal calcium status may be associated with the development of gestational hypertension (UNICEF 1997).

2.2.3 Adverse newborn outcomes

The most commonly used pregnancy outcomes for newborns in low-income countries include peri-and neonatal mortality, preterm birth and low birthweight baby.

About eight million perinatal deaths are reported annually worldwide - almost all in low-income countries. This may even be an underestimate since perinatal deaths, particularly stillbirths delivered at home are frequently underreported. In most low-income countries, perinatal mortality rates range between 40 to 70 per 1,000, whereas in developed countries, rates range from 6 to 10 (McDermott et al 1996a, WHO 1996). From all first year deaths, neonatal mortality has been estimated to account for 50-60% in low-income countries. The figure can exceed 100 per 1,000 in more than 70% of sub-Saharan African countries (Bergström et al. 1994, UNICEF 1994). Both perinatal and neonatal deaths are largely determined by delivery complications and delivery care as well as maturity of the foetus, as reflected by birthweight or gestational age (Walsh 1994, WHO 1998).

Pre-term birth is defined as a birth before 37 completed weeks of pregnancy (Kraemer, 1987). In most low-income countries precise information on gestational lengths are scarce since exact dating is difficult because of the unavailability of reliable menstrual data and non-attendance to or late booking in antenatal care (Andersson and Bergström 1995). It has been estimated, however, that up to 50% of all infants are born preterm in the poorest countries (UNICEF 1987). In affluent societies the incidence of preterm birth ranges between approximately 4 and 16% (Paneth et al. 1986, Vienonen 1986, WHO 1995a).

The known risk factors for preterm birth in low-income countries comprise pre-eclampsia, maternal infections especially malaria and sexually transmitted diseases, multiple pregnancy and foetal malformations (Osman et al. 1995. Bergsjo and Villar 1997, Sullivan et al. 1999). Whereas perinatal survival also depends to a large extent on delivery and newborn care, it is commonly stated that the earlier the birth the graver the outlook for the newborn. Those infants born premature have higher risks of mental defects and other neurological sequelae, risk of infection and sepsis during neonatal period (Bergsjo and Villar 1997).

UNICEF (1999) estimates that at the global level about 17% of infants are born with birthweight less than 2,500 grams. The prevalence of low birthweight is not uniform throughout the world: the estimates of low birthweight vary in low-income countries from about 10 to 30% as compared to developed countries with proportions of about 4-10% (UNICEF 1999). Two major processes determine birthweight: duration of gestation and intraterine growth rate. Most studies from low-income countries do not distinguish intraterine growth retardation from preterm infants (Kraemer 1987). An analysis of the available studies from low-income countries suggest that intraterine growth retardation probably results in the majority of low birthweights in low-income countries (Villar and Belizan 1982, Kraemer 1987). Both maternal and foetal factors are known to
influence the weight of the newborn baby. Among the maternal variables the most commonly reported are: parity, birth interval, nutritional status as reflected by weight, pre-pregnancy weight for height and weight gain, health status of the mother indicated as the presence of anaemia, antenatal infections or complications of pregnancy and behavioural conditions like antenatal attendance and physical activity during pregnancy. Among the factors related to foetus, the important ones are gender, congenital malformations and multiple pregnancy (Kraemer 1987, WHO and UNICEF 1992, WHO 1995a). Many of these factors are strongly associated with the socio-economic status of the mother (Kraemer 1987, Sprundel et al. 1988, Victoria et al. 1992, Andersson and Bergström 1997).

The low birthweight of newborn has been shown to be a significant determinant of foetal and neonatal health (Kraemer 1987, WHO and UNICEF 1992). The WHO defines low birthweight as a birthweight less than 2,500 grams. Birthweight specific infant mortality begins to rise rapidly below this value (Kraemer 1987). This was recently demonstrated by a study from rural Zaire where the annual proportion of low birthweight infants increased by 10% between years 1989 and 1994. In the same period infant mortality rate in Zaire increased from 81 to 120 per 1,000 (Newby and Lovel 1995).

2.3 Antenatal care as a tool to improve maternal and child health

2.3.1 Antenatal care

Antenatal care is a broad term used to describe the medical procedures and care that are carried out during pregnancy (McDonagh 1996). The overall aim of antenatal care is to produce a healthy mother and baby at the end of the pregnancy (Lindmark and Gnattigius 1991). In theory, a series of health examinations with predefined content should enable health personnel to identify ailments and other conditions in the mother and her foetus(es) which may threaten the pregnancy. In addition planning for a safe delivery is an integral part of antenatal care (Rosen et al. 1991).

Antenatal care programmes, as currently practised, originate from models developed in the early decades of 20th century in Europe. Although medical knowledge and technology have evolved, the core of these early models remains practically unchanged in current programmes (WHO 1993, Brouwere et al. 1998). There is, however, considerable variation in the content of antenatal care worldwide and there are no agreed criteria on what exactly constitutes antenatal care (McDonagh 1996). Many authors have agreed that it should consist of motherhood education, prevention of potential problems, identification and treatment of common diseases, risk screening and referral of risk mothers (McDonagh 1996, Rooney 1992, Brouwere et al. 1998).

To a large extent, low-income countries have adopted the antenatal programmes of developed countries with some adjustments pertaining to endemic diseases (Villar and Bergsjo 1997, Brouwere et al. 1998). In general, the validity of the content and the rationale for frequency and timing of visits have not been evaluated in low-income countries. Some of the observations that have been made have, however, questioned the impact of antenatal care on maternal and perinatal morbidity and mortality (Rooney 1992, McDonagh 1996, Villar and Bergsjo, 1997).
2.3.2 Antenatal risk screening method

As the awareness of high maternal mortality rates in low-income countries increased throughout the 1970s and 1980s, the public health authorities concentrated on the improvement of the antenatal clinics as an ideal solution to the problems of maternal mortality (Brouwere et al. 1998). The concept of “risk factors” was developed to screen populations of pregnant women regularly during pregnancy. The objective of screening for “at risk factors” was to identify any pre-existing factors that could increase the risk of complications during pregnancy or delivery to the mother or the infant and to recommend for these “high risk” women to deliver in a health facility that can treat complications arising (McDonagh 1996).

The risk approach was challenged only sporadically until in early 1990s when several studies in Africa and Asia clearly criticized the method (Brouwere et al 1998). The studies showed that most risk assessments classify a high percentage of patients as at high risk and that even in low-income countries where the prevalence of risk is high, antenatal screening has a low predictive value because of its low sensitivity and its relatively low specificity (Hall et al. 1980, Walsh et al. 1994, Acharya 1995, Rohde 1995, Yuster 1995, McDonagh 1996).

2.4 Targets for further investigations

As discussed above, the health situation of women and children remain poor in many low-income countries. To improve the situation and to use the available resources to a maximum, action programmes would require reliable baseline data on the levels and causes of poor maternal and child health. It is true, that a number of socio-economic, antenatal and obstetric factors have already been associated with adverse pregnancy outcomes. However, their relative importance in low-income countries remain largely unknown, especially in rural areas. This is due to the sparsity of published studies in general and to the fact that most studies on maternal and neonatal health are carried out in large hospitals (Voorhoeve et al. 1979, Greenwood et al. 1987, Fauveau et al. 1990, Fikree et al. 1994, Airede 1996, Fikree and Gray 1996, Osman 2000). Such hospital-based studies may not, however, be applicable to the general population. Therefore prospective, community-based studies are needed to enhance maternal and newborn health in low-income countries.
3. AIMS OF THE PRESENT STUDY

The current study forms the first part of the larger research project called Lungwena Child Survival Study that was designed to analyse maternal and child health in a low-income country through a prospective cohort study at community level. The objective of the present study was to identify and analyse the association between different antenatal factors and adverse pregnancy outcomes. The specific aims of this study, conducted in a rural area in southern Malawi were:

1. To describe the socio-economic situation among pregnant women (I).

2. To describe gestational health especially in relation to dietary intake and infectious diseases (II, III).

3. To describe maternal weight, mid-upper arm circumference and fundal height gain and to develop standard curves for maternal weight gain and SFD growth charts in the setting studied (III).

4. To describe delivery events and delivery complications and to identify the predictors of preterm births (IV, V).

5. To identify the socio-economic, antenatal and obstetric factors associated with new born weight among term, live born, singleton infants (III).

6. To determine the prevalence of maternal risk factors and to analyse their predictive value for adverse pregnancy outcome (IV).

7. To describe the magnitude of peri-and neonatal mortality and to identify the socio-economic, antenatal and obstetric variables associated with such mortality (V).
4. SUBJECTS AND METHODS

4.1 Setting of studies and study subjects

4.1.1 Study area

The study was performed in Malawi which is situated in the inland of southeastern Africa, fig 1. The country has a total population of 11 million people, out of whom 85% live in rural areas. On a national level maternal and infant mortality rates stand at 620/100,000 and 135/1,000 live born children (National Statistical Office 1994). More detailed information about Malawi can be found in appendix I (page 57).

Lungwena is a 20 km long and roughly 5 km wide rural area in the Rift Valley between the escarpment and the south-eastern shore of Lake Malawi (fig 1). Approximately 17,000 people occupy a total of 4,200 households in the 23 villages of this area. The predominant religion is Islam and the major ethnic group is the Yaos, Chi-Yao being the main language in the area. Farming and fishing form the main occupations. Family organisation is matrilineal, as a result men move to the wife’s village at the time of marriage whereas women remain near their mother’s home. Traditionally, land is also inherited by the women. However, men are normally considered heads of households because they have stronger influence on important family decisions.

A demographic and health survey in 1994 revealed that the health situation, as measured by childhood mortality figures, was even worse in Lungwena than in other parts of
Malawi (own unpublished observation). To improve the situation, the Malawi Ministry of Health, the Medical College of the University of Malawi and a Finnish non-governmental organisation, the Mannerheim League for Child Welfare, launched a primary health care programme in the area. The Lungwena Health Project aimed to provide improved and accessible health services, develop a field training site for community health professionals and carry out appropriate research. The present project is part of the research activity.

The Lungwena Training Health Centre located in the middle of the Lungwena area provided normal preventive and curative modern health services like family planning, antenatal and delivery care, growth monitoring, vaccinations, and treatment of common illnesses. Modern care could also be obtained from the Namalaka Health Centre, Malindi Hospital or Mangochi District Hospital, situated 23 km, 15 km and 32 km respectively from the health centre. The health centre was equipped with a motorvehicle ambulance, although it was often unavailable locally because of calls to other parts of the district.

All 23 villages in Lungwena area were served by a traditional birth attendant who had attended a 5-week training course, including a 120 hours’ theory course on modern antenatal and delivery care. The training had covered aspects related to safe delivery, early identification of problems in delivery and prompt referral of mothers experiencing them. Since some of the traditional birth attendants provided antenatal care the training covered also antenatal recognition of individuals at risk for delivery complication and their appropriate referral for a health centre or hospital.

There were also numerous traditional and religious healers in Lungwena. No official data exists on the relative roles of modern and traditional medicine in the area, but both are frequently used by the local population.

4.1.2 General set-up of studies

The five studies presented here form the first part of the Lungwena Child Survival Study, a prospective cohort investigation of pregnant women and their offspring. The Lungwena Child Survival Study aims at describing women’s gestational health and pregnancy outcomes, as well as children’s growth, development, morbidity and mortality during their first five years of life. Within the present sub-studies, the follow-up time started from early or mid-pregnancy and ended up at neonatal period (the child’s 28th day of life). The author of this thesis has been responsible for field supervision and co-ordination of the study about one and half years in Lungwena. The study has been approved by the Malawi Health Science Research Committee, at the University of Malawi.

4.1.3 Study subjects

The study subjects included 795 pregnant women enrolled for antenatal care at the Lungwena health centre between June 1995 and September 1996 and children born to them. More than 95% of all pregnant women in the area attended the clinic and only two declined participation in our follow-up. Informed consent was obtained verbally from each participant.

All the 795 study subjects were included to study I. The analysis of study II was confined to 593 women who participated the dietary assessment survey and who delivered after completing this survey. The study III included 581 women giving birth to a term, live, singleton baby while the study IV included all 778 mothers who completed the antenatal follow-up. After excluding the gestational (n=17) and neonatal (n=3) drop-outs 796 births and 757 live births could be evaluated for perinatal and neonatal outcome, respectively, in the study V (see page 28).
4.2 Methods

4.2.1 Preparatory phase of the study

The main study project was preceded by a three-month pilot study and an information campaign. During this period altogether twelve research assistants were hired and trained, and study questionnaires as well as laboratory procedures were tested. In addition the purpose and consequences of the study were discussed in the local management committee for the Lungwena Health Project, each of the 23 village chiefs as well as the heads of the two traditional authorities in the area were met individually and finally a total of 44 village meetings were arranged. Some changes, such as the omission of venous blood collection, were made to the study protocol as a result of the feedback from the local people.

4.2.2 Sequence of study examinations

Figure 2 illustrates the sequence of the study examinations. The pregnant women were enrolled to study at their first antenatal clinic visit at the Lungwena health centre. The subjects were asked to attend the antenatal clinic at monthly intervals up to their 37th gestation week and weekly thereafter. Except for the dietary assessment, all study examinations were done during these routine antenatal clinic visits. Within approximately one week of delivery a research assistant visited the mothers to collect information on delivery events and the baby. In addition the surviving newborns were medically examined within four weeks from birth by a member of the research team. Peri- and neonatal outcomes were documented by research assistants during home visits carried out one month after delivery.

Figure 2. Sequence of study examinations.

ANTENATAL PERIOD

<table>
<thead>
<tr>
<th>Enrolment visit:</th>
<th>Nutrition visit:</th>
<th>Home visit:</th>
<th>Newborn clinic:</th>
<th>Home visit:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Socio-economic background data, obstetric history, measurement of laboratory tests</td>
<td>24-hour recall</td>
<td>Delivery events and pregnancy outcome</td>
<td>Health of the child</td>
<td>Mortality</td>
</tr>
</tbody>
</table>

Every antenatal visit:
Palpation of foetus, listening for foetal heart sounds and measurements of fundal height, weight and MUAC, examination of blood pressure, peripheral oedema and pallor, distribution of malaria prophylaxis, iron supplements and tetanus toxoid according to national recommendations

DELIVERY AND CHILD FOLLOW-UP

Weeks of gestation

15 20 25 30 35 40 0 4

Weeks from birth
4.2.3 Summary of studied variables

Table 3 shows the summary of socio-economic, antenatal and obstetric variables studied and tested for their association with peri-and neonatal mortality among singleton infants (V) and birthweight among term, live and singleton infants (III).

Variables listed in the Malawian antenatal card and summarised in table 4 were considered “risk” characteristics, assumed to predispose pregnant women or their offspring to an adverse outcome. According to national recommendations, Malawian women demonstrating one or more of these “at risk” characteristics should give birth in a modern medical facility. For the present study, most of the risk factors were sought for at the first antenatal visit. Blood pressure was measured repeatedly and the number of foetuses as well as presentation were verified during the delivery. Thus, for the purpose of this study (IV), the final classification into “at-risk” or “no-risk” categories was finalised after the delivery.

4.2.4 Socio-economic background information and assessment of dietary intake

Most of the socio-economic background information was obtained through personal interviews which were carried out by five research assistants using structured native-language questionnaires. Collection of socio-economic data are explained in detail in original publication I.

A modified 24-hour recall method was used to assess the dietary intake of women. At the antenatal clinic visit closest to 32 weeks of gestation, study participants were invited to a discussion where the 24-hour recall method was explained to the women. During the following days research assistants made a total of three home visits at intervals of two to three days to carry out the dietary recall. A modified 24-hour recall method consisted of a 24-hour period when participants ticked the foods they had eaten in a food-picture calendar and an in-depth interview on the following day. The method has been developed and validated in Malawi by Ferguson and her collaborators in 1995 (for details of dietary assessment see original publication II).

4.2.6 Antenatal procedures

At each visit a nurse-midwife inquired about any episodes of recent ill health and measured maternal weight and blood pressure. Abdominal examination included manual external palpation of the foetus, listening for foetal sounds and fundal height measurement (see original studies III and V). Haematological and serological laboratory tests for infectious diseases and anaemia were done from one finger prick blood sample (details of laboratory methods are explained in original publication V).

In accordance with national policy all women attending antenatal clinic routinely received iron supplements, at least two doses of tetanus toxoid and malaria prophylaxis (SP: sulphadoxine 1500mg; pyrimethamine 75mg), one at the first antenatal clinic visit after the first trimester and the second dose at 28-34 weeks of gestation. Otherwise women received malaria prophylaxis if symptomatic. The women took malaria prophylaxis at the health centre under the supervision of a midwife. If women had a positive test for syphilis, their sexual partners and newborn babies were treated with intramuscular injections of benzathine penicillin (2.4 mU for adults and 50 kU/kg for newborns).
Table 3. Variables analysed as predictors of peri-and neonatal mortality (III) as well as birthweight among term, live, singleton infants (IV).

<table>
<thead>
<tr>
<th>Socio-economic variables</th>
<th>Antenatal</th>
<th>Obstetric/newborn variables</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age of parents</td>
<td>Number of antenatal clinic visits</td>
<td>Duration of pregnancy</td>
</tr>
<tr>
<td>Educational level of parents</td>
<td>Parity</td>
<td>Month of birth</td>
</tr>
<tr>
<td>Literacy of parents</td>
<td>Maternal height</td>
<td>Place of delivery</td>
</tr>
<tr>
<td>Occupation of parents</td>
<td>Maternal relative weight at 16., 32. and 36.gw</td>
<td>Attendant of delivery</td>
</tr>
<tr>
<td>Religion of parents</td>
<td>Maternal weight gain at 16., 32. and 36.gw</td>
<td>Mode of delivery</td>
</tr>
<tr>
<td>Number of people in the household</td>
<td>Total gestational weight gain</td>
<td>Presentation of the foetus</td>
</tr>
<tr>
<td>Gender of the head of the family</td>
<td>Total gestational MUAC gain</td>
<td>Delivery complications</td>
</tr>
<tr>
<td>Present marital status of the mother</td>
<td>Relative fundal height at 16., 32. and 36. gw</td>
<td>Gender of the child</td>
</tr>
<tr>
<td>Size and building material of the house</td>
<td>Fundal height gain at 16., 32. and 36. gw</td>
<td>First recorded weight of the newborn</td>
</tr>
<tr>
<td>Source of drinking water</td>
<td>Total gestational fundal height gain</td>
<td></td>
</tr>
<tr>
<td>Presence of pit latrine at home</td>
<td>Diastolic and systolic BP at 16., 32. and 36.gw</td>
<td></td>
</tr>
<tr>
<td>Size of cultivated land area</td>
<td>Increase of diastolic BP ≥15mmHg at any visit</td>
<td></td>
</tr>
<tr>
<td>Ownership of domestic animals</td>
<td>Increase of systolic BP ≥30mmHg at any visit</td>
<td></td>
</tr>
<tr>
<td>Distance between home and health centre</td>
<td>Signs of oedema at any antenatal visit</td>
<td></td>
</tr>
<tr>
<td>Age of mother at first pregnancy</td>
<td>Pallor at any antenatal visit</td>
<td></td>
</tr>
<tr>
<td>Age of previous child at new delivery</td>
<td>Maternal haematocrite level at first antenatal visit</td>
<td></td>
</tr>
<tr>
<td>Number of previous infants in family</td>
<td>Maternal malaria status at first antenatal visit</td>
<td></td>
</tr>
<tr>
<td>Number of under-five deaths in family</td>
<td>Maternal HIV status</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Maternal syphilis reactivity at first antenatal visit</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of tetanus toxoid doses received</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Number of malaria prophylaxis received</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Total energy intake of mother at 32.gw</td>
<td></td>
</tr>
</tbody>
</table>
The ultrasound technology was not available in the study area for assessment of gestational age. In addition due to frequent pregnancies and breast feeding between deliveries the date of the latest menstrual periods was very seldom known by women. Therefore, the duration of pregnancy was assessed using information from the maternal fundal height at her first antenatal examination. Finnish reference values were used to determine the gestational age for fundal height (Vienonen 1991).

The production of local weight gain and fundal height curves as well as the calculation of relative maternal weight for gestational age are explained in study III. Since the pre-pregnancy weight values of the mothers were not available and the first weight measurements were taken at different points of pregnancy, a relative weight value at 16. week of gestation was used as a proxy for maternal pre-pregnancy weight.

### Past obstetrical problems

<table>
<thead>
<tr>
<th>Caesarean section</th>
<th>Age of mother less than 18 or more than 35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Obstructed labour</td>
<td>Primiparity or parity ≥ 4</td>
</tr>
<tr>
<td>Toxaemia</td>
<td>Height of mother &lt;150cm</td>
</tr>
<tr>
<td>Stillbirth</td>
<td>Moderate or severe anaemia¹</td>
</tr>
<tr>
<td></td>
<td>High blood pressure &gt;140/90mmHg</td>
</tr>
<tr>
<td></td>
<td>Breech, feet or cord presentation</td>
</tr>
<tr>
<td></td>
<td>Multiple pregnancy</td>
</tr>
</tbody>
</table>

¹Packed cell volume < 26%, corresponding to a haemoglobin value of approximately 80g/l (Rickman and Anning 1995).

4.2.7 Delivery events and pregnancy outcome

A research assistant visited the mother normally within one week of delivery and interviewed the mother, filled in a structured questionnaire about delivery events and measured the weight and height of the newborn. If the delivery took place at a health centre or a hospital, written provider records were used to verify the information collected. Thereafter the mother was asked to visit the newborn clinic of the Lungwena health centre with the child where one of the study supervisors verified the data collected during the home visit and the child was weighed again. The information of peri- and neonatal deaths were collected by research assistants during home visits one month after delivery.

Delivery complications were classified into seven categories: maternal death, excessive obstetric haemorrhage (approximately 0.5 l or more), retained placenta, obstructed labour (labour pains for more than 12 hours), large (stage III) perineal tear, puerperal fever and convulsions. If the women experienced any of these events the delivery was deemed complicated. The mode of delivery was classified as a normal vaginal delivery, assisted vaginal delivery i.e. vacuum or forceps extraction and caesarean section.

An infant was considered to be born alive if the newborn had breathed or shown any other signs of life such as movements of voluntary muscles or heartbeat. Newborn weights,
measured with spring scales accurate to the nearest 100 g, were considered birthweights if taken within one week of the delivery. Otherwise, no birthweight was recorded.

### 4.2.8 Statistical methods

Data entry was done on EPI-INFO 6.04b, and Microsoft Excel 7.0 while analyses were carried out with SPSS 9.0 statistical software. In nutrition analysis a self made programme on a Microsoft Excel 7.0 spreadsheet was used to calculate amounts of food and daily intakes of energy. The statistical details of nutrition analysis have been described more thoroughly in original publication II.

The squared correlation coefficient ($r^2$) was used to assess the univariate importance of the variables in explaining the variance of birthweight. The Pearson partial correlation coefficient (partial r) was used to assess the independent effect of the variables when they were adjusted for all those factors that had a statistically significant effect on birthweight in univariate analysis.

Identification of variables associated with delivery complications or peri- and neonatal deaths was carried out with cross-tabulation of dichotomous variables. Relative risks and their 95% confidence intervals were calculated using routine methodology and statistical significance, evaluated at 0.05 level, was assessed with Pearson Chi-Square Tests.

Logistic regression was used for multivariate modelling of peri- and neonatal mortality as well as for pre-term delivery. The models included variables that were statistically significantly ($p<0.05$) associated with mortality in univariate analyses as well as pertinent confounding factors: maternal age ($<20$ or $\geq 20$ years), HIV-infection (yes/no) and syphilis screening (positive/negative), distance between mothers’ home and the health centre ($\leq 5$ or $>5$ km), household cultivated land area, presence of a fisherman in the family (yes/no), ownership of domestic animals (yes/no) and latrine (yes/no), source of drinking water (safe /unsafe) and month of the child’s birth (categorised in 12 categories). Birthweight was excluded from the model because it was unknown for a large number of infants and because there was an association between the known birthweights and gestational ages at birth (Pearson correlation coefficient 0.44). Maternal weight gain was excluded because several women (especially those with preterm delivery) had insufficient follow-up time to determine average weekly gain. Month of birth was modelled as a categorical variable (each month forming one category).
5. RESULTS

5.1 Success of enrolment and follow-up (I, IV, V)

Of the 799 women attending antenatal care at the Lungwena Health Centre during the study period, 797 (99.7%) chose to participate. Two of the women were not pregnant and 18 were carrying twins. Thus, the total number of enrolled women and foetuses was 795 and 813, respectively. Fifteen mothers and foetuses (1.9%) discontinued the follow-up during their pregnancies, two mothers aborted before the 22nd gestational week and 36 babies were stillborn. Of the 760 live born infants, three (0.4%) were lost to follow-up during the neonatal period. Thus, 796 births and 757 live births were evaluable for perinatal and neonatal outcome, respectively, figure 3 (IV, V).

Of the 778 women that were followed up to delivery, the mean (SD) duration of pregnancy at the time of antenatal care enrolment and last visit were 24 (5) and 36 (4) gestation weeks, respectively. The median number of antenatal visits during the follow-up was 5 with the range from 1 to 11 (IV).

Active surveillance through local traditional birth attendants and study participants identified only 37 pregnant women who were not receiving antenatal services from Lungwena. Thus, 95.2% (795/834) of all pregnant women in the area were eligible for study. There were no socio-economic differences between those women who attended the Lungwena health centre and those who did not (I, V).

5.2 Socio-economic situation (I, V)

Out of those 789 women whose age information was available, the mean (SD) age was 26 (9) years. About one fifth of them (22%) of them were younger than 20 years. Twenty-four per cent of women were pregnant for the first time. Among these primigravid women (n=189), the mean age (range) was 18 (13 - 33) years and the proportion of women under 20 years was 77% (I, V). With a few exceptions (a five per cent Christian minority), respondents were Muslims (I).

Table 5 summarises the main housing characteristics of the 795 households in Lungwena (I). A majority of the households (67%) obtained their water from an unprotected well, a lake, a river or a pond, i.e. a source that could not be considered safe. Boreholes were infrequent and the most common source of safe water was a protected well. Sanitation structures were more common being found in about three quarters of the households. Thus, the access to safe water was inadequate but sanitation reasonably good in Lungwena. Nineteen per cent of the households lacked both a sanitary facility, as well as easy access to a safe water source (I).

The distance between the participants’ home and the health centre ranged from 0.7 km to 11.0 km with a median of 5 km. Fifty per cent of the study participants lived more than 5 km away from the health centre (I).

Two indicators were used to describe the educational level of the individuals. These were the number of school-years completed and the self-reported ability to read and write. Only 17% of the women and 37% of the men had attended school at all. Few had attended secondary school (more than 8 years of education). Accordingly, the women reported
Fig 3. Flow chart of enrolment and follow-up of study participants.

- Enrolled: 795 women
- Started follow-up: 813 foetuses
- Evaluable for perinatal outcome: 796 children
- Born alive: 760 children
- Evaluable for neonatal outcome: 757 children

- 18 twin pregnancies
- 2 abortions
- 15 gestational drop-outs
- 36 stillbirths
- 16 early neonatal deaths
- 12 late neonatal deaths
- 3 neonatal drop-outs

that only 14% of themselves and 43% of their husbands could read and write. In 52% of the families, there were no literate adults (I).
The mean (SD) holding size was 0.6 (0.8) hectares. Only those households that had either sufficient land or potential regular cash income, sufficient animals, a fisherman in the family or two or more supporters, were considered to have food security (see methods section in original publication I). Seventy-three per cent of the households fulfilled at least one of the criteria for food security (I). A calculation was made as to how commonly the same households lacked several of the studied determinants of health: Inadequate water supply and sanitation (neither safe water nor sanitary facilities), poor access to health care (distance more than 5 km), insufficient educational level of the parents (neither parent could read) or food-insecurity. The mean (SD) number of missing

Table 5. Housing conditions for the 795 participants

<table>
<thead>
<tr>
<th>Number of household members:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-mean (±SD) number household members</td>
<td>3 (1.5)</td>
</tr>
<tr>
<td>-number of under-five-year old children</td>
<td></td>
</tr>
<tr>
<td>none</td>
<td>52%</td>
</tr>
<tr>
<td>one</td>
<td>41%</td>
</tr>
<tr>
<td>two or more</td>
<td>7%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>House construction:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-burnt brick</td>
<td>19%</td>
</tr>
<tr>
<td>unburned brick</td>
<td>70%</td>
</tr>
<tr>
<td>mud, straw or other</td>
<td>11%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Size of house</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-two or more rooms</td>
<td>16%</td>
</tr>
<tr>
<td>-one room</td>
<td>84%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Source of drinking water:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-piped water or borehole</td>
<td>12%</td>
</tr>
<tr>
<td>protected well</td>
<td>21%</td>
</tr>
<tr>
<td>unprotected well</td>
<td>39%</td>
</tr>
<tr>
<td>lake, river or pond</td>
<td>28%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Sanitation facility:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-traditional pitlatrine</td>
<td>77%</td>
</tr>
<tr>
<td>-none</td>
<td>23%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Kitchen:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-separate outside kitchen</td>
<td>58%</td>
</tr>
<tr>
<td>-outside fireplace</td>
<td>39%</td>
</tr>
<tr>
<td>-inside house</td>
<td>1%</td>
</tr>
<tr>
<td>-other or not known</td>
<td>2%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Ownership of domestic animals or household durable goods:</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>-cows</td>
<td>3%</td>
</tr>
<tr>
<td>-goats or sheep</td>
<td>25%</td>
</tr>
<tr>
<td>-chicken</td>
<td>34%</td>
</tr>
<tr>
<td>-mattress</td>
<td>11%</td>
</tr>
<tr>
<td>-radio</td>
<td>36%</td>
</tr>
<tr>
<td>-bicycle</td>
<td>27%</td>
</tr>
<tr>
<td>-car</td>
<td>1%</td>
</tr>
</tbody>
</table>
socio-economic determinants of health was 2 (1) per household. The proportion of households lacking none, one, two, three or four elements of good health was 8%, 24%, 40%, 23%, and 5%, respectively (I).

5.3 Maternal health in relation to diet and infectious diseases (II, III)

Among the 574 pregnant women whose dietary intake were analysed the mean daily intake was 1,880 (660) kcal per woman. On average two-thirds of the energy was provided by cereals, mainly maize. Other important sources were roots and tubers (11%), fish (5%), fruit (4%), legumes (4%) and vegetables (3%). There was a sharp fall in energy intake during the rainy month of February, the mean (+SD) intake being 1,525 (549) kcal per day per woman. This was followed by a two to three months’ period around harvest-time when the mean (SD) daily intakes rose to up to 2,252 kcal (769) per woman, fig 4 (II). The low values of energy intake in January-March were mainly explained by a decreased consumption of roots, tubers, fruit, legumes and vegetables. The later peak in energy intake was associated with a marked increase in the consumption of these food items (II).

The prevalence of maternal anaemia, human immunodeficiency virus or malaria infections and syphilis-reactivity at antenatal care enrolment among 581 women that gave birth to a term, live, singleton infant are shown in table 6. Because of the frequent positive results in syphilis screening, those samples with sufficient volume (n=111) were retested with a more specific Treponema Pallidum Haemagglutination assay. With TPHA, only 10 (9%) of the tested sera gave a positive result (III). The prevalence of anaemia or infectious diseases did not differ significantly from the corresponding data among all study participants (III, V).

Figure 4. Seasonal variation in the energy intake by 574 pregnant women in Lungwena.

The number of dietary recalls in each moth is indicated on the x-axis. Thin bars represent 95% confidence intervals for the means. The thick grey bars indicate the rainy season and the white box the harvesting period for the staple food maize.
Mean (SD) maternal weight, height, mid-upper-arm circumference (MUAC) and fundal height (FH) at antenatal care enrolment were 52 (6) kg, 155 (6) cm, 25 (2) cm and 20 (4) cm, respectively. Fifteen per cent of the mothers were less than 150 cm tall (III).

There was no change in the mean MUAC value during pregnancy among study mothers. Figure 5 summarises maternal weight and fundal height distribution at weekly intervals throughout the pregnancy and demonstrates mean values of weight and fundal height gain for a western reference (Vienonen 1991).

Maternal weight increased at a mean (SD) rate of 259 (192) g/week and maternal fundal height at a rate of 11 (5) mm per week. Thirty-seven percent of the women gained less than 200 g per week and 5% lost weight. Variation in fundal height gain was smaller and none lost fundal height (III).

The mean (SD) time of delivery was 39 gestation weeks and about 22% of deliveries took place preterm i.e. before 38th gestation week (V). Univariate analyses indicated that primiparity, maternal age less than 20 years and maternal peripheral malaria parasitaemia were all associated with preterm delivery (relative risks 2.3, 1.6 and 1.9, respectively, p<0.001 for each variable, Pearson Chi-Square Test). When controlled for each other as well as month of delivery and for potential confounding variables (see methods, page 27) primiparity was the only independent predictor of preterm delivery (adjusted OR 2.7, p=0.002). Maternal malaria infection appeared to have an independent effect as well but the finding failed to reach statistical significance (adjusted OR 1.5, p=0.07) (V).

The places and attendant of delivery are given in tables 7 and 8 (IV).
Table 7. Place of delivery among 778 study participants followed up to delivery.

<table>
<thead>
<tr>
<th>Place of delivery</th>
<th>Number</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Home</td>
<td>457</td>
<td>58.7%</td>
</tr>
<tr>
<td>TBA facility</td>
<td>97</td>
<td>12.5%</td>
</tr>
<tr>
<td>Health centre</td>
<td>129</td>
<td>16.6%</td>
</tr>
<tr>
<td>Hospital</td>
<td>83</td>
<td>10.7%</td>
</tr>
<tr>
<td>Other</td>
<td>12</td>
<td>1.5%</td>
</tr>
</tbody>
</table>

TBA= Traditional birth attendant

Table 8. Attendant of delivery among 778 study participants followed up to delivery.

<table>
<thead>
<tr>
<th>Attendant</th>
<th>Number</th>
<th>Proportion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Friend or relative</td>
<td>280</td>
<td>36.0%</td>
</tr>
<tr>
<td>Trained TBA</td>
<td>272</td>
<td>35.0%</td>
</tr>
<tr>
<td>Medical professional</td>
<td>201</td>
<td>25.8%</td>
</tr>
<tr>
<td>No one</td>
<td>25</td>
<td>3.2%</td>
</tr>
</tbody>
</table>

TBA= Traditional birth attendant

Of the 778 evaluable deliveries 740 (95%) were normal vaginal and 10 (1%) assisted vaginal (vacuum or forceps extraction). The Caesarean section was done for 22 (3%) mothers. For the remaining six deliveries the mode of delivery was not known (IV).

The prevalences of individual maternal delivery complications are summarised in table 9. In total, a complication was observed in 127 (17%) deliveries. There were 4 maternal deaths, corresponding to a maternal mortality ratio of 500 per 100,000 deliveries (IV).

5.6 The association between antenatal findings and newborn weight (III)

Of the 581 singleton live-born term infants, 386 (66%) were examined within seven days from delivery. For these babies, the mean (SD) duration of pregnancy at birth was 40 (2) gestation weeks and the mean (SD) newborn weight 3.2 (+0.5) kilograms (III).

Table 10 lists the socio-economic, antenatal and obstetric variables that were statistically significantly (p<0.05) associated with newborn weight.
weight in a univariate and multivariate analysis. A multiple regression model which included the statistically significant variables from univariate analysis, explained 24% of the variance in newborn weight (R-square 0.235, p<0.001). In such a multivariate analysis, duration of pregnancy and maternal parity proved to bear the strongest association to newborn weight. Maternal weight at antenatal clinic enrolment, her gestational weight gain and sex of the child also had an independent, albeit smaller, influence on newborn weight. When adjusted for these variables, neither maternal infections, anaemia at antenatal clinic enrolment or the number of antenatal visits nor any of the socio-economic determinants had any independent effect on newborn weight (III).

### Table 9: Prevalence of main delivery complications among 778 women followed up to delivery.

<table>
<thead>
<tr>
<th>Delivery complications</th>
<th>Number</th>
<th>Prevalence</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>620</td>
<td>83.0%</td>
</tr>
<tr>
<td>Any</td>
<td>127</td>
<td>17.0%</td>
</tr>
<tr>
<td>Maternal deaths</td>
<td>4</td>
<td>0.5%</td>
</tr>
<tr>
<td>Excessive obstetric haemorrhage</td>
<td>50</td>
<td>6.7%</td>
</tr>
<tr>
<td>Retained placenta</td>
<td>28</td>
<td>3.7%</td>
</tr>
<tr>
<td>Obstructed labour</td>
<td>20</td>
<td>2.7%</td>
</tr>
<tr>
<td>Perineal laceration (stage III)</td>
<td>13</td>
<td>1.7%</td>
</tr>
<tr>
<td>Puerperal fever</td>
<td>7</td>
<td>0.9%</td>
</tr>
<tr>
<td>Convulsions</td>
<td>5</td>
<td>0.7%</td>
</tr>
<tr>
<td>Obstructed labour and excessive haemorrhage</td>
<td>3</td>
<td>0.4%</td>
</tr>
<tr>
<td>Retained placenta and puerperal fever</td>
<td>2</td>
<td>0.3%</td>
</tr>
<tr>
<td>Obstructed labour and puerperal fever</td>
<td>1</td>
<td>0.1%</td>
</tr>
</tbody>
</table>

5.7 Maternal risk factors and their predictive value for adverse pregnancy outcomes (IV)

The prevalence of various maternal characteristics commonly considered to be associated with increased risk for adverse delivery outcome were high (table 11). Up to 74% of the women met at least one of the defined risk criteria. The frequency of health centre or hospital deliveries amongst these “at-risk” and amongst the “no-risk” women were 30% and 21%, respectively. Most (63%) of those women, who had experienced a caesarean section and a large proportion of those with multiple pregnancy (50%) or increased blood pressure (43%) delivered at a modern facility. The other “risk” characteristics were not associated with markedly increased proportion of health centre or hospital deliveries, table 11 (IV).

In a relative risk analysis, delivery complications were associated with primiparity and abnormal presentation of the foetus. Compared to women with no “risk”
characteristics, those with any of them had a 70% higher probability for delivery complications. Thirteen per cent of delivery complications were observed amongst the 26% of women who had no risk characteristics (IV). The classification of a woman as being “at-risk” (if she had any of the traditional risk characteristics) had an 86% sensitivity and 29% specificity to predict delivery complications, the positive predictive value being only 20% (IV).

Out of maternal risk characteristics (see table 4, page 26) only a few variables, a maternal history of stillbirth, moderate or severe maternal anaemia, and abnormal presentation of the foetus in the current pregnancy predicted perinatal mortality (IV, V). In addition a maternal history of a previous Caesarean section was associated to perinatal deaths in univariate analysis (p=0.013, RR=4.4, 95% CI 1.4 to 13.9) if the analysis was confined to multiparous mothers and the mothers with no previous obstetrical problems was taken as a referent group (IV). Compared to women with no “risk” characteristics, those in whom one or more was present had a 60% higher probability for a perinatal death. However, 17% of perinatal deaths occurred in the 26% of women with no risk characteristics. The risk factor classification of a woman as being “at-risk” had an 83% sensitivity 26% specificity to identify perinatal mortality. The positive and negative predictive values were 7% and 96% respectively (IV).

5.8 Levels and determinants of peri-and neonatal mortality (V)

Of the 796 births that were evaluable for peri-and neonatal outcome, 36 were stillborn, 16 died within 7 days of delivery and another 12
before the 28th day. Thus, the perinatal mortality rate was 65 deaths per 1,000 births and neonatal mortality rate 37 deaths per 1,000 live births (V).

Gender-specific mortality rates are summarised in table 12. Boys appeared to have an increased risk of dying during the peri- and neonatal period but numbers were too small to draw definitive conclusions about the differences (p = 0.29 and 0.14 for peri- and neonatal mortality, respectively, Pearson Chi-Square Test). Twins had a higher risk of death than singletons but statistical significance was reached only for perinatal mortality (p=0.012, Pearson Chi-Square Test) (V).

Table 13 shows the socio-economic, antenatal and obstetric variables associated with perinatal mortality according to univariate and multivariate analysis (V). Preterm birth was the strongest predictor of perinatal mortality (adjusted OR 9.6) in univariate as well as in multivariate analysis after controlling for a number of socio-economic variables, month of delivery, month of delivery,

<table>
<thead>
<tr>
<th>Risk factor</th>
<th>Prevalence</th>
<th>Proportion of H/C or hospital deliveries</th>
</tr>
</thead>
<tbody>
<tr>
<td>None observed risk factors</td>
<td>26% (202/778)</td>
<td>21%&lt;sup&gt;4&lt;/sup&gt;</td>
</tr>
<tr>
<td>Any of the risk factors below</td>
<td>74% (576/778)</td>
<td>30%</td>
</tr>
</tbody>
</table>

### Past obstetric problems

- Caesarean section: 3% (19/594) [63%]
- Obstructed labour: 6% (35/594) [20%]
- Toxaemia: 5% (29/594) [28%]
- Stillbirth: 25% (146/594) [28%]
- Any: 32% (188/594) [29%]

### Present pregnancy

- Age of mother <18 years: 8% (64/773) [36%]
- Age of mother > 35: 8% (63/773) [32%]
- Primiparity: 24% (184/778) [37%]
- Parity ≥ 4: 29% (229/778) [27%]
- Height < 150 cm: 16% (121/778) [26%]
- Moderate or severe anaemia<sup>3</sup>: 4% (28/768) [18%]
- Blood pressure > 140/90 mmHg: 6% (47/778) [43%]
- Abnormal presentation: 5% (34/757) [27%]
- Twin pregnancy: 2% (18/778) [50%]
- Any: 67% (518/778) [30%]

<sup>1</sup>Health centre, <sup>2</sup>Proportion delivering at a H/C or hospital from all those women who have the indicated risk characteristic, <sup>3</sup>Packed cell volume < 26%, corresponding to a haemoglobin value of approximately 80g/l (Rickman and Anning 1995), <sup>4</sup>Breech, feet or cord.
maternal age, HIV-infection and positive syphilis screening test (V).

Of the studied socio-economic, antenatal and obstetric factors seven factors were associated with neonatal mortality (table 14). Multivariate analysis indicated that preterm birth was the only statistically significant independent predictor (adjusted OR 11.0). Maternal peripheral malaria parasitemia at antenatal clinic enrolment appeared to be associated with neonatal mortality although this finding just failed to reach statistical significance (p=0.055), table 14 (V).

Table 12. Peri- and neonatal mortality rates in Lungwena.

<table>
<thead>
<tr>
<th>Group</th>
<th>Boys</th>
<th>Girls</th>
<th>All</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>PMR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Singletons</td>
<td>69 (27/389)</td>
<td>51 (19/372)</td>
<td>60 (46/476)</td>
</tr>
<tr>
<td>Twins</td>
<td>158 (3/19)</td>
<td>67 (1/15)</td>
<td>167 (6/36)</td>
</tr>
<tr>
<td>All</td>
<td>74 (30/408)</td>
<td>52 (20/387)</td>
<td>65 (52/798)</td>
</tr>
<tr>
<td>NMR</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Singletons</td>
<td>46 (17/370)</td>
<td>24 (9/356)</td>
<td>36 (26/726)</td>
</tr>
<tr>
<td>Twins</td>
<td>118 (2/17)</td>
<td>0 (0/14)</td>
<td>65 (2/31)</td>
</tr>
<tr>
<td>All</td>
<td>49 (19/387)</td>
<td>24 (9/370)</td>
<td>37 (28/757)</td>
</tr>
</tbody>
</table>

PMR = perinatal mortality rate, NMR = neonatal mortality rate. Rates are given per 1,000 births for perinatal mortality and 1,000 live births for neonatal mortality. The absolute numbers of observed deaths / number of evaluable children are marked in parentheses. No sex data was available for the two children who died perinatally.
### Table 13. Variables associated with perinatal mortality among singleton newborns in Lungwena.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Univariate</th>
<th>Multivariate</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RR</td>
<td>95% CI</td>
<td>p-value</td>
<td>AOR</td>
</tr>
<tr>
<td>Birth before 38th gestation week</td>
<td>6.0</td>
<td>3.4 to 10.7</td>
<td>&lt;0.001</td>
<td>9.6</td>
</tr>
<tr>
<td>Birthweight ≤ 2500 grams¹</td>
<td>5.6</td>
<td>1.4 to 22.0</td>
<td>0.005</td>
<td>not included in the model</td>
</tr>
<tr>
<td>Abnormal delivery²</td>
<td>3.9</td>
<td>2.2 to 6.8</td>
<td>&lt;0.001</td>
<td>4.0</td>
</tr>
<tr>
<td>Previous stillbirth</td>
<td>2.8</td>
<td>1.6 to 4.9</td>
<td>&lt;0.001</td>
<td>3.7</td>
</tr>
<tr>
<td>Mild maternal anaemia³</td>
<td>2.0</td>
<td>1.1 to 3.5</td>
<td>0.013</td>
<td>2.4</td>
</tr>
</tbody>
</table>

N = 731 for multivariate analysis. RR=Relative risk, CI=Confidence interval, AOR=adjusted odds ratio, p-value, Pearson Chi-Square Test. ¹ Only children who were weighed within a week after delivery were analysed. ² Breech, feet or cord presentation of the child and/or assisted vaginal delivery or Caesarean section and/or complications to the mother. ³ Packed cell volume <34%, corresponding to a haemoglobin value of a 110g/l (Rickman and Anning 1995).

### Table 14. Variables associated with neonatal mortality among singleton newborns in Lungwena.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Univariate</th>
<th>Multivariate</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>RR</td>
<td>95% CI</td>
<td>p-value</td>
<td>AOR</td>
</tr>
<tr>
<td>Birth before 38th gestation week</td>
<td>6.7</td>
<td>3.0 to 14.8</td>
<td>&lt;0.001</td>
<td>11.0</td>
</tr>
<tr>
<td>Maternal malaria at enrolment</td>
<td>4.2</td>
<td>1.9 to 9.4</td>
<td>&lt;0.001</td>
<td>NS</td>
</tr>
<tr>
<td>Birthweight ≤ 2500 grams¹</td>
<td>3.3</td>
<td>1.0 to 11.0</td>
<td>0.041</td>
<td>not included in the model</td>
</tr>
<tr>
<td>Mild maternal anaemia²</td>
<td>2.9</td>
<td>1.2 to 6.7</td>
<td>0.010</td>
<td>NS</td>
</tr>
<tr>
<td>Maternal primiparity</td>
<td>2.4</td>
<td>1.1 to 5.1</td>
<td>0.022</td>
<td>NS</td>
</tr>
<tr>
<td>Abnormal delivery³</td>
<td>2.2</td>
<td>1.0 to 4.8</td>
<td>0.037</td>
<td>NS</td>
</tr>
<tr>
<td>Maternal age &lt; 20 years</td>
<td>2.2</td>
<td>1.0 to 4.8</td>
<td>0.039</td>
<td>NS</td>
</tr>
</tbody>
</table>

N = 726 for multivariate analysis. RR=Relative risk, CI=Confidence interval, AOR=adjusted odds ratio, p-value, Pearson Chi-Square Test, NS=not significant. ¹ Only children who were weighed within a week after delivery were analysed. ² Packed cell volume <34%, corresponding to a haemoglobin value of a 110g/l (Rickman and Anning 1995). ³ Breech, feet or cord presentation of the child and/or assisted vaginal delivery or Caesarean section and/or complications to the mother.
6. DISCUSSION

In the following chapters, the validity and implications of the present study’s results will be systematically discussed. The main emphasis will be on principal concepts whereas technical details are discussed more thoroughly in the original papers. The structure of discussion will follow the main aims of the study. At first, the characteristics and patterns of maternal and newborn health will be discussed in relation to socio-economic factors, prevalence of infectious diseases, maternal nutrition and maternal anthropometry. The next chapters will focus on the analytical part of the study. The associations between antenatal factors and different adverse pregnancy outcomes i.e. preterm births, newborn weight, delivery complications and newborn mortality, will be discussed and related to the performance of Malawian antenatal procedures. The last two chapters will sum up the main strengths and limitations of the study and take a view of future prospects for research in this area.

6.1 Socio-economic situation (I)

Since the Alma-Ata meeting, primary health care has formed a cornerstone of most national health strategies all over the world. Despite knowledge and good will, however, translation of primary care into health for all has been slow, especially in many low-income countries (Hellberg and Mäkelä 1994). Recently, this slow pace has increasingly been attributed to general poverty, interfering with the establishment of adequate socio-economic support for good health (WHO 1995b, Bergström and Mocumbi 1996, Guerrero et al. 1998). The most dramatic example is sub-Saharan Africa where poverty is at its starkest and marginalization from the global economy is pronounced. The continent contains 33 of the world’s 50 poorest countries. By the end of the 1990s two-thirds of Africans lived in absolute poverty (Logie and Benatar 1997).

The present study revealed that pregnant women and their families in rural Malawi were still lacking the socio-economic support for good health. Thus, the majority of the households had no access to safe water and sanitation, and adult literacy rate was very low, especially among the women. Both of these features have been associated with malnutrition, increased childhood mortality and other health problems, although the mechanisms of action are not completely clear (Lindskog 1987, Reed et al. 1996, Harrison 1997). Access to health care was also sub-optimal, as half of the people lived further than 5 km away from the hospital. Since walking is the means of transportation for most people in Lungwena, travelling 5 km takes approximately one hour, thus efficiently restricting access to modern care. Indeed, our study group has observed an indirect relationship between the distance from home to the health centre and the use of curative services (Lungwena Health Centre data, unpublished). Others have also shown that such a long distance to a health facility is one of the most important determinants in the decision not to seek modern health care even when needed (King 1966, Thaddeus and Maine 1994).

The cultivated land areas were strikingly small in Lungwena, considering that most of the households made their living from subsistence farming. Theoretically, if unfertilized maize is cultured, the minimum plot size for a farmer household in Lungwena would be 0.2 hectares per person (see original publication I). Our survey indicated, that only one third of the families controlled this amount of land. Thus, it appeared evident, that farming alone could not fulfil the dietary needs of the
population in Lungwena.

A large proportion of households had potential sources of extra income, either through the sale of fish or domestic animal products or through an additional adult economically supporting the family. In this way, the inadequate land areas could partially be compensated by cash money that could be used for purchasing food. However, even when all these potential sources of income were considered, more than a quarter of the people appeared to live in households with inadequate food security. Moreover, this figure might be an underestimate, since the money obtained through the sale of fish or domestic products was not necessarily directed into the procurement of food for all members in the family. It is therefore evident, that the small plot sizes seriously limited food security in Lungwena, which, in turn, is likely to be a hindrance to a positive health development in this area.

6.2 Maternal health (II,III)

In the present study gestational health was described in relation to the maternal nutritional situation in mid-pregnancy and presence of anaemia, malaria, syphilis and HIV-infection at antenatal enrolment. These infectious diseases were selected because they were known to play an especially important role in maternal morbidity and adverse pregnancy outcomes (Bergsjo and Villar 1997, Villar and Bergsjo 1997).

The pregnant women in Lungwena had a relatively good annual average energy intake (1880 kcal per day). This figure was 10-25% higher than that observed in some other rural studies in Malawi and other East-African countries (Prentice et al. 1981, Ferguson et al. 1995, Huddle et al. 1998). However, the present study identified a remarkable fluctuation in energy intake resulting from an almost complete disappearance of other sources of energy other than the stable food (maize) during the rainy season. Low energy intakes may predispose pregnant women for poor gestational weight gain and newborns for low birthweight (Prentice et al. 1981). Therefore, caloric supplementation of pregnant women during the hunger months may act as beneficial intervention.

Anaemia was highly prevalent among the study women. This result corresponds to previous reports which have revealed that almost 50% of the population of pregnant women in Africa could be considered anaemic using the standards of WHO (haemoglobin < 110 g/dl) (UNICEF 1997). Among 2235 pregnant women in Tanzania (1991-1993) 60% were anaemic (Hb <105 g/l) and 2.2% (Hb < 85 g/l) were severely anaemic when they registered at an antenatal clinic (Massawe et al. 1999). The frequency of maternal peripheral malaria parasitemia (27%), maternal HIV- infection (17%) and syphilis (9%) at antenatal enrolment was high and comparable to that found in other studies in Malawi and many other sub-Saharan countries (Cooper-Poole 1986, Chin 1990, Brabin 1991, Aiken 1992, McDermott et al. 1993, Quinn et al. 1996, Sullivan et al. 1999, Verhoeff et al. 1999). It is thus obvious that lots of effort should be put into HIV-prevention also in rural areas of Malawi. Similarly, the high antenatal prevalence of syphilis demonstrates that its screening should not be limited to urban areas.

6.3 Maternal anthropometric measurements and the gain in weight and symphysis-fundal height (III)

Anthropometric indicators such as maternal height, pre-pregnancy weight, gestational weight gain and mid-upper arm circumference have been used as proxy measures of current or past nutritional status, which in turn bears directly or indirectly on pregnancy outcome (WHO 1995a). Due to their simplicity and low cost, anthropometric measurements are often considered useful screening tests during
antenatal examinations especially in low-income countries. However, the true ability of maternal anthropometry to predict foetal and maternal outcomes has mostly remained unclear, which is why it still forms the subject of continuing research (Kelly et al. 1996).

The present data on maternal weights, heights, mid-upper-arm circumferences and fundal heights were comparable to results from other studies in low-income countries (Kieserud 1986, Möller et al. 1989b, WHO 1995a). Whereas, the average total weight gain in developed countries ranges from 10 to 16 kg, the corresponding figure among poorly nourished women of low-income countries is generally 5-9 kg (Möller et al. 1989b, WHO 1995a, McDonagh 1996, Andersson and Bergström 1997). According to the average maternal weight gain found in this study (259 g/week of gestation), the present study population typically represents the latter group.

Because of the significant variation of maternal gain in different populations, universal norms for maternal weight development cannot be given. From a clinician’s point of view, the limits of optimal maternal weight gain thus remain unclear (McDonagh 1996). As demonstrated in our study, the development of a local reference curve for weight gain allowed the expression of maternal weight as a relative value (weight for duration of pregnancy Z-score). Similar curves have been developed and used for expressing the relative heights and weights of growing children. With such an approach, it is possible to compare gestational weights with each other, even if the measurements are not carried out at the same point of pregnancy.

The gestational recording of gain in symphysis-fundal height has been adopted as a routine procedure for antenatal clinics in many low-income countries. In the absence of ultrasound, several authors have found it useful for suspecting intra-uterine growth retardation or small for gestational age foetuses, twin pregnancy and large for gestational age foetuses (Tjon et al. 1985, Neilson 1988, Bergström and Liljestrand 1989, Kennedy 1990, Walraven et al. 1995b, Osman 2000). In our study the mean fundal-height gain of rural Malawian women and that of a Finnish reference population were almost identical. In the light of these results, the production of a local standard curve for gestational fundal height gain appears unnecessary in rural Malawi. Instead, western symphysis-fundal height standards may also apply in antenatal clinics of at least some Sub-Saharan African countries. Similar findings have been previously observed by other researchers (Kieserud 1986, Andersson and Bergström 1995).

6.4 Proportion and predictors of preterm births (V)

The proportion of preterm births (22%) was higher in Lungwena than in some earlier studies from Sub-Saharan Africa (Steketee et al. 1996, Wessel et al. 1998, WHO 1995a). In theory, this might suggest that the current results were not widely applicable. Many of the earlier studies were, however, hospital-based and they thus might easily have missed a significant proportion of pregnancies ending prematurely at home. This hypothesis is supported by the fact that recent studies with careful follow-up have documented comparably high (15-20%) proportions of preterm deliveries in Sub-Saharan Africa (Sullivan et al. 1999, Osman 2000). Therefore it can be concluded that the results are valid and applicable to wider populations in low-income countries.

In endemic areas like Malawi, maternal malaria infection, especially if manifested as placental parasitaemia, is known to predispose babies for preterm births and low birthweight (McGregor 1984, Steketee et al.1996). Primigravid mothers are at greatest risk, apparently because they have not yet acquired selective immunity that develops during subsequent pregnancies (McGregor 1984, Fried et al. 1998). In our material, preterm deliveries and peripheral malaria parasitaemia
at antenatal clinic enrolment were both markedly more common among primigravid women. Furthermore, even when adjusted for parity, maternal malaria parasitaemia appeared to predict preterm birth. It is therefore obvious that malaria contributed significantly to prematurity in the cohort despite the routine malaria prophylaxis given to all pregnant women. This hypothesis is consistent with a recent findings from rural Malawi that one or two antenatal doses of sulfadoxine-pyrimethamine have little influence on malaria parasitaemia at term, although is has been shown to clear the infection for some weeks (Verhoeff et al. 1998, Sullivan et al. 1999, Verhoeff et al. 1999). The potential role of malaria is further substantiated by the fact that a large share of other third world studies emphasizing the importance of prematurity in causing peri- or neonatal mortality, have also been done in a malaria-endemic area (Barros et al. 1987, Greenwood et al. 1987, Bhatia 1989, Möller et al. 1989a, Fauveau et al. 1990, Gray et al. 1991, Kasirye-Bainda and Musoke 1992, Manji et al. 1998).

6.5 Factors associated with newborn weight (III)

One of the aims of the present research was to identify antenatal determinants of newborn weight. Such variables have actually been identified already in previous epidemiological investigations (Kraemer 1987, WHO and UNICEF 1992, WHO 1995a), but few of these studies have been carried out in rural areas in low-income countries. Therefore, the present community-based cohort study could add important information to this acquired knowledge.

From all factors routinely measured at the antenatal visits in Lungwena, only a few factors predicted newborn weight. Moreover, a model including findings from all routine antenatal examinations could explain 24% of the overall variability in newborn weights. This finding is in accordance with earlier results from low-income countries (Bantje 1986, Kusin and Jansen 1986, Möller et al 1989b), and suggests that routine antenatal investigations have a limited value in predicting newborn weight and hence the health of live born term infants. These results are, however, not directly applicable to preterm or stillborn babies, and therefore they cannot be used to determine the total benefits of antenatal monitoring for newborn health. In addition due to the probable interaction between the studied variables, some antenatal factors may have had an influence on newborn weight via some other variables even if they did not appear to be statistically significant predictors of newborn weight. In current analysis the impact of these variables may have been underestimated.

The necessity of routine recording of maternal weight at each antenatal visit has also been periodically questioned. Some studies have undoubtedly suggested that lower maternal weight taken at pre- or early pregnancy is associated with low birthweight and intrauterine growth retardation (Kraemer 1987, WHO 1995a). However, maternal gestational weight gain has not proven to have good predictive power as a screening test for adverse foetal outcomes (Möller et al. 1989, Dawes and Gruzinskas 1991, Dawes et al. 1992, Parker and Abrams 1992, Theron and Thompson 1993). The present study identified that a single measurement of weight in early pregnancy and total maternal weight gain were associated with the newborn weight of the child. Since often in low-income countries women visit the antenatal clinic only a few times, a measurement of weight at the first antenatal clinic visit may suit best for screening purposes.
6.6 Antenatal risk screening approach (IV)

One strategy to reduce maternal and newborn mortality is based on the antenatal risk screening approach. According to this approach screening at antenatal care should lead to identification of pregnancies likely to develop complications, and refer them to higher level of care (Brouwere et al. 1998). This usually means the hospitals at first referral level, where necessary expertise and equipment is available to prevent or minimise the anticipated adverse pregnancy outcome. In Malawi this issue is of particular interest because the coverage of antenatal care is almost complete (95%) with an average of four antenatal visits per pregnancy.

In the Malawian antenatal “at risk” screening studied, an unacceptably high proportion of mothers were classified as at risk (74%). Whereas all of these women should, according to national recommendations, have delivered in a modern health facility, only 30% of them in fact did so. Delivery complications were frequent and perinatal mortality common but these adverse pregnancy outcomes were not strongly predicted by the traditional maternal risk characteristics. The high maternal mortality ratio (500 deaths / 100,000 live births) is comparable to figures found in earlier studies in Malawi (National Statistical Office). Thus, the risk approach did not appear to be effective in ensuring safe motherhood in this rural community.

Studies carried out in other low-income countries have confirmed that “traditional” risk characteristics occur so commonly that more than half of the pregnant population may easily be identified as “high risk” (Fortney and Whitehorne 1982, McDonagh 1996). If all of these women followed advice to deliver under medical supervision, maternity units would be completely unable to cope with the workload. In the absence of an obvious association between the “at-risk” definitions and an adverse outcome, women are more likely to consider advice to deliver under medical supervision as over-cautious and hence to ignore it (Yuster 1995). Indeed, in present study, there was little difference in the proportion of the “at risk” and “no-risk” women delivering in the health centre or at home.

The poor predictive value of antenatal risk characteristics to foresee adverse delivery outcomes is a major set-back of the risk approach (Yuster 1995, McDonagh 1996). Whereas our “at-risk” definition had a reasonable (>80%) sensitivity to detect an adverse outcome, its low (<30%) specificity meant that two thirds of those identified as “at-risk” were in real terms incorrectly defined. Furthermore, up to 30% of all complications to the mother or foetus occurred amongst the small minority (26%) of “no-risk” women. These findings and similar findings observed in other studies suggest that the criteria used for the identification of “at-risk” women are not really effective in practice (Rohde 1995, McDonagh 1996). Although the present study was not designed to develop an alternative set of risk indicators, we also tried this approach (data not shown). As other researchers before, however, we were not able to identify any set of variables, that would satisfactorily identify those women at a true risk for delivery complications (Möller 1989a, McDonagh 1996).

6.7 Levels and determinants of peri-and neonatal mortality (V)

Data from several, mainly hospital-based or surveillance studies from Malawi have suggested that a large share of early childhood mortality occurs during the peri- and neonatal period (National Statistical Office 1994, Bloland et al. 1996). The present community-based prospective study with high coverage (99.7%) and very low drop out rate (1.9%) confirmed this observation. The number of unnoticed perinatal deaths was likely to be
small, since most women enrolled relatively early in antenatal care. Thus the observed peri- and neonatal mortality rates of 65 deaths per 1,000 births and 37 deaths per 1,000 live borns were representative of the population in Lungwena. For a country with almost universal antenatal coverage, such mortality figures are quite suspicious. However, similar figures have been found in other low-income countries, with large emphasis on antenatal care but limited availability of well-equipped delivery facilities (Wessell 1998).

Preterm birth was the strongest predictor of both peri- and neonatal mortality in the present study material. This is in marked contrast to many studies from low-income and industrialised countries, which tend to emphasize the importance of delivery events on early mortality (Harrison 1985, Van Roosmalen 1989, Gray et al. 1991, Akapala 1993, Geetha et al. 1995, McDermott et al 1996b). Theoretically, a part of the difference might be explained by the methods used for gestational age assessment. In our study, the length of gestation was estimated from maternal fundal height at the first antenatal visit. Whilst such an approach may give inaccurate results for some individuals with poorly growing babies, the method has, however, been shown to be reliable on a population level in low-income countries (Kennedy 1990). A study of 604 pregnant women from rural Central Africa showed that the mean deviation of the actual week of delivery from the fundal-height based predicted week was only half a week (Andersson and Bergström 1995). Others have shown that predictions of delivery date from the fundal height may be as accurate as those derived from the last menstrual period (Jiminez et al. 1983, Kennedy 1990). Thus a more likely explanation for the apparent discrepancy on the importance of prematurity in current study was the community-based enrolment at mid-pregnancy. This approach ensured inclusion in the analysis of preterm and other home-deliveries, that might easily have been missed in hospital-based studies in low-income countries. Furthermore, complicated deliveries were not selectively concentrated in the cohort, as might occur in hospital samples from areas where only a minority of deliveries take place in health facilities.

As in many other studies, low birthweight was associated with increased peri- and neonatal mortality in the present cohort (Harrison et al. 1985, Barros et al. 1987, Fauveau et al. 1990, Gray et al. 1991, Kasirye-Bainda and Musoke 1992, Akapala 1993, Geetha et al. 1995, Bloland et al. 1996, McDermott et al. 1996b, Manji et al. 1998, Wessell et al. 1998). In fact, the correlation between gestational age and birthweight suggests that part of the increased mortality risk for preterm infants was explained by their low birthweight. Unfortunately, an assessment of the individual impact of the variables was not possible due to the large number of unknown birthweights. Thus, we could not evaluate the importance of growth retardation amongst term babies. The main conclusion, that preterm birth, usually associated with low birthweight, was a major risk factor for peri- or neonatal mortality remains, however, valid.

6.8 Strengths and limitations of the study

Looking back it is obvious that the study had some strengths and limitations. The main strength of the present study lies in its prospective, community based and rural set-up. This design facilitates the production of unbiased results that are representative for majority of the population. In addition the high antenatal coverage and minimal loss to follow-up ensured a representative study sample in the present study. As only a few such prospective cohort studies have previously been carried out in low-income countries, both the descriptive and analytical results of this study are of general interest.

There were also some limitations that caused a theoretical risk for bias in the study.
The most obvious ones were lack of ultrasound in assessment of gestational age, absence of complete birthweight data, limitations in the design of laboratory procedures and limitations concerning the sample size of the study.

In the absence of ultrasound the length of gestation was estimated mainly by fundal height at the first antenatal clinic visit which might give inaccurate results at least on individual level. Because of this it could be argued that gestational age has been partly incorrectly estimated which can lead to incorrect determination of preterm birth and may invalidate the main findings of the study. Another major limitation of the study was the absence of complete birthweight data. The number of unknown birthweights prevented the inclusion of birthweight in the analysis while examining the predictors of newborn mortality. It also made analysis of the individual impact of growth retardation on newborn mortality among term infants impossible. As discussed, the correlation between gestational age and birthweight in current study suggests that part of the increased mortality risk for preterm infants was indeed explained by their low birthweight. However, this does not alter the main conclusion, that preterm birth, often associated with low birthweight, was a major risk factor for newborn mortality.

Some limitations in design of laboratory procedures hampered the interpretation of the study results. The results suggested that malariaparasitemia was causal for preterm delivery. However, with current study design (one peripheral blood sample at antenatal enrolment) it was not possible to conclude if the timing or intensity of the infection had affected the pregnancy outcome. Also the efficiency of given malaria prophylaxis could not be evaluated. Another problem appeared to be with syphilis screening since only a minority of the samples initially screened as positive had been confirmed by appropriate testing. Due to adequate treatment given to all mothers with syphilis positive screening test, this may not have affected the analytical part of the study. However, it calls into question the prevalence of syphilis among the study population.

The sample size of the cohort was sufficiently large to analyse the associations between risk factors and main outcomes of the study. However, the size of the study sample limited the power to detect risks for some outcomes with low prevalence. In the analysis these rare variables (for example different types of delivery complications), were grouped in order to achieve higher prevalence (“any delivery complications”) and more power of analysis. The cost was evidently the loss of some interesting detailed information.

6.9 Future prospects for research

This study belongs to one of the first community-based prospective assessments of maternal and newborn health in rural Malawi. As a whole, the study generated a lot of quantitative data whereas little qualitative data was collected. In order to broaden the knowledge and add new dimensions to some of the present findings, more qualitative data should be collected in future. For example, the apparent gap between the professionally defined need and the actual use of obstetric care led the researchers to question which factors influence pregnant women’s decision whether or not to seek modern obstetric care.

One of the main results of the study was that newborn mortality could be reduced if preterm births could be prevented. However, the absence of ultrasound hampered the interpretation of the study results. A similar type of study with the precise, ultrasound based information on gestational lengths could validate the current results. The high antenatal clinic attendance and relatively early booking in antenatal care would provide a good opportunity for such studies in Malawi. Simultaneously, the standard curves presented
for fundal height gain and weight gain during pregnancy could have been validated.

The current study suggested that one or two doses of malaria prophylaxis (sulphadoxine-pyrimethamine, SP) might not reduce the level of preterm births. In addition another recent studies from Malawi suggested that two antenatal doses of SP had little influence on malaria parasitemia at the time of delivery (Sullivan et al. 1999, Verhoeff et al. 1999). A randomized controlled trial of ability of two doses versus more frequent doses of SP to reduce malaria parasitemia at pregnancy and delivery, to reduce preterm births and to reduce newborn mortality should be considered. Such a study would be extremely valuable and would provide the necessary confirmation that the current two-dose strategy might not be optimal in the study area or similar areas. This study would, however, require reliable assessment of gestational age as well as both peripheral and placental determinations of malaria parasitemia.
7. CONCLUSIONS

The following may be concluded from the five studies discussed:

1) A large number of pregnant women and their families in rural Malawi are still lacking the socio-economic prerequisites of good health. Improvement in socio-economic conditions is required. In addition further investigations are needed to assess the feasibility of obtaining more sensitive and predictive socio-economic data during the antenatal period. Subsequent health interventions should strengthen investments into general poverty alleviation while the access to good quality medical services should be developed concomitantly.

2) The average daily energy intake appeared to be reasonably good, but anaemia and infectious diseases were still prevalent among the study women. Screening and treating women with positive syphilis serology should be included in antenatal and intrapartum care programmes in Malawi.

3) Maternal weight gains differed significantly from reference values of an affluent women population emphasizing that local reference values are useful. The development of a local weight gain curve permitted the expression of maternal weight as a relative value (weight for duration of pregnancy Z-score). Such an approach is very useful in the setting of low-income countries because it facilitates the comparison of gestational weights with each other, even if the measurements were not carried out at the same point of pregnancy. The striking similarity between locally constructed fundal height graph and the reference graph derived from Finland indicated that fundal height growth in rural Malawi is similar to that in affluent societies. There is no need to construct local fundal height graphs for Malawi.

4) The proportion of preterm births (22%) was higher than one could expect on the basis of previous, mainly hospital-based, studies from sub-Saharan Africa. Maternal malaria parasitemia appeared to be associated with preterm birth in the cohort despite the routine malaria prophylaxis given to all pregnant women.

5) Our data support the validity of the following risk factors for birthweight of the infant: the duration of pregnancy, maternal parity, her initial weight and her gestational weight gain. Even if these parameters explained only 24% of the overall variability in birthweight, their routine and repeated measurement may be useful in antenatal monitoring. From the point of view of a term, live born infant, the value of other routinely collected data appears restricted.

6) The Malawian antenatal risk classification investigated was not an effective tool for prediction of maternal delivery complications and perinatal deaths. Too many healthy women were declared at risk, while the large share of adverse outcomes occurred among women not classified at “high risk”. The risk-approach should be complemented by provision of modern maternity services for all women in labour.

7) The level of peri-and neonatal mortality was high. Preterm birth was the most important determinant of this mortality.
Children born to primigravid women were at greatest risk for preterm birth, possibly because of maternal malaria parasitaemia. Prevention of preterm birth, especially among primigravidae, are likely to result in large reductions in peri- and neonatal mortality.
8. SUMMARY

Malawi is a sub-Saharan African country with one of the highest maternal and childhood mortality rates in the world despite reasonable investments in maternal and child care. The objective of the present study was to characterize and analyse maternal and newborn health and to identify socio-economic, antenatal and obstetric variables associated with adverse pregnancy outcome in Lungwena, a rural area of southern Malawi.

This study forms the first part of the Lungwena Child Survival Study, a community-based cohort investigation of pregnant women and their offspring. Within the present study the follow-up time started from early or mid-pregnancy and ended at the end of the neonatal period. The study subjects included 795 pregnant women enrolled for antenatal care at the Lungwena health centre between June 1995 and September 1996 and children born to them. More than 95% of all pregnant women in the area attended the antenatal clinic and participated in the study. Data was collected prospectively in a series of personal interviews, regular antenatal examinations during pregnancy and home visits after delivery. Dietary intakes were analysed with a modified 24-hour recall method in mid-pregnancy.

Numerous households in Lungwena were lacking literate adults, adequate water source and sanitation, easy access to modern health care and food security. The frequency of maternal anaemia (42%), peripheral malaria parasitaemia (27%), HIV-infection (17%) and syphilis (9%) at antenatal enrolment was high. The mean daily energy intake of women varied from 1520 kcal/woman in February (rainy season) to 2250 kcal/woman in April (post harvest period). Maternal weight gain (259g/week) was slower but increase in fundal height (11mm/week) comparable to that of an affluent western population.

About 22% of deliveries took place earlier than expected (<38th week of gestation). Preterm delivery was associated with primiparity and peripheral malaria parasitaemia of the mother.

The mean (SD) weight of live-born, term newborns was 3.2 (0.5) kilograms. The duration of pregnancy, maternal parity, her initial weight, gestational weight gain and gender of the child were independently associated with newborn weight. However, a regression model including data from all routine antenatal examinations explained only 24% of the variance in newborn weights.

Up to 74% of pregnant women had at least one characteristic commonly associated with poor pregnancy outcome. Only 30% of these “at risk” women delivered in a modern health facility. The “at-risk” classification had over 80% sensitivity but less than 30% specificity to predict delivery complications or perinatal deaths. Most individual “risk” characteristics were not associated with adverse delivery outcomes.

Peri- and neonatal mortality rates were 65 deaths per 1,000 births and 37 deaths per 1,000 live births, respectively. Preterm birth was the strongest independent predictor of both peri- and neonatal mortality.
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APPENDIX: MALAWI IN A NUTSHELL

The country

Malawi is situated in the interior of southeastern Africa. The country approximately covers a total area of 118,000 km$^2$ and borders Tanzania on the north, Mozambique on the east and south, Zambia on the west. The great Rift Valleys runs through the country with Lake Malawi which covers about one fifth of the total area of the country. Of the remaining land area about fifty percent is arable. Malawi experiences a tropical continental climate. From May to August the climate is cool and dry. From September to November, average temperatures rise with the rainy season beginning towards the end of this period. The rainy season extends to April or May with an average rainfall of 800-1,000mm (National Statistical Office 1994).

With a population of about 11 million, Malawi is one of the most densely populated countries in Africa (UNICEF 1999). The annual population growth rate is 3.4 per cent (UNICEF 1999). Chichewa and English are the official languages of the country. About 65% of Malawians are nominally Christian and 16% Muslim but traditional religions are practised alongside the other religions. The degree of urbanisation is only 12% indicating that the majority of Malawians live in rural areas (National Statistical Office 1994, UNICEF in Malawi and Government of Malawi 1993).

Economy

Malawi belongs economically to the ten least developed countries in the world and has a Gross National Product of 180 US$ per capita (UNICEF 1999). The economy is predominately agricultural and accounts for 45% of GDP, about 90% of export revenues and provides over 80% of total employment. Maize is the dominant subsistence crop covering about 80% of the land under cultivation. Over half of the households have less than one hectare and one quarter less than 0.5 hectare. Thus, a striking feature of the agricultural economy is the intense pressure on land so that most of the farmers have an inadequate amount of land to produce sufficient food to meet household requirements. Since non-farm employment opportunities are extremely restricted too, about 85% of the rural population lives below the absolute poverty level (UNICEF and Government of Malawi 1993).

Health indicators

Public health is a major problem in Malawi as indicated by main health indicators in the table below.
Health services

Malawi has a relatively well-developed network of health facilities offering basic health services. Health services in Malawi are provided by the Ministry of Health, the Ministry of Local Government and non-governmental organisations (NGO), particularly missionary organizations. Health services are provided at three levels: With dispensaries, maternity units and health centres at the primary level, district hospitals at the secondary level and central hospitals at the tertiary level (National Statistical Office 1994, UNICEF in Malawi and Government of Malawi 1993). In addition there are about 1,000 trained traditional birth attendants, with links to health facilities (National Statistical Office 1994, UNICEF in Malawi and Government of Malawi 1993). Besides the formal health sector, the 18,000 registered traditional health practitioners are active mainly in rural areas but there are no established links with the formal health sector (UNICEF in Malawi and Government of Malawi 1993).

Maternal and child health services had been indicated for the first time as a national programme in 1973 by the so called “Miniplan” following the understanding of the high risk and the multiple health deficiencies of this group and its great contribution to morbidity and mortality figures. Immunization programmes and health and nutrition education were the central elements of the “Miniplan” but the maternal and child health services remained mainly hospital based (Meyer 1992).

Following the signing of the Declaration of Alma Ata in 1978 the preventive and promotive outreach activities started to grow up and expand increasingly. The 1982 plan for primary health care set out the initial steps elaborated by the government for the implementation of primary health care. The focus of primary health care activities was above all put on maternal and child health services, water and sanitation and the treatment of prevailing disease. Primary health care services were then extended to all districts throughout the country (Meyer 1992).

Despite the discouraging health indicators, Malawi has been successful in providing some maternal and child health services. National statistics indicate that about 95% of women visit the antenatal clinic at least once during pregnancy. Accordingly nearly three quarters

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Value</th>
<th>Source</th>
</tr>
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<tbody>
<tr>
<td>Life expectancy at birth (years)</td>
<td>41</td>
<td>UNICEF 1999</td>
</tr>
<tr>
<td>Maternal mortality (per 100, 000 live births)</td>
<td>620</td>
<td>DHS¹ 1992</td>
</tr>
<tr>
<td>Total fertility rate (children/woman/lifetime)</td>
<td>6.7</td>
<td>UNICEF 1999</td>
</tr>
<tr>
<td>Neonatal mortality rate (per 1,000 live births)</td>
<td>41</td>
<td>DHS¹ 1992</td>
</tr>
<tr>
<td>Infant mortality (per 1,000 live births)</td>
<td>133</td>
<td>MSIS² 1995</td>
</tr>
<tr>
<td>Under-five mortality (per 1,000 live births)</td>
<td>215</td>
<td>UNICEF 1999</td>
</tr>
<tr>
<td>Proportion of children born with birthweight &lt;2500g</td>
<td>20%</td>
<td>UNICEF 1999</td>
</tr>
<tr>
<td>Proportion of underweight under-fives</td>
<td>30%</td>
<td>MSIS² 1995</td>
</tr>
</tbody>
</table>

¹ Malawi Demographic and Health Survey 1992 (National Statistical Office 1994)
² MSIS= Malawi Social Indicator Survey (Ministry of Economic Planning and Development et al. 1996)
of births receive the protection of two or more doses of tetanus toxoid during pregnancy. (National Statistical Office 1994). On average 86% of children under two years had a vaccination card as a sign of visits at under-five clinic and, except the measles vaccination, 85% of children had received the essential EPI vaccinations before their first birthday (National Statistical Office 1994).

The Malawi National Safe Motherhood Programme, launched in 1994, is based on the assumption that appropriate antenatal care will facilitate the identification of women at greatest risk for an adverse outcome. These “high risk” women are then recommended to deliver at modern health facilities. Those delivering elsewhere are encouraged to consult traditional birth attendants who have received additional training from health professionals (Ministry of Health and Population and Ministry of Women and Children Affairs, 1994).

The Malawi Social Indicator Survey 1995 indicated that nationally about 41% of mothers have their babies at home. About one-half delivered at hospital (29%) or at a health centre (23%), while about 8% delivered at traditional birth attendant’s house. Nationally 48% of births were assisted by a nurse or a midwife. Family members assisted in one-third of the cases (34%). About one tenth were assisted by traditional birth attendant. Medical assistants or clinical officers and physicians attended only about 1% of births. Nearly one woman in twenty had no one in attendance during births (Ministry of Economic Planning and Development et al. 1996).