UNIVERSITY OF SOUTHAMPTON

The Determinants of Poor Maternal Health Care and Adverse Pregnancy Outcomes in Kenya

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Doctor of Philosophy

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October 1999

This thesis is dedicated to my beloved family my husband, Joseph; son, John-Paul, and daughters, Antoinette, Immaculate and Winnie

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ABSTRACT

FACULTY OF SOCIAL SCIENCES

DEPARTMENT OF SOCIAL STATISTICS

Doctor of Philosophy

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By Monica Akinyi Magadi

Most previous studies on maternal outcomes in Kenya have been based on hospital data or used data from specific communities and, hence, produced results applicable only to subgroups of the population. Kenya still lacks a reliable picture of the magnitude and patterns of maternal mortality and other adverse pregnancy outcomes. The aim of this study is to improve our understanding of factors associated with poor maternal health care and adverse pregnancy outcomes in Kenya. This is achieved by examining factors associated with maternal mortality and poor maternal health care and identifying the direct and indirect pathways of the determinants of poor birth outcomes and Caesarean section deliveries in Kenya. The findings will help identify the specific elements that should be targeted by the safe motherhood intervention programmes for improved maternal and newborn health.

The analysis is based on data from two national surveys the 1994 Kenya Maternal Mortality Baseline Survey, used in the analysis of maternal mortality, and the 1993 Kenya Demographic and Health Survey, used in the analysis of the determinants of maternal health care, poor birth outcomes and Caesarean section deliveries. The statistical methods used include multilevel models, loglinear analysis and graphical chain models.

The results from the analysis of maternal mortality show that the probability of a maternal death at the hospitals depends on the women's characteristics as well as the hospitals' effect. The hospitals' effect on maternal mortality is particularly strong for women with least favourable socio-demographic characteristics, such that this group of women have an extremely high probability of a maternal death if admitted in hospitals associated with high maternal mortality risks. The analysis of maternal health care shows that prenatal and delivery care in Kenya are determined by a wide range of socio-economic and cultural factors relating to the woman or her household; her demographic status and reproductive behaviour relating to a specific pregnancy; and factors relating to availability and accessibility of health services within her community. In addition, maternal health care utilization varies significantly between women and between communities. The analysis of the determinants of poor birth outcomes and Caesarean section deliveries identified a vast number of potential pathways of the determinants of these outcomes. The analysis revealed that even though some of the socio-economic and demographic factors such as maternal education, marital status and the desirability of a pregnancy have no direct associations with premature deliveries or the size of baby at birth, they have an indirect contribution to these outcomes through intermediate factors such as antenatal care. Antenatal care was identified as a central link between many of the socio-economic and reproductive factors and birth outcomes, hence, an important factor that should rank high in terms of priorities for the safe motherhood intervention programmes.

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Acknowledgements

I am deeply indebted to Professor Ian Diamond who made it possible for me to pursue the PhD programme at the Department of Social Statistics, University of Southampton. The work was supervised by Prof. Ian Diamond and Dr. Nyovani Madise. I wish to express my heartfelt appreciation to both of them for their untiring guidance and encouragement throughout the course of the study.

My sincere gratitude to the Faculty of Social Sciences of the University of Southampton and to the Population Council, New York, for their financial support. The first two years of the programme was funded by the research studentship grant of the Faculty of Social Sciences, University of Southampton, while the final year was funded by the Population Council's fellowship award.

This work benefitted greatly from the discussions with a number of staff members and fellow research students at the Department of Social Statistics of the University of Southampton. In particular, I would like to thank most sincerely Roberto Rodriguez, for his invaluable assistance in editing the thesis, and Dr. Peter Smith, for his technical advise on graphical models. Special gratitude to Iun da Costa Leite, Maletela Tuoane, Chiweni Chimbwete and James Brown, with whom I had exceptionally fruitful discussions.

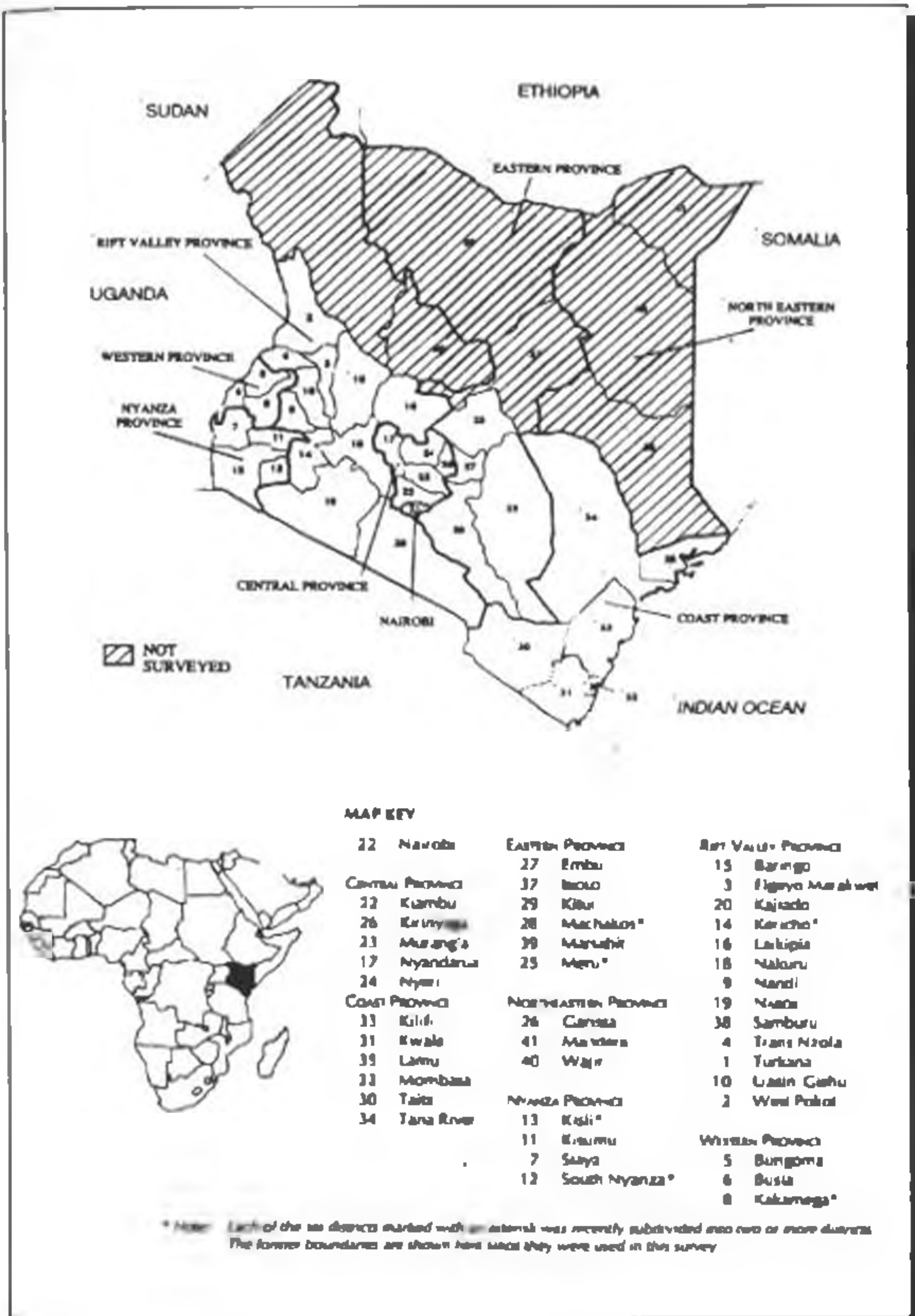
I am grateful to the University of Nairobi for granting me study leave to pursue my PhD studies. Special thanks to Professor A.B.C. Ocholla-Ayayo, the Director of the Population Studies and Research Institute, for his fatherly advice and encouragement.

Last, but not least, my profound appreciation to my husband Joseph and children John Paul, Antoinette, Immaculate and Winnie for their moral support. Despite being thousands of miles away, their total support and encouragement was a great inspiration to this work throughout the study period, even during the difficult times.

Abbreviations and Acronyms

AIDS	-	Acquired Immune Deficiency Syndrome
ANC	-	Antenatal care
APH	-	Antepartum haemorrhage
BMI	-	Body Mass Index
CHW	-	Community Health Workers
CBS	-	Central Bureau of Statistics [Kenya]
DHS	-	Demographic and Health Survey
FGD	-	Focus Group Discussion
HIV	-	Human Immunodeficiency Virus
IGLS	-	Iterative Generalised Least Squares
ICPD	-	International Conference on Population and Development
KDHS	-	Kenya Demographic and Health Survey
KMMBS	-	Kenya Maternal Mortality Baseline Survey
MI	-	Macro International
MOH	-	Ministry of Health [Kenya]
MQL	-	Marginal quasi likelihood
NASSEP	-	National Sample Survey and Evaluation Programme [Kenya]
NCPD	-	National Council for Population and Development [Kenya]
NSO	-	National Statistics Office [Philippines]
OLS	-	Ordinary Least Squares
OR	-	Odds Ratio
PAHO	-	Pan American Health Organization
PQL	-	Predictive quasi likelihood
PPH	-	Postpartum haemorrhage
PSRI	-	Population Studies and Research Institute
REML	-	Restricted Maximum Likelihood
RIGLS	-	Restricted Iterative Generalised Least Squares
STD	-	Sexually Transmitted Disease
TBA	-	Traditional Birth Attendant
UNFPA	-	United Nations Population Fund
UNICEF	-	United Nations Children's Fund
WHO	-	World Health Organization

Map of Kenya Showing the Regions



Source: Adapted from NCPD, CBS and MI (1994: xxiv)

Chapter 1

General Introduction

There is no doubt that fertility regulation contributes to improvements in women's health by reducing the number of pregnancies and the associated risks and by giving women more control over their lives. However, despite the substantial drop in both fertility and infant mortality rates in the developing countries over the past three decades, progress has been much slower in the area of maternal morbidity and mortality. The persistently high maternal mortality rates in the developing countries have prompted calls for action by governments around the world over the past decade. For example, the reduction of maternal mortality has been a common goal in the following international conferences: the 1987 Nairobi Safe Motherhood Conference, the 1990 World Summit for Children; the 1994 International Conference on Population and Development (ICPD); and the 1995 Fourth World Conference on Women. The 1994 ICDP conference in Cairo recommended that steps be taken to achieve a rapid and substantial reduction in maternal morbidity and mortality and to reduce the difference between and within developed and developing countries. The conference also urged that if there was commitment to women's health and well being, there would be a significant reduction in the number of deaths and morbidity from unsafe abortion.

Despite these repeated calls, progress has been slow. A decade after the call for action at the International Safe Motherhood Conference in Nairobi, there is no evidence that maternal mortality and morbidity has declined at levels anticipated at the conference. This presents a real challenge to both the International Safe Motherhood Initiative and national programmes which have set explicit targets. However, maternal mortality is only the tip of the iceberg. For every one maternal death, acute obstetric complications cause suffering in nearly 100 women, and 1000 women suffer stunting and/or anaemia (Koblisky, 1995). These problems have an adverse impact on the pregnancy outcomes for both the mother and the newborn. Other indicators of progress in safe motherhood are increasingly being advocated at an international level. Whilst the focus on maternal mortality remains, safe motherhood today has incorporated three other outcomes: maternal morbidity, the health of the newborn, and positive health of the mother (Graham and Murray, 1997).

The tragedy of maternal morbidity and mortality goes beyond the untimely and unnecessary death or suffering of the woman herself. It has consequences for her family, her community and ultimately the socio-economic development of her country. A healthy mother who has the physical and emotional resources to give birth to and bring up a healthy child is laying the foundation for a healthy start for the next generation of mothers and children (Winikoff, 1987). It is known that new born infants fare particularly poorly when their mothers die. Frequently, infant and maternal deaths occur simultaneously. Emphasis on maternal mortality thus complements the growing concern about infant and child survival.

1.1 Rationale for the Study

1.1.1 Safe Motherhood Situation in Kenya

The 1989 Kenya Population Census and the 1993 Kenya Demographic and Health Survey (KDHS) data show that the sex ratio of the Kenyan population is unity or in favour of females for most 5-year age groups, except for those aged between 30 and 44 years, when males are slightly in excess. Such a pattern of sex ratio is partly attributable to the impact of maternal mortality in the later part of the reproductive period (Graham and Murray, 1997). However, until the 1990s, a reliable picture of the magnitude and patterns of maternal mortality and other adverse maternal outcomes in Kenya was lacking.

Before the 1990s, various studies in Kenya have shown varying levels of maternal mortality in the country. Many of these studies have focused on different subgroups of the Kenyan population using different approaches, hence, the estimates are not comparable and cannot be used to establish consistent patterns of maternal mortality in the country. A study of maternal deaths at the Kenyatta National Hospital, Nairobi in 1978 showed a maternal mortality ratio of 240-400 deaths per 100,000 live births at the hospital between 1972 and 1977 (Ewbank *et al.*, 1986). In contrast, a 1987 study of maternal deaths at Pumwani Maternity Hospital, another public hospital in Nairobi, found a much lower ratio of 67 deaths per 100,000 live births over the period 1975-84 (Ngoka and Bansel, 1987). Maternal mortality ratios are also available from a few population-based studies in Kenya. A longitudinal study in the 1970s in a low mortality area in central Kenya yielded a maternal mortality ratio of 90 per 100,000 live births for the period 1975-78 (Voorhoeve *et al.*, 1984a). A study undertaken in Kwale district, Coast province in 1987 employing the "networking" method, found the maternal mortality ratio in that district to be 600-700 deaths per 100,000 live births (Boerma and Mati, 1989).

Two national surveys in the 1990s, the 1994 Kenya Maternal Mortality Baseline Survey (KMMBS) and the 1998 KDHS, collected information on maternal mortality in the country, based on the sisterhood method. In the 1994 national baseline survey, the national maternal mortality ratio was estimated at 365 maternal deaths per 100,000 live births for the five-year period preceding the survey. The baseline survey observed wide regional maternal mortality differentials. Very high ratios of over 1,000 deaths per 100,000 live births were observed in the coastal and western regions of the country, while fairly low rates of below 100 maternal deaths per 100,000 live births were observed in the low mortality areas of Central Province (Population Studies and Research Institute (PSRI) and UNICEF, 1996). The 1998 KDHS estimated the maternal mortality ratio at 590 maternal deaths per 100,000 live births for the ten-year period before the survey (1989-1998) (National Council for Population and Development (NCPD), Central Bureau of Statistics (CBS) and Macro International (MI), 1999). The results from these two surveys might suggest that the maternal mortality situation in Kenya may have worsened over the recent years. This is, however, not conclusive since the observed differences in the maternal mortality levels might be a result of methodological differences in the two national surveys.

The major contributing factors to poor maternal and perinatal outcomes in Kenya include poor maternal health care and pregnancy or childbirth complications. Even though almost all (95 per cent) of the births in Kenya receive at least some professional antenatal care, more than half (55 per cent) of all births take place at home under the assistance of a Traditional Birth Attendant (TBA), a relative, a friend or no one (National Council for Population and Development (NCPD) [Kenya], Central Bureau of Statistics (CBS) [Kenya] and Macro International (MI), 1994). The fact that the majority of women in Kenya do not seek professional assistance from medical personnel during childbirth is an issue of great concern, since the risk of complications and/or death increases under these circumstances.

Improving maternal and child health in Kenya would require greater efforts towards providing appropriate antenatal, delivery and postnatal care to all mothers, including those in the remote rural areas who do not have easy access to modern health care. Having recognised the important contribution of the TBAs in the provision of maternal health care, particularly in the rural areas, the Government of Kenya, in collaboration with the World Health Organization (WHO), developed a 'National Curriculum for Traditional Birth Attendants' in 1990/91. The aim of the curriculum was to train TBAs in antenatal care, hygienic and safe deliveries, and postnatal care, using the available appropriate technologies at the community level. Impact evaluation studies of the TBA training programme in the pilot areas have indicated that the programme is making a positive impact on maternal and child health care (Omoro and Kwinga, 1993; WHO and Ministry of Health (MOH) [Kenya], 1996). On the other hand, the lack of evidence of corresponding improvements in the maternal mortality rates in the 1990s might be due to the existence of other important factors.

Hospital-based data indicate that about 20 per cent of pregnant women in Kenya develop complications during pregnancy, while another 20 per cent develop complications during childbirth. The complications which are direct causes of maternal deaths include haemorrhage, sepsis, hypertensive diseases in pregnancy and abortion, all of which constitute obstetric emergencies. Lack of a functional referral system, transport and facilities to handle emergencies at the referral centres are significant contributing factors to maternal morbidity and mortality (MOH, 1996). Other predisposing factors to maternal morbidity and mortality include anaemia, malnutrition and malaria, among others.

One of the most topical areas in reproductive health today is the consequences of unsafe-induced abortion. Safe motherhood initiatives have continued to highlight the contribution of unsafe abortion to the persistent high rates of maternal morbidity and mortality in sub-Saharan Africa. In Kenya, unsafe-induced abortion is responsible for one-third of maternal deaths (MOH, 1996). Under the current Kenya law, abortion is permitted only for the preservation of the woman's life (Rogo *et al.*, 1996). Because of this legal restriction, many women with unwanted pregnancies resort to clandestine unsafe abortion.

In accordance with the 1994 ICPD's challenge to provide comprehensive reproductive health services, the Kenyan national strategy for reproductive health care has integrated safe motherhood into the broader framework of reproductive health. The main components of reproductive health include safe motherhood (antenatal care, clean and safe delivery, postnatal care and essential obstetric care) and child survival; family planning unmet need; management of STDs and HIV/AIDS; promotion of adolescent and youth health; management of infertility; gender issues and reproductive rights; and other reproductive health issues, such as cancers of reproductive organs. Safe motherhood goals proposed in the national strategy include a reduction of maternal mortality ratio from 365 in the early 1990s to 170 deaths per 100,000 live births by the year 2010; to markedly reduce maternal morbidity rates during the same period; to increase professionally attended deliveries from 45 per cent in 1995 to 90 per cent in 2010; to reduce perinatal mortality rate from the current estimate of 45 per 1000 live births to less than 30 per 1000 by the year 2010; and to establish the magnitude of maternal and perinatal morbidity and mortality (MOH, 1996).

1.1.2 The Research Problem

Despite remarkable gains in the reduction of fertility and infant mortality levels in Kenya over the last few decades, there is lack of evidence of a corresponding reduction in the maternal mortality and perinatal mortality levels over the years. Furthermore, reduction in perinatal mortality rates have lagged behind the strides made in the reduction of infant and child mortality rates (MOH, 1996). The causes of perinatal mortality are quite similar to the causes of maternal mortality and include: poor maternal health, inadequate care during pregnancy; inappropriate management of complications during pregnancy, childbirth and immediately after childbirth; and poor hygiene during delivery. Most of these conditions are preventable, making both maternal mortality and perinatal mortality rank high in order of priorities of reproductive health concerns.

Adverse pregnancy outcomes for the mother and the newborn include maternal mortality; perinatal mortality (still birth and early neonatal mortality); early fetal loss, complications during childbirth; low birth weight, and premature delivery. These outcomes are closely interrelated. For instance, abortion and childbirth complications are some of the main factors associated with maternal mortality, maternal mortality is often accompanied with a perinatal mortality; and premature births and intrauterine growth retardation are closely associated with neonatal mortality. The pregnancy outcome is influenced by the reproductive status and the health of the mother, including her nutritional status as well as the quality of maternal health care, which encompasses antenatal care, delivery care and postnatal care. The quality of maternal health care is in turn influenced by a wide range of cultural, socio-economic and demographic factors relating to the individual woman, her household and the community in which she lives, including health service accessibility. Graham and Murray (1997:1,11) summarised the interrelationships between these factors as follows:

> *"As the meaning of safe motherhood broadened, particularly in the early 1990's, so did the range of factors regarded as determinants of poor maternal health, with women's low socio-economic status seen as one of the root causes... There is now widespread recognition that the causes of maternal deaths cannot be considered simply in terms of final medical diagnosis. They also include the whole complex of social, cultural, economic, legal and political factors which help to define women's status and, in many situations, condemn them to lifelong suffering and inequality. It is also well proven that reproductive behaviour influences women's risks of adverse pregnancy outcomes. The provision and utilization of health care plays a key role through appropriate*

management of normal pregnancies and deliveries - so preventing complications, and through effective care of complications once they have arisen - so preventing death".

The estimates of maternal mortality show wide differences between areas of the sub-continent and between individual countries. Graham and Murray (1997) noted that the explanations for this diversity are numerous, but the closest correlations are with indicators of fertility, wealth, maternity care and women status. They recognised that Kenya is a country characterised by huge internal differences - demographic, economic, ethnic, climatic and environmental. All these factors are, therefore, likely to have a significant contribution to the safe motherhood situation in Kenya. It is widely acknowledged that many women in Kenya endure a lifetime of poor health and nutritional status as a direct consequence of societal, cultural, political and economic factors which discriminate against them. The risks that women throughout the world face during pregnancy and childbirth are seriously exacerbated by these factors in Kenya, making women in Kenya particularly vulnerable to adverse outcomes, both for themselves as well as for their infants (Graham and Murray, 1997).

Although the majority of births in Kenya do not take place within health facilities, most studies on adverse pregnancy outcomes have been hospital-based, yielding results applicable only to the small sub-population who have access to the health facilities. The comparative rarity of maternal deaths on a short term basis means that extremely large surveys are needed to yield current population-based figures, which are very costly and logistically complex. Furthermore, there has not been any major survey gathering data on maternal morbidity in Kenya. Graham and Murray (1997) have pointed out that one of the difficulties in gauging the true burden of pregnancy-related morbidity, is the lack of recent and reliable data.

It has been noted that one of the major problems hindering investigations of the effects of socio-demographic variables on a wide range of pregnancy outcomes is the scarcity of well structured multivariate techniques to determine the relative importance of the various socio-demographic factors that have an impact on pregnancy outcomes (Hajo and Wildschut, 1995). The impact of maternal health care on reproductive health outcomes has also not been conclusively documented. Obermeyer (1993) recommended further research to understand the connection of antenatal care and hospital delivery to pregnancy outcomes and to assess the importance of the use of modern health care, as compared with traditional home care. It has been suggested that further information about the content of the modern health care that is received will help identify which components of the care are most relevant to improved health.

1.2 Research Objectives

Maternal mortality is the most commonly used indicator for women's health status but other unfavourable pregnancy outcomes also do threaten the life of the mother and the newborn. For example, premature births or low birth weight babies have been associated with a significantly increased risk of perinatal mortality, while delivery by Caesarean section represents difficult delivery that is likely to result in a maternal or perinatal death if appropriate health care is not received during childbirth. On the other hand, rates of Caesarean section deliveries may also be used to assess whether or not facilities are providing life-saving obstetric services. It is important that factors associated with these birth outcomes are well understood in order to devise appropriate ways to avert or at least minimise such outcomes. It is also important to understand the mechanisms through which various factors may operate to influence pregnancy outcomes. The pathways will help safe motherhood programmes identify specific aspects or elements to be targeted by the intervention programmes.

An important factor that is likely to play a crucial role in minimizing adverse pregnancy outcomes is appropriate maternal health care. Appropriate antenatal and delivery care are both useful in preventing as well as treating or managing pregnancy and childbirth complications, thus averting undesirable outcomes. An investigation of factors associated with maternal health care utilization is necessary for an improved understanding of factors hindering effective maternal health care for the development of appropriate intervention programmes.

The overall aim of this study, therefore, is to improve understanding of factors associated with poor maternal health care and adverse pregnancy outcomes in Kenya. The specific objectives are (a) to examine factors associated with maternal mortality; (b) to establish the determinants of maternal health care; and (c) to identify the direct and indirect pathways of the determinants of poor birth outcomes and Caesarean section deliveries.

In examining the factors associated with maternal mortality in Kenya, both hospital-based and survey-based data are analysed. The study of the determinants of maternal health care will focus on the associations of antenatal and delivery care with a wide range of factors relating to an individual birth, maternal characteristics and the availability and accessibility of health facilities within a community. The poor birth outcomes that will be analysed include premature births and the size of baby at birth. A wide range of factors are hypothesized to influence these outcomes either directly or indirectly, as illustrated in the framework in Chapter two

In addition to bridging the gap in our understanding of the patterns and determinants of maternal outcomes in Kenya, this study is the first to apply multilevel models to investigate the determinants of maternal health care and adverse pregnancy outcomes in Kenya. This strategy allows us to identify individual women's, as well as hospitals' and community effects on these outcomes. Since many of the potential determinants of the adverse pregnancy outcomes are likely to be interrelated, this study also uses graphical loglinear models to explore the association structure between the various factors which may contribute to poor birth outcomes and Caesarean section deliveries either directly or indirectly

1.3 An Outline of the Thesis

This thesis is divided into eight chapters. Chapter two presents the conceptual framework and literature review. Preceding the conceptual framework is an overview of adverse pregnancy outcomes, with particular focus on the magnitude of maternal mortality in the developing countries. The literature review is divided into three broad sections: the socio-demographic risk factors of adverse pregnancy outcomes, maternal health care and adverse pregnancy outcomes; and maternal health status, including maternal nutritional status and medical factors influencing pregnancy outcomes. Finally, a discussion on the literature, addressing gaps in the literature that this study seeks to address, is given.

The third chapter on methodology includes a description of the data that are used and the statistical methods applied. The first section describes the data, including a brief overview of potential data sources. The bulk of the analysis is based on the 1993 KDHS data. However, the chapter on maternal mortality uses information from the 1994 KMMBS. The statistical methods include multilevel models, loglinear models and graphical chain models. The second section of this chapter describes these methods, giving the model specifications and the estimation procedures.

Chapter four presents findings from the analysis of factors associated with maternal mortality in Kenya. This chapter uses both the hospital-based and survey-based data from the KMMBS. The first section uses the hospital data to investigate the factors influencing maternal mortality in Kenyan hospitals using a 2-level logistic regression model. Both the socio-demographic characteristics of women and the hospitals' effect on maternal mortality are examined. The second section examines the interrelationships between pre-disposing factors, maternal health care factors and circumstances of maternal deaths based on the household survey data on maternal deaths among sisters of the survey respondents.

The next three chapters are based on the 1993 KDHS data. Chapter five investigates the determinants of maternal health care in Kenya. The analysis of antenatal care, based on frequency of visits and timing of the first antenatal care visit, uses 3-level linear regression models. The determinants of delivery care is based on multilevel logistic and multilevel multinomial models for the place of delivery and the type of childbirth attendant, respectively. In addition to the reproductive factors and the background socio-economic factors, the analysis includes factors relating to the availability and accessibility of health care services within communities.

Chapters six focuses on factors associated with poor birth outcomes (premature delivery, small size of baby at birth) and Caesarean section deliveries in Kenya. Multilevel logistic regression models are used to identify factors associated with these outcomes. Factors considered to be potentially important include various socio-demographic risk factors, maternal nutritional status and maternal health care.

Chapter seven is an extension of the analysis of determinants of poor birth outcomes and Caesarean section deliveries. This chapter uses graphical loglinear models to explore the association structure between the various factors which are likely to contribute to these outcomes either directly or indirectly. The modelling procedure involves partitioning the variables into subsets, ordered to form a chain, based on possible causal direction. The study of intra-block associations as well as associations between variables in different blocks provides direct and indirect pathways from each of the determinants to the outcomes.

Finally, Chapter eight gives the summary of the main findings and the conclusions that are derived from these findings, including policy implications and recommendations for future research.

Chapter 2

Conceptual Framework and Literature Review

This chapter presents the conceptual framework and reviews literature on the determinants of adverse pregnancy outcomes. It starts with an overview of adverse pregnancy outcomes with special focus on maternal mortality, then presents the conceptual framework used to study the determinants of adverse pregnancy outcomes. This is followed by a review of literature on the factors associated with adverse pregnancy outcomes: the socio-economic and demographic factors, maternal factors such as the health status, type and quality of antenatal care and nutritional status. The chapter concludes with a discussion, highlighting gaps in the literature that this study seeks to address.

2.1 General Overview of Adverse Pregnancy Outcomes

2.1.1 The Magnitude of Maternal Mortality in the Developing Countries

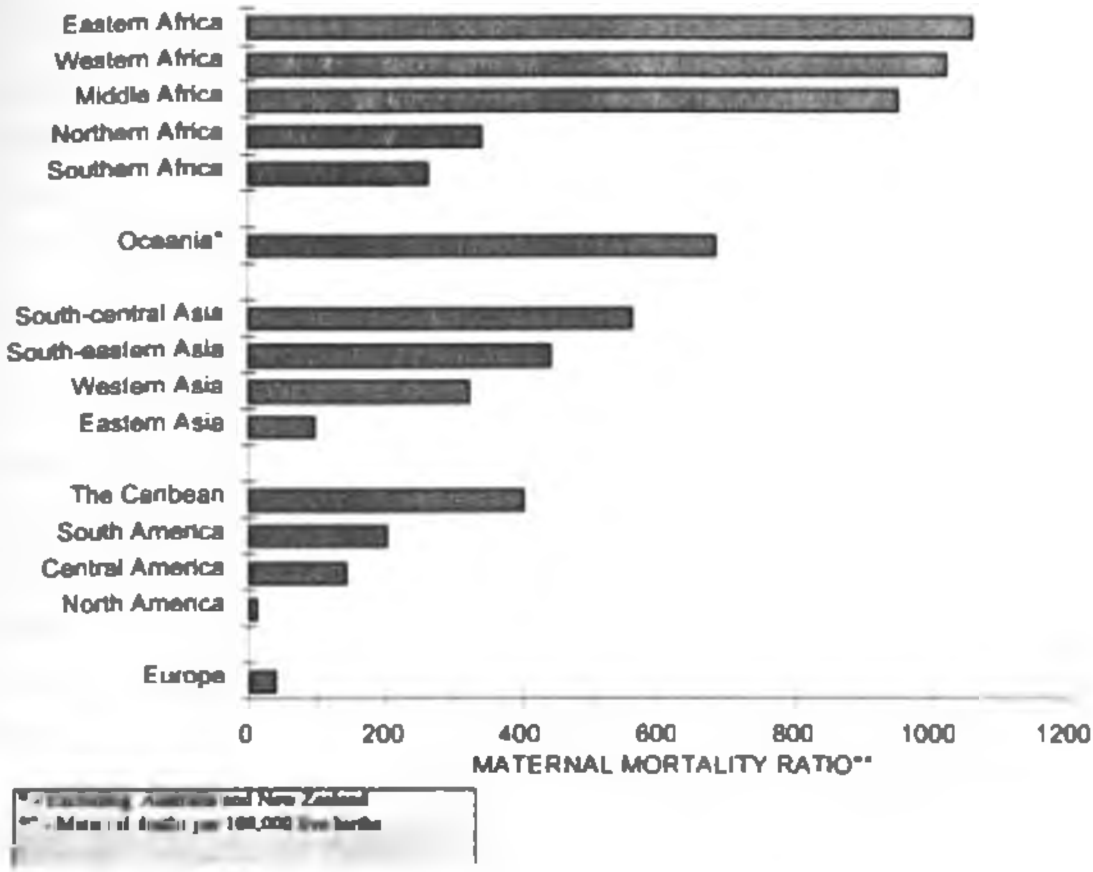
Maternal mortality is defined in the Tenth International Classification of Diseases as: "The death of a woman while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy from any cause related to or aggravated by the pregnancy or its management, but not from accidental or incidental causes" (WHO, 1977:764). The measures of maternal mortality include maternal mortality ratio, maternal mortality rate and lifetime risk of a maternal death. The maternal mortality ratio, which is the most commonly used measure, refers to the number of maternal deaths per 100,000 live births. This measure indicates the risk of a maternal death among pregnant and recently pregnant women. It reflects a woman's basic health status, her access to health care and the quality of services that she receives (WHO and UNICEF, 1996; UNICEF/WHO/UNFPA, 1997). On the other hand, the maternal mortality rate is the number of maternal deaths per 100,000 women aged 15-49 per year. This measure reflects both the risk of death among pregnant and recently pregnant women, and the proportion of all women who become pregnant in a given year. It can, therefore, be reduced by either making childbearing safer and/or reducing the number of pregnancies (UNICEF/WHO/UNFPA, 1997). The lifetime risk of a maternal death reflects the probability of maternal death faced by an average woman over her entire reproductive life-span. It reflects both a woman's risk of dying from maternal death, as well as her risk of becoming pregnant. It also takes into account the accumulation of risk with each pregnancy (WHO and UNICEF, 1996; Graham and Campbell, 1991).

Complications related to pregnancy and childbirth are among the leading causes of mortality for women of reproductive age in many parts of the developing world. Between about a quarter to a third of deaths to women of reproductive age in developing countries are due to maternal causes (Graham and Murray, 1997). Although reliable data on maternal mortality rates in the developing countries is lacking, it is estimated that 99 per cent of the 585,000 annual maternal deaths occur in the developing world (WHO and UNICEF, 1996). For each maternal death, there are, in addition, several cases of maternal morbidity (WHO, 1994c). An estimated 88 per cent to 98 per cent of these deaths are preventable with modest levels of health care (Graham and Murray, 1997).

The regional differentials in maternal mortality levels reflect the widest disparity in human development indicators between industrial and developing countries. Figure 2.1 illustrates the maternal mortality levels based on the WHO/UNICEF 1990 estimates. The estimates were developed using a dual strategy which involved using available data wherever possible, adjusted to account for the common problems of under-reporting and misclassification of maternal deaths, and developing a simple model to predict values for countries with no reliable national data (WHO and UNICEF, 1996). Maternal mortality ratios for the developed and the developing nations are estimated at 27 and 480 maternal deaths per 100,000 live births, respectively. Among the developing countries, the maternal mortality ratios range from 190 deaths per

100,000 live births in Latin America and the Caribbean to 870 deaths per 100,000 in Africa.

Figure 2.1 Regional estimates of maternal mortality ratios, 1990



Source: WHO and UNICEF (1996:6)

A woman's life-time risk of a maternal death, which is also affected by the total number of children women bear, is much higher (almost 40 times) in the developing countries, since women bear many more children than women in the developed world. The lifetime risk of dying from pregnancy is 1-in-48 for developing countries, compared to 1-in-1,800 in developed countries. It has been estimated that in Eastern or Western Africa, where the ratio is over 1,000 maternal deaths per 100,000 live births, a woman runs a 1-in-12 risk of dying from pregnancy related causes during her lifetime. In Northern or Southern Europe, the risk falls to 1-in- 4,000. The country-level differentials are even wider: for instance, 1 out of every 7 women die from pregnancy related causes in Sierra Leone, as compared to 1-in-9,200 in Hong Kong (WHO and UNICEF, 1996).

2.1.2 Other Undesirable Pregnancy Outcomes

Maternal mortality is the end result of illness and suffering which mainly include severe bleeding, infections, unsafe abortions, eclampsia, obstructed labour and indirect causes such as anaemia and malaria. Even among those who survive, the consequences of these conditions can be severe. At least 40 per cent of women experience complications during pregnancy, childbirth and the postpartum period, and an estimated 15 per cent of pregnant women develop potentially life-threatening complications (WHO, 1994c; Graham and Murray, 1997). According to preliminary results from household surveys of 16,000 women in five developing countries, about 7 out of every 10 women reported a health problem related to their last pregnancy, delivery or postpartum period or to a chronic condition stemming from pregnancy or childbirth. The results from Egypt, Ghana and Indonesia indicated that for each maternal death, there are some 240-230 maternal morbidy cases (Family Health International, 1994).

Some of the pregnancy or childbirth complications may require a Caesarean section delivery to avert maternal or infant morbidity and mortality. However, like other major surgical procedures, Caesarean section deliveries carry high risks of injury and even death. A study in Kenya noted that high post-operative wound infection rate can be a major concern (Colombo and Ferrari, 1990). De-Muylder (1993) pointed out the short- and long-term effects of Caesarean section deliveries to include: increased maternal mortality following a Caesarean section than after complicated instrumental extraction for the same complication, mainly due to anaesthetic accidents, technical problems during surgery and a high incidence of infection; long-term side effects of secondary infertility and an increased risk of uterine rupture in subsequent pregnancies due to the uterine scar and; induced prematurity and respiratory distress due to elective Caesarean section, often resulting in neonatal death. It is, however, important to note that the relative 'unsafeness' of a Caesarean section depends on improvements in medical technology, including hygienic conditions, and may not hold in all developing countries. Furthermore, Caesarean sections in some countries are no longer solely associated with medical concerns, but often a matter of choice.

It makes sense to consider maternal and perinatal health together, because both the mother and child are affected by the direct causes of death and disability and because the interventions designed to promote maternal and perinatal health often overlap and are operationally linked (Tsui *et al.*, 1997). Each year, almost eight million perinatal deaths occur (WHO, 1996). Perinatal deaths include stillbirths and deaths during the first week of life. These deaths are caused largely by the same factors that lead to maternal death and disability, that is, women's poor health and nutritional status during pregnancy, inadequate care during delivery, and lack of newborn care (WHO, 1997; Koblinsky, 1995).

Perinatal mortality is also influenced by low birth weight, which in turn is largely due to intra-uterine growth retardation or prematurity or both. The perinatal mortality rate of a low birth weight baby is thirty times higher than that of a foetus or infant of normal weight (Koblinsky, 1995). Furthermore, low birth weight infants who do not die may have serious developmental or health problems. Infants delivered following preterm labour are at varying degrees of risk depending on the gestational age and etiology of the preterm labour. The WHO (1994a) noted that there are no well-defined cost effective ways of preventing premature labour, but it is necessary to have a health facility delivery if gestational age is less than eight months.

Community or population-based studies on pregnancy outcome in Kenya are limited. A longitudinal study in a low mortality area of Machakos district in Kenya during the late seventies singled out breech delivery as constituting the highest risk of perinatal mortality. Among the 58 breech deliveries, 33 died during the perinatal period. The resulting perinatal death rate of 569 per 1000 was 14 times the rate of 40 per 1000 for vertex deliveries. However, breech deliveries had a better chance of survival when delivery was in hospital. Both the still birth and the neonatal mortality rates were higher for males than for females. Caesarean section, forceps and vacuum extraction also carried high perinatal death rates but were often performed on an already compromised foetus (Voorhoeve *et al.*, 1984a)

2.2 A Conceptual Framework of the Determinants of Adverse Pregnancy Outcomes

The number of possible factors which have an effect on pregnancy outcomes is vast. These include a set of background socio-economic and cultural factors, which act through a wide range of intermediate variables to influence pregnancy outcomes. Some of the adverse pregnancy outcomes are closely interrelated and are influenced by a number of common factors. However, there are factors which are specific to particular pregnancy outcomes, which makes it necessary to discuss factors associated with the different outcomes separately.

Maternal mortality is clearly the most adverse pregnancy outcome. From clinical literature, the immediate causes of maternal deaths are usually obstetric complications which account for the majority of maternal deaths. Most of these deaths could be averted through essential obstetric care. Delay, occurring in different phases, has emerged as a pertinent factor contributing to a substantial proportion of maternal deaths (Thaddeus and Maine, 1994). This is a concept that unifies a number of seemingly disparate factors, such as women's socio-economic status, accessibility of health care facilities and the quality of care. The decision to seek care is usually influenced by one's socio-economic status (i.e. economic, educational and women's status) and illness characteristics. Factors to do with the health facility, such as the accessibility and the quality of care may influence the timing when care is received. Accessibility is likely to influence delay in reaching a health facility, while quality of care may influence delay in receiving needed care at the facility. Both of these factors are also likely to influence delay in the decision to seek care.

Limited research on Caesarean section deliveries in developing countries makes it difficult to identify the important determinants of Caesarean section rates (De-Muylder, 1993). Factors that have been identified as important include advanced maternal age and maternal nutritional status. Gonzalez-Perez and Vega-Lopez (1996) identified socio-demographic factors such as maternal age of 35 years and over, and living in overcrowded conditions to be associated with increased Caesarean section deliveries in Guadalajara (Mexico). Living in overcrowded conditions is possibly associated with poor maternal nutrition which can lead to foetal distress, making it necessary to have a Caesarean section delivery. Efiong (1979) observed a comparably higher incidence of Caesarean section among the underweight mothers in Nigeria, mainly necessitated by foetal distress.

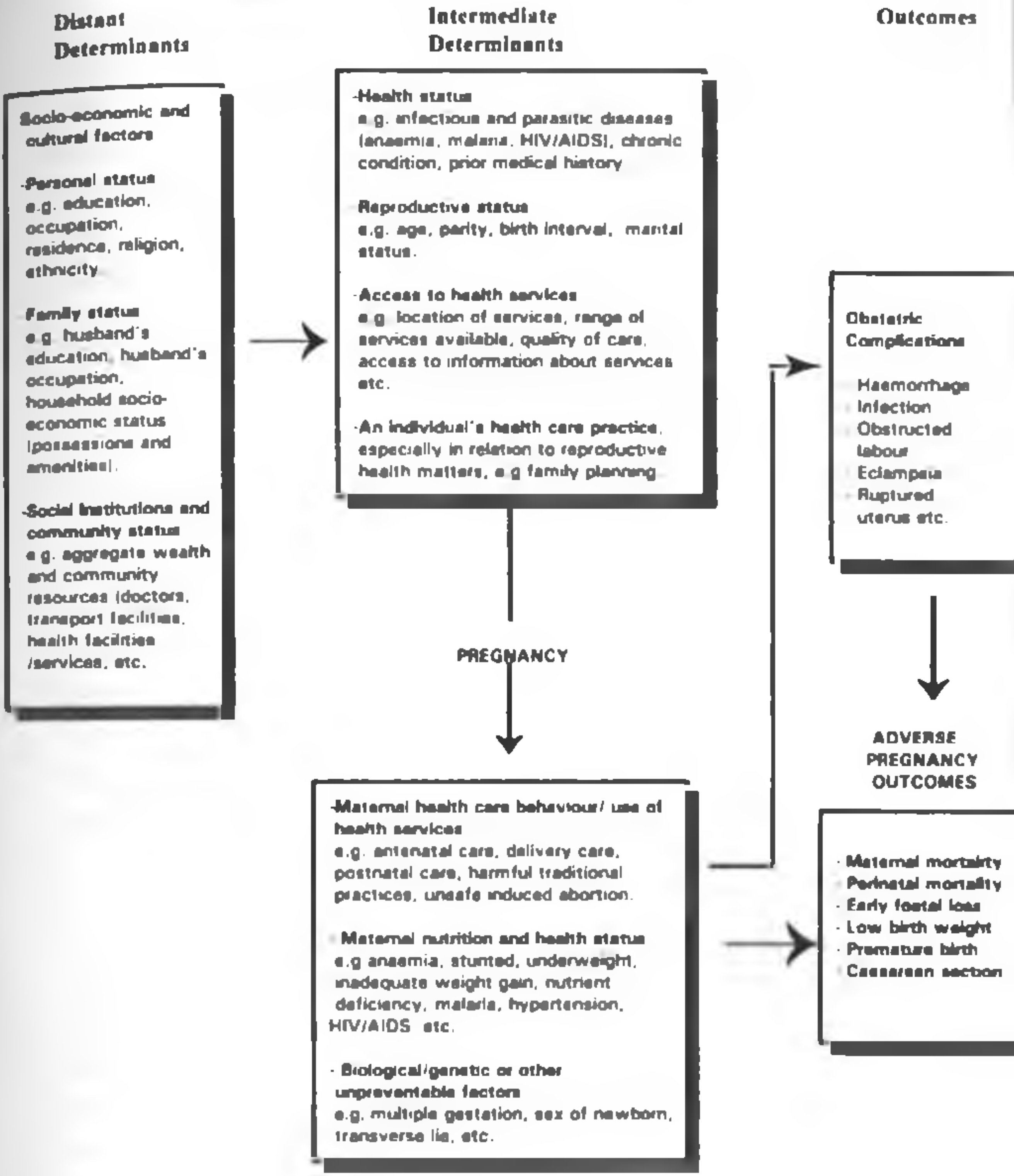
Nordbeck *et al.* (1984) found that in rural Kenya maternal nutritional status and delivery management played an important role in perinatal mortality. In addition, they identified other risk factors such as breech delivery, multiple birth and first pregnancies. Although there are many causes of perinatal mortality besides those which are life threatening to women during pregnancy and delivery, studies which do show a link between perinatal and the obstetrical complications that can lead to maternal mortality infer that at least three-quarters of perinatal deaths are associated with life threatening conditions to women, delivery management or women's health or nutritional status (Koblinsky, 1995).

An important factor in perinatal mortality is low birth weight, which can result from prematurity or intrauterine growth retardation. The principal risk factors for low birth weight include: socio-demographic risks, medical risks predating pregnancy, and medical risks in current pregnancy. A major determinant of prematurity and intrauterine growth retardation in both the developed and the developing countries is maternal nutritional status, including low pre-pregnancy weight and short maternal stature (Kramer, 1987; Berendes, 1993; Koblinsky, 1995). Other factors such as sex of newborn, multiple births, history of premature deliveries, racial origin and malaria have also been observed to be important (Kramer, 1987; Taha, 1992; Berendes, 1993; Kuate-Defo and Partin, 1993).

Clearly, an adverse pregnancy outcome is the result of complex interactions between socio-economic and cultural factors, reproductive behaviour, health care utilization, maternal health and other biological factors. Meaningful understanding of the interrelationships between the various factors is made easier when these factors are organised in a systematic way. A comprehensive framework of the determinants of maternal mortality, developed by McCarthy and Maine (1992), shows that socio-economic factors act through a diverse range of reproductive and health care variables to influence maternal mortality. This framework forms the basis of the conceptual framework of the determinants of adverse pregnancy outcomes presented in Figure 2.2, which is adopted in this study.

There are two major differences between the conceptual framework presented in Figure 2.2 and the original McCarthy and Maine (1992) framework. The first main difference is the inclusion of other adverse pregnancy outcomes in the present framework, besides maternal mortality and disability, addressed in the original framework. Secondly, while the original framework considers pregnancy as one of the outcomes, the present study views pregnancy strictly as a pre-condition for the maternal factors such as maternal health care and obstetric complications, and hence, the shift in its position in the framework. Considering pregnancy as a precondition for the maternal factors enables us to address the intermediate factors both prior to and after the start of the pregnancy. Some of the pre-existing conditions relating to women's health status are exacerbated by pregnancy and, therefore, are referred to twice in the framework.

Figure 2.2 A conceptual framework for studying determinants of adverse pregnancy outcomes



Source: Adapted from McCarthy and Maine (1992:26) Framework on Determinants of Maternal Mortality

The position of Caesarean section deliveries in the framework needs clarification. Although strictly speaking Caesarean section is not a pregnancy outcome, it is considered as one of the response variables of interest, which can be influenced by various obstetric complications. Caesarean section may influence some of the pregnancy outcomes such as maternal mortality and perinatal mortality, yet factors directly responsible for, say, prematurity or low birth weight, usually occur prior to a Caesarean section. Thus, the direction of influence of Caesarean section with respect to the various pregnancy outcomes could be either way. In view of this, it has been considered appropriate to have Caesarean section in the same block as the other adverse pregnancy outcomes.

An adverse pregnancy outcome is most directly influenced by obstetric complications which are in turn influenced by various sets of intermediate determinants, comprising pre-pregnancy characteristics as well as factors relating to the period during the current pregnancy, childbirth and the postpartum period. The pre-pregnancy factors include the general health status of the woman; her reproductive status; her access to health services; and her health care behaviour, especially in relation to reproductive health matters, such as family planning practice. Factors relating to the period during pregnancy, delivery and the postnatal include maternal health care, maternal nutrition and a set of biologic or genetic factors. Finally, socio-economic and cultural background factors may operate through these intermediate determinants to influence pregnancy outcomes.

The biologic or genetic factors which have an influence on adverse pregnancy outcomes include multiple gestation, the sex of the child and traverse lie, among others. Multiple gestation is associated with increased maternal and perinatal mortality and morbidity due to associated preterm birth, hypertensive disorders of pregnancy, obstructed labour and postpartum haemorrhage (WHO, 1994b). The female infant is more likely to be of low birth weight, but less likely to experience neonatal mortality (see, for example Voorhoeve *et al.*, 1984b; Taha, 1992; Kuate-Defo and Partin, 1993). A traverse presentation often leads to obstructed labour which is a major determinant of Caesarean section deliveries and a major direct cause of maternal and perinatal mortality. Though unpreventable, efficient and appropriate management procedures can minimise adverse pregnancy outcomes resulting from these biologic or genetic factors.

Maternal health care behaviour and maternal health status, including nutritional status are important maternal characteristics which influence pregnancy outcomes either directly or indirectly. Poor maternal nutritional or health status play an important role on birth outcomes, especially low birth weight and prematurity. Appropriate maternal health care can avert adverse pregnancy outcomes mainly through prevention or effective management of the obstetric complications. Other health care behaviours related to pregnancy and childbirth are also likely to have important influences on pregnancy outcomes. Obvious examples include unsafe abortions and harmful traditional practices during pregnancy and childbirth.

A woman's personal health status prior to a pregnancy can have an important influence on the outcome of her pregnancy. The leading pre-existing health conditions that are exacerbated by pregnancy and delivery and account for approximately one-quarter of maternal deaths in developing countries are malaria, hepatitis, anaemia and malnutrition (Maine, 1987; Royston and Armstrong, 1989). These same conditions have been observed to have an adverse effect on the health and survival of the fetus or newborn.

The relationship between adverse pregnancy outcomes and reproductive factors indicate a higher risk in the early and late childbearing years and increases with parity and shorter birth intervals. The desirability of a pregnancy is also an important variable, especially since women who have an unwanted pregnancy are more likely than others to seek an abortion, even if the only procedure available is unsafe. Abortion greatly increases the risk of maternal mortality (Kwast and Liff, 1988).

For women to be able to use health-care services, they need to be informed about the available services, which should be affordable and accessible. In addition to accessibility of services, an important factor in the decision to seek care is the quality of care. These factors would influence the women's general health care behaviour, especially in reproductive health matters, since many societies consider such conditions as normal, and therefore not warranting special medical attention

A step backwards takes us to the background variables. The risk of dying may be strongly influenced by one's position in society. For women, their status in the family and community can be related to their education level, their occupation, their level of personal income or wealth and their autonomy (McCarthy and Maine, 1992). The low socio-economic status of women have a negative impact on safe motherhood through poor health and nutritional status before, during and after pregnancy, limited knowledge and awareness of health; lack of decision making power and lack of resources for seeking health care; weak negotiating power in terms of sexual and reproductive rights; heavy physical workload regardless of pregnancy status, and exposure to injury through violence (Graham and Murray, 1997). At the family level, status can be associated with aggregate family income as well as with the occupation and education of family members, mainly the husband. Finally, the collective resources and wealth of a local community are also important dimensions of socio-economic status that are likely to have an influence on the health of community members (McCarthy and Maine, 1992).

Since the focus of this study is on adverse pregnancy outcomes, we consider the direction of the influence from the determinants to the pregnancy outcomes, even though we are aware that some of the outcomes have reverse influences. For instance, multiple births often exert an economic burden on the family due to the demand for a substantial amount of resources in terms of both time and finance. The same would apply to other adverse outcomes such as premature births, low birth weight, and Caesarean section, since the mother and the newborn need more intensive care in such cases

This study focuses on adverse pregnancy outcomes for both the mother and the newborn, and will include analyses on maternal mortality, low birth weight, premature birth and Caesarean section deliveries. Due to data limitations, the obstetric complications and some of the adverse pregnancy outcomes (perinatal mortality and early foetal loss) will not be investigated. Both the intermediate as well as the background determinants of the adverse pregnancy outcomes will be addressed. The intermediate determinants are the most amenable to policy intervention. Of primary interest in this study is maternal health care, which is considered to be a key factor in adverse pregnancy outcomes. The background variables represent the social context of morbidity and mortality and also need to be properly understood for the development of appropriate, effective and relevant intervention programs.

2.3 Socio-economic and Demographic Factors Associated with Adverse Pregnancy Outcomes

Various socio-economic and demographic factors have been cited in the literature to influence pregnancy outcomes. Generally, risks of adverse pregnancy outcomes are higher for very young women, or those aged over 35 years; for women in their first pregnancy or after four previous pregnancies; for women with certain preexisting health conditions; for poor, malnourished, and uneducated women, and for women beyond the reach of adequate health care (Herz and Measham, 1987; Anandalakshmy *et al.*, 1993; Population Studies and Research Institute (PSRI) and UNICEF, 1996).

2.3.1 Socio-economic Factors and Adverse Pregnancy Outcomes

The socio-economic factors associated with adverse pregnancy outcomes that have been addressed in the literature include maternal education, maternal occupation, rural-urban residence, household socio-economic status, and marital status, among others. In a study of risk factors for preterm delivery in Burkina Faso, education was observed to be a risk factor for prematurity (Prazuck *et al.*, 1993). The researchers suggested that educated mothers are more likely to use motorized transport on bumpy roads for several hours at a time, which caused inter-uterine vibrations, resulting in preterm delivery. Elsewhere (in the United States), high levels of maternal education have been observed to reduce the risk of a low birth weight (Kuate-Defo and Partin, 1993).

The Philippines National Safe Motherhood Survey observed that even though urban residence and higher education levels are associated with lower fertility, there was no variation in the average number of pregnancy losses by urban-rural residence or education level. However, first order and pregnancies of order six and above, to women with no college education, were associated with increased risk of perinatal mortality (National Statistics Office (NSO) [Philippines] and Macro International (MI), 1993).

In a study of determinants of poor pregnancy outcomes in Mexico city, Hollander (1997) observed that working women in the commercial and service sectors were significantly more likely than professionals to have an under-sized infant, as were those delivering in hospitals that served unemployed and uninsured persons. A community-based prospective cohort study in India confirmed that low birth weight infants were more likely to be born to mothers of very low socioeconomic status (Hirve and Ganatra, 1994).

Low socio-economic status has also been linked to adverse pregnancy outcomes for the mother (see, for example, Gonzalez-Perez and Vega-Lopez, 1996). It is important to point out that low socio-economic status probably has no direct effect on adverse pregnancy outcomes, but rather more likely to influence these outcomes through the expected association with lack of appropriate maternal health care and poor nutritional status.

Being single has also been observed to be associated with preterm delivery, low birth weight and perinatal mortality (Voorhoeve *et al.*, 1984a; Prazuck *et al.*, 1993; Kuate-Defo and Partin, 1993). Unwanted pregnancies, usually common among single mothers, have been observed to be associated with increased risk of maternal mortality and morbidity from unsafe abortion and possible psychosocial problems, and increased perinatal and infant mortality and morbidity from preterm labour and potential neglect or abuse. Although all women need some psychosocial support during pregnancy, women with extreme social disruption or deprivation, particularly those with an unwanted pregnancy, the very young, refugees, and victims of domestic violence do require more intensive health care (WHO, 1994a).

2.3.2 Demographic Risk Factors of Adverse Pregnancy Outcomes

Reproductive factors associated with poor pregnancy outcomes include pregnancies that are too early, too late, too many and too close. Studies examining the association between pregnancy outcomes and age show the highest risks of adverse outcomes for women aged 35 years and above (Voorhoeve *et al.*, 1984a; Jansen *et al.*, 1984; Anandalakshmy *et al.*, 1993; Yadav, 1994; Viegas *et al.*, 1994). A matched case-control study in India based on hospital statistics revealed that maternal mortality was 3.4 times higher among mothers aged 35 years or more compared to mothers aged 20-24 years (Anandalakshmy *et al.*, 1993). A study on advanced maternal age and pregnancy in Ghana observed that although advanced maternal age was associated with a significantly lower rate of Caesarean section and other instrumental delivery, they were more likely to have a foetal malpresentation delivery, had a higher stillbirth rate and faced a higher risk of maternal mortality than the younger women (Obed *et al.*, 1995). In a study of obstetrical outcome with increasing age in Singapore, Viegas *et al.* (1994) observed that older women were more likely to suffer from pregnancy-induced hypertension and diabetes. They were also more likely to have a breech delivery, among other conditions requiring intervention during delivery. Advanced maternal age is associated with a number of pregnancy complications, including miscarriage, chromosomal abnormalities, uterine fibroids, hypertensive disorders, prolonged labour, and preterm delivery (Hajo and Wildschut, 1995).

The risk of poor pregnancy outcomes for advanced maternal age is increased further for first pregnancies (Jansen *et al.*, 1984; Aldous and Edmonson, 1993). Jansen *et al.*(1984) observed the highest perinatal mortality rate among the elderly primigravidae. In a retrospective study of low birth weight and prematurity among first live births in Washington State, Aldous and Edmonson (1993) observed the greatest risk of a low birth weight and a premature birth among women aged 40 years and above. Llewellyn-Jones (1974) had pointed out that preeclampsia, hypertension and prolonged labour, often resulting in a forceps or Caesarean delivery are among the problems of the older primigravida

Teenage pregnancies have also been observed to be associated with higher risks of maternal mortality than pregnancies among women aged 20-24 years. Studies in both the developed and the developing world have shown that low maternal age is associated with preterm birth and low birth weight (Jansen *et al.*, 1984; Prazuck *et al.*, 1993; Hirve and Ganatra, 1994; Yadav, 1994; Wessel *et al.*, 1996; Miller *et al.*, 1996; DuPlessis *et al.*, 1997; Olausson *et al.*, 1997). In a study of the impact of age on pregnancy outcomes in California, DuPlessis *et al.* (1997) observed that mothers 10-13 years of age were 2.5 times more likely to have a low birth weight infant and 3.4 times more likely to have a preterm birth than mothers 20-24 years old. A study of risk factors of preterm delivery in Burkina Faso (West Africa) observed that adolescents had odds of a premature birth almost 7 times that of older women (Pradzuck *et al.*, 1993).

Very young women aged 15 years or below are at an increased risk of maternal and perinatal mortality and morbidity due to anaemia, obstructed labour and pre-eclampsia/ eclampsia because their own physical growth and maturation is not complete. They may present added risk if the pregnancy is unplanned and unwanted and results in induced abortion or in their being ostracized by their family or community. Hajo and Wildschut (1995) attributed detrimental effects of teenage pregnancies to social problems rather than physical or medical problems. They noted that the majority of teenage pregnancies originate from low socio-economic class, are unwanted and are more likely to end up in abortion. Teenagers also tend to book late for delivery and, on the whole, do not make proper use of the facilities for antenatal care. These explanations are consistent with the view of Olausson *et al.* (1997) that the higher risk of late foetal death and infant mortality associated with low maternal age is to a large extent an effect of teenagers' poorer socioeconomic situation. They, however, attributed the increase in preterm delivery among younger teenagers to the fact that young maternal age may be a biologic risk factor for preterm birth. The WHO (1994a) recommends awareness of the increased nutritional needs of pregnant adolescents and available social services in health promotion at the community level.

With respect to parity, studies have identified first pregnancies and higher order pregnancies (particularly of order 6 and above) to be associated with poor pregnancy outcomes (Voorhoeve *et al.*, 1984a; Taha, 1992; Prazuck *et al.*, 1993; Hirve and Ganatra, 1994; Walraven *et al.*, 1997; Wessel *et al.*, 1997). Taha (1992) observed that high parity was a significant predictor of foetal deaths and neonatal mortality in Central Sudan. In a study of the aetiology of low birth weight in a rural area of Tanzania, Walraven *et al.* (1997) observed significant associations between first pregnancies and low birth weight (adjusted odds ratio (OR), 3.32), prematurity (adjusted OR, 2.16) and small-at-term (adjusted OR, 3.59). Wessel *et al.* (1997) confirmed first pregnancies as a significant risk factor of low birth weight (adjusted OR, 5.2).

The Machakos study in Kenya observed that the outcomes were least favourable for first pregnancies in terms of neonatal and infant death. For stillbirths, the rates were highest for parity six and above, followed by first pregnancies (Voorhoeve *et al.*, 1984a). The WHO (1994a) pointed out that first pregnancies are at an increased risk of maternal and perinatal morbidity and mortality associated with obstructed labour and hypertensive disorders of pregnancy, while high order pregnancies are at an increased risk due to antepartum or postpartum haemorrhage and obstructed labour associated with abnormal foetal presentation.

Short birth intervals have also been observed to be associated with poor pregnancy outcomes (Mavalankar *et al.*, 1992, Taha, 1992; Hirve and Ganatra, 1994). A low birth weight relative risk of 1.48 for cases where the interval between delivery and the next pregnancy was less than 6 months was observed in India (Hirve and Ganatra, 1994). Taha (1992) also observed that birth-to-conception interval of less than 18 months was associated with increased risks of low birth weight, foetal death and neonatal mortality in Central Sudan. However, in the Machakos study, the length of the birth interval did not show any conclusive association with pregnancy outcome. In fact, there was a general tendency for stillbirths and neonatal death rates to increase with increasing birth interval. Voorhoeve *et al.* (1984b) suggested that this finding does not necessarily mean that short birth intervals have no adverse effect, since there could be an adverse effect on the previous child, or the adverse effect may only become important after infancy among the one to three year-old-children, the age group that is most vulnerable to malnutrition and infectious diseases. They further suggested that the apparent increase in stillbirths and neonatal death rate with birth interval was probably an effect of age, since pregnancies among older women were on the whole more widely spaced. Short birth intervals are also likely to lead to adverse pregnancy outcomes for the mother, but conclusive studies establishing the precise relationships are lacking

Changes in reproductive behaviour can bring about reduction in maternal mortality through two main processes. First, by averting unwanted pregnancies, the risks of pregnancy-related deaths, which are elevated if women resort to unsafe induced abortion, can be avoided. Second, by changing the timing and distribution of pregnancies within a woman's reproductive life, the risks of complications during pregnancy and childbirth can be reduced. Graham and Murray (1997) observed that such changes in behaviour can be stimulated by a variety of factors, such as increased woman's education and changes in family size preferences. They noted that the most optimistic scenario would be to prevent all unwanted pregnancies, births to women aged less than 18 years or greater than 39 years, birth interval less than 18 months, and births of order 6 or more

2.4 Maternal Health Care and Pregnancy Outcomes

2.4.1 The Determinants of Maternal Health Care in Developing Countries

Factors influencing maternal health care include a range of socio-economic, cultural, demographic and service availability and accessibility factors. Women in many parts of the developing world may be prevented from receiving appropriate health care by physical, cultural, technical and economic barriers, especially in the rural areas, where women may hesitate to seek care because of costs related to distance. Poor roads and bad weather make a long trip to a hospital hazardous, particularly for a woman who is haemorrhaging or having convulsions (Family Health International, 1994).

Distance and accessibility of services exert a dual influence in health care utilization. Long distance or inaccessibility of services can be an actual obstacle to reaching a health facility or can be a disincentive to even trying to seek care. The issue of access is an acute problem for rural inhabitants in most developing countries. The nature of the terrain and the condition of the roads often imply that the journey to a health facility will take longer. Those living in rural areas often have to walk or improvise means of transportation to reach a health care facility. The role of distance and accessibility can be assessed by the severity of the condition in which patients arrive at the facility. Those who reach the facility at an advanced stage of illness are likely to have travelled a longer distance or spent a longer time travelling. Studies from different parts of the developing world have recorded sizable proportions of maternal deaths, especially in the rural areas, occurring on the way to hospital (Thaddeus and Maine, 1994).

Various other factors also play an important role in health care utilization. In a small scale study in Meru, Kenya, admission rates did not show substantial improvements with improved roads and shortened length of travel to hospital, suggesting that other barriers, such as financial cost of treatment, are also important for health care utilization and may limit the advantages of shorter distance. Cost and distance often go hand in hand as considerations in the decision making process, since longer distance entails higher costs. However, quality of care has often been observed to be a more important consideration in the decision to seek care than cost (Thaddeus and Maine, 1994). Modern medical facilities have a culture of their own which often clashes with the culture of potential users. Health seeking behaviour is also strongly influenced by the characteristics of the illness, such as severity and etiology as perceived by individuals (Thaddeus and Maine, 1994).

Studies have shown that rural-urban residence, the level of a woman's education, exposure to mass media, the standards of living and parity are important predictors of maternal health care (Obermeyer and Potter, 1991; Obermeyer, 1993; National Statistics Office (NSO) [Philippines] and Macro International (MI), 1993). In a study of maternal health care utilization in Jordan, Obermeyer and Potter (1991) observed that the mother's level of education, the average level of education in the household, the place of residence, the standard of living and the number of children in the household had a significant effect on antenatal care. Higher levels of education were associated with greater use of antenatal care, and larger numbers of children in the household and rural residence were associated with less use of antenatal care. In the Philippines Safe Motherhood Survey of 1993, respondents having their first births, most with college education and those in urban areas most often saw a doctor, while those with primary or no education, and in rural areas, more often saw a midwife or a TBA and were more likely to receive fewer components of antenatal care. The less educated were also less likely to receive tetanus toxoid (NSO and MI, 1993)

In a study of determinants of maternal health care in India, Bhatia and Cleland (1995) confirmed the important role played by socio-economic factors on use of maternal health services. Higher maternal education and higher levels of personal hygiene were observed to be associated with a significantly higher probability of routine antenatal checkup, while women in low caste were observed to have reduced probabilities of routine antenatal checkup. Demographic factors were also observed to play an important role. Mothers aged below 18 years were less likely to have routine antenatal checkup, while women in their first pregnancy were more likely to receive routine antenatal checkup.

Factors predicting place of delivery have been observed to be quite similar to predictors of antenatal care, that is, factors associated with health facility deliveries are much the same as those associated with greater use of formal antenatal care. However, exceptions have been observed for some socio-economic characteristics, such as standard of living, which have been noted to have somewhat reduced predictive power on place of delivery, while urban residence has been observed to be an important predictor of institutional delivery (Obermeyer and potter, 1991; Bhatia and Cleland, 1995). Cultural factors have also been observed to play an important role in determining delivery care. In a study of cultural influences on health care use in India, Basu (1990) noted that fear and the physical inconvenience of a hospital delivery were the predominant reasons among Indian mothers for reluctance to have hospital deliveries.

In the Machakos (Kenya) study, factors such as distance to hospital, previous hospital delivery, and age were related to place of delivery intentions. Those who lived further away, those who had no previous deliveries in hospital and those aged over 30 years were less likely to plan for a hospital delivery. Women in their first pregnancy were more, and those of high parity less inclined to plan for hospital delivery. Women who had experienced difficulties with previous deliveries, like Caesarean sections, forceps or vacuum extraction, post-partum haemorrhage or perinatal death were significantly more inclined to plan for hospital delivery than those who had a history of only spontaneous births. A significantly higher proportion of women with height below 150 centimetres, than those taller than 150 centimetres, did actually go to hospital, as did a higher proportion of primigravidae than multigravidae. Women of parity 6 and above, who are usually aged over 30 years, went less frequently to hospital for delivery than younger women. The analysis of characteristics of women who did not deliver where intended showed that, in most cases, this was due to inability to reach the hospital. Women who had never before delivered in hospital and those who lived far away were the least likely to deliver in hospital, even if they had meant to do so. For the majority of women, whether or not to deliver in hospital seemed mainly a question of opportunity (Voorhoeve *et al.*, 1984b)

An important component of the analysis of health care utilization, which has recently started receiving attention, is the extent to which health-related behaviour is homogenous within households and within communities. In their investigation of the extent to which family and community characteristics affect the use of formal health services in Guatemala based on multilevel logistic regression models, Pebley *et al.* (1996) observed that characteristics of an individual pregnancy, of the woman and her family, and of her community were all significantly associated with the use of formal pregnancy-related care. Non-indigenous women, women with higher educational attainment, those living in predominantly non-indigenous communities, those who watched TV daily, and those living closer to health facilities were significantly more likely to use such care. The study also indicated that the use of formal health services was highly clustered within families and communities in Guatemala. The type of antenatal and delivery assistance used by a woman during one pregnancy was closely related to the type she would use in subsequent pregnancies.

The link between women's status and health care utilization has generally been overlooked, even though studies confirm that the low value placed on women adversely affects their use of health services. Thaddeus and Maine (1994) noted that the low value placed on women in many societies limits their autonomy in decision making, limits their access to transportation, leads to discrimination in health care utilization (especially where cost is a constraint) and leads to neglect of women's health.

2.4.2 Association Between Maternal Health Care and Pregnancy Outcomes

The four 'pillars' of safe motherhood are: antenatal care, clean and safe delivery, essential obstetric care and family planning (WHO, 1994c). The provision and uptake of acceptable, effective, affordable and accessible care can reduce adverse pregnancy outcomes through primary prevention and effective management of complications (Graham and Murray, 1997).

Family planning can reduce the number of pregnancies, thereby decreasing a woman's lifetime risk of dying in childbirth, and it can reduce the number of deaths due to high risk pregnancies. In addition, by preventing unplanned and unwanted pregnancies, family planning can help reduce the number of women who risk their lives seeking unsafe abortion. On the other hand, emergency obstetric care is crucial to save the lives of women who suffer from the major complications of pregnancy such as haemorrhage, infection, obstructed labour, hypertensive disorders and the effects of unsafe abortion (Family Health International, 1994)

Low levels of health care use are associated with poor reproductive health outcomes (Obermeyer, 1993). Appropriate antenatal and delivery care are important in preventing adverse pregnancy outcomes for both the mother and the baby. Several studies have demonstrated an association between adverse pregnancy outcomes and both antenatal care and delivery care. In particular, lack of antenatal care has been identified as a risk factor for maternal mortality in various settings of the developing world (Harrison, 1989, Anandalakshmy *et al.*, 1993; Mbizvo *et al.*, 1993; Fawcus *et al.* 1996). Antenatal care can avert maternal deaths through the early detection of conditions which may lead to eclampsia or catastrophic haemorrhage (Fawcus *et al.*, 1996). In a study of antenatal screening in Zimbabwe, Tsu (1994) observed that with simple algorithms based on maternal height, parity and obstetric history, more than one third of women at risk for potentially fatal complications could be identified at relatively small cost to themselves or the health care system.

Studies have also demonstrated the importance of antenatal care in reducing other adverse pregnancy outcomes such as perinatal mortality, low birth weight, premature delivery, pre-eclampsia and anaemia (Llewellyn-Jones, 1974; Sadio, 1991; Ahmed and Das, 1992; NSO and MI, 1993; Coria-Soto *et al.*, 1996; Hollander, 1997). A study on prenatal benefits and birth outcomes among working Mexican women indicated that women whose jobs offered no prenatal leave benefits were 1.5 times more likely to bear an infant who was small for gestational age and three times as likely to give birth prematurely (Hollander, 1997). In consistence with these findings, Sadio (1991) observed that mothers in rural Senegal who received prenatal care regardless of the timing of the visit were more likely to have heavier infants than those who received no care. According to Llewellyn-Jones (1974), lack of sound prenatal care rather than any biologic inefficiency was responsible for the chief problems among teen-age and unmarried pregnant women such as pre-eclampsia, anaemia and low birth weight babies.

Apart from mere attendance of antenatal care, the quality of care received (mainly the content and frequency of antenatal care) does significantly influence pregnancy outcomes (Ahmed and Das, 1992; NSO and MI, 1993; Coria-Soto *et al.*, 1996). Receiving fewer components of antenatal care has been observed to be associated with increased perinatal death in the Philippines (NSO and MI, 1993). A study on the effectiveness of prenatal care on birth weight in Mexico showed that although the content of prenatal visits had no independent effect on intra-uterine growth retardation, women who received poor content prenatal care faced a 76 per cent higher risk of low birth weight associated with premature delivery than those who received adequate content antenatal care. Women who attended an inadequate number of visits for gestational age faced a 63 per cent higher risk of intra-uterine growth retardation and a 51 per cent higher risk of low birth weight associated with premature delivery than those who attended an adequate number of visits (Coria-Soto *et al.*, 1996). In a study of the beneficial effects of antenatal care on birth weight in Bangladesh, Ahmed and Das (1992) observed that birth weight had a positive correlation with the frequency of antenatal care visits. Three antenatal care visits were observed to be quite effective in reducing the proportion of low birth weight infants. The results showed that motivating pregnant women to seek antenatal care can be productive even if they are in the last trimester of pregnancy.

Regular antenatal checkups are necessary to establish confidence between the woman and her health care provider, to individualise health promotion messages, and to identify and manage any maternal complications or risk factors. The visits are also useful for providing essential services such as toxoid immunization and preventing anaemia through nutrition education and provision of iron/folic acid tablets. Ideally, antenatal care functions to identify and monitor women at risk of future complications, to detect and treat pre-existing and concurrent illness of pregnancy, to provide preventive care and information to women and their families, and to establish a relationship between providers and women early in pregnancy (WHO, 1994a).

Although various studies have shown evidence of significant gains in maternal and child health that is due to antenatal care, there is increasing debate as to what components of antenatal care are really important (Rooney, 1992, McDonagh, 1996; Villar and Bergsjo, 1997). In a review of antenatal care programs, focussing on the interventions of the leading causes of maternal mortality and morbidity, Rooney (1992) concluded that the most effective interventions are those that deal with chronic conditions rather than acute conditions which arise near delivery. On the other hand, McDonagh (1996) argues that there is insufficient evidence to reach a firm decision about the effectiveness of antenatal care, yet there is sufficient evidence to cast doubt on the possible effect of antenatal care. Consequently, the author recommended urgent research in order to identify those procedures which ought to be included in the antenatal process. In the final analysis, it was asserted that the greatest impact will be achieved by developing a domiciliary midwifery service supported by appropriate local efficient obstetric services

In a recent study to identify the elements of antenatal care which are of proven benefit in preventing or ameliorating specific adverse outcomes, Villar and Bergsjo (1997) made various conclusions and recommendations, some of which would depend on specific circumstances. These included: fewer routine visits for low-risk women do not put pregnancies at increased risk; bleeding in pregnancy has many causes, none of which can be eliminated through antenatal care; risk factors can be identified by history taking; routine iron supplementation is not necessary in well-nourished populations, but iron and folate should be provided for every pregnant woman in areas of high anaemia prevalence; haemoglobin determination as a routine test is more important late (around week 30) than early in pregnancy; it is uncertain whether early detection of pre-eclampsia will prevent more severe disease, but improved detection and care may lead to better outcome, and height of nulliparas should be recorded where hospital birth is not routine and a discriminatory level for hospital delivery decided locally

The debate on antenatal care content is of direct relevance to the Kenya situation, even though it is clear that further research in specific areas would be required to be able to come up with more conclusive recommendations. One specific area worth taking notice of is with respect to the recommendation on iron and folate supplementation, since anaemia is highly prevalent and is one of the major causes of maternal mortality in Kenya Another important point is with respect to height, given that hospital delivery is not routine. Even though there is no evidence that antenatal care can help eliminate adverse conditions such as bleeding in pregnancy or eclampsia, early detection and appropriate care is likely to lead to better outcomes, hence, the need for early initiation of antenatal care. For factors such as haemoglobin determination, further research would be required to establish if the current practice needs to be changed For instance, it is usual practise in Kenya to test for haemoglobin level during the first visit, which may be quite early in pregnancy, yet research elsewhere have suggested that haemoglobin determination is more important late in pregnancy

With respect to delivery care, the National Statistics Office [Philippines] and Macro International (1993) noted that although most women experience no major problems during labour and delivery, complications that do occur can be unpredictable and sudden in onset, requiring immediate action. Maternal and perinatal outcomes in such instances are improved when such complications occur in the presence of a trained attendant. However, the survey results indicated that poor perinatal outcomes were less common among births in which the respondent was attended by a TBA or a midwife during delivery, and more common when births took place in a public facility. It was pointed out that these results did not indicate a causal relationship, but probably reflected self-screening or referral of complicated cases, perhaps after a delay. Similar results have been observed in different studies. Alisjahbana *et al.* (1995) noted that women with complications were more likely to be referred and to deliver in a health facility, leading to lower perinatal mortality among those delivered by TBAs and a subsequent increase in perinatal mortality among health facility deliveries.

Similar results have been observed in Kenya. In the Machakos study, stillbirth rates were 23 per 1,000 for home deliveries and 44 per 1,000 for hospital deliveries. Neonatal and infant death rates were also slightly lower among the children born at home. The high mortality accompanying deliveries attended by doctors was attributed to complicated cases referred by either trained or traditional midwives. The hospital stillbirth rate, almost twice that for home deliveries, was seen as indicating that the hospital was at least fulfilling its purpose of attracting high-risk mothers. For a great majority of women, delivering at home or in hospital did not make much difference to pregnancy outcome. Adverse conditions in hospitals (greater danger of infections, greater anxiety for woman in labour) were likely to be offset by adverse conditions at home, such as lack of running water, lack of electricity and lack of knowledge and equipment to handle complications (Voorhoeve *et al.*, 1984a). It was further noted that the common habit of medical personnel of not informing patients that a breech or transverse lie was suspected, in order not to cause undue anxiety, was a dangerous form of kindness, since unsuspecting women often delivered a breech at home unaware of the fact that their antenatal record showed the position had been detected.

Antenatal screening in the Machakos study identified four groups of pregnant women (totalling 13 per cent of all pregnant women) who appeared to account for 41 per cent of all perinatal deaths. Nordbeck *et al.* (1984) observed that more than half of these deaths could probably have been avoided had timely measures been taken. Breech delivery was associated with a very high perinatal mortality rate and it was the only factor that did show a higher perinatal mortality rate for home than hospital deliveries. It was thus recommended that in areas where TBAs provide obstetric care for a large proportion of mothers, recognizing a breech presentation is an extremely worthwhile subject for training. WHO (1994a) suggested that where abnormal lie/presentation persists after 36 weeks gestation, hospital delivery should be recommended, since abnormal lie and presentation in labour are associated with increased risk of maternal and perinatal mortality due to obstructed labour. The Machakos study further recommended that the TBAs should also be able to recognize twin pregnancies, since these were observed to be associated with high rates of perinatal mortality.

While a small number of maternal deaths or other adverse pregnancy outcomes are unavoidable, the large majority are either entirely or probably preventable. Avoidable factors can be attributed to the patient or to the facility. At the facility, insufficient and unqualified staff, clinical mismanagement of patients, unavailability of blood, shortage of essential drugs, and missing supplies and equipment limit individual's access to appropriate and lifesaving procedures. Studies have reported cases of clinical mismanagement as a result of shortage of trained qualified personnel, leading to maternal mortality (Thaddeus and Maine, 1994). According to Koblinsky (1995), the management of delivery impacts more on the vulnerable infant than on the mother, and the fact that almost 20 per cent of perinatal deaths are associated with difficulties at delivery probably indicates a poor capability of providers to manage obstetrical emergencies.

2.5 Maternal Health Status and Pregnancy Outcomes

A woman's health can have a very dramatic impact on her quality of life and productivity, and the life of her newborn baby. In particular, the largest category of perinatal mortality has linked foetal or newborn deaths with the loosely defined conditions of women's health and nutritional status. At least three million perinatal deaths and an unknown number of infant deaths are associated with women's health during pregnancy (Koblinsky, 1995). This represents over one-third of the perinatal deaths. This category is made up primarily of infants or stillbirths of low birth weight. Koblinsky (1995) noted that women with poor nutritional status (short stature, poor pre-pregnancy weight, inadequate weight gain during pregnancy, and anaemia) or various infections during pregnancy are more likely to have babies with low birth weight. Adverse perinatal outcomes, including stillbirths and low birth weight, are also increased with both severe and moderate maternal anaemia. These are issues of great concern, especially given the fact that the perinatal mortality rate of a low birth weight baby is thirty times higher than that of a foetus or infant of normal weight (Koblinsky, 1995).

Maternal health also contributes significantly to adverse pregnancy outcomes for the mother. Anaemia is one of the major indirect causes of maternal mortality in the developing countries and short maternal stature has been linked to high rates of Caesarean section deliveries. However, comprehensive studies relating maternal health to adverse pregnancy outcomes for the mother are limited.

2.5.1 Association Between Maternal Nutritional Status and Pregnancy Outcomes

The precise number of women affected by malnutrition is not known. However, conservative estimates suggest that among the 1,130 million women aged 15 years or older who were living in developing countries in 1985, over 500 million were stunted as a result of childhood protein malnutrition, about the same number were anaemic and approximately 100 million suffered effects of iodine deficiency. Levels of acute malnutrition during pregnancy remain unknown, but the fear of having a large baby and hence difficult labour is known to cause women in several cultures to 'eat down' (Brems and Berg, 1988, cited in Koblinsky, 1995). For this reason, or because of lack of food, women in a number of countries, including India, Ethiopia, Kenya, Bangladesh and Indonesia gain less than the minimum recommended weight during pregnancy

(Koblinsky, 1995). The United States National Centre for Health statistics considers a weight gain of at least 7 kg adequate for foetal growth.

Anaemia deserves special mention given its high prevalence and impact on the lives and survival chances of the women and newborns. Over half of the pregnant women in the world are anaemic, with those in South Asia most affected (64-75 per cent), followed by those in South-East Asia (56-63 per cent), Latin America, especially the Caribbean Islands (52-90 per cent) and Africa (52 per cent) (WHO, 1992). Severe anaemia is considered an associated cause in up to half of maternal deaths worldwide (United Nations, 1991). Maternal anaemia also impacts on other adverse pregnancy outcomes such as prematurity, stillbirths, spontaneous abortions, perinatal and neonatal mortality (Tsui *et al.*, 1997). In a hospital based study in northern Nigeria, nearly 50 per cent of births to women with very severe anaemia (maternal haematocrit level below 18 per cent) were stillbirths, and another 15 per cent of the newborns died in the neonatal period (Harrison, 1985). In developing countries, anaemia is commonly caused by nutritional deficiencies. However, other causes include blood loss due to menstruation, childbirth, hookworm infestation and haemorrhage, and, infections such as malaria and HIV/AIDS. Genetic defects (sickle cell) and metabolic disorders also make substantial contributions. Anaemia in pregnancy is often due to multiple causes, especially in Africa, where the three most common causes are iron and folate deficiencies and malaria (Koblinsky, 1995).

Inferior nutritional status of mothers is one of the factors with the largest impact on intrauterine growth retardation and premature birth in both the developing and the developed countries (Berendes, 1993). Many studies indicate that maternal anthropometric indicators of pre-pregnancy weight, height, weight gain in pregnancy and arm circumference are important predictors of pregnancy outcomes.

Several studies in different parts of the world have identified short maternal stature as a risk factor for adverse pregnancy outcomes (Martorell, 1991; Voorhoeve, *et al.*, 1984a; NSO and MI, 1993; Mavalankar *et al.*, 1994; Achadi *et al.*, 1995). Achadi *et al.* (1995) observed that maternal height was positively associated with neonatal weight and length in Indonesia. The 1993 Philippines Safe Motherhood Survey also showed that the risk of low birth weight was higher for short women (NSO and MI, 1993). A case control study in India showed significant associations between shortness and perinatal death and low birth weight (Mavalankar *et al.*, 1994).

In the Machakos study in Kenya, the perinatal death rate among women with a height of 163 centimetres and above was lower than among women of height less than 148 centimetres. Women of height less than 148 centimetres needed Caesarean section more often (Voorhoeve *et al.*, 1984a). Caesarean sections were observed to be clearly related to maternal height. The fact that no increased perinatal death rate was observed among women of short stature was considered a tribute to the antenatal and obstetric services. It seemed that short stature was recognised as a risk and the women who were likely to require a Caesarean section were convinced of the need for hospital delivery. Women who had a previous Caesarean section also seemed well aware of the need for subsequent hospital delivery.

Low height is associated with chronic socio-economic deprivation over generations and is useful in identifying women at nutritional risk. Martorell (1991) noted that stunting effects are a product of growth retardation in early childhood across several generations, and stunting in the first three years is the most critical period for affecting stunting in adult life. Maternal height has also been used to identify women at risk of difficult delivery since short stature is sometimes correlated with small pelvis size. The optimal cut-off point varies among populations, but is likely to be in the range 140-150 centimetres (NSO and MI, 1993).

Apart from height, studies have shown that other maternal anthropometric indicators, such as, pre-pregnancy weight, weight gain in pregnancy, body mass index and mid-upper arm circumference are also significantly associated with perinatal outcomes (Eflong, 1979; Mavalanker *et al.*, 1994; Sharma *et al.*, 1994; Achadi *et al.*, 1995; Amal-Nasir, 1995; Pelletier *et al.*, 1995). Achadi *et al.* (1995) observed a positive association between maternal pre-pregnancy weight and neonatal weight and length in Indonesia. A hospital-based case-control study on risk factors for low birth weight in Malaysia showed that low maternal pre-pregnancy weight, among other nutritional indicators, was an independent risk factor for low birth weight. In the same study, Amal-Nasir (1995) noted that maternal pre-pregnancy weight, premature birth and poor quality of antenatal care were important and potential modifiable risk factors, suggesting that nutritional and health intervention programs could reduce the incidence of low birth weight.

Eflong (1979) conducted a case-control study on pregnancy outcomes among the underweight Nigerian women and observed that prematurity was twice as prevalent among the underweight women as in the control group. The incidence of foetal distress was more common at delivery among the underweight mothers. There was also a comparatively higher incidence of Caesarean section in the underweight group, most necessitated by foetal distress. Babies of underweight mothers tended to weigh less than babies born to the normal weight mothers.

In another case-control study in three teaching hospitals in India, Mavalankar *et al.* (1994) observed that low maternal weight was associated with all three poor perinatal outcomes, namely perinatal death, preterm low birth weight and small-for-gestational-age. The weight-height ratio index and the weight-height product index were significantly associated with all three perinatal outcomes. Maternal weight had higher attributable risks than maternal height for the three outcomes. The findings showed that low weight contributes much more than low height to poor perinatal outcomes. The authors attributed this to the fact that low height was probably mediated through low weight and other factors.

Body Mass Index (BMI) is useful in assessing thinness or obesity. Chronic energy deficiency is generally defined as a BMI of 18.5 or lower. Mid-upper arm circumference can be used as an indicator of maternal nutritional status in non-pregnant women because of its high correlation with maternal weight-for-height. It is also used as a tool during pregnancy to screen for risk of low birth weight and late foetal and infant mortality. The recommended cut-off points are 21-23 centimetres (NSO and MI, 1993). An examination of maternal anthropometry's relationship to prematurity and intra-uterine growth retardation in Malawi revealed that women of low weight, low body mass index, and small mid-upper arm circumference, especially during the third trimester, were more likely to deliver a small-for-gestational age infant than their counterparts. Maternal anthropometry was stronger in predicting intra-uterine growth retardation than in predicting prematurity (Pelletier *et al.*, 1995).

Maternal weight gain during pregnancy has also been observed to be associated with pregnancy outcomes. A probability sample survey study on intermediate variables as determinants of adverse pregnancy outcomes in Pennsylvania showed that maternal weight gain of less than 25 pounds during pregnancy was associated with a two fold increase in low birth weight (Sharma *et al.*, 1994).

There is a large body of evidence indicating that in preterm births and foetal growth retardation, the basic disorder is poor nutritional status of the mother. Hence, improvement in maternal nutrition would reduce both the frequency of low birth weights and perinatal mortality. Although conclusive findings on risk factors of maternal malnutrition are still lacking, the Philippines Safe Motherhood Survey observed that the percentages below the cut off points for various nutritional indicators were consistently higher for the youngest respondents, those in their first pregnancy of after five pregnancies, those with primary or no education, and those residing in rural areas (NSO and MI, 1993). Across the board, more attention should be focused on improving the nutritional status of women of child-bearing age prior to pregnancy (Achadi *et al.*, 1995). Such attention should start early in adolescence.

2.5.2 Medical Conditions Influencing Pregnancy Outcomes

Comprehensive population or community-based surveys addressing medical factors affecting pregnancy outcomes in the developing countries are few. However, life threatening obstetric complications, such as haemorrhage, obstructed labour, eclampsia /pre-eclampsia and puerperal sepsis have consistently ranked as the most common causes of poor pregnancy outcomes in community based studies conducted in various settings where maternal mortality is high (Boerma and Mati, 1989; NSO and MI, 1993; Berandes, 1993; Alisjahbana *et al.*, 1995). In addition, conditions such as anaemia, malaria, high blood pressure and HIV infection have also been observed to play an important role (Taha, 1992; Mavalankar *et al.*, 1992; Besley, 1993; Taha *et al.*, 1995; PSRI and UNICEF, 1996).

In the Philippines Safe Motherhood Survey, haemorrhage was the most common problem experienced during the three years preceding the survey, followed by Caesarean section due to obstructed labour and severe infection and eclampsia. All symptoms of complications, except Caesarean section due to obstructed labour, were more common in births resulting in perinatal deaths. Haemorrhage, eclampsia and fever (sepsis) occurred with perinatal deaths three times as often as with surviving children. Background characteristics showed minimum variations with these complications, but Caesarean section deliveries were higher among first births as well as the more educated and urban residents, most probably indicating the importance of service access (NSO and MI, 1993).

A community based study in West Java (Indonesia) observed that about one-fifth of the pregnant women experienced a problem either antenatally or during delivery, and about one-third experienced a postpartum complication. The most common complications were bleeding, prolonged labour, malpresentation and edema. Women who experienced an intrapartum complication were significantly more likely to suffer a poor pregnancy outcome such as a perinatal death (Alisjahbana *et al.*, 1995). Berendes (1993) observed that complications during pregnancy which adversely affect perinatal outcomes are eclampsia /preeclampsia, and antepartum haemorrhage.

Infections such as sexually transmitted diseases and malaria can also result in poor pregnancy outcomes (Taha, 1992; Besley, 1993). Taha (1992) observed that malaria contributed greatly to low birth weight in Central Sudan. A prospective study in Malawi showed that HIV infection increases the risk of intra-uterine growth retardation and premature delivery (Taha *et al.*, 1995). Poor pregnancy history, clinical anaemia and hypertension were observed by Mavalankar *et al.* (1992) as significant independent risk factors for term and preterm low birth weight infants born in three teaching hospitals in India.

Previous obstetric experience has also been observed to have a significant influence on pregnancy outcomes (Voorhoeve *et al.*, 1984a; Berendes, 1993; Sharma *et al.*, 1994). Voorhoeve *et al.* (1984a) observed that the perinatal death rate in a community in Kenya was significantly higher for mothers who had experienced a previous perinatal death. In Pennsylvania, a two-fold increase in the risk of both premature delivery and low birth weight was observed among respondents who had experienced a prior pregnancy loss (Sharma *et al.*, 1994). History of preterm births and history of spontaneous abortions are among the major factors associated with premature births in both the developing and developed countries (Berendes, 1993).

For Kenya, limited population-based data on causes and risk factors for maternal mortality are available from a small scale survey in coastal province and one national baseline survey. The coastal survey identified 35 maternal deaths through a 'networking' method. Causes of death were established for 27 of these deaths to include haemorrhage, sepsis, obstructed labour or ruptured uterus, eclampsia and renal failure due to toxic herbs. Indirect causes included anaemia, malaria and cardiac disease (Boerma and Mati, 1989). In the national baseline survey employing the sisterhood method, the respondents attributed the highest proportion of maternal deaths to pregnancy and childbirth complications and anaemia was perceived to be a significant indirect cause of maternal death (PSRI and UNICEF, 1996). Even though hospital statistics would be expected to provide more accurate information on causes of death, results derived from hospital records are subject to selectivity bias, since the majority of births in Kenya do not take place within a health facility.

Nevertheless, Graham and Murray (1997) observed that the medical causes of maternal deaths derived from hospital statistics in Kenya show a fairly typical distribution as regards direct obstetric deaths, with haemorrhage, sepsis, pre-eclampsia/eclampsia, ruptured uterus and complications of induced abortion accounting for the vast majority of these deaths. They also recognised some indications that indirect obstetric causes, such as malaria, anaemia, tuberculosis and HIV/AIDS probably play a more significant role in maternal deaths in Kenya. The authors, however, suggested that these finding could be an artefact of the data sources and the issue deserves further investigation.

2.6 Addressing Gaps in the Literature

The available literature shows a fairly consistent relationship between adverse pregnancy outcomes and demographic factors such as age and parity. The risk of adverse outcomes is relatively higher for advanced maternal age, teenagers, first pregnancies and higher order pregnancies, usually of order 6 and above. The relationship between pregnancy outcomes and birth interval, maternal education and occupation, however, is not as consistent. While it is hypothesised that short birth intervals are likely to increase the risk of adverse pregnancy outcomes, some studies do in fact show a relationship in the reverse direction. Similarly, although education and occupation are expected to improve pregnancy outcomes by improving women's status and access to information and services, some research findings have suggested that the more educated women are more likely to experience adverse pregnancy outcomes such as premature delivery. The existence of several compounding factors probably make it difficult to accurately establish specific relationships using the traditional modelling procedures.

It has been observed that a substantial proportion of adverse pregnancy outcomes in both the developed and the developing nations still remains unexplained. Kramer (1987) pointed out that there is need for further research on the effect of maternal work, antenatal care, and certain vitamin and mineral deficiencies on intra-uterine growth retardation, and the effect of genital tract infection, antenatal care, maternal employment, stress and anxiety on prematurity. McCarthy and Maine (1992) recognised the need for further research to address the relative importance of different factors on maternal morbidity and mortality as well as need for studies to specify the intermediate mechanisms through which background socio-economic factors affect the outcomes that culminate in death or morbidity. These are among the major issues highlighted in this study.

Most studies also indicate that the use of health care services increases as economic status improves, but the mechanisms through which economic status operates to affect utilization are not clear. With respect to maternal education, it has been noted that even though the positive association between education level and use of child health services has been repeatedly documented, the association between maternal education and the use of adult health services is not as consistent (Thaddeus and Maine, 1994). It has been pointed out that the mechanism through which education may play a role are not well understood, but hypotheses include the following effects of education: increased knowledge and awareness by shaping thought patterns, the introduction of a new modern culture; increased access to information and; increased self confidence, respect and influence.

An important component of the analysis of health care utilization, which has recently started receiving attention, is the extent to which health-related behaviour is homogenous within households and within communities. While investigating the extent to which family and community characteristics affect the use of formal health services in Guatemala based on multilevel logistic regression models, Pebley *et al* (1996) observed that characteristics of an individual pregnancy, of the woman and her family, and of her community were all significantly associated with use of formal pregnancy-related care. The study also indicated that the use of formal health services was highly clustered within families and communities in Guatemala. The type of antenatal and delivery assistance used by a woman during one pregnancy was closely related to the type she would use in subsequent pregnancies. This result points out the importance of addressing both family and community effects in the analysis of factors influencing health care utilization.

Studies addressing the socio-demographic risk factors of adverse pregnancy outcomes in both the developed and the developing nations are numerous. However, these studies have almost exclusively been based on hospital data. This is a serious limitation in the developing world where the majority of births do not occur within health facilities. The results of hospital-based studies in communities where a substantial proportion of mothers do not use modern health care are subject to selectivity bias and cannot accurately be generalised for the entire population. A more comprehensive understanding of factors associated with poor pregnancy outcomes in these communities calls for population-based studies that would include women who use modern as well as traditional forms of maternal health care.

It is clear that there is need for a better understanding of factors associated with adverse pregnancy outcomes in the developing countries. Maternal health care (including antenatal care, delivery care, postnatal care and essential obstetric care) is an important factor in maternal outcomes for both the mother and the newborn. A comprehensive understanding of the determinants of maternal health care is needed to determine how such care can be improved. This study addresses antenatal and delivery care, but not postnatal care or essential obstetric care, due to data limitations.

An adverse pregnancy outcome for the mother that has received prominent attention in the literature is maternal mortality, but the major causes of death are still not fully understood. A major limitation is the lack of scientific studies based on the population rather than hospital data. This is not to say that hospital-based data are irrelevant. Even though hospital-based data represent only a select subgroup of the population, it is equally important that factors associated with maternal deaths at the hospitals be well understood, since hospital factors may contribute to maternal deaths.

Although reproductive morbidity occurs far more frequently than maternal mortality and greatly affects the quality of life for the mothers and the newborn, studies of the factors associated with maternal morbidity have not received much attention. This is mainly because standard measures for assessing morbidity have not yet been fully developed. It remains unresolved whether to rely upon women's self reports, clinical diagnoses or laboratory examinations (Bulut *et al.*, 1995). Results from the Philippines' Safe Motherhood Survey indicated that interview-based diagnosis, though expensive, may be the only way to obtain an idea of the prevalence of some kinds of maternal morbidity in many developing societies (Stewart *et al.* 1996). Although we recognize that this is an important area for research, it will not be addressed in the present study due to lack of data and resource constraints.

With respect to Caesarean section deliveries, it has been noted that the limited research in the developing countries makes it difficult to establish the most significant factors (De-Muylder, 1993). Caesarean section may be viewed as an adverse outcome because of the increased risks of a maternal death, often due to sepsis anesthetic accidents or technical problems during surgery. Furthermore, Caesarean section deliveries represent difficult delivery that is likely to result into a maternal and perinatal morbidity or mortality if appropriate care is not received during childbirth. Hence, it is important to identify women at high risks of Caesarean section deliveries for whom it is critical that timely appropriate delivery care is sought. On the other hand, very low Caesarean section delivery rates among specific groups of women might indicate lack of essential obstetric care, since experience suggests that about five per cent of deliveries in a population would require Caesarean section deliveries to avert morbidity or even death to the mother and the newborn (UNICEF /WHO /UNFPA, 1997).

The adverse pregnancy outcomes for the newborn include early foetal loss, perinatal mortality, premature delivery and low birth weight (or small size of the baby at birth). Studies have shown that premature delivery and/or low birth weight are strongly associated with perinatal mortality. A better understanding of the determinants of these outcomes will help design appropriate programmes for improved newborn health and survival. This study will include analysis of factors influencing premature births and size of the baby at birth. However, due to data limitations, factors associated with early foetal loss and perinatal mortality will not be addressed.

In summary, this study focuses on adverse pregnancy outcomes for the mother and the newborn, paying special attention to the issues that have emerged from existing literature. Specifically, refined modelling strategies will be employed to minimise spurious relationships arising from non-observable factors relating to individual pregnancies, a particular woman or a specific community or health facility, and an attempt will be made to establish the pathways through which various factors influence pregnancy outcomes. The analyses will largely utilise population-based data, though some analysis of hospital-based information is also included.

Chapter 3

Data and Methods

This chapter describes the data and the statistical methods used in this study. The data are provided by two national surveys: the 1994 Kenya Maternal Mortality Baseline Survey and the 1993 Kenya Demographic and Health Survey. The first section provides a description of these two data sets as well as an indication of their limitations. This is preceded by a brief overview of the limitations of potential sources of data on safe motherhood in Kenya. The second section describes the statistical methods applied (multilevel models, loglinear analysis and graphical chain models), with particular focus on model specifications, estimation procedures and issues relating to interpretation of the results derived from the analyses.

3.1 The Data

Potential sources of data on maternal mortality and other adverse pregnancy outcomes include vital registration (in the case of maternal mortality), community or population based surveys and health service statistics. Vital registration in Kenya is incomplete and the cost of a population based survey of maternal outcomes, providing sufficient data for reliable statistical analysis, would be substantial. Health service statistics are available but biased, since they represent only the sub-population with access to these facilities. Only 44 per cent of births in Kenya take place in a health facility (34 per cent in a public health facility, 8 per cent in a mission health facility, and 2 per cent in a private facility) (National Council for Population and Development (NCPD) [Kenya], Central Bureau of Statistics (CBS) [Kenya] and Macro International (MI), 1994).

Reliable data on adverse pregnancy outcomes in Kenya, as in other developing countries, have been scarce. Although it is generally acknowledged that a substantial proportion of pregnancies in Kenya end up in abortion, with the expected adverse consequences, the magnitude of this problem cannot be accurately established, since most of these cases go unrecorded. This is partly due to the legal position (Abortion is illegal in Kenya, except where the life of the mother is at risk) and partly due to the social stigma attached to abortion. Similarly, a substantial proportion of stillbirths go unrecorded, unless the confinement ends at a health facility. None of the national population based surveys in Kenya have sought any information on foetal loss. Even where information on recent pregnancy histories has been sought, this has been limited exclusively to pregnancies ending in live births. With respect to health facility data, the quality of record keeping at some of the hospitals has been observed to be quite poor (Population Studies and Research Institute (PSRI) and UNICEF, 1996), and hence, cannot provide reliable information that would allow a detailed investigation of the factors associated with poor maternal outcomes.

National surveys that have collected some information on maternal health care and adverse pregnancy outcomes are the 1994 Kenya Maternal Mortality Baseline Survey (KMMBS) and The Kenya Demographic and Health Surveys (KDHS). This study is based on further analysis of information relating to this subject obtained in the 1994 KMMBS and the 1993 KDHS data sets. The 1998 KDHS data was not available for further analysis at the time of this study

3.1.1 The 1994 Kenya Maternal Mortality Baseline Survey

The 1994 Kenya Maternal Mortality Baseline Survey (KMMBS) was the first national survey of maternal mortality in Kenya. The survey was conducted by the Population Studies and Research Institute (PSRI) of the University of Nairobi, with financial support from UNICEF's Kenya Country Office. The main objective of the survey was to provide information on the magnitude and patterns of maternal mortality in the country. In an attempt to capture pertinent information on maternal mortality, the KMMBS adopted three complementary approaches: a national survey of households, assembling of hospital data from district and provincial hospitals, and obtaining qualitative information from focus group discussions (FGDs) in selected districts.

The household survey covered a representative sample of rural clusters within the third National Sample Survey and Evaluation Programme [Kenya] (NASSEP-3), a national master sample, maintained by the Central Bureau of Statistics [Kenya] of the Ministry of Planning and National Development. In all, the frame comprises 1048 rural clusters, with an average of 100 households per cluster. The KMMBS sampled a total of 18,316 households from 503 rural clusters. All adults aged 15-50 years in the selected households were targeted for the household interviews. A total of 24,260 respondents were successfully interviewed. The respondents provided general information on the survival status of their siblings and specific information on all their sisters who ever attained menarche. This information was used to establish the magnitude of maternal mortality based on the sisterhood method. The household survey sought further information on predisposing conditions and circumstances relating to the identified maternal deaths. This particular information is analysed in the second section of Chapter four.

The KMMBS included a total of 19 district and provincial hospitals in Kenya, selected from different parts of the country to give a national representation. The hospital information was collected using pre-designed forms of three types. The first form was used to extract information from files of each woman in-patient admitted due to a pregnancy-related condition during the year 1993. The basic information collected included age, parity, marital status, education, attendance of antenatal and postnatal clinic, medical history, survival status of the patient at the time of discharge and the cause and time of death, where applicable.

The second form was used to collect summary information from the maternity and gynaecology wards for each month in the period January to December 1993. This form included information on the number of maternity admissions, the number of deliveries by mode of delivery (e.g. normal, forceps, vacuum, Caesarean section), the number of still births and live births, and the number of maternal deaths. Information on the number of admissions due to abortion and the number of abortion-related deaths, deaths due to ectopic pregnancy and deaths during puerperium was also included.

The third form was a semi-structured questionnaire administered to hospital personnel on matters pertaining to major causes of maternal mortality at the hospitals, antenatal and post-natal services, as well as the referral system from traditional birth attendants (TBAs).

The hospital registry staff were trained on how to complete the first form using information extracted from individual in-patient files, while the remaining two summary forms were completed by the sisters-in-charge of maternity and obstetrics and gynaecology wards in each of the hospitals. The KMMBS hospital data is used in the analysis of factors associated with maternal mortality in Kenyan hospitals, presented in the first section of Chapter four.

3.1.2 The 1993 Kenya Demographic and Health Survey (KDHS)

The 1993 KDHS was a national-level sample survey, excluding the three sparsely populated districts in North-Eastern province and four other northern districts. Together, the excluded areas account for less than four per cent of Kenya's population. The KDHS sample points were selected from the NASSEP-3 sample frame. This master sample follows a two-stage design, stratified by rural-urban residence, and within the rural stratum, by individual district. The entire master sample consists of 1048 rural and 325 urban sample points (clusters). A total of 536 clusters, 92 urban and 444 rural, were selected for coverage in the 1993 KDHS. Of these, 520 were successfully covered.

After the selection of the KDHS sample points, a household listing operation was carried out prior to the launching of the fieldwork. A systematic sample of households was then selected from these lists, with an average 'take' of 20 households in the urban clusters and 16 households in the rural clusters, for a total of 8,864 households selected. All women aged 15 to 49 years in the selected households were eligible for the interviews. Of the 7952 eligible women, successful interviews were held with 7540. A total of 6115 births had occurred to 3929 of these women in the five years preceding the survey. These cases form the basis of analysis of maternal health care and birth outcomes, presented in Chapters five, six and seven.

Information obtained in three of the schedules (the household questionnaire, the individual women's questionnaire and the service availability and accessibility questionnaires) is used. The household questionnaire provided information for assessing household socio-economic status, based on household possessions and amenities, while the service availability and accessibility questionnaire provides cluster level information relating to accessibility of antenatal and delivery care services as well as availability of other forms of health care within various communities. The individual questionnaires provided information on both women's characteristics as well as information relating to specific pregnancies or births during the five years preceding the survey.

3.1.3 Data Limitations

A major limitation of this study is the availability of reliable data. Nationally representative surveys that could provide comprehensive information on safe motherhood in Kenya are limited. Even though the data from the two national surveys (the 1993 KDHS and the 1994 KMMBS) provide valuable information to improve our understanding of this important subject, it is important to recognize their limitations.

The KMMBS was the first national survey to seek information on maternal mortality in Kenya. This was a baseline survey with the primary aim of establishing the magnitude and patterns of maternal mortality in the country. As such, detailed information that would allow a comprehensive investigation of factors associated with maternal mortality was not gathered. Two limitations of the 1994 KMMBS information, that is analysed in this study are worth mentioning. First, when examining factors associated with maternal mortality based on hospital statistics, it is important to be aware of potential selectivity bias within this sub-population. The issue of selectivity bias and its potential effect on the results is discussed in detail in Chapter four. Second, the analysis of interrelationships of factors relating to maternal deaths in Kenya is based on 271 maternal deaths reported to have occurred among the sisters of the survey respondents in the 10 years period prior to the survey. These cases are too few to permit any rigorous statistical analysis.

Although the 1993 KDHS information on maternal health care (antenatal and delivery care) as well as information on birth outcomes for live births within the five years preceding the survey is useful in shedding some light on poor birth outcomes and Caesarean section deliveries in the country, a more meaningful and complete picture would have emerged had information on other adverse pregnancy outcomes such as still births and early foetal loss been included. Secondly, a better understanding of maternal health care would require information on postnatal care as well as obstetric care to manage pregnancy or childbirth complications. These issues are not addressed in this study due to lack of data. It is also important to recognize that self-reported pregnancy outcomes are selective since maternal deaths are naturally excluded.

The information on characteristics of the woman and her household in the KDHS refer to the time of the interview and not when the births in question took place. This implies that if some of these characteristics had changed after the birth in question had taken place, then the relationships obtained between these characteristics and the outcomes cannot accurately be considered as causal. This problem would have been minimized if information relating to characteristics that are likely to change rapidly over time were available in a calender format, but this might have, in turn, led to an unwieldy questionnaire. By restricting the analysis to births within the five years period before the survey, this problem will be minimized.

Finally, it is important to recognise that both the 1994 KMMBS and the 1993 KDHS samples were not self-weighting. Even though the analyses use unweighted data, any bias in the estimates is minimized by including in the models variables used in the sampling designs, such as rural-urban residence and region (see Madise *et al.*, 1999).

3.2 Statistical Methods

The statistical models used in this study include multilevel linear models, multilevel logit models, multilevel multinomial models, loglinear models and graphical chain models. Most of the data analysed in this study are hierarchical in nature, hence, multilevel models are used to take into account the data structure. One of the objectives of this study is to establish the indirect determinants of birth outcomes. To realise this objective, loglinear graphical chain models will be used. The loglinear models are useful in examining the interrelationships between categorical variables while graphical chain models are important in establishing the pathways of the determinants. These models are described in the following sections.

3.2.1 Multilevel Models

Many kinds of data, including population sample surveys and health facility data have a hierarchical or clustered structure. For instance, children born to the same mother tend to be more alike in both physical and genetic characteristics. Similarly, women living in the same locality are likely to exhibit relatively similar behaviour since they share the same traditional values and are likely to experience similar conditions relating to availability and accessibility of health services within the communities. In the case of health facility data, patients in the same facility would be subjected to similar risk factors attributable to the facility such as administration and management procedures, availability of qualified staff, equipment and supplies.

A hierarchy consists of units grouped at different levels. For example patients may be the lowest level units (level 1) nested within hospitals that are the second level units. Alternatively, children may be the level 1 units in a three level structure where the level 2 units are the families and the communities are the level 3 units. Once the groupings are established, even if their establishment is effectively random, they will tend to become differentiated, which implies that the group and its members both influence and are influenced by the group membership. To ignore this relationship, risks overlooking the importance of group effects, and may render invalid many of the traditional statistical analysis techniques used for studying data relationships (Goldstein, 1995).

The problem of choice of an appropriate unit of analysis has long been recognised by researchers in different disciplines. Before multilevel modelling became well developed as a research tool, the problem of ignoring hierarchical structures were reasonably well understood, but they were difficult to solve, since appropriate tools were unavailable. Although special purpose software for the analysis of genetic data, for example, has been available longer, this was restricted to 'variance components' models and was not suitable for handling generalised linear models. In sample survey methods as well, the importance of taking into account the clustering structure in complex sample designs has been recognized for many years. When population surveys are carried out, the sample design typically mirrors the hierarchical population structure, in terms of geography and household membership. Elaborate procedures have been developed to take such structures into account when carrying out statistical analysis. While such procedures have usually been regarded as necessary, they have not generally merited serious substantive interest. Thus, the population structure, insofar as it is mirrored in the sample design, was seen as a 'nuisance factor'. By contrast, the multilevel modelling approach views the population structure as of potential interest in itself, so that a sample designed to reflect that structure is not merely a matter of saving costs, as in traditional survey design, but can be used to collect and analyse data about the higher level units in the population. The subsequent modelling can then incorporate this information and obviate the need to carry out special adjustment procedures, which are built into the analysis model directly (Goldstein, 1995).

3.2.1.1 Multilevel linear models

A simple single-level regression model may be expressed as:

$$y_i = \beta_0 + \beta_1 x_i + e_i \qquad [3.1]$$

Where: y is the response variable; subscript i refers to the i^{th} unit; β_0 is the intercept; β_1 is the slope of the regression line; x is the explanatory variable; and e_i is the residual for the i^{th} unit.

If the level-1 units are nested within level-2 units, we can describe simultaneously the relationships for several level-2 units, j, as:

$$y_{ij} = \beta_{0j} + \beta_{1j}x_{ij} + e_{ij} \qquad [3.2]$$

Whenever an item has an $_i$ subscript, it varies between level-1 units within a level-2 unit, and where an item has a $_j$ subscript only, it varies across level-2 units but has the same value for all level-1 units within a level-2 unit. As it stands, equation [3.2] is still essentially a single level model, although describing a separate relationship for each level-2 unit. In situations where there are only a few level-2 units and the interest centres on just these units in the sample, we may assume a common 'within level-2 unit' residual variance and separate regression lines for each unit.

However, if the focus is not just on these level-2 units, but on a wider 'population' of units, then we would need to regard the chosen units as giving us information about the characteristics of all the units in the population. Such a sample can provide estimates of the variation and covariation between units in the slope and intercept parameters, and allow comparison of units with different characteristics.

To make Equation [3.2] into a 2-level model, we let β_{0j} and β_{1j} become random variables and assume that: $\beta_{0j} = \beta_0 + u_{0j}$ and $\beta_{1j} = \beta_1 + u_{1j}$, where u_{0j} and u_{1j} are random variables with parameters:

$$E(u_{0j}) = E(u_{1j}) = 0, \quad and$$
$$var(u_{0j}) = \sigma^2_{u0}, \quad var(u_{1j}) = \sigma^2_{u1}, \quad cov(u_{0j},u_{1j}) = \sigma_{u01} \qquad [3.3]$$

Thus, [3.2] can now be written in the form:

$$y_{ij} = \beta_0 + \beta_1 x_{ij} + (u_{0j} + u_{1j}x_{ij} + e_{ij}) \qquad [3.4]$$

where the response variable, y_{ij}, is expressed as the sum of a fixed part and a random part (within the brackets). In [3.4], both the intercepts and the slopes of the regression lines are allowed to vary randomly at level-2, giving rise to the random slopes model. However, if only the intercepts and not the slopes are allowed to vary randomly at level-2, then [3.4] simplifies to:

$$y_{ij} = \beta_0 + \beta_1 x_{ij} + (u_j + e_{ij}) \qquad [3.5]$$

where:

$$var(u_j) = \sigma_u^2; \quad var(e_{ij}) = \sigma_e^2$$

A multilevel model of this type, where only the intercept is allowed to vary randomly, is known as a random intercepts model, or a 'variance components model'.

In the case of many covariates, equations [3.4] and [3.5] may be expressed respectively in matrix notation as:

$$y_{ij} = X_{ij}'\beta + Z_{ij}'u_j + e_{ij} \qquad [3.6]$$

And

$$y_{ij} = X_{ij}'\beta + u_j + e_{ij} \qquad [3.7]$$

where:

y_{ij} is the response for the i^{th} level-1 unit in the j^{th} level-2 unit;

X'_{ij} is the matrix of covariates corresponding to the i^{th} level-1 unit in the j^{th} level-2 unit;

β is the associated vector of fixed parameter estimates;

Z'_{ij} is a matrix of covariates (usually a subset of X'_{ij}) the effects of which vary randomly at level-2;

u_j is a vector of level-2 random effects, and

e_{ij} is the random effect associated with the level-1 units.

The two-level models can be extended to the case of three levels. The general form for the three-level linear regression model can be written as:

$$y_{ijk} = X_{ijk}'\beta + Z_{ijk}'u_{jk} + W_{ijk}'v_k + e_{ijk} \qquad [3.8]$$

Where:

- y_{ijk} - is the response for level-1 unit, i, in level-2 unit, j, within level-3 unit, k;
- X'_{ijk} - is the matrix of covariates which may be defined at level-1, level-2 or level-3;
- β - is associated vector of fixed parameters;
- Z'_{ijk} - is a matrix of covariates (usually a subset of X'_{ijk}) the effects of which vary randomly at level-2;
- W'_{ijk} - is a matrix of covariates (usually a subset of X'_{ijk}) the effects of which vary randomly at level-3;
- u_{jk} - is a vector of level-2 random effects;
- v_k - is a vector of level-3 random effects; and
- e_{ijk} - is the random effect associated with level-1 units

The multilevel linear regression models are used in the analysis of timing and frequency of antenatal care visits presented in the first section of Chapter five

3.2.1.2 Multilevel Logistic Model

In the previous sections, we had assumed that the response variable is continuously distributed. However, many kinds of statistical modelling deal with categorical responses. In the simplest and most common case of proportions or dichotomous response data, a multilevel logistic regression model is used to describe factors associated with the response variable. The 2-level random intercepts logistic model is of the form:

$$logit(\pi_{ij}) = X_{ij}^{\prime}\beta + u_j, \qquad u_j \sim N(0,\sigma_u^2) \qquad [3.9]$$

where:

π_{ij} is the probability of an event occurring for the i^{th} level-1 unit in the j^{th} level-2 unit;

X'_{ij} is the matrix of fixed (observed) covariates corresponding to the i^{th} level-1 unit in the j^{th} level-2 unit;

β is the associated vector of parameter estimates for the effects of fixed covariates and;

u_j is the vector of level-2 random effect, which represents unobserved level-2 characteristics.

Similarly, we can describe the general three-level logit model as:

$$Logit\ \pi_{ijk} = X_{ijk}^{\prime}\beta + Z_{ijk}^{\prime}u_{jk} + W_{ijk}^{\prime}v_k \qquad [3.10]$$

Where:

π_{ijk} - is the probability of an event occurring to a particular level-1 unit i in a level-2 unit j within a level-3 unit k, and the other parameter are as defined in [3.8].

3.2.1.3 Multilevel Multinomial Model

The model with a single proportion as the outcome may be extended to the case of a set of proportions. The response is now polychotomous and a generalization of the ordinary logit model can be used to define a multinomial logit for a 2-level random intercepts model as follows:

$$\log\left(\frac{\pi_{(s)ij}}{\pi_{(1)ij}}\right) = X_{ij}^{\prime}\beta_{(s)} + u_{(s)j}, \qquad s = 2,\dots,t \qquad [3.11]$$

where subscript (1) represents the base category, and (s) the other t-1 categories of the response variable and may take the values 2 to t. Choosing one category as the base category avoids redundancy and a singular covariance matrix, and hence the need to introduce generalised inverses into the estimation (see Goldstein, 1995:104). The other parameters are as defined in [3.9].

For the case of three levels, the general three-level multinomial model can be described as:

$$\log\left(\frac{\pi_{(s)ijk}}{\pi_{(1)ijk}}\right) = X'_{(s)ijk}\beta_{(s)} + Z'_{(s)ijk}u_{(s)jk} + W'_{(s)ijk}v_{(s)k}, \quad s = 2,\dots,t. \quad [3.12]$$

where $u_{(s)jk} \sim N(0,\ \sigma^2_{(s)u})$ and $v_{(s)k} \sim N(0,\ \sigma^2_{(s)v})$, and the other parameters are as defined in [3.8] and [3.10].

The multilevel models for discrete response data (multilevel logistic and multinomial models) are used in the analysis of maternal mortality in Kenyan hospitals, presented in the first section of Chapter four; delivery care, presented in the second section of Chapter five; and birth outcomes, presented in Chapter six.

3.2.1.4 Estimation procedures

Recall equation [3.4], which is of the form:

$$y_{ij} = \beta_0 + \beta_1 x_{ij} + (u_{0j} + u_{1j}x_{ij} + e_{ij})$$

This equation requires the estimation of two fixed coefficients β_0, β_1 and four random parameters σ_{u0}^2, σ_{u1}^2, σ_{u01} and σ_e^2. Considering the simplest 2-level model (the random intercepts model), the variance of the response about the fixed component is the sum of level-1 and level-2 variance, that is:

$$var(y_{ij}|\beta_0,\beta_1,x_{ij}) = var(u_j + e_{ij}) = \sigma_u^2 + \sigma_e^2$$

This implies that the total variance for each level-1 unit is constant and the covariance between two level-1 units, i_1 and i_2, within the same level-2 unit is given by:

$$cov(u_{i_1}, u_{i_2}) = \sigma_u^2$$

The existence of a non-zero intra-unit correlation, resulting from the presence of more than one residual term in the model, means that traditional estimation procedures, such as 'ordinary least squares' (OLS) which are used, for example, in multiple regression, are inappropriate. Considering the covariance structure of a 2-level data set, the block-diagonal covariance matrix for two level-2 units, one with three and the other with two level-1 units, may be represented using general notation as:

$$\Sigma_2 = \begin{pmatrix} \sigma_u^2 J_{(3)} + \sigma_e^2 I_{(3)} & 0 \\ 0 & \sigma_u^2 J_{(2)} + \sigma_e^2 I_{(2)} \end{pmatrix}$$

where $I_{(n)}$ is the (nxn) identity matrix and $J_{(n)}$ is the (nxn) matrix of ones. The subscript *2* for Σ indicates a 2-level model. In a single-level OLS models σ_u^2 is zero and this covariance matrix then reduces to the standard form $\sigma^2 I$, where σ^2 is the (single) residual variance (Goldstein, 1995).

If the values of the variances are known, we can directly construct the block diagonal matrix, Σ, and then apply the usual Generalised Least Squares (GLS) estimation procedure to obtain the 'best' linear unbiased estimator (BLUE) for the fixed coefficients β, as

$$\beta = (X' \Sigma^{-1} X)^{-1} X' \Sigma^{-1} Y \qquad [3.13]$$

with covariance matrix $(X' \Sigma^{-1} X)^{-1}$

where

$$X = \begin{pmatrix} 1 & X_{11} \\ 1 & X_{12} \\ \cdots & \cdots \\ \cdots & \cdots \\ 1 & X_{nm} \end{pmatrix}, \qquad Y = \begin{pmatrix} Y_{11} \\ Y_{12} \\ \cdots \\ \cdots \\ Y_{nm} \end{pmatrix}, \qquad \textit{and } X' \textit{ is transpose of } X \text{ .}$$

with m level-2 units and n_j level-1 units in the j^{th} level-2 unit.

However, in multilevel models, Σ is unknown. The estimation is based on an iterative procedure, starting from 'reasonable' estimates of the fixed parameters, usually from an initial OLS fit (see Goldstein, 1995). When the residuals have normal distributions, the estimator for the fixed coefficients in equation [3.13] also yields maximum likelihood estimates. The Iterative Generalised Least Squares (IGLS) estimation is the method underlying MLn, one of the programs used for multilevel analysis in this study. The IGLS procedure may produce biased estimates, especially when the sample size is small. A simple modification leads to restricted iterative generalised least squares (RIGLS) or restricted maximum likelihood (REML) estimates which are unbiased (Goldstein, 1995).

For the categorical response models, the estimation procedure in MLn involves the linearisation of equation [3.9] based on one of the two available approximations. The simplest and computationally more robust, is based on a first order approximation, while the second is based on a second order approximation. Greater accuracy is to be expected if the second-order approximation is used rather than the first-order based upon the first term in the Taylor expansion. In predicting the π_{ij}, we also have two choices. We can choose to use simply the fixed part of the model (marginal quasi likelihood - MQL), or we can add in the level-2 estimated residuals to the linear component of the nonlinear function when forming the Taylor expansion, in order to work with a linearized model (predictive quasi likelihood - PQL). In many applications, the MQL procedure will tend to underestimate the values of both the fixed and random parameters, especially where there are a few level-1 units per level-2 unit. Although more accurate. PQL is computationally less stable and sometimes convergence is never achieved. In some circumstances, especially with binary responses, where there are very small numbers of level-1 units per level-2 unit, even the second order PQL method may be biased, with a tendency to underestimate the level-2 variation, although the fixed effect estimates are not generally seriously biased (Goldstein, 1995; Yang *et al.*, 1996). The recently developed windows version of MLn, MLwiN, has included procedures, such as the bootstrap bias correction and the Metropolis-Hastings approach, that can correct for the bias in MQL or PQL approximations. However, these procedures can be extremely time consuming.

An alternative to the quasi-likelihood approximation procedures in MLn / MLwinN packages is MIXOR, which uses maximum marginal likelihood estimation (Hedeker and Gibbsons, 1996). Assuming either a probit, logistic, or complementary log-log response function, a maximum marginal likelihood solution is implemented using multidimensional quadrature to numerically integrate over the distribution of random effects. A Fisher scoring solution provides relatively quick convergence for the model parameters. MIXOR can accommodate random coefficient models, but unfortunately cannot handle models of more than two levels.

The bulk of multilevel analysis in this study is carried out using MLn / MLwiN statistical package, which is probably the most versatile multilevel package available. However, in the cases of two-level logit models where there are only a few level-1 units per level -2 unit, MIXOR is used, since the estimation procedures in MLn are likely to underestimate the parameters under such circumstances.

3.2.1.5 Significance Tests

In this section, we consider tests of significance for the fixed and the random parameters. The fixed part parameters, together with their standard errors are adequate for hypothesis testing separately for each parameter (Goldstein, 1995). The estimates and their accompanying standard errors can be used to construct Z-statistics, where $Z \sim N(0,1)$, by dividing the parameter estimate by its standard error

(Wald test). However, if we are interested in testing the significance of a combination of parameters, then either the R-test or the likelihood ratio test (see Goldstein, 1995:33) or the F-test may be used. These tests generally yield similar inferences for linear models.

While the use of standard errors to perform significance tests for the fixed effects is generally reasonable, the practise is problematic for the random parameters and the likelihood-ratio χ^2 test can be used instead (Hedeker and Gibbsons, 1996). In this case, it is necessary to consider the deviance (-2 loglikelihood) as a 50-50 mixture of a chi-square random variable with one degree of freedom and a point mass at zero (see Maller and Zhou, 1996). Hence, a critical value of 2.71 rather than 3.84 is used for a significance test at 5 per cent level. However, the likelihood ratio test is not reliable for testing significance of neither the fixed nor the random parameters in non-linear models (Yang *et al.*, 1996).

In this study, tests of significance for the fixed and random parameters in the linear multilevel models are based on the likelihood ratio test. For the multilevel logistic models, the F-test is used for the fixed parameters while the significance test for the random parameters are based on the R-test.

3.2.1.6 Intra-unit correlations

The estimates of the random effects can be used to calculate intra-unit correlation coefficients to measure the degree of homogeneity between units. The degree of homogeneity can be measured after taking into account the effect of significant covariates. The correlation between two level-1 units within a level-2 unit, referred to as the 'intra-unit correlation', is given by:

$$\rho_u = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_e^2}$$

where:

ρ_u measures degree of homogeneity within level-2 units;

σ_u^2 is the total variance at level-2; and

σ_e^2 is the total variance at level-1.

The correlation measures the proportion of the total variance, which is between level-2 units

In a three-level model, the estimates of level-3 and level-2 variances can be used to calculate intra-unit correlation coefficients in order to examine the extent to which level-2 units, as well as level-3 units, are consistent in a given behaviour of interest. Since level-2 units are nested within level-3 units, the level-2 unit correlations include level-3 unit correlations. Thus

$$\rho_v = \frac{\sigma_v^2}{\sigma_v^2 + \sigma_u^2 + \sigma_e^2}$$

represents the correlations of level-3 units, while the correlations of level-2 units is given by:

$$\rho_u = \frac{\sigma_v^2 + \sigma_u^2}{\sigma_v^2 + \sigma_u^2 + \sigma_e^2}$$

where

ρ_v measures degree of homogeneity within level-3 units;

ρ_u measures degree of homogeneity within level-2 units;

σ_v^2 is the total variance at level-3;

σ_u^2 is the total variance at level-2; and

σ_e^2 is the total variance at level-1

In the case of a multilevel logistic regression model, the intra-unit correlation coefficient is better understood in terms of an underlying continuous latent variable Y^*_{ijk}, representing the propensity of obtaining a particular response for the i^{th} level-1 unit of the j^{th} level-2 unit in the k^{th} level-3 unit. We assume that a particular response is observed (i.e. $Y_{jk}=1$) only if the propensity is positive (i.e. $Y^*_{jk}>0$). Under these assumptions, the multilevel logit model [3.10] is equivalent to a multilevel linear model for the latent variable of the form [3.8], where the individual error term, e_{jk}, is assumed to have a standard logistic distribution with mean 0 and variance $\pi^2/3$, where π is the constant 3.1416 (see Pebley *et al.*, 1996; Hedeker and Gibbsons, 1996).

3.2.1.7 Simultaneous confidence intervals

An important class of situations arise when we wish primarily to have information about each individual level-n unit in the sample, but where we have a large number of units which would require estimating a very large number of parameters. Furthermore, some level-n units may have rather small number of cases, resulting in imprecise estimates. In such cases, if we regard the units as members of a population and then use our population estimates of the mean and between-unit variation, we can use this information to obtain more precise estimates for each individual level-n unit (See Goldstein, 1995)

To compare performance between the different level-n units, residuals can be estimated for each of the level-n units and units with substantially different residuals identified. In terms of significance testing, we might be interested in establishing whether a specific unit has a smaller residual than another. The residuals are arranged in order of magnitude and intervals about each residual constructed, so that the criterion for judging statistical significance at a given level for any pair of residuals is whether their confidence intervals overlap. The general procedure defines a given set of confidence intervals for each residual, j as: $u_j \pm c(s.e.)_j$ where the value c is determined so that the average over all possible pairs is equivalent to a given confidence level (Goldstein and Healy, 1995).

3.2.2 Loglinear Models

The loglinear models are useful in describing association patterns among categorical variables. The name is so derived from the fact that linear models are applied to the logarithms of the expected cell counts. With the Loglinear approach, cell counts in a contingency table are modelled in terms of associations between the variables. The loglinear model formulas make no distinction between response and explanatory variables and may be based on one of the different sampling schemes: multinomial sampling scheme, in which the total number of observations is considered fixed; row-multinomial, in which the row totals are fixed; and the independent Poisson sampling scheme, which imposes no restrictions on the cell counts. Nevertheless, much of the theory carries through, regardless of which sampling scheme is adopted (Edwards, 1995).

When all variables are categorical, the data may be displayed by a multidimensional contingency table. Using a three-variable case, denoted by X, Y and Z, for illustration, the distribution of X-Y cell counts at different levels of Z can be displayed using cross sections of the three-way contingency table. These cross sections, where Z is controlled for, are called partial tables. On the other hand, the two-way contingency table obtained by combining the partial tables and ignoring the value of Z, is called the X-Y marginal table. Partial tables can exhibit quite different association patterns from marginal tables. Various authors have illustrated how misleading it can be to analyse only the marginal tables of a multi-way table (Simpson, 1951; Edwards, 1995; Agresti, 1996).

In terms of independence, if X and Y are independent in each partial table, then X and Y are said to be conditionally independent, given Z. All conditional odds ratios between X and Y then equal 1. Conditional independence of X and Y given Z, does not imply marginal independence of X and Y. That is, when odds ratios between X and Y equal 1 at each level of Z, the marginal odds ratio may differ from 1. However, the collapsibility conditions (see Agresti, 1996:176) suggest that the X-Y marginal odds ratios are identical to corresponding X-Y partial odds ratios when Z is independent of X given Y or Z independent of Y given X.

3.2.2.1 Simpson's paradox

The Simpson's paradox phenomenon shows the inadequacy of only studying marginal pairwise associations between variables. In the following example, we illustrate Simpson's paradox using hypothetical data from two health facilities in a district, one in a rural setting and another in an urban setting. Suppose we are interested in examining sex differentials in case fatality rates based on admissions due to a given fatal condition. Table 3.1 shows hypothetical data of deaths to patients admitted due to the condition at both facilities in a given year, cross-classified by sex.

Table 3.1: Hypothetical data on Patients admitted and number of Deaths, cross-classified by Sex

Sex	Number Admitted	No. of deaths	Per cent of deaths
Male	1000	250	25.0
Female	1000	300	30.0

Table 3.1 suggests that the condition is more fatal for female than the male patients. However, suppose that the information is further broken down by facility, as follows

Table 3.2: Hypothetical data on Patients admitted cross-classified by Sex, Facility and Number of Deaths

Facility	Sex	Number Admitted	No. of deaths	Per cent of deaths
Urban	Male	800	150	18.75
	Female	350	50	14.29
Rural	Male	200	100	50.00
	Female	650	250	38.46

Further cross-classifying the information by facility does show that the disease is more fatal among men than women at each of the facilities, which contradicts results from the marginal associations given in Table 3.1. What appears to be happening is that men are more likely to be admitted to the urban facility, while women are more likely to be admitted to the rural facility. Also the two facilities appear to differ greatly in their ability to manage the given condition, with the urban facility being more efficient. Although the case considered here is hypothetical, it is possible for a situation like this to arise in real life.

This illustration shows that a marginal association can have different direction from the conditional associations (Simpson's paradox). A situation may also arise when a pairwise marginal association may exhibit spurious direct associations which then vanish when other important variables are controlled for. Similar situations can also occur with continuous variables. The lesson to be learnt from these cases is that relying on pairwise marginal associations may be very misleading. It is necessary to take a multivariate approach by involving all relevant variables in the analysis so as to study the conditional, rather than the marginal associations (Edwards, 1995)

On the other hand, it is important to realise that some complications are likely to arise as the number of dimensions in a contingency table increases. The main problem is the tremendous increase in the number of possible interaction patterns and number of cells, leading to many zero cell counts. Agresti (1996) shows how this problem can cause difficulties in the modelling process.

3.2.2.2 Model specification

For a three-variable Poisson sampling model, cell counts are independent Poisson random variables with means $\{m_{ijk}\}$. The general loglinear model for a three-way table is given by:

$$Log\ m_{ijk} = \mu + \lambda_i^X + \lambda_j^Y + \lambda_k^Z + \lambda_{ij}^{XY} + \lambda_{ik}^{XZ} + \lambda_{jk}^{YZ} + \lambda_{ijk}^{XYZ} \qquad [3.14]$$

Where m_{ijk} denotes expected cell frequencies; singly-subscripted λ's are the main effects; doubly-subscripted terms pertain to two-factor interactions; and the triply-subscripted terms pertain to three-factor interactions.

Usually, of primary interest are the properties, such as independence or conditional independence, or quantities, such as cell probabilities, cross-product ratios and odds ratios, rather than the numerical values of the interaction terms in themselves. Equation [3.14] represents the saturated model which perfectly fits the data, and setting certain parameters in the equation equal to zero yields models of marginal, conditional or mutual independence. Attention is invariably restricted to hierarchical loglinear models, meaning that whenever the model contains higher-order effects, it also incorporates lower-order effects composed from the variables.

The loglinear models can be identified using the model formula consisting of terms (generators) corresponding to the maximum interaction terms in the model. The model formula corresponding to the saturated model in [3.14] is (XYZ). Special cases of the general model can be defined by setting some of the terms to zero. For example, setting all 2nd and 3rd order interaction terms to zero gives the model of mutual independence, (X,Y,Z), while setting $\lambda^{YZ} = \lambda^{XYZ} = 0$, gives $(Y \perp Z \mid X)$ read as: Y is conditionally independent of Z given X, (XY, XZ). Given a model formula, an independence graph may be formed by connecting all pairs of vertices that appear in the same generator.

3.2.2.3 Estimation and model selection

Suppose we have N observations of three discrete variables, X, Y and Z, where variable X has *x* levels, Y has *y* levels and Z has *z* levels. We can form a three-way table of counts by cross-classifying X, Y and Z and represent a typical count as n_{ijk}, where *i* can take the values 1,...,*x*, *j* can take values 1,...,*y* and *k* can be 1,...,*z*. We can also denote the cell probability as p_{ijk} and the expected cell count as $m_{ijk} = N\, p_{ijk}$. Under the multinomial sampling scheme, the likelihood of a given table $\{n_{ijk}\}$ is given by:

$$L(\{p_{ijk}\}|\{n_{ijk}\}) = \frac{N!}{\prod_{ijk} n_{ijk}!} \prod_{ijk} p_{ijk}^{n_{ijk}} \qquad [3.15]$$

The values of p_{ijk} that maximize [3.15] for a given model are the maximum likelihood estimates (MLEs), denoted as $\hat{p}_{ijk}$. The MLEs also maximize the log likelihood, since the logarithmic function is monotonic. Thus:

$$l(\{p_{ijk}\}|\{n_{ijk}\}) = \ln\left(\frac{N!}{\prod_{ijk} n_{ijk}!}\right) + \sum_{ijk} n_{ijk}\ln(p_{ijk}) \qquad [3.16]$$

The likelihood ratio test of a fitted model, M_f, versus the saturated model M_s is the deviance of the model M_f and is given by: $2(\hat{l}_s - \hat{l}_f)$, where $\hat{l}_s$ and $\hat{l}_f$ are maximized log likelihoods under M_s and M_f respectively. The following three properties make the deviance a convenient measure of the goodness of fit of M_f:

I. When $M_f = M_s$, the deviance is zero.

II. When M_f is true, then it is asymptotically $\chi^2_{(v)}$ distributed, where the degrees of freedom, v, is the difference in number of free parameters between M_f and M_s, and thus, E(deviance) = v under M_f

II. When M_f is not true, then the asymptotic distribution of the deviance is stochastically larger than $\chi^2_{(v)}$, so that, E(deviance) > v.

Under M_s, the MLEs of the p_{ijk} are n_{ijk}/N so that the deviance under M_f is given by

$$G^2 = 2\left(\sum_{ijk} n_{ijk}\ln(n_{ijk}/N) - \sum_{ijk} n_{ijk}\ln(\hat{p}_{ijk})\right)$$

$$= 2\sum_{ijk} n_{ijk}\ln\left(\frac{n_{ijk}}{\hat{m}_{ijk}}\right). \qquad [3.17]$$

The $\hat{p}_{ijk}$ are the MLEs of p_{ijk} under M_f and $\hat{m}_{ijk}$ are the corresponding fitted cell counts, that is: $\hat{m}_{ijk} = N\hat{p}_{ijk}$. This expression for the deviance is also valid under other sampling schemes, such as row-multinomial or independent Poisson sampling (Edwards, 1995).

The deviance difference of two nested models is a more reliable test compared to overall goodness-of-fit tests based on G^2, since their null distribution is closer to their asymptotic reference distribution (Edwards, 1995). For two nested models, $M_f \subseteq M_1$, the difference in the deviances is given by:

$$d = 2\sum_{ijk} n_{ijk} \ln\left(\frac{\hat{m}^{1}_{ijk}}{\hat{m}^{f}_{ijk}}\right), \qquad [3.18]$$

where $\hat{m}^{f}_{ijk}$ and $\hat{m}^{1}_{ijk}$ are the MLEs under M_f and M_1, respectively. When M_f is true, d is asymptotically $\chi^2_{(v)}$ distributed, where v is the difference in number of free parameters between M_f and M_1.

The results of the 3-way tables discussed above can be extended to multi-way tables with, say, k discrete variables which can be summed up in a k-dimensional table of counts, formed by cross-classifying the k discrete variables. Under the multinomial sampling scheme, the log likelihood of a given table $\{n_i\}$ $i \in I$ is given by:

$$\frac{N!}{\prod_{i \in I} n_i!} \prod_{i \in I} p_i^{\,n_i} \qquad [3.19]$$

where n_i is the number of observations in cell i, p_i is the probability of cell i, and I is the set of all cells in the table.

The formulae for the deviance and deviance difference are similar to those given in Equation [3.17] and [3.18], where ijk is replaced with $i \in I$.

3.2.3 Graphical Models

Graphical modelling is a form of multivariate analysis, where graphs are used to represent models. It is a powerful method for formulating and interpreting complex multivariate models. The models enable concise representations of associational and causal relations between variables under study (Edwards, 1995). Graphical association models include graphical loglinear models for contingency tables and covariance selection models for correlation matrices. Our attention mainly focuses on graphical loglinear models for categorical data analysis, which are applied in this study.

3.2.3.1 Graph theory and notations

Graphical models are concerned with the description of associations between variables. Each model is represented by a graph where variables are represented by dots (or circles in case of continuous variables). Connections between variables are either lines, representing symmetric association between variables, or arrows, representing directional influences. Each missing connection represents a conditional independence.

A graph is defined as a pair $\mathcal{G} = (V,E)$, where V is a finite set of vertices and the set of edges E is a subset of the complete set of ordered pairs of distinct vertices. A graph is said to be complete if all vertices are joined by an arrow or a line. Basic elements in all models are the saturated interaction models given by $M(\mathcal{G})$, where $\mathcal{G}$ is an undirected graph with all edges present. A class of graphs of special interest is the class of chain graphs. These are the graphs where the vertex set V can be partitioned into numbered subsets, forming the so-called dependence chain, such that all edges between vertices in the same subset are undirected and all edges between different subsets are directed, pointing from the set with lower number to the one with higher number. This class of graphs is discussed in detail in Section 3.2.3.2

Two variables are said to be conditionally independent, given the remaining variables, if and only if all interaction terms involving the two variables are zero. Thus, in a graphical association model, a specified set of pairs of variables are conditionally independent, given the rest, if all terms involving any of these variable pairs are set to zero. The model can be represented as an undirected graph whose vertices are given by the variable set $V = \{A, B, C, D\}$ and whose edges connect variable pairs that are not conditionally independent, given the rest of the variable in the model. Suppose $A \perp B \mid C,D$ and $C \perp D \mid A,B$, then the corresponding independence graph of the model is:

The independence graph is useful because it summarizes the conditional independence structure of the model in the following sense. If for any three disjoint sets v_1, v_2 and v_3 of V, we have that v_3 separates v_1 and v_2 in the sense that all paths connecting v_1 and v_2 intersect v_3, then $v_1 \perp v_2 \mid v_3$ for all distributions in the model.

3.2.3.2 Graphical chain models

Graphical chain models tie up with the early proposal for path analysis where the use of graphs with arrows and lines were suggested to characterize a correlation structure of interval-scaled variables and to use linear equations, which are in one-to-one correspondence with the graph, to formulate a statistical model. In path analysis, an indirect relation means that the simple correlation coefficient of the variable pair can be expressed and explained in terms of the remaining simple correlations of those pairs which have direct connections in the graph. Wermuth and Lauritzen (1990a) viewed graphical chain models as extending this proposal in four directions: there may be more than one response variable to each set of inferences, in addition to correlated quantitative variables the system can contain qualitative inferences and qualitative responses; each indirect relation corresponds to a conditional independence statement, and some of the variables may be latent and thus information on them only indirectly obtained with the help of other directly observable variables.

Graphical chain models correspond to special types of graphs consisting of points and directed or undirected connections between selected pairs of vertices, used to describe relationships between variables. There are important links between the directed and the undirected models. Essentially, the assumed distributional framework is that of an ordering of the variables $(V_1,...,V_n)$ such that V_i is prior to V_{i+1} for $i=1,...,n-1$, and a corresponding recursive factorization of the form:

$$f(v_1)f(v_2|v_1)...f(v_n|v_{n-1}\ v_{n-2}\ ...v_1)\ .$$

For $i<j$, an arrow is drawn from v_i to v_j unless $(f(v_j|v_{j-1},\ v_{j-2}\ ...v_1)$ does not depend on v_i (Edwards, 1995:192). This ordering may derive from a well established subject matter context or from temporal ordering. Although problems with complete causal orderings seem to be the exception rather than the rule in applications, partial orderings are often available. It is common in social science research to come across situations where given characteristics of interest are clearly antecedent to others. To capture this type of prior information, the chain graphs combine undirected and directed graphs into a single framework.

The chain graphs are based on a partition of the vertex set V into disjoint subsets, $V = S_1 \cup S_2 ... \cup S_k$ and a corresponding factorization of the joint density $f(V_1,...,V_n)$ as:

$$f(S_1)f(S_2|S_1)...f(S_k|S_{k-1},\ S_{k-2}\ ...S_1)$$ (see Edwards, 1995).

The subsets S_i are called chain components or blocks. Variables in the same block are concurrent, thus, their association structure is assumed symmetric, without causal ordering. The components are ordered such that S_i is prior to S_{i+1} for $i = 1...k-1$. All edges between vertices in the same block are undirected, and all edges between different blocks are directed, pointing from the block with the lower number to the higher. If a line is missing between two vertices v, w in the same block S_i, or an arrow is missing from $v \in S_j$ for $j<i$, then this means that:

$$v \perp w \mid S_1 \cup S_2 \ldots \cup S_i$$

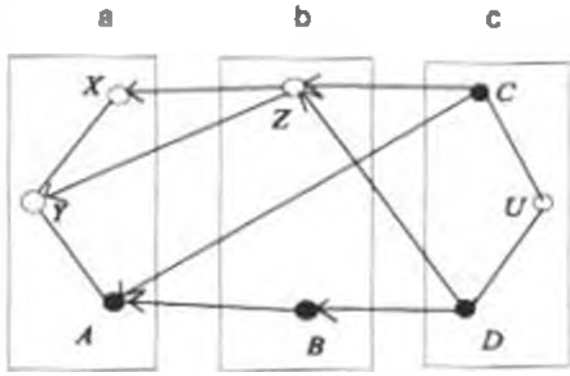
read as, v is independent of w, given the rest of the factors in the current and previous blocks.

Chain graphs can be characterized as graphs containing only undirected cycles. The chain components are perhaps best interpreted as delineating a data analysis strategy: first, an undirected model for the variables in S_1 will be chosen, then the conditional distribution of S_2 given S_1 will be modelled, then the conditional distribution of S_3 given S_1 and S_2 will be modelled, and so on.

Association is not the same as causality and any direction to an edge in a chain graph must be supplied *a priori* by the researcher. Such prior information is derived from theoretical subject matter considerations only or from evidence in previous empirical studies, or from both. It is at this stage of formulation of research hypotheses where causal reasoning is likely to be important also for association models (Wermuth and Lauritzen, 1990b).

Graphical chain models have been shown to provide a unifying concept for many statistical techniques that had in the past proven to be useful in data analysis and at the same time provide tools for new types of analysis (Wermuth and Lauritzen, 1990a). Graphs depicting association structures may have two interpretations. They may be used to formulate research hypotheses about indirect relations in an association structure and/or identify a corresponding statistical model for association. Wermuth and Lauritzen (1990a) gave an example of a graph with both interpretations, presented in Figure 3.1.

Figure 3.1 <u>Example of a research hypothesis about indirect relations among four qualitative variables (A, B, C, D) and four quantitative variable (X, Y, Z, U)</u>



Source: (Wermuth and Lauritzen, 1990a:22)

If viewed as a substantive research hypothesis, the graph contains two type of properties of observational units: categorical and continuous variables. There are two types of direct associations directional associations for variable pairs, where one is regarded as a response variable and the other as an explanatory variable, and symmetric associations, where there is no direction of dependence in the relationship. Symmetric associations are used for variables considered to be on an equal footing: they are all response variables like those in *a*; or all explanatory variables, like those in *c*; or they are intermediate variables, in the sense of being both responses and influences, like the variables in *b*.

However, if the graph is viewed as characterizing a statistical model, then the graph is a mathematical object and could be a graphical chain model defined for sets of both discrete and continuous random variables in terms of specific distributional assumptions and a set of conditional independence restrictions. Each missing direct connection for a variable pair corresponds to a specific conditional independence statement, while the set of all independence restrictions represents a conditional independence structure.

In this study, graphical chain models are used in Chapter seven, primarily to formulate hypotheses about indirect relations in an association structure. The procedure involves partitioning the variables into sub-sets (blocks), ordered to form a chain, based on possible causal direction. The analysis entails the study of intra-block associations and associations between variables in different blocks to provide direct and indirect pathways from each of the determinants to the outcome variables. Any association between two variables from the same block is assumed to be non-causal, while association between two variables from different blocks is considered as potentially causal. Linking the blocks into a chain gives the direct and indirect paths between any variables and their potential determinants. This method has been applied successfully in the analysis of determinants of infant mortality in Malaysia (see Mohamed, Diamond and Smith, 1998).

3.2.3.3 Collapsibility

There are specific models where relations between a set of variables can be examined by using the marginal tables of these variables. Such models are said to be collapsible onto the given set of variables. A theorem given by Asmussen and Edwards (1983:267) states that:

> 'A hierarchical log-linear model *L* is collapsable onto a set of variables *a* if and only if the boundary of every connected component of a^c (the compliment of a) is contained in the generator of *L*'.

Collapsibility onto a set of variables a means that inferences concerning variables in a not contained in a boundary of connected component of a^c can be performed in the marginal table of a.

Collapsibility requires that the marginal distribution be consistent with a particular model for the marginal variables. If collapsing over extraneous variables does not lead to misleading inference, then it should improve the efficiency of the analysis (Whittaker, 1990). Collapsibility is important for two main reasons. Firstly, collapsible models permit a factorization into a marginal and a conditional model that enables conditional models to be handled in the joint framework. Secondly, by applying such factorizations recursively, complex models involving many variables can sometimes be broken down into relatively simple models involving fewer variables (Edwards, 1990).

Some of the loglinear models in this study involve a rather large number of variables. For this reason, the collapsibility theorem is considered useful not only in enabling complex models be represented with simpler models involving fewer variables, but also in reducing problems in modelling arising from sparseness of cells. Furthermore, the problem of having an insuficient number of cases for analysis is a major limitation in some of the analyses, hence, the need to reduce the problem of sparseness of cells is a critical one.

3.2.3.4 Model selection

The model selection procedure involves a sequence of model comparisons in order to select the simplest model that explains the data well (the parsimonious model). In graphical modelling, our interest is in the inclusion or exclusion of an edge (association/ interaction between variables) and not individual variables. Standard procedures for model selection include backward elimination, which starts with the saturated model and eliminates the least significant edge at each step; forward inclusion,which starts with the model of mutual independence and includes the most significant edge at each step; and the stepwise selection procedure, which alternates between forward inclusion and backward elimination procedures.

Forward and backward selection procedures may result in different parsimonious models, since there is a technical difference in the selection criteria. Backward elimination directly examines conditional independence structures, while forward selection starts with the test for marginal independence. It is generally recommended that if forward selection is used, then the selected model should be re-tested using backward elimination. A procedure proposed by Whittaker (1990) involves: first, testing the pairwise conditional independence from the maximal model and removing all non-significant edges, then conducting a partial test using the global Markov property to see if any edges that had been removed in the first step should now be included. In the second step, it is possible to use marginal tables, depending on the result from the first step.

The decision to include or exclude a particular edge in the model is usually based on the log-likelihood ratio test. When a model is compared with the corresponding saturated model or nested model, the likelihood ratio test statistic is referred to as the deviance or deviance difference, respectively. Both the deviance and the deviance difference have an asymptotically chi-square distribution with degrees of freedom equal to the difference in degrees of freedom associated with the two models under comparison. Thus, the hypothesis that the reduced model holds is accepted if this model is not significantly different from the comparison model, otherwise, it is rejected. Model selection in this study is mainly based on backward elimination procedure. Starting with the model with all edges present, the non-significant edges (based on edge exclusion deviances) are removed, starting with the least significant edge, until only the significant edges are left in the model.

The analyses of associations between variables in this study are based on simple loglinear analysis and graphical loglinear models. The second section of Chapter four examines the interrelationships between factors associated with maternal deaths in Kenya using simple loglinear models fitted in GLIM statistical package. In Chapter seven, graphical loglinear chain models are used to identify the direct and indirect paths through which various factors might influence birth outcomes. The analysis is carried out in MIM statistical package.

Chapter 4

Factors Influencing Maternal Mortality in Kenya

The aim of this chapter is to identity factors associated with maternal mortality in Kenya. The analysis is based on the 1994 Kenya Maternal Mortality Baseline Survey (KMMBS), which represented one of the first attempts to understand maternal mortality in Kenya at the national level. The first section focus on the maternal mortality in Kenyan hospitals, using the hospital-based data, while the second section examines the interrelationships among factors relating to maternal deaths, based on the household survey data.

4.1 Maternal Mortality in Kenyan Hospitals

Less than half of the births in Kenya take place in a health facility: 34 per cent in public facility, 8 per cent in mission health facility and 2 per cent in private facility (National Council for Population and Development [Kenya] (CBS) and Macro International (MI), 1994). Data from the 1994 KMMBS show that 46 per cent of maternal deaths in Kenya were observed to occur in a health facility. Among those who died during or after childbirth, 47 per cent of the deliveries had taken place in a health facility.

These results indicate that it is important to note that health statistics are likely to be biased, since they represent only the sub-population with access to these facilities. Furthermore, one should also be aware of potential selectivity bias within this sub-population. For instance, what is the specific reason for entry into a hospital? Is it likely that women of specific characteristics will only go to a hospital when they develop complications?

The predominant reasons given for not delivering in a health facility were: facility being too far (38 per cent), lack of transport (20 per cent), ignorance, traditional beliefs and refusal (18 per cent). Therefore, for the majority of cases (58 per cent), entry into a hospital mainly depends on availability and accessibility of such facilities. This may be associated with varying maternal mortality risks for women of different socio-demographic characteristics, even though women of specific characteristics may be more likely to live in areas with easy access to health facilities, such as urban centres. However, for about 28 per cent of cases (ignorance, traditional beliefs and refusal), entry into a hospital is likely to be associated with some of the factors to be investigated, such as maternal age and education, which would result in varying maternal mortality risks for women of different characteristics.

The variables included in the analysis are age, antenatal attendance, parity, education and marital status. Data based on hospital staff reports regarding the maternal mortality situation at the hospital were also examined. The analysis is preceded by a brief description of the data and methods and a consideration of issues related to data quality and selectivity.

4.1.1 Data and Methods

The data are from 16 district and provincial hospitals in Kenya, selected from different parts of the country to give a national representation. The data were collected as part of a national baseline study on maternal mortality conducted by the Population Studies and Research Institute, University of Nairobi. Information was extracted for all obstetric admissions during the year 1993 in these hospitals. This included a total of 66080 patients, out of which 234 maternal deaths were recorded. However, due to missing information on some variables, only 58151 cases, consisting of 182 maternal deaths, are included in this analysis. The implications of excluding some cases from the analysis due to missing data is addressed in the preliminary analysis to assess the quality of data.

A multilevel logistic regression model is used to investigate factors associated with maternal mortality. The two-level logistic model used is of the form:

$$logit(\pi_{ij}) = X_{ij}'\beta + \sigma u_j$$

where

- π_{ij} is the probability of maternal mortality for i^{th} woman in j^{th} hospital;
- X_{ij} is the vector of covariates corresponding to the i^{th} woman in j^{th} hospital;
- β is the vector of parameter estimates;
- σ is a scale parameter, and
- u_j is the hospital risk factor and has a standard normal distribution.

The hospitals included in this analysis are a sample of the major hospitals in the country. A hospital is not just the building, but represents quality of service provided, which is a product of a variety of factors, such as, the administrative and medical management, qualified staff, facilities and supplies, all of which operate as a complex random process. Maternal mortality risks within a hospital are expected to be related and the random effects model is adopted here to deal with the expected variation in maternal mortality between hospitals. The modelling process also took into consideration contextual information, based on the per cent of abortion and Caesarean section cases at each of the hospitals, to establish if the hospitals' maternal mortality risks could be affected by the proportion of complicated cases handled. The analysis has been carried out using the MLn package.

The per cent distribution of the sample by specific characteristics is shown in Table 4.1.

Table 4. 1 Per cent distribution of the sample by specific characteristics, based on hospital data from 1994 KMMBS

Variable	Per cent Distribution (N=58151)	Variable Description
Explanatory Variables		
Age group		
10-19	22.1	Categorical variable representing patient's age group. The '20-24' years age group is used as reference category.
20-24	41.4	
25-29	22.3	
30-34	9.7	
35+	4.5	
Antenatal Attendance		Categorical variable for antenatal clinic attendance, coded as 1-attended, 2-not attended 'Attended' is used as reference category.
Attend	89.1	
Not Attend	10.9	
Parity		
0	24.1	Categorical variable for number of children. Parity '1-2' is used as reference category.
1-2	46.3	
3-4	18.7	
5+	10.9	
Education Level		Categorical variable representing patient's education level 'None /primary' education is used as reference category
None/ Primary	23.4	
Secondary +	8.3	
Not stated	68.4	
Marital Status		Categorical variable for marital status 'Married' is used as reference category
Not married	16.8	
Married	83.2	
Abortion	6.2[1]	Contextual variable measuring the proportion of abortion cases handled at the hospitals
Cesarean section	7.9[1]	Contextual variable measuring the proportion of cesarean section cases handled at the hospitals.
Outcome Variable		
Maternal Mortality		Maternal mortality coded as:
Dead	0.31	1- maternal death
Survive pregnancy	99.69	0- survive

(1) Mean percentages

simultaneous confidence intervals were constructed for hospital level residuals to enable multiple comparison of maternal mortality risks between different hospitals, after controlling for significant socio-demographic characteristics of women. These confidence intervals are illustrated graphically using error bars (see Goldstein and Healy, 1995).

4.1.2 Data Quality

Even though the hospital-based data would be expected to provide probably the most accurate information on maternal mortality and the associated factors, there are some limitations. Firstly, information was collected only on patients admitted in the maternity and obstetrics/gynaecology wards, while it is possible that some pregnancy related problems, especially early in pregnancy, might have ended up in other wards if the pregnancy status was not known at the time of admission. Secondly for cases where records were available, some of the information, especially relating to the socio-economic characteristics of the patients, such as educational attainment, was often missing. The quality of information depended, to some extent, on hospital administration and management, such that some hospitals had reasonably complete information on their patients while others did not.

In addition to the problem of possible omission of some pregnancy related cases and missing information on some of the important variables, the other limitation of hospital-based data relates to its representativeness of the entire Kenyan population. Assessment of data quality involved examining the distribution of the data in order to understand: (i) implications of missing data on the results; and (ii) potential bias due to the selectivity of the data.

4.1.2.1 Missing Data

Although information was extracted for a total of 66080 patients, only 58151 cases were included in the analysis, implying that about 12 per cent of the total cases were excluded from this analysis because they were missing data for some of the variables. If missing information was random, such that maternal mortality risks within various subgroups do not change significantly, then the bias in results due to missing data is unlikely. However, if missing information was selective by survival status for specific subgroups of women, then this exclusion is likely to bias the results. It is also important to note that information on education was missing for a substantial number of cases. In order to avoid excluding these cases from the analysis and at the same time measure the effect of education whenever information was available, another category for education (not stated) was included in the analysis. Table 4.2 gives completeness of information in analysis sample by hospital.

Table 4.2 Completeness of information by hospital, 1994 KMMRS

Hospital	Per cent of cases excluded due to missing data	Maternal mortality rate per 100,000 admissions		Per cent change in maternal mortality rate	Per cent missing information on education
		all cases (n=66080)	cases in analysis (n=58151)		
Baringo	11.8	70	80	14.3	0.1
Bungoma	1.6	200	200	0.0	25.0
Busia	5.2	720	570	20.8	15.7
Embu	3.8	60	70	16.7	100.0
Homabay	6.2	510	410	19.6	93.8
Kilifi	0.7	450	410	6.7	0.4
Kisii	3.5	1050	1090	3.8	29.7
Kisumu	21.9	960	1110	15.6	18.1
Kitui	14.3	140	170	21.4	90.4
Nairobi	3.1	70	80	14.3	70.9
Nakuru	62.5	180	220	22.2	100.0
Nyeri	5.6	170	170	0.0	80.3
Siaya	14.6	3420	3220	5.8	87.0
Taita Taveta	25.3	140	190	35.7	61.0
Trans Nzoia	6.2	1080	1070	0.9	99.9
Uasin Gishu	20.7	1180	930	21.2	88.2
All cases	**12.0**	**350**	**310**	**11.4**	**68.4**

In general, excluding some cases from the analysis due to missing data has resulted in a reduction of 11.4 per cent in the maternal deaths (from 350 to 310 deaths per

100 000 admissions). The figures imply that results for some of the hospitals are likely to be biased due to missing data. Nakuru hospital, for example, has 63 per cent of all cases excluded from the analysis due to missing data, with the result of an increase of 22.2 per cent in the maternal death rates (from 180 to 220 deaths per 100,000 admissions). Other hospitals whose estimates may be biased due to missing data include Kilifi, Kitui, Uasin Gishu and Busia, all of which have changes in maternal mortality rates exceeding 20 per cent of the original rate. Furthermore, for hospitals where almost all cases lack information on education level, estimates obtained will not have controlled for the effect of education level sufficiently.

4.1.2.2 Selectivity bias

Most previous maternal mortality studies in Kenya have been based on small sub-groups of the population from one or two selected hospitals or small communities. The data analysed here represent one of the few attempts to understand maternal mortality at the national level. It is important to point out potential selectivity bias of the data, which may be due to two main factors: the nature of the sample, and the unrepresentativeness of health facility-based data.

First, selectivity bias in the data could result from the fact that the sample included only major public hospitals. It is possible that women of higher socio-economic status are more likely to go to private hospitals, compared to women of lower socio-economic status. Consequently, the public hospitals would tend to have a relatively lower proportion of women of high socio-economic status. Furthermore, the major public hospitals act as referral centres for smaller health facilities, and hence would tend to handle a higher proportion of complicated cases. For these reasons, the data cannot be used to provide accurate estimates of maternal mortality levels in Kenyan hospitals.

Secondly, given that less than half of the births in Kenya take place in health facilities, it is important to recognise potential bias due to selectivity nature of hospital-based data. The issue of selectivity bias in hospital data was addressed through a comparison of the distribution of variables of interest in the study population with the expected national distribution. Since only 44 per cent of births in Kenya take place in a health facility, understanding specific variability in this proportion is necessary for accurate interpretation of results derived from hospital statistics. Table 4.3 compares the distribution of pregnancy related admissions in Kenyan hospitals in 1993 analysed in this chapter with the distribution of births during the last five years, as reported in the 1993 Kenya Demographic and Health Survey (KDHS).

Table 4.3 Distribution of 1993 pregnancy related hospital admissions obtained in the 1994 KMMBS and reported births during the five years preceding the 1993 KDHS, by socio-demographic characteristics of women

Characteristic	Proportion of Hospital Admissions (N = 58,151)	Proportion of KDHS Reported Births* (N = 6, 062)
Age Group		
< 20	0.22	0.17
20-34	0.73	0.70
35 +	0.05	0.13
Antenatal Care		
Attended	0.89	0.95
Not attended	0.11	0.05
Parity		
0	0.24	0.20
1-2	0.46	0.31
3-4	0.19	0.22
5 +	0.11	0.26
Education		
None	0.19	0.19
Primary	0.55	0.59
Secondary +	0.26	0.22

Source: (*)National Council for Population and Development [Kenya], Central Bureau of Statistics [Kenya] and Macro International (1994: 94)

The comparison gives some evidence of selectivity bias. For women aged 35 years and above, only 5 per cent of pregnancy related hospital admissions, according to the KMMBS, compared to 13 per cent of births, reported in the 1994 KDHS, involved women of this age group. The same pattern is observed in relation to parity. For example, the KMMBS recorded only 11 per cent of the in-patients with parity 5 and above, compared to 26 per cent of reported births in the KDHS for this group. This probably suggests that many older women or those of higher parities are likely to visit hospitals only when they develop complications. It is surprising that antenatal attendance is lower in hospital based data. This is probably due to the fact that some of the admissions involved pregnancies which were not yet full term, and some women attend antenatal care only towards the end of their pregnancy. The distribution of women by the level of education in the hospital data is close to that shown in the KDHS survey childbearing pattern. However, a slightly higher proportion of women with secondary level education is observed in the hospital based data than in the KDHS data, as opposed to women with primary level education.

Although it is not possible to measure the extent of selectivity bias using information that is available, it is important to recognise the potential effect of this bias on the results to be obtained. It is possible that maternal mortality risks for women of given characteristics will be overstated. This would most likely be the case if the smaller than expected proportion of women with low educational attainment, or aged 35 years or more, observed in the hospital data, is because these women are more likely to go to the hospital only when they develop complications. However, if the smaller proportions in these sub-groups is due to the fact that only a small proportion of women of such characteristics reside in areas with easy access to health facilities, such as urban centres, then it is unlikely that their maternal mortality risks will be overstated. This could be supported by the fact that in the 1993 KDHS sample of women of reproductive age, the proportion of urban residents was 20 per cent for women in their twenties, compared to 10 per cent for women aged 35 years and above. In the absence of information on precise reasons for entry into hospital, the extent of bias due to selectivity nature of hospital-based data cannot be adequately assessed. It is therefore reasonable to consider the results presented in this section to describe maternal mortality only in Kenyan hospitals. These results cannot be safely generalised for the entire population, since the rest of the population may exhibit different maternal mortality patterns.

4.1.3 Socio-demographic Characteristics of Women and Maternal Mortality

4.1.3.1 Bivariate Analysis

Prior to model fitting, bivariate analysis was carried out in order to understand the distribution of maternal deaths by socio-demographic characteristics of women considered in this analysis. This involved cross tabulations of maternal deaths by women's background characteristics, including Chi-square tests. The results are presented in Table 4.4.

Table 4.4 Maternal mortality rates by socio-demographic characteristics of women, 1994 KMMBS hospital-based data

Variable	Per cent Maternal Deaths	Total number of Cases
Age group **		
10-19	0.33	12846
20-24	0.18	24062
25-29	0.36	12976
30-34	0.44	5626
35+	0.87	2641
Antenatal Attendance**		
Attend	0.30	51833
Not Attend	0.46	6318
Parity**		
0	0.26	14031
1-2	0.23	26933
3-4	0.39	10877
5+	0.67	6310
Education Level**		
Not stated	0.27	39763
None/ Primary	0.46	13590
Secondary and above	0.27	4798
Marital Status		
Never/ previously married	0.36	9760
Married	0.30	48391
All women	0.31	58151

(**) Significant at 1 per cent level

The distribution of maternal mortality risk by age shows the expected J-shaped pattern with relatively high mortality rate among teenagers, lowest mortality for the 20-24 year age group and the highest mortality among women aged 35 years and above. Similarly, the distribution of maternal deaths by parity shows the expected pattern of relatively high mortality among women of high parity. Antenatal clinic attendance and secondary school education are both observed to be associated with reduced maternal mortality levels. The difference in maternal mortality by marital status is not statistically significant.

One problem with the bivariate approach is that it ignores the possibility that a collection of variables, each of which is weakly associated with the outcome, can become an important predictor of outcome when taken together (Hosmer and Lemeshow, 1989). Furthermore, the preceding analysis examines the association of individual variables with maternal mortality without taking into account the effect of other important variables. In the next sub-section, we discuss the results of the multilevel logistic regression analysis.

4.1.3.2 Multilevel Logistic Regression Analysis

All variables, except marital status, are individually observed to have a significant association with maternal mortality in the bivariate analysis. However, all variables and possible second order interactions were considered potentially important and included in multilevel logistic regression analysis while controlling for observable contextual variables and random hospital variation. Variables in the final model were selected by stepwise forward selection procedure.

The regression results show that maternal age, antenatal clinic attendance, educational attainment and the random hospital effect significantly influence maternal mortality. The contextual variables relating to the proportion of abortion admissions and Caesarean sections were observed not to have a significant association with maternal mortality risks at specific hospitals. It is important to note that the probability of maternal mortality here depends on both the observed covariates associated with a particular woman and the unobserved random hospital effect. The odds ratios estimated from the model by the exponentiated parameter estimates are hospital specific and thus represent the effect on the odds of maternal death of the particular variable within a particular hospital. Since the covariates are only significant in the fixed effects part of the model, this hospital specific odds ratios is constant for all the hospitals. The exponential of fixed parameters are interpreted as average odds ratios because of random hospital effect (See Curtis, 1992). The parameter estimates and corresponding odds ratios for significant variables are presented in Table 4.5.

Table 4.5: Parameter estimates, standard errors and average odds ratios of maternal mortality, 1994 KMMBS hospital-based data

Parameter	Estimate	Standard error	Odds Ratio
Fixed effects			
Constant	-5.74*	0.356	
Age group (20-24)[1]			
10-19	0.24	0.227	1.27
25-29	0.71*	0.219	2.03
30-34	0.79*	0.262	2.20
35+	1.32*	0.271	3.74
Antenatal Attendance (Attend)[1]			
Not Attend	1.07*	0.240	2.92
Education Level (None /Primary)[1]			
Secondary +	-0.58*	0.235	0.56
Not stated	-0.78*	0.217	0.46
Random effect variance			
Hospital - level	1.21*	0.496	

(*) Significant at 5 per cent level
(1) is reference category

The risk of maternal mortality by age shows the expected J-shaped pattern with lowest risk for women aged 20-24 years. The odds of maternal mortality appear to increase significantly with age after age 25 years. Women in age groups 25-29 and 30-34 have average odds of maternal mortality about double the odds for those aged 20-24 years. The greatest risk of maternal mortality in relation to maternal age is associated with late childbearing. The average odds of maternal mortality for women aged 35 years and above is greater than for women in the 20-24 age group by a factor of 3.7, after controlling for the effects of antenatal care attendance, education level and random variation between hospitals. Previous studies had linked advanced maternal age with a number of pregnancy complications including miscarriage, chromosomal abnormalities, uterine fibroids, hypertensive disorders, prolonged labour, and preterm delivery among other problems (Hajo and Wildschut, 1995).

Antenatal clinic attendance is observed to be significantly associated with reduced maternal mortality. The odds of maternal mortality for women who do not attend antenatal care is greater than that of women who attend antenatal care by a factor of 2.9, indicating a highly significant reduction in maternal mortality due to antenatal care. Antenatal care can avert maternal deaths through the early detection of pregnancy induced hypertension before onset of eclampsia or investigation of antepartum haemorrhage for the diagnosis of placenta praevia before the onset of catastrophic haemorrhage (Fawcus et al., 1996)

Maternal education is negatively associated with the odds of maternal mortality. The average odds ratio of maternal mortality for women with secondary education and above, compared to those with primary or no formal education, is 0.56. The significantly low odds of maternal mortality associated with women whose education level were not stated would probably imply that education records were more complete for cases of maternal death than for those who survived pregnancy.

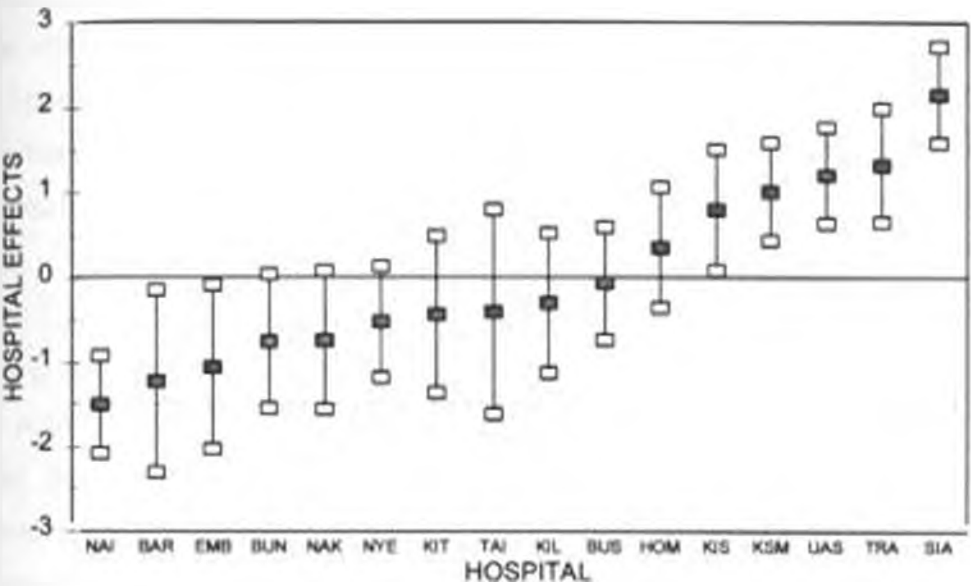
4.1.4 Hospital Effect on Maternal Mortality

From the multilevel logistic regression results, the scale parameter for the hospital effect is 1.2, indicating a large variability in maternal mortality between hospitals ($p<0.05$). This suggests that there are unobservable hospital factors which make some hospitals have higher maternal mortality rates than others.

4.1.4.1 Simultaneous Confidence Intervals for Hospital Effects

The hospital effects on maternal mortality is illustrated by simultaneous 95 per cent confidence intervals for ranked hospital residuals presented in Figure 4.1. Any two hospitals whose confidence intervals do not overlap are considered to be associated with significantly different effects on maternal mortality.

<u>Figure 4.1.</u> <u>Simultaneous 95 per cent confidence intervals for hospital effects on maternal mortality, 1994 KMMBS hospital-based data</u>



Key
NAI - Nairobi, BAR - Baringo, EMB - Embu, BUN - Bungoma,
NAK - Nakuru, NYE - Nyeri, KIT - Kitui, TAI - Taita Taveta,
KIL - Kilifi, BUS - Busia, HOM - Homabay, KIS - Kisii,
KSM - Kisumu, UAS - Uasin Gishu, TRA - Trans Nzoia, SIA - Siaya

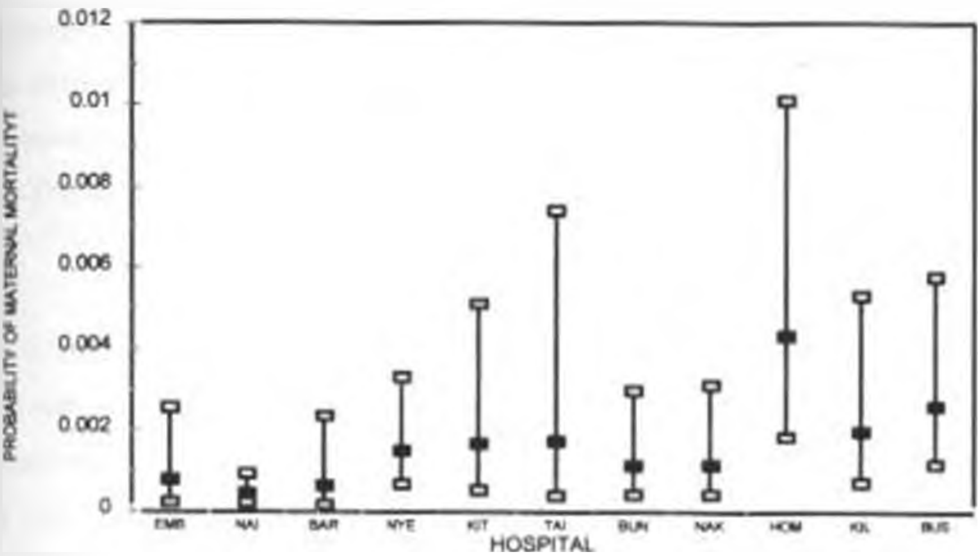
The simultaneous confidence intervals of hospital effects give evidence of a significant hospital effect on maternal mortality, with Pumwani Hospital in Nairobi (NAI) being associated with the most desirable effect of low observed mortality than expected, while Siaya Hospital is associated with the most undesirable effect. However, the results need to be interpreted with caution, since the hospital effects may have been biased by the poor quality of record keeping at some of the hospitals. In particular, preliminary analysis had shown that exclusion of some cases from the analysis due to missing data is likely to bias downwards maternal mortality risks for Uasin Gishu and Busia hospitals, but bias upwards risks for Taita Taveta, Kitui and Nakuru hospitals.

The hospital effect reveals that most hospitals associated with significantly lower maternal mortality risks are from the Central and Eastern parts of the country, which are almost malaria-free and relatively more developed socio-economically. On the other hand, hospitals associated with higher maternal mortality risks are predominantly from the malaria zone in the relatively less developed western parts of the country. These hospitals are more likely to handle a higher proportion of anaemia cases resulting from malaria or malnutrition. This observation is supported by hospital staff reports which identified anaemia as the predominant cause of maternal mortality at the hospitals.

Comparing the two extreme hospitals, for instance, Pumwani hospital in Nairobi is the largest maternity hospital in the country and is relatively advantaged in terms of qualified personnel and facilities to handle expected childbirth complications. Furthermore, the hospital mainly handles patients from Nairobi or surrounding areas who have easy access to the hospital and are likely to reach the hospital in good time. In addition, some of the complicated obstetric cases, including abortions, are referred to the Kenyatta National Hospital, which is also a referral hospital within Nairobi. Thus, it is not surprising that Pumwani Hospital is associated with the lowest maternal mortality risk. By contrast, Siaya district hospital is in Nyanza province, which is in one of the least developed regions of the country, with a high prevalence of malaria. Hospital staff reports cited anaemia and delay in arrival at the hospital as the major causes of maternal mortality at the hospital. This is not surprising, since high prevalence of malaria, coupled with malnutrition due to high poverty levels, is likely to result in high incidence of anaemia, while poor transport infrastructure would make the hospital less accessible, leading to delays in arrival at the hospital.

The hospital-level residuals have been used to estimate the probability of maternal mortality at the hospitals, after controlling for observable socio-demographic characteristics of women. Figure 4.2 gives the estimated probabilities of maternal mortality for each hospital with 95 per cent simultaneous confidence intervals for hospital effects. These probabilities have been calculated while holding the significant fixed covariates at their mean values. The hospitals are ordered from left to right by increasing raw probabilities of maternal death, and five hospitals with very high risks have been omitted to enable clear illustration of variations in maternal mortality risks.

Figure 4.2: Estimated average probabilities of maternal mortality by hospital with 95 per cent simultaneous confidence intervals for hospital effects, 1994 KMMBS



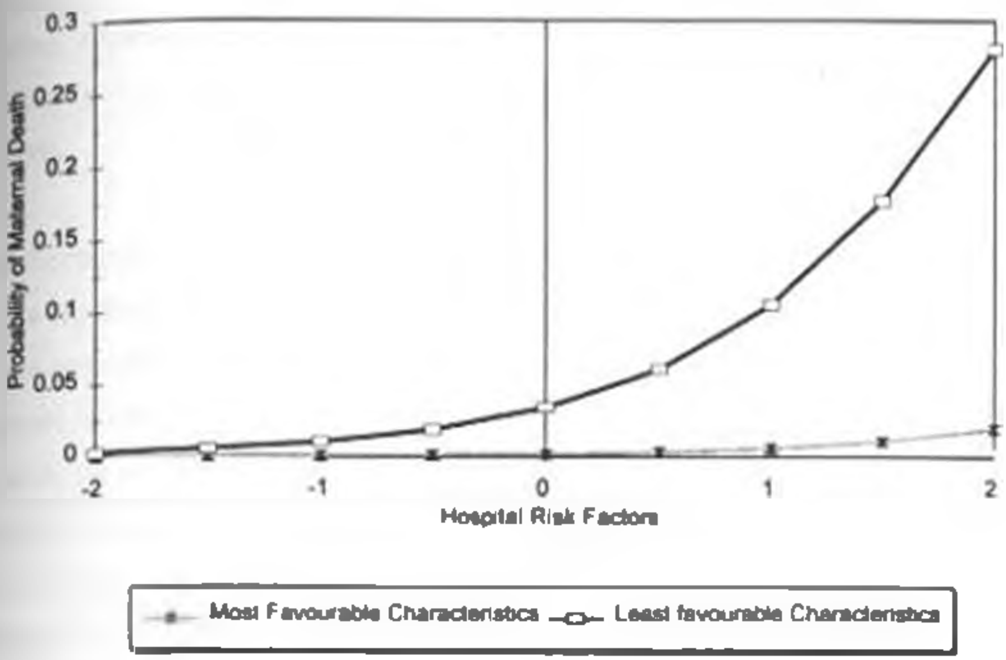
Since the hospitals are ordered from left to right by increasing raw probabilities of maternal mortality, it is evident that raw probabilities would tend to overestimate maternal mortality risks in some hospitals, while underestimating risks in other hospitals. For instance, Kilifi (KIL) and Busia (BUS) district hospitals have higher raw probabilities of maternal mortality than Homabay (HOM) district hospital, but this trend is reversed when socio-demographic characteristics of women are controlled for. This implies that hospitals like Kilifi and Busia district hospitals may seem to be associated with higher risk of maternal mortality mainly because they handle a higher proportion of women in high risk groups.

4.1.4.2 Hospitals Effect for Women of Specific Characteristics

Further analysis explored the implications of hospitals effect on the probability of maternal mortality for women with specific characteristics. This is illustrated by comparing probabilities of maternal death for women with most favourable and least favourable characteristics for varying values of hospital risk factors, u_j. Women aged 20-24, who attended antenatal care and attained at least secondary education are considered to have most favourable characteristics, while those aged 35 years and above, who did not attend antenatal care and had only primary or no education are considered to have least favourable characteristics. Since the u_j's have a standard normal distribution, the values are varied between -2 (representing hospitals with very low maternal mortality risk) and +2 (representing hospitals with high maternal mortality risks). The estimated probabilities are presented in Figure 4.3.

Figure 4.3 indicates that the hospital effect on maternal mortality is strongest for women with least favourable socio-demographic characteristics. For women with the most favourable characteristics, estimated maternal deaths per 1000 admissions may be as low as 0.16 in low risk hospitals and as high as 19.6 in high risk hospitals. Among women with the least favourable characteristics, estimated maternal deaths may be as low as 3.13 and as high as 281 maternal deaths per 1000 obstetric admissions. Comparing the risks at the two extreme hospitals, Pumwani hospital in Nairobi has estimated maternal deaths per 1000 obstetric admissions of 0.3 and 5.7 for women with most favourable and least favourable characteristics respectively. On the other hand, Siaya district hospital in Nyanza province has corresponding estimates of 23.4 and 319 maternal deaths per 1000 admissions for women with most favourable and least favourable characteristics, respectively

Figure 4.3: Estimated Probabilities of Maternal Death for Women with Most Favourable and least favourable Characteristics at varying values of u, 1994 KMMBS hospital-based data



To complement patient records data, hospital staff in charge of the maternity section provided general information relating to the maternal mortality situation at each of the hospitals. A summary of the hospital staff reports is given in Appendix 4.1

4.1.5 Discussions on Maternal Mortality in Kenyan Hospitals

In general, this analysis shows patterns of maternal mortality consistent with what has been observed in previous studies in relation to maternal age, antenatal attendance and education level (Herz and Measham, 1987; Anandalakshmy *et al*., 1993; Population Studies and Research Institute (PSRI) and UNICEF, 1996). However, the magnitude of the relative importance of factors observed in this analysis are generally lower than in previous studies. It is possible that bivariate analysis, or multiple regression analysis that do not control for some of the important variables would tend to overestimate effects of various factors on maternal mortality. In the current analysis, preliminary results obtained from bivariate analysis resulted in larger relative effects of the socio-demographic factors considered. However, when other explanatory variables and random variations between hospitals are controlled for, relative effects of these factors are reduced, resulting in less significant parameter estimates. For instance, bivariate analysis showed a highly significant effect of parity on maternal mortality ($p<0.01$), but this significance diminishes in the multilevel logistic model ($p>0.05$).

The investigation of the hospital effect on maternal mortality has revealed that there exists a significant variation in maternal mortality between hospitals. These differences are to a large extent attributable to unobserved underlying factors associated with the hospitals, such as the available hospital resources (staff and finances), equipment, supplies, as well as hospital administration and management. Comparing the two extremes for instance, Pumwani hospital in Nairobi is the largest maternity hospital in the country and is relatively more advantaged in terms of qualified personnel and facilities to handle expected childbirth complications. By contrast, Siaya district hospital is in Nyanza Province, which is in one of the least developed regions of the country. The visits to the hospitals during the survey confirmed that the hospital was indeed in an adverse state and did not even have water supply at the time of the survey. Patients admitted at the hospitals had to rely on visiting relatives and friends to bring them water, often from contaminated sources, for general use, including bathing. Furthermore, most of the equipment available at the hospital at the time were non-functional. It is no doubt that patients admitted to such a hospital, especially those with complications that may require, say, a Caesarean section delivery, would have an extremely high risk of a maternal death.

In addition to the unobserved hospital factors, the variation in maternal mortality between hospitals may partly be attributable to a regional effect, reflecting factors such as different health problems, transport infrastructure and unmeasured socio-economic characteristics of women. Nevertheless, despite the evidence of regional effects, there still exists substantial differences between hospitals within some regions. For example, Baringo is associated with one of the lowest, while Trans Nzoia and Uasin Gishu district hospitals have among the highest maternal mortality levels, yet these hospitals are within the same region of Rift valley province. This supports the earlier assertion that the variations in maternal mortality between the hospitals is probably largely due to the unobserved underlying hospital factors.

4.1.6 Summary of Factors Influencing Maternal Mortality in Kenyan Hospitals

This section has investigated factors associated with maternal mortality in Kenyan hospitals using in-patient data. We recognise potential bias in the results due to the selective nature of hospital data, since the majority of births in Kenya do not take place in health facilities. The assessment of selectivity bias in the preliminary analysis gave some evidence of possible selectivity bias, suggesting that the results cannot accurately be generalised for the entire Kenyan population, but should be seen as reflecting maternal mortality in Kenyan hospitals.

The analysis of 58151 obstetric admissions in 16 selected public hospitals reveals that the probability of maternal mortality at the hospitals depends on both the observed covariates associated with a particular woman and the unobserved random hospital effect. The covariates observed to have a significant effect were maternal age, antenatal clinic attendance and educational attainment. In general, the results show patterns of maternal mortality consistent with what has been observed in previous studies. The relationship between maternal mortality and age show the expected J-shaped pattern, with lowest maternal mortality risk for women aged 20-24 years and highest risk for those aged 35 years and above. The average odds of maternal mortality for women aged 25-29, 30-34 and those aged 35 years and above are higher than for women aged 20-24 years by a factor of 2.0, 2.2 and 3.7 respectively, after controlling for the effects of antenatal clinic attendance, education level and random variation between hospitals. Antenatal care and maternal education beyond primary level were both observed to be significantly associated with reduced maternal mortality risk. The average odds of maternal mortality between women who did not attend antenatal care and those who attended antenatal care is almost triple, while women with secondary education and above have a 44 per cent lower odds of maternal mortality, compared to those with only primary or no formal education.

In addition to the observed women characteristics, the results show a significant variation in the risk of maternal mortality between different hospitals. The estimates of hospital level residuals were used to predict the effect of the hospitals on maternal mortality, after controlling for significant socio-demographic characteristics of women. The results suggest that raw probabilities of maternal mortality would give biased estimates of maternal mortality risks associated with particular hospitals. A further analysis of the implications of hospital effects on the probability of maternal deaths for women of specific characteristics revealed that the hospital effect on maternal mortality is strongest for women with least favourable socio-demographic characteristics. Based on results of hospitals effect on maternal mortality, any intervention aimed at reducing maternal mortality in Kenyan hospitals should address critical issues within specific hospitals. For the hospitals associated with high maternal mortality risks, greater emphasis should be put on reducing maternal mortality among women in the high risk groups.

4.2 Interrelationships Between Factors Associated with Maternal Deaths in Kenya

This section uses the KMMBS household survey data to explore the interrelationships between factors relating to maternal deaths. The household-based survey involved interviews with 24,260 adults aged 15-50 years. The respondents provided survival information on all their sisters, born to the same natural mother, who ever attained menarche. Follow-up questions on circumstances of death for sisters who had died led to identification of maternal deaths. A total of 425 maternal deaths were reported among the sisters of the respondents. For the identified maternal deaths, further information relating to demographic and pre-existing health conditions, reproductive health care behaviour and circumstances of death was sought.

Although the majority of respondents could recall fairly well circumstances leading to the death of their sisters, for some of the cases, especially where the deaths either occurred a long time ago, or where the deaths occurred when the respondent was still young, some information could not be provided. It was, therefore, considered appropriate to select only cases of maternal deaths occurring during the last ten years, which are expected to have more reliable information for analysis. The recent cases are also more likely to provide relevant information for any policy interventions that would be recommended based on results from this analysis.

The analysis is based on information for 271 maternal deaths reported to have occurred within the last 10 years preceding the 1994 Kenya Maternal Mortality Baseline Survey. The analysis is divided into two parts. The first looks at characteristics of maternal deaths based on per cent distribution of factors relating to the reported maternal deaths, while the second focuses on analysis of associations between these factors, using loglinear analysis.

A major limitation of this analysis that is worth noting is lack of sufficient number of cases to permit detailed statistical analysis. A better understanding of factors involved would require an analysis that simultaneously takes into account the influence of various factors which are likely to be associated with poor pregnancy outcomes. Another limitation in the data relates to the significant proportion of the responses in the 'not stated' categories. It is possible that this may bias the results if the 'not-stated' category of responses is selective for particular sub-groups of maternal deaths. However, if these cases are fairly random with respect to the variables of interest, then it is unlikely that the results would be biased.

4.2.1 Characteristics of Maternal Deaths

The factors addressed here include predisposing conditions and risk factors of maternal deaths, maternal health care factors and circumstances of maternal deaths. The distribution of maternal deaths by these factors is discussed in the following sub-section.

4.2.1.1 Predisposing conditions and maternal risk factors

Predisposing conditions and risk factors addressed in this analysis include demographic and reproductive factors as well as general health care behaviour on reproductive matters

Pregnancies to teenage mothers or women aged 35 years and above, first pregnancies or births of order 5 or higher, or where the preceding birth interval is less than two years are considered to be high risk pregnancies. Similarly, women who have experienced a major illness in their lifetime, those with history of stillbirths or abortions, or those who had experienced previous pregnancy or childbirth complications are also considered to have predisposing conditions that put them at a high risk of a maternal death. In addition, the general health care behaviour of women on reproductive matters, such as family planning practise, or place of previous deliveries is likely to be related to her health care behaviour during the index pregnancy. The distribution of maternal deaths by predisposing conditions and risk factors is given in Table 4 6

Table 4.6 Distribution of maternal deaths by predisposing conditions and risk factors, 1994 KMMBS

Characteristic	Frequency	Per cent
Age group		
14-19	37	13.7
20-24	64	23.6
25-29	61	22.5
30-34	39	14.4
35+	44	16.2
Not stated	26	9.6
Parity		
0	77	28.4
1-2	89	32.8
3-4	52	19.2
5+	49	18.1
Not stated	4	1.5
Preceding birth interval		
Less than 2 years	25	9.2
2 - 3 years	91	33.6
4 years or more	56	20.7
Not stated /not applicable	99	36.5
Experienced major illness in lifetime		
Yes	96	35.4
No	159	58.7
Not stated	16	5.9
History of stillbirths or abortions		
Yes	43	15.9
No	213	78.6
Not stated	15	5.5
Previous pregnancy or birth complications	69	25.5
Yes	180	66.4
No	22	8.2
Not stated		
Desirability of pregnancy		
Wanted pregnancy	146	53.9
Unwanted pregnancy	58	21.4
Not stated	67	24.7
FP practise before index pregnancy		
Yes	42	15.5
No	133	49.1
Not stated/ unknown	96	35.5
Place of previous deliveries		
All in health facility	54	19.9
Some h/facility, some home	45	16.6
All at home	52	19.2
Not stated/ not applicable	120	44.3
All	**271**	**100.0**

This table shows that a substantial proportion of maternal deaths involved women in the high risk groups. About one third of the deaths (where age was stated) occurred among teenagers or women aged 35 years and above, ages known to be associated with increased maternal mortality risks. The proportion of deaths among women aged 35 years and above is particularly high, given the expected proportion of births that occur to women in this age group.

If women in all age groups had similar risks of a maternal death, then the per cent distribution of maternal deaths by age would be expected to be similar to the distribution of births by age. However, a comparison of the distribution of maternal deaths with the expected proportion of live births to women in various age groups, as reported in the 1993 KDHS, shows that women aged 35 years and above contribute 18 per cent of maternal deaths (excluding cases where age was not stated), yet only 12 per cent of all live births occur to women in this age group. One possible interpretation of this result is that there is an increased risk of maternal death for older women, especially those aged 35 years and above. On the other hand, pregnancies among younger women seem less likely to end in a maternal death. Although women aged less than 25 years contribute about half of live births, they contribute about 40 per cent of maternal deaths, suggesting that younger women have lower maternal mortality risks than the older women.

With respect to parity, the groups usually considered to be at high risks of a maternal death (first pregnancies or pregnancies of order five or higher), constituted about 45 per cent of all the maternal deaths. A comparison of the distribution of maternal deaths and live births by parity highlight the increased risk of maternal mortality associated with the first pregnancy. First births constitute 20 per cent of all live births, yet almost 30 per cent of maternal deaths occur to women of parity zero. On the other hand, there is no evidence of an increased maternal mortality risk for higher order births. The fact that births of order 5 and above constitute about 27 per cent of all live births while only 18 per cent of maternal deaths occur to women of at least four previous births may indeed suggest that higher order births are at a relatively lower risk of a maternal death.

In relation to other risk factors, a substantial proportion of deaths also involved women who had experienced major illness in their lifetime, those with history of stillbirths or abortions, those with previous pregnancy or childbirth complications, where the preceding birth interval was less than two years or the index pregnancy was not desired at the time. With respect to the general health care behaviour on reproductive matters, such as family planning practise and previous delivery care, only 15 per cent of the maternal deaths involved women who had used family planning before index pregnancy, and only 20 per cent had all previous deliveries in a health facility. These percentages should, however, not be interpreted as representing maternal risk factors associated with specific groups, since they merely show the distribution of deaths by specific characteristics.

4.2.1.2 Maternal health care factors during index pregnancy

Maternal health care factors during pregnancy and childbirth has an influence on pregnancy outcomes. One important factor is accessibility of health services, which is likely to have an influence on antenatal care, delivery care and type of medical care in cases of pregnancy or puerperal complications. The distribution of maternal deaths by maternal health care factors is presented in Table 4.7.

The majority of the deaths (65 per cent of valid cases) occurred among women who lived more than 5 km away from a health facility. In relation to health care behaviour during index pregnancy, 24 per cent of the maternal deaths involved women who had not received any antenatal care. For the deaths which occurred during or after childbirth, and where the place of delivery was known, more than half of the women (86 out of 149) had delivered outside a health facility. However, modern health care had been sought in at least half of the cases of the maternal deaths.

Table 4.7 Distribution of maternal deaths by maternal health care factors, 1994 KMMBS

Characteristic	Frequency	Per cent
Distance to nearest health facility		
Less than 1km	16	5.9
1 - 5 km	51	18.8
5 - 10 km	55	20.3
More than 10 km	68	25.1
Not stated	81	29.9
Attended antenatal clinic		
Yes	151	55.7
No	65	24.0
Not stated	55	20.3
Place of delivery		
Health Facility	64	23.6
Home /other	85	31.4
Not stated /not applicable	122	45.0
Medical care before death		
Modern health care	137	50.6
Traditional health care	36	13.3
None /not stated	98	36.2
All	**271**	**100.0**

4.2.1.3 Circumstances of maternal death

Situations relating to circumstances of maternal death included factors such as place of death, timing of death (during pregnancy, childbirth, or puerperal), age of pregnancy, for those who died during pregnancy, perceived cause of death and status of the index child. The distribution of maternal deaths by these factors is shown in Table 4.8.

Table 4.8 Distribution of maternal deaths by circumstances of death, 1994 KMMBS

Characteristic		Frequency	Per cent
Time of death			
	When pregnant	91	33.6
	During childbirth	62	22.9
	After childbirth	71	26.2
	Not stated	47	17.3
Age of pregnancy at time of death			
	First trimester	9	3.3
	Second trimester	32	11.8
	Third trimester	35	12.9
	Not stated /not applicable	195	72.0
Place of death			
	Health facility	125	46.1
	Home/ on the way	139	51.3
	Not stated	7	2.6
Perceived cause of death			
	Induced abortion	22	8.1
	Pre-existing condition/ illness	92	33.9
	Pregnancy /childbirth complications	71	26.2
	Lack of medical care	40	14.8
	Unknown / other causes	46	17.0
Status of index child			
	Alive	47	17.3
	Dead	61	22.5
	Never born	49	18.1
	Not stated	114	42.0
	All	**271**	**100**

The highest proportion of deaths occurred among pregnant women, mainly during the second and third trimester. More than half of the deaths occurred at home or on the way to a health facility. Although it was not possible to obtain the precise cause of maternal death from the available data, perceived cause of death was derived from information on respondent's or medical personnel's perception of cause of death, combined with comments given on circumstances relating to maternal deaths. The causes have been classified into five broad categories: abortion (including all cases where the women attempted inducing abortion through non-medical (usually the case) or medical procedures); pre-existing condition or illness (comprising mainly cases of anaemia and other conditions such as asthma, malaria, hypertension, tuberculosis, diabetes etc.); complications of pregnancy and childbirth (comprising direct obstetric causes such as haemorrhage, sepsis, obstructed/ prolonged labour, difficult delivery etc.); lack of medical care (due to factors relating to availability and accessibility of services, traditional beliefs, ignorance, negligence etc.); and other causes (e.g wife beating, overworking etc.) or cases for which the cause of death was unclear or unknown.

For cases where multiple factors were reported to have caused death, factors ranking higher in the above classification took precedence. For instance, if death was due to pregnancy complications resulting from induced abortion, the cause of death would be classified as abortion. Similarly, if the complications were as a result of a pre-existing health condition, the cause of death would be classified as pre-existing condition. However, if cause of death was pregnancy or childbirth complications coupled with lack of transport to go to hospital, then pregnancy/ childbirth complications would take precedence.

This classification shows that a subatantial proportion of maternal deaths (about one-third) could be attributed to pre-existing health conditions of the women. The proportion of abortion cases (8 per cent) is likely to be an underestimate, since some respondents may not have been aware if the sister had induced an abortion before experiencing complications such as sepsis or haemorrhage, and some would be reluctant to provide this information, since abortion is illegal in Kenya.

Information on the status of the index child was not provided for more than 40 per cent of the cases. However, for the cases of reported live births, 56 per cent (61 out of 108) of the children had died by the time of the survey (i.e within 10 years). This highlights the adverse impact of maternal mortality on child survival. The life tables based on the 1989 Kenyan population cencus data suggest that more than 85 per cent of newborns in Kenya are expected to survive to 10 years of age (Government of Kenya, 1996).

4.2.2 Interrelationships Between Pre-disposing Factors, Maternal Health Care Factors and Circumstances Relating to Maternal Deaths

This section of the analysis aims at establishing interrelationships between pre-existing demographic and health conditions of the women, maternal health care factors during index pregnancy, and circumstances relating to the maternal deaths. The set of factors have been partitioned into three blocks as shown in Figure 4.4.

Figure 4.4 Predisposing conditions, maternal health care factors and circumstances relating to maternal deaths, 1994 KMMBS

Predisposing conditions / Risk factors

Age group
Parity
Preceding birth interval*
Major illness in lifetime
Abortion or stillbirth history
Previous pregnancy or childbirth complications
Desirability of pregnancy
Family planning practise before index pregnancy
Place of previous deliveries*
Distance to nearest health facility

⇓

Health care behaviour during index pregnancy

Antenatal care
Place of delivery*
Medical care before death

⇓

Circumstances relating to maternal deaths

Timing of death
Age of pregnancy at time of death*
Place of death
Cause of death
Status of index child

Note. (*) Only applicable to a sub-set of the cases

A series of loglinear models are fitted in GLIM statistical package to explore the interrelationships between the factors. In this analysis, we model cell counts in a contingency table in terms of associations among the variables. The cell counts are assumed to be independent Poisson random variables. To minimize problems of sparse cells, some categories with small number of cases are combined and the generating classes for the loglinear models are limited to only three factors at a time.

The specific question under investigation is whether there is any association between antenatal care and circumstances of maternal death and how pre-disposing or risk factors affect this relationship. This part of the analysis excluded the variables relating to timing of death, since the majority of those who died early during pregnancy were unlikely to have started seeking antenatal care. The circumstances relating to maternal deaths which were addressed in the modelling process included place of death, cause of death and status of the index child. The loglinear models showing significant associations between any two factors, conditioned on a third factor, are summarised in Appendix 4.2. The scaled deviance, with corresponding degrees of freedom, are also included to give an indication of the fitness of the selected loglinear models.

4.2.2.1 Association Between Antenatal Care and Place of Death, Given Various Predisposing Conditions or Risk Factors.

The loglinear models show a fairly consistent association pattern between antenatal care, place of death and predisposing conditions or risk factors. Place of death is conditionally dependent on antenatal care, given any of the predisposing risk factors. Representing the predisposing risk factors with R, antenatal care with A and place of death with P, the models selected showed that the association between A and P was independent of R (R, AP), where R represented age, parity, birth interval, major illness in lifetime, history of stillbirths or abortions and previous pregnancy or childbirth complications. In addition to the strong link between antenatal care and place of death, antenatal care is also significantly associated with both desirability of pregnancy

(W) and family planning practise (F). Thus, the models (WA, AP) and (FA, AP) were selected when desirability of pregnancy and family planning practice were included in the models, respectively. The relationship between distance to nearest health facility (D), antenatal care and place of death indicates that all of the pairs of factors are conditionally dependent, and the association between each pair does not vary according to the level of the third factor, since there is no three-factor interaction (DA, DP, AP). This model may be presented as:

$$Log\ m_{ijk} = \mu + \lambda_i^A + \lambda_j^D + \lambda_k^P + \lambda_{ij}^{AD} + \lambda_{ik}^{AP} + \lambda_{jk}^{DP}$$

> Where: m_{ijk} denotes expected cell frequencies; singly-subscripted λ's are the main effects; and the doubly-subecripted terms pertain to two-factor interactions.

A detailed analysis of the patterns of associations between antenatal care and place of death is based on partial and marginal odds ratios. For models where antenatal care and place of death are conditionally dependent, but the predisposing condition is jointly independent of antenatal care and place of death, the collapsibility condition (see Agresti, 1996) implies that the marginal odds ratio for the antenatal care and place of death association is identical to the corresponding partial odds ratios. Thus, marginal odds ratios are used where only one pair of factors is conditional dependent, but where we have at least two pairs of conditionally dependent factors, partial odds ratios have been used. Both partial and marginal odds ratios confirm that deaths involving women who had not attended antenatal care are more likely to occur outside a health facility than for those who had attended antenatal care, as shown in Table 4.9.

Table 4.9: Fitted number of maternal deaths by antenatal care and place of death for different categories, 1994 KMMBS

Category	Place of Death: Home/ On the way	Place of Death: Health Facility	Odds Ratio
Wantedness of Pregnancy			
Desired			
Antenatal care	46	58	
no antenatal care	19	7	3.42
Undesired			
Antenatal care	7	10	
no antenatal care	19	7	3.88
FP Practise			
Use			
Antenatal care	15	16	
no antenatal care	4	2	2.13
Non-use			
Antenatal care	35	40	
no antenatal care	33	12	3.14
Place of Prev. Deliveries			
All Hospital			
Antenatal care	9	26	
no antenatal care	7	3	6.74
Hospital+Home			
Antenatal care	7	20	
no antenatal care	9	2	12.86
All Home			
Antenatal care	18	11	
no antenatal care	13	1	7.94
Dist. to Nearest H/Facility			
Less 5 km			
Antenatal care	15	30	
no antenatal care	7	3	4.67
5-10 km			
Antenatal care	14	25	
no antenatal care	5	2	4.46
Over 10km			
Antenatal care	13	15	
no antenatal care	22	6	4.23
All Cases			
Antenatal care	**64**	**86**	
no antenatal care	**46**	**17**	**3.64**

The marginal table for antenatal care by place of death shows that the odds of death occurring outside a health facility for women who did not attend antenatal care, as opposed to those who attended antenatal care is more than triple (3.64). However, the strength of this association is influenced by controlling for the presence of variables exhibiting significant associations with either antenatal care or place of death. The fitted partial tables for antenatal care and place of delivery by desirability of pregnancy as well as family planning practise (both factors are significantly associated with antenatal care) indicate stronger associations between antenatal care and place of death for cases of undesired pregnancy or non-use of family planning. The odds of dying outside a health facility for those who had not attended antenatal care, compared to those who had attended antenatal care was 3.4 and 3.9 for desired and undesired pregnancies, respectively. With respect to family planning practise, the odds were 2.1 and 3.1 for use and non-use of family planning respectively.

When variables which have significant associations with place of death, such as place of previous deliveries and distance to the nearest heath facility are controlled for, the association between antenatal care and place of death is strengthened. This relationship is observed to be fairly uniform for different distances to nearest health facility (odds ratio slightly above 4), but varies considerably for different places of previous deliveries. The association is particularly strong for cases with some previous deliveries at home and some at a health facility. For this group, the odds of dying outside a health facility for those who had not attended antenatal care compared to those who had attended antenatal care was about 13 times.

4.2.2.2 Association Between Antenatal Care and Cause of Death or Status of Index Child Given Various Predisposing Conditions or Risk Factors

Most of the models which included cause of death (C), antenatal care (A) and predisposing risk factors (R) showed mutual independence among the factors (R, A, C). For two of the models with antenatal care, cause of death and either age group of parity, the association structures could only be adequately explained by the saturated models (RAC). This implies that all the pairs are conditionally dependent, given the third factor, but the association between each pair varies according to the level of the third factor.

The loglinear analysis further showed that cause of death does not depend on the desirability of pregnancy (W) and antenatal care association (AW, C). On the other hand, previous pregnancy or childbirth complications (P) have a significant association with cause of death, but antenatal care is jointly independent of previous obstetric complications and cause of death (A, PC). Place of previous deliveries (P) has a significant association with both antenatal care and cause of death, but antenatal care and cause of death are independent even when place of previous deliveries is controlled for (PA, PC).

Almost all of the models which included status of index child, antenatal care and predisposing conditions showed mutual independence among the factors. However, desirability of a pregnancy was observed to have a significant association with both antenatal care and status of index child (S), but antenatal care and status of index child are independent when desirability of pregnancy is controlled for (WA, WS).

In summary, the above loglinear analysis shows that both the cause of death and status of index child are not significantly influenced by antenatal care. However, some of the predisposing conditions have a direct association with cause of death and status of index child. Specifically, previous obstetric complications and place of previous deliveries are associated with cause of death, while the desirability of a pregnancy is associated with the status of the index child.

A more detailed examination of these association patterns using local and global odds ratios based on fitted partial tables shows that cases with previous obstetric complications are about three times as likely to have died of preexisting health condition rather than of other cause (odds ratio of 3.36 for those who attended antenatal care and 3.17 for those who did not attend antenatal care); deaths attributed to preexisting health conditions are twice as likely to involve cases with at least a previous delivery in a health facility, compared to deaths attributed to other causes; and pregnancies that were desired were about eight times more likely to result in a live birth, compared to undesired pregnancies, regardless of antenatal care attendance.

Other specific association patterns which were considered of interest include association between place of delivery or medical care before death and status of index child, given various predisposing conditions or risk factors; and association between medical care before death and timing of death, given various predisposing conditions or risk factors. However, examination of these patterns of associations based on loglinear analysis was hindered by the insufficient number of cases available for these analyses.

4.2.3 Conclusions and Recommendations

The results of the loglinear analysis show that the place of death is dependent on antenatal care given any of the predisposing risk factors. Those who attended antenatal care were less likely to have died outside a health facility. This group of women seem to appreciate modern health care in dealing with pregnancy and childbearing. Thus, improving quality of obstetric care at the existing health facilities is likely to make a substantial contribution in reducing the incidence of maternal mortality among this group of women.

One important finding is the importance of desirability of pregnancy which seems to be strongly associated with antenatal care and circumstances of maternal death. Unwanted pregnancies are less likely to benefit from antenatal care and also less likely to result in live birth. These findings, together with the fact that non-use of modern family planning services is also associated with lack of antenatal care, which in turn is associated with maternal deaths outside a health facility, suggest the importance of appropriate community based services to reach this group of women. Women in this group are unlikely to visit health facilities for reproductive matters such as family planning, antenatal care or obstetric complication and thus probably only reachable through community-based services. Furthermore, the associations between family planning, antenatal care and obstetric care illustrate the importance of integrating maternal health care and family planning services.

Further efforts to reach women should also address the issue of accessibility of health care services. Long distance to a health care facility has been observed to be associated with lack of antenatal care and maternal deaths occurring outside a health facility.

In conclusion, the different sets of analyses in this chapter have come up with a number of useful findings, despite the data limitations. The results from the analysis of both the hospital data as well as the household survey data suggest that several efforts would be required by the safe motherhood programme to reduce the incidence of maternal mortality in Kenya. These include improving quality of obstetric care at the existing facilities to ensure appropriate obstetric care for those who visit the facilities; intensifying primary health care education, expanding community based services to reach women who are unlikely to seek modern reproductive health care services; improving the integration of maternal health and family planning services, and ensuring accessibility of affordable reproductive health services.

Chapter 5

Determinants of Maternal Health Care in Kenya

5.1 Introduction

Maternal health care plays an important role in pregnancy outcomes. Appropriate antenatal and delivery care are important in preventing adverse pregnancy outcomes for both the mother and the baby. Studies have shown that lower levels of health care use are associated with poor reproductive health outcomes (Obermeyer, 1993). In particular, lack of antenatal care has been identified as a risk factor for maternal mortality in various settings of the developing world (Kwast *et al*, 1989; Harrison, K. A. 1989; Anandalakshmy *et al.*, 1993; Mbizvo *et al*, 1993; Fawcus *et al*. 1996). With respect to delivery care, it has been noted that even though most women experience no major problems during labour and delivery, complications that do occur can be unpredictable and sudden in onset, requiring immediate action. Maternal and perinatal outcome in such instances are greatly improved when such complications occur in the presence of a trained attendant.

Factors influencing maternal health care include a range of socio-economic, cultural, demographic and service availability and accessibility characteristics. An important component of the analysis of health care utilization, which had previously been ignored by researchers, but has recently started receiving attention, is the extent to which health-related behaviour is homogenous within households and within communities. Pebley *et al*. (1996) observed that the use of formal health services was highly clustered within families and communities in Guatemala. A recent study on the impact of premarital childbearing on maternity care in Kenya and Namibia utilising the DHS data recognized the fact that inclusion of more than one child per woman in a multivariate analysis would lead to inappropriate conclusions regarding the significance of coefficients (Gage, 1998). This problem was circumvented by randomly selecting one child per woman for inclusion in the multivariate analysis and further correcting for the clustered sampling design. In this analysis, the family and community effects are of substantive interest. Hence, the magnitude of these random effects will be estimated rather than merely corrected for.

This chapter examines the determinants of maternal health care in Kenya with particular focus on the extent to which family and community characteristics affect such care. The analysis focuses on both antenatal and delivery care and is based on three-level models that take into account covariates at individual pregnancy, woman or family and community levels. An important aspect of maternal health care utilization is the extent to which some of the elements of reproductive behaviour, such as the desirability of a pregnancy, would affect such care. We hypothesize that mistimed or unwanted pregnancies are at a greater risk of not receiving appropriate heath care, compared to desired pregnancies. In addition to the socio-economic, cultural, demographic and reproductive behaviour as well as health service accessibility factors, the extent to which availability of other forms of reproductive health care services within communities affect maternal health care utilization is also explored.

5.2 Data and Methods

The analysis uses the 1993 Kenya Demographic and Health Survey (KDHS) data. Information obtained in three of the schedules: the Household Questionnaire, the Woman Questionnaire and Service Availability and Accessibility Questionnaire are utilized. The Household Questionnaire provided information used for assessing household socio-economic status, based on household possessions and amenities, while Service Availability and Accessibility Questionnaire provided cluster level information relating to accessibility of antenatal and delivery care services as well as availability of other forms of health care within various communities. The Woman Questionnaire provided information on the characteristics of the women as well as information relating to specific pregnancies or births based on the women's birth histories during the last five years preceding the survey

For both antenatal and delivery care, the analysis is based on three-level models that take into account the pregnancy-level, the woman or family-level and cluster-level effects. The analysis of antenatal care is based on the frequency of visits and the timing of the first visit, using multilevel linear regression models, while a multilevel logistic and multilevel multinomial regression models are used to establish determinants of place of delivery and childbirth attendant, respectively. The modelling allowed for potential correlation between the random effects and the observed covariates.

The general form for the three-level linear regression model used in the analysis of frequency and timing of antenatal care visits can be written as:

$$y_{ijk} = X_{ijk}^{\prime}\beta + Z_{ijk}^{\prime}u_{jk} + W_{ijk}^{\prime}v_{k} + e_{ijk}$$

Where: y_{ijk} is the response (frequency of antenatal care visits or timing of first visit) for an individual pregnancy i for woman j in cluster k;

$X^{\prime}_{ijk}$ is a vector of observed (fixed) covariates which may be defined at the individual child, woman or cluster level;

β is associated vector of fixed parameter estimates.

$Z^{\prime}_{ijk}$ is a vector of covariates (usually a subset of $X^{\prime}_{ijk}$) the effects of which vary randomly at woman level;

$W^{\prime}_{ijk}$ is a vector of covariates (usually a subset of $X^{\prime}_{ijk}$) the effects of which vary randomly at cluster level;

u_{jk} is a vector of woman level random effects, $u_{jk} \sim N(0, \sigma_u^2)$;

v_k is a vector of cluster level random effects, $v_k \sim N(0, \sigma_v^2)$; and

e_{ijk} is the random effect associated with a specific birth, $e_{ijk} \sim N(0, \sigma_e^2)$.

For the case of delivery care, we model place of delivery using a three-level logistic regression model of the form:

$$Logit\ \pi_{ijk} = X'_{ijk}\beta + Z'_{ijk}u_{jk} + W'_{ijk}v_k$$

Where: π_{ijk} - is the probability of a home delivery for an individual birth I for woman j in cluster k.

The analysis of childbirth attendant is based on a multilevel multinomial model of the form:

$$\log\left(\frac{\pi_{(s)ijk}}{\pi_{(1)ijk}}\right) = X'_{(s)ijk}\beta_{(s)} + Z'_{(s)ijk}u_{(s)jk} + W'_{(s)ijk}v_{(s)k}, \qquad s = 2,3,4.$$

where $u_{(s)jk} \sim N(0,\ \sigma^2_{(s)u})$, $v_{(s)k} \sim N(0,\ \sigma^2_{(s)v})$ And X'_{ijk}, β, Z'_{ijk} and W'_{ijk} are defined as above. π_{ijk} represents the probability of a given childbirth attendant for an individual birth i for woman j in cluster k. There are 4 response categories and the first category (medical personnel) is taken as the base category. The subscript (s) represents the other categories of childbirth attendants and may take the values 2, 3 or 4 for 'TBA', 'relative or other unskilled person' or 'no one' respectively.

In the final multilevel multinomial model, the probabilities associated with the response variable, childbirth attendant, are categorised as: π_1 - qualified medical personnel (doctor, nurse or midwife); π_2 - traditional birth attendant (TBA); π_3 - Relative or other unskilled person; and π_4 - no one. Taking 'qualified medical personnel' as the reference category, we can write:

$$Log(\frac{\pi_2}{\pi_1}) = z_2, \quad Log(\frac{\pi_3}{\pi_1}) = z_3, \quad Log(\frac{\pi_4}{\pi_1}) = z_4,$$

$$where\ z_i = \beta_{0i} + \beta_{1i}x_1 + \beta_{2i}x_2 + \ldots, \qquad [5.1]$$

x_i's being the covariates and β's the associated coefficients. The random components are taken at their mean values which equals zero. Taking the exponent of each side of [5.1] and multiplying through by π_1 yields:

$$\pi_2 = \pi_1 e^{z_2}, \quad \pi_3 = \pi_1 e^{z_3}, \quad \pi_4 = \pi_1 e^{z_4}. \; \textit{Note that } \pi_1 + \pi_2 + \pi_3 + \pi_4 = 1 \qquad [5.2]$$

Solving [5.2] we get:

$$\pi_1 = \frac{1}{1+\sum_{i=2}^{4} e^{z_i}}, \quad \pi_2 = \frac{e^{z_2}}{1+\sum_{i=2}^{4} e^{z_i}}, \quad \pi_3 = \frac{e^{z_3}}{1+\sum_{i=2}^{4} e^{z_i}}, \; \textit{and } \pi_4 = \frac{e^{z_4}}{1+\sum_{i=2}^{4} e^{z_i}} \qquad [5.3]$$

The table of estimated probabilities of childbirth attendant classified by each of the significant covariates is then constructed from [5.3], while holding the remaining significant covariates at their mean values.

The estimates of the cluster level and woman level variances are used to calculate intra-community and intra-family correlation coefficients in order to examine the extent to which families, as well as residents of a particular community are consistent in maternal health care utilization. The degree of homogeneity can be measured after taking into account the effect of significant covariates. Since births of the same woman occur in the same community (i.e. women nested within community), intra-family correlations include community correlations (Pebley *et al.*, 1996). Thus

$$\rho_v = \frac{\sigma_v^2}{\sigma_v^2 + \sigma_u^2 + \sigma_e^2} \quad \textit{represents intra-community correlations,}$$

and

$$\rho_u = \frac{\sigma_v^2 + \sigma_u^2}{\sigma_v^2 + \sigma_u^2 + \sigma_e^2} \quad \textit{represents intra-family correlations}$$

where:

ρ_v measures degree of homogeneity within communities;

ρ_u measures degree of homogeneity within families,

σ_v^2 is the total variance at cluster level;

σ_u^2 is the total variance at family level; and

σ_e^2 is the total variance at individual birth or pregnancy level.

In the case of the multilevel logistic (binomial and multinomial) regression models, the intra-unit correlation coefficients are better understood in terms of an underlying continuous latent variable representing the propensity of a particular health care behaviour. Thus, the multilevel logistic model may be viewed as an equivalence of the multilevel linear model for the latent variable, where the level-1 residuals, e_{ijk}, may be assumed to have a standard logistic distribution with mean zero and variance $\pi^2 / 3$ (See Pebley *et al.*, 1996; Hedeker and Gibbsons, 1996).

5.3 Antenatal Care in Kenya

Although the Kenya Demographic and Health Survey (KDHS) 1993 data indicate that almost all (95 per cent) pregnant women in Kenya receive antenatal care from medical personnel, there is concern regarding the frequency and timing of these visits. The number and timing of antenatal care visits is considered to be important in preventing adverse pregnancy outcomes. The timing of an antenatal check is important because some pregnancy-related problems, if not diagnosed and treated early, may endanger the life of the mother and the unborn baby. Antenatal care is most effective if the visits are started early during pregnancy and continue at regular intervals throughout the pregnancy. It is generally recommended that antenatal care visits be made monthly for the first 7 months, fortnightly in the 8th month, and then weekly until birth. If the first visit is made at the third month of pregnancy, this schedule translates to a total of about 12 to 13 visits (National Council for Population and Development (NCPD) [Kenya], Central Bureau of Statistics (CBS) [Kenya] and Macro International (MI), 1994).

For births in the five years preceding the KDHS 1993 survey, 64 per cent of mothers made four or more antenatal care visits, while 30 per cent made only 1-3 visits. Four per cent of the women did not make any visits to health facilities for antenatal care during their pregnancies. The median number of antenatal care visits was 4.7, far fewer than the recommended 12 visits With regards to the timing of first antenatal care visits, 56 per cent of births in Kenya benefit from antenatal care before the sixth month of gestation. However, one third of pregnant women do not receive antenatal care until the sixth or seventh month of pregnancy The median time at which mothers start antenatal visits is 5.6 months (NCPD, CBS and MI, 1994).

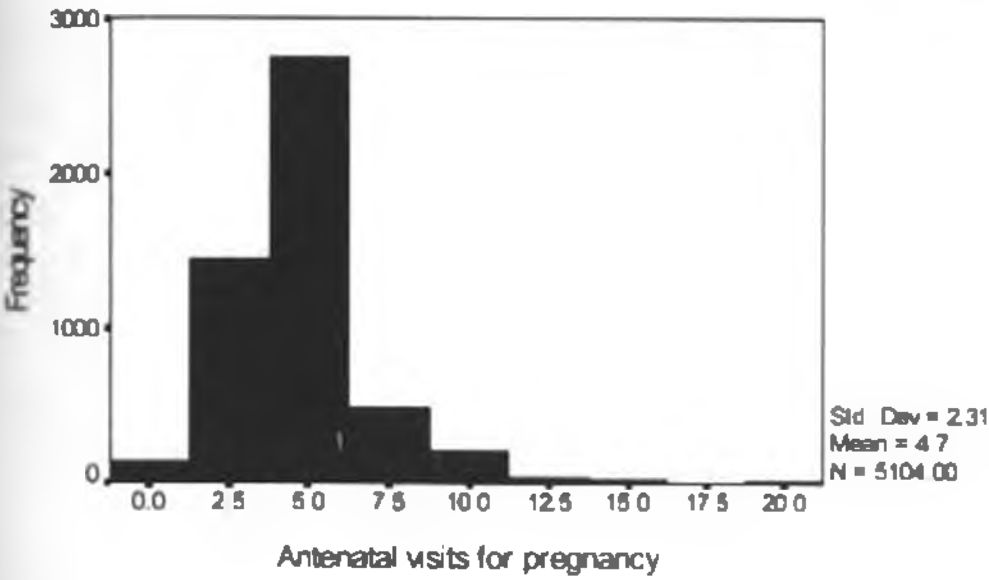
The general content of antenatal care includes preventive, curative and educational components The first visit usually includes blood tests (for haemoglobin levels, malaria parasites, or sometimes HIV virus, etc), reproductive and obstetric history, height measurements, etc. in addition to the routine checks on blood pressure, weight and urine. The preventive services, usually given at particular stages during pregnancy, include tetanus toxoid injections, iron/folate tables and some vitamin supplements for improved maternal and perinatal health In addition to these services, antenatal care is expected to provide health education on a variety of issues relating to maternal and child health. Despite the increasing international debate as to what components of antenatal care are really important in improving maternal and child health (Rooney, 1992; McDonagh, 1996; Munjanja et al., 1996; Villar and Bergsjo, 1997), this area is not addressed in the current study due to lack of data Nonetheless, the available studies on the content of antenatal care in Kenya suggest that services relating to health education on factors such as breast feeding and lactation, are often inadequate (See, for example, Esamai and Songa, 1994).

This section of the analysis focuses on factors influencing the frequency of antenatal care visits and timing of the first antenatal check in Kenya. Factors considered in the analysis include a range of individual pregnancy, woman/household and cluster level socio-economic, cultural, demographic and health care characteristics Also considered in the analysis is availability of other forms of health care and accessibility of antenatal care services within communities The analysis relates to births occurring during the last five years preceding the KDHS 1993 survey. A total of 5104 cases with complete information on all variables were included in this analysis Significant explanatory variables for frequency of antenatal care visits and timing of the first antenatal visit were selected by stepwise forward selection procedure. Selection of the variables in the fixed part of the model is based on the log-likelihood test while selection of terms in the random part of the model is based on the R-test. Preliminary analysis of the data involved examining the distribution of the dependent variables (frequency of antenatal care visits and timing of first antenatal care visit).

5.3.1 Factors Associated with Frequency of Antenatal Health Care Visits

Preliminary analysis showed that the number of antenatal care visits during a pregnancy ranged from 1 to 20, with a mean of 4.7 visits and a median of 4.0. The distribution of frequency of visits is given in Figure 5.1.

Figure 5.1 The distribution of frequency of antenatal care visits, 1993 KDHS



The distribution of frequency of antenatal care visits is slightly positively skewed with a large majority (82 per cent) of women attending two to six antenatal care visits during a pregnancy. However, residuals analysis for the final model gave no evidence of violation of the normality assumptions. The results of the multilevel linear regression model for frequency of antenatal visits is presented in Table 5.1.

Table 5.1 Parameter estimates for the frequency of antenatal health care visits during pregnancy, 1993 KDHS

Parameter	Parameter Estimate	Standard Error	No. of cases
Fixed Effects			
Constant	5.56	0.269	
Region			
(Central)[1]	-	-	552
Nairobi	0.24	0.386	133
Coast	-0.38*	0.165	585
Eastern	-0.48*	0.145	747
Nyanza	-0.67*	0.143	999
Rift Valley	-0.47*	0.135	1275
Western	-0.14	0.150	813
Residence			
(urban)[1]	-	-	479
rural	-0.30	0.219	4625
Socio-economic Status			
(low)[1]	-	-	1753
medium	0.11	0.078	2789
high	0.68*	0.143	562
Marital Status			
(married (monogamous))[1]	-	-	4185
single	-0.57*	0.131	381
married (polygamous)	0.31	0.183	206
previously married	-0.14	0.142	332
Preceding Birth Interval			
(less than 2 yrs)[1]	-	-	1038
2-3 years	0.04	0.073	1840
more than 3 yrs	0.22*	0.083	1196
first birth	0.13	0.090	1030
Age at first birth			
(20 yrs and above)[1]	-	-	1636
below 15 years	-0.51*	0.161	298
15-19 years	-0.28*	0.077	3170
Desirability of pregnancy			
(pregnancy wanted then)[1]	-	-	2452
Later	-0.21*	0.068	1803
No more	-0.41*	0.090	849

1 - represents reference category
* - Significant at 5 per cent level

Table 5.1 Parameter estimates for the frequency of antenatal health care visits during pregnancy, 1993 KDHS (continued)

Parameter	Estimate	Standard error	No. of Cases
Ideal Family size			
(0-3 children)[1]	-	-	1721
4	-0.09	0.085	2016
5-6	-0.12	0.109	862
7 or more	-0.40*	0.136	505
Family Planning practise			
(never used any method)[1]	-	-	2327
used only traditional	0.17	0.106	753
ever used modern	0.37*	0.081	2054
Distance to nearest health facility providing antenatal care			
(less than 5 km)[1]	-	-	2669
5-10 km	0.11	0.091	1777
more than 10 km	-0.22*	0.111	658
Time to nearest health facility with antenatal service			
(less than 1 hour)[1]	-	-	2023
1-2 hours	-0.20*	0.089	2349
more than 2 hours	-0.17	0.126	732
Random Effects			
Community Level Variance			
Constant	0.12*	0.047	
Distance >10 km /Constant	-0.11*	0.040	
Woman Level Variance			
Constant	7.34*	0.682	
Rural residence /Constant	-2.38*	0.341	
Pregnancy desired later /Constant	-0.86*	0.182	
Pregnancy desired later	1.26*	0.312	
Individual Birth			
Constant	2.00*	0.077	

(1) represents reference category
(*) Significant at 5 per cent level

6.3.1.1 Fixed effects covariates for frequency of antenatal care visits

The background socio-economic factors which are significantly associated with the frequency of antenatal health care visits include region of residence and household socio-economic status. Mothers in Nyanza, Eastern, Rift Valley and Coast provinces attend, on average, significantly fewer antenatal care visits compared to mothers in Central province. The socio-economic status of the household, measured by household possessions and amenities, appear to play an important role in the frequency of antenatal care visits. The number of antenatal care visits during pregnancy for births in households of high socio-economic status exceed those for births in low status households by an average of 0.7.

Demographic factors and reproductive health care behaviour appear to play a significant role on the frequency of antenatal care visits. The demographic factors observed to be important include marital status, the length of the preceding birth interval and the age at first birth. Births to single women, or where the mothers' age at first birth was below 20 years received fewer antenatal health care visits than those to married mothers, or where the mothers' age at first birth was 20 years or more, respectively. Births occurring after a long birth interval of more than three years received more frequent antenatal visits, compared to cases where the preceding birth interval was less than 2 years.

Of particular interest is the significant influence of desirability of a pregnancy, ideal family size and reproductive health care behaviour relating to family planning practice on frequency of antenatal care visits. Unwanted or mistimed pregnancies were associated with significantly fewer antenatal visits during pregnancy. Compared to desired pregnancies, unwanted pregnancies or pregnancies that were desired later had an average of 0.41 and 0.21 fewer antenatal visits during pregnancy, respectively. Also, women desiring a large family size tended to have fewer antenatal visits. For instance, women whose ideal family size was 7 children or more had an average of 0.4 fewer antenatal health care visits than those whose ideal family size was three children or less. It is possible that women desiring large families are unaware of the health risks associated with child bearing and consequently less likely to seek regular antenatal care during pregnancy. Ever use of modern family planning methods is also associated with more antenatal visits during pregnancy. This finding too is not surprising, since family planning practise is an indicator of the general health care behaviour of women in relation to reproductive matters.

The frequency of antenatal care visits is also influenced by accessibility of antenatal care services within a community. As expected, an increase in distance or time to nearest health facility with antenatal service is associated with fewer antenatal visits during pregnancy.

5.3.1.2 Variations in frequency of antenatal care visits between communities and between women

The results presented in Table 5.1 show a significant variation in frequency of antenatal care visits between clusters, between women and between births. The community level variance, though significant, is relatively small, compared to the woman level variance. The significant negative covariance between distance greater than 10 km and the constant at community level implies that the community effect on frequency of antenatal visits is weaker for cases more than 10 km away from the nearest antenatal health care facility.

A large amount of variance in frequency of antenatal care visits is observed between women within communities. The family effect on the frequency of antenatal care visits does vary significantly by rural/urban residence and desirability of a pregnancy. The significant negative covariance between pregnancy desired later and constant at women level, suggests that the family effect on frequency of antenatal care is reduced for mistimed pregnancies. Similarly, the negative covariance between rural residence and constant at woman level implies that the family effect on frequency of antenatal health care visits is weaker for rural residents.

5.3.1.3 Intra-unit Correlations

The use of intra-class correlations to determine the degree of homogeneity within communities or families is complicated by the fact that the total variance at either of these levels is a function of various covariates. For instance, the total variance at cluster level depends on distance to the nearest health facility, while the total variance at the woman level depends on both urban/rural residence and the desirability of a specific pregnancy.

The total variance at cluster level is the variance of the sum of the two random variables for CONSTANT and DIST>10, and is given by: $\sigma_{v0}^2 + 2\sigma_{v0v1}W_{ij} + \sigma_{v1}^2W_{ij}^2$, where σ_{v0}^2 is the cluster level variance for CONSTANT (0.12); σ_{v1}^2 is the cluster level variance for DIST>10 (0); σ_{v0v1} is the covariance between CONSTANT and DIST>10 (-0.11); and W_{ij} takes the value of 1 if distance to the nearest antenatal facility is greater than 10km, and a value of 0 otherwise. Similarly, the total variance at woman level is the variance of the sum of the three random variables, CONSTANT, RURAL and MISTIMED, and is given by:

$$\sigma_{u0}^2 + \sigma_{u1}^2 Z1_{ij}^2 + \sigma_{u2}^2 Z2_{ij}^2 + 2\sigma_{u0u1}Z1_{ij} + 2\sigma_{u0u2}Z2_{ij} + 2\sigma_{u1u2}Z1_{ij}Z2_{ij}.$$

Substituting the results of woman-level variance given in Table 5.1, the total variance in frequency of antenatal visits at woman level is given by: $7.34 + 1.26Z2_{ij}^2 - 4.76Z1_{ij} - 1.72Z2_{ij}$, where $Z1_{ij}$ and $Z2_{ij}$ take the value of 1 for rural residence and mistimed pregnancy respectively, and a value of 0 otherwise. The terms containing variance for rural residence and covariance between rural residence and mistimed pregnancies are not included because they are not significantly different from zero. The intra-class correlations for frequency of antenatal visits during pregnancy for the different categories are presented in Table 5.2.

Table 5.2 Intra-community and intra-family correlations for frequency of antenatal visits during pregnancy, 1993 KDHS

Distance to nearest facility	Urban /rural residence	Desirability of pregnancy	Intra-community correlations	Intra-family correlations
10km or less	Urban	Not mistimed	0.0127	0.79
		Mistimed	0.0132	0.78
	Rural	Not mistimed	0.0255	0.58
		Mistimed	0.0282	0.53
More than 10km	Urban	Not mistimed	-	0.79
		Mistimed	-	0.78
	Rural	Not mistimed	-	0.56
		Mistimed	-	0.52

Note It was not possible to obtain estimates of intra-community correlation coefficients for distance more than 10km away from an antenatal care facility, since the total community level variance is very small, resulting in a negative estimate

The small intra-community correlations imply that there is little homogeneity in the frequency of antenatal visits for women within the same community after controlling for observable covariates. The variation in the frequency of antenatal care visits during pregnancy that is due to residence in different communities only accounts for about 1.3 per cent and 2.7 per cent of the total variation for urban and rural residents, respectively. For cases more than 10 km away from a health facility, there is hardly any homogeneity in frequency of antenatal visits between communities. A separate analysis for cases more than 10 km away from an antenatal care facility confirms non-existence of the community effect for these cases. It is possible that: where there is poor access to health facilities, a number of unexplained factors will contribute to antenatal care behaviour, resulting in reduced homogeneity within communities

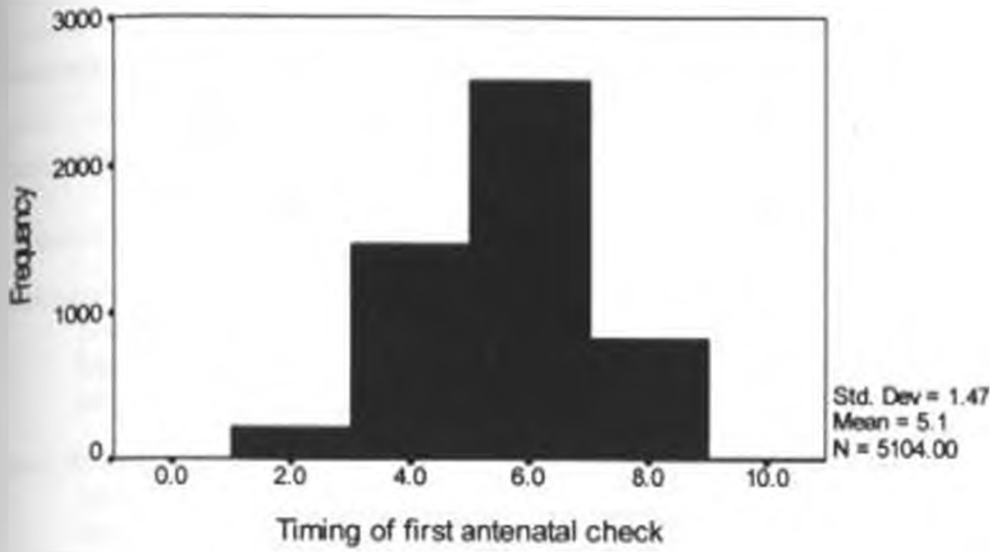
The estimates of intra-family correlations are fairly large, indicating that women are highly consistant in their antenatal care behaviour relating to the frequency of antenatal visits during subsequent pregnancies. The intra-family correlations are particularly high for women living in urban areas, further confirming that higher consistency in frequeny of antenatal care visits would be expected where there is easy access to health care services. The total unexplained variation in frequency of antenatal visits during pregnancy that is attributable to the woman or family effect is almost 80 per cent for births in urban areas and just over 50 per cent for births in rural areas. It is likely that antenatal care behaviour by women in urban areas is almost entirely influenced by family factors, since decisions are usually made at the family-level with minimal influence of factors external to the family. On the other hand, the health care behaviour or decisions by women in rural areas is likely to be partly influenced by the community because of the kinship ties and the common cultural values within a community, which consequently reduce the consistency in antenatal care behaviour within families.

The results also show that the consistency in the frequency of antenatal care visits by women is slightly reduced for mistimed pregnancies. This may be partly attributable to ambivalence towards unplanned pregnancies.

5.3.2 Factors Associated with Timing of the First Antenatal Care Visit

The distribution of the timing of the first antenatal care visit (Figure 5.2) is fairly normal, ranging from the first to the ninth month, with a mean of 5.1. The median time for the first antenatal health care visit for cases included in the analysis is at 5.0 months, which is slightly lower than the time of 5.6 months for all cases, implying that cases excluded from the analysis due to missing data comprised a higher proportion of women who started attending antenatal care late in pregnancy.

Figure 5.2 The distribution of timing of the first antenatal care visit, 1993 KDHS



The parameter estimates for the significant factors in the timing of antenatal care are presented in Table 5 3.

5.3.2.1 Fixed effects covariates

The background socio-economic and cultural characteristics of the woman and her household have a significant effect on the timing of the first antenatal health care visit. Important factors include the socio-economic status of the household, employment status and ethnicity. On average, women in households of high socio-economic status have their first antenatal check 0 17 months earlier than those in households of low socio-economic status In relation to employment status, the visits tend to start earlier for women in paid employment The timing of the first antenatal care visit also varies significantly between different ethnic groups The Kikuyu, Meru/Embu and Mijikenda on average start antenatal care later in pregnancy than the Kalenjin

Table 5.3 Parameter Estimates and Standard Errors for Timing of the First Antenatal Visit, 1993 KDHS

Parameter	Parameter Estimate	Standard Error	No. of Cases
Fixed Effects			
Constant	4.83	0.096	
Socio-economic Status			
(low)[1]	-	-	1753
Medium	0.03	0.052	2789
High	-0.17*	0.085	562
Work Status			
(unemployed)[1]	-	-	2216
employed	-0.13*	0.049	2888
Ethnicity			
(Kalenjin)[1]	-	-	803
Kamba	-0.12	0.105	544
Kikuyu	0.65*	0.094	799
Kisii	-0.07	0.117	386
Luhya	0.06	0.092	939
Luo	0.02	0.099	718
Meru /Embu	0.49*	0.128	295
Mijikenda	0.36*	0.127	290
Other	-0.06	0.119	330
Birth order			
(first birth)[1]	-	-	1030
2-3	0.06	0.051	1579
4-5	0.15*	0.061	1136
6-7	0.14*	0.072	710
8+	0.19*	0.083	649
Desirability of pregnancy			
(pregnancy wanted then)[1]	-	-	2452
Later	0.23*	0.044	1803
No more	0.32*	0.063	849
Ideal Family size			
(0-3 children)[1]	-	-	1721
4	0.11*	0.055	2016
5-6	0.12	0.072	862
7 or more	0.18	0.092	505

(1) represents reference category
(*) Significant at 5 per cent level

Table 5.3 Parameter Estimates and Standard Errors for Timing of the First Antenatal Visit, 1993 KDHS (continued)

Parameter	Parameter Estimate	Standard Error	No. of Cases
Family Planning practise			
(never used any method)[1]	-	-	2327
used only traditional	0.11	0.071	753
ever used modern	-0.15*	0.054	2024
Community Health Workers			
(not available)[1]	-	-	2417
Available	-0.16*	0.055	2687
Random Effects Variance			
Community Level			
Constant	0.07*	0.020	
Woman Level			
Constant	1.11*	0.062	
Pregnancy desired later /Constant	-0.30*	0.080	
Pregnancy desired later	0.39*	0.137	
Specific Birth			
Constant	0.94*	0.036	

(1) represents reference category
(*) Significant at 5 per cent level

Reproductive factors and health care behaviour appear to play a significant role on timing of the first antenatal health care visit. Factors observed to be particularly important include birth order, desirability of pregnancy, ideal family size and reproductive health care behaviour relating to family planning practice. Increasing birth order is associated with a late start of antenatal care. With respect to desirability of a pregnancy, unwanted pregnancies or pregnancies that were desired later were associated with a significantly late start of antenatal health care. Compared to desired pregnancies, unwanted pregnancies or pregnancies that were desired later received their first antenatal check on average 0.32 and 0.23 months later respectively. Women desiring a family size of 4 children also tended to start antenatal visits later in pregnancy, than those who desired to have no more than three children. Also, ever use of modern family planning methods is associated with an early start of antenatal care.

On the availability and accessibility of health care facilities, it was observed that clusters in which Community Health Workers were present tended to be associated with an early start of antenatal care. However, accessibility of nearest health facility providing antenatal care did not seem to play a significant role in timing of first antenatal check.

5.3.2.2 Variations in timing of the first antenatal care visit between communities and between women

There is significant variation in the timing of antenatal care between communities, between women/families within communities and between births to individual women as shown in Table 5.3. The estimates of between community variance is 0.07. The woman effect on timing of the first antenatal care visit is fairly strong, but varies depending on the desirability of a pregnancy. There exists a significant negative covariance between pregnancy desired later and the constant at woman level, implying that the woman effect on timing of the first antenatal visit is reduced for mistimed pregnancies.

The total variance for the timing of the first antenatal health care visit at woman level depends on the desirability of a pregnancy, and is given by: $\sigma_{u0}^2 + \sigma_{u1}^2 Z_{ij}^2 + 2\sigma_{u0u1} Z_{ij}$, where Z_{ij} takes a value of 1 for mistimed pregnancy, and 0 otherwise. The intra-cluster and intra-family correlations for timing of the first antenatal check classified by desirability of pregnancy are presented in Table 5.4.

Table 5.4 Intra-community and intra-family correlations for timing of the first antenatal visit, 1993 KDHS

Desirability of pregnancy	Intra-community correlations	Intra-family correlations
Not mistimed	0.033	0.56
Mistimed	0.037	0.51

The results show that women are highly consistent in timing of first antenatal care visit for different pregnancies, but there is little homogeneity within communities. The total unexplained variation in timing of first antenatal check attributable to community effect is less than 4 per cent, while the woman effect accounts for more than 50 per cent of total unexplained variation The observed covariance between mistimed pregnancies and the constant for the timing of antenatal care further supports the arguement that ambivalence towards unplanned pregnancy reduces women's consistency in antenatal care behaviour

5.3.3 Discussions on Antenatal Care

The analysis of antenatal care has shown that the timing and the frequency of antenatal care visits in Kenya are associated with a range of socio-economic and demographic factors However, these factors do not explain all the variation in the use of such health care since significant unexplained variation exists between individual births, women, and communities The results suggested that membership to a particular community explains part of the variation in the use of antenatal services between women and that this effect is stronger for rural than urban communities. Further, after taking into account many covariates, there are differences at the woman level in the frequency and initiation of antenatal care. The strength of the correlation for individual women suggests that women are consistent in their use of antenatal services in general

The importance of access to health services is demonstrated by a number of significant variables. It is common knowledge that proximity to an antenatal clinic is important for frequent use of maternity services and this study confirms this. However, the significant unexplained variability in the use of antenatal services for communities with a nearby health centre implies that other factors, not included in the model, are important. Such factors could be traditional health beliefs which discourage the use of maternity services or a lack of awareness of the need for antenatal care during pregnancy.

Rural or urban residence can also act as a proxy for access to health services since many developing countries have disproportionate numbers of health services favouring urban communities. The results suggest low use of antenatal care in rural communities in general, but even in the urban communities, there is wide variability in the frequency of antenatal visits. Another related variable is the presence of a health worker in the community. The results suggest that these workers may have a positive influence on women to initiate antenatal care early.

Among the socio-economic and cultural factors considered, the region of residence, the household socio-economic status, the employment status of the mother and ethnicity are observed to be important. The socio-economic status of the household, measured by household amenities and possessions, is particularly important, influencing both the frequency and timing of antenatal care visits. Studies in many areas of the world have demonstrated a link between low socio-economic status and under-utilisation of health services (McKinlay and McKinlay, 1972; Miles-Doan and Brewster, 1998). Higher socio-economic status enables women to afford such services but it is also believed to empower women to seek health services.

Several studies have found a significant association between maternal education and the use of maternity services (Oberymeyer and Potter, 1991; Bhatia and Cleland, 1995). The present analysis gives no evidence of such an effect possibly because of the range of factors included in the model and the multivariate nature of the statistical analysis. The bivariate analysis showed an association between the level of maternal education and the use of antenatal services but this association disappeared when other covariates had been controlled for. Another study which used multivariate techniques found that maternal education was not significant as a determinant of the use of prenatal services in the Philippines (Miles-Doan and Brewster, 1998).

With respect to demographic factors and reproductive behaviour the important factors include marital status, birth order, the length of the preceding birth interval, the age at first birth, the desirability of a pregnancy, the ideal family size and family planning practice. Women of higher parity, those who desire large families, those who start childbearing in their teens, and those who have never used modern family planning methods tend to be those with more traditional health beliefs and are less likely to seek appropriate maternity services.

The desirability of a pregnancy appears to be highly correlated with both the frequency of antenatal visits and the timing of the first visit. Pregnancies that were unwanted at the time are associated with a late start of antenatal care and less frequent visits compared to pregnancies that were wanted. Similarly, the use of antenatal care for mistimed pregnancies is lower on average. The results also suggest that mistimed pregnancies are associated with atypical behaviour, for example as a delay in the timing of the first antenatal visit for women who usually start early. Women whose pregnancy is mistimed or unwanted may be reluctant to initiate antenatal care in the hope that the pregnancy will disappear (Weller et al., 1987). It is also highly probable that women whose pregnancies are mistimed or unwanted are women of lower education, those who do not use contraception, teenage mothers, or older mothers - those who are less likely to use antenatal services in the first place.

The magnitude of intra-family correlation coefficients compared to intra-community correlations indicate that women are highly consistent in antenatal care behaviour but there is less homogeneity within communities for births occurring to different women net of the observed covariates. It is reasonable to assume that once a woman starts to attend antenatal care, she will do so for other pregnancies. Exceptions may occur with specific pregnancies, such as those that are unplanned.

Some of the heterogeneity in the use of antenatal services between communities is explained by factors already included in the models such as the distance to a health centre, ethnicity, urban or rural residence and region. Local health beliefs may follow the patterns of ethnic origin so that once this is accounted for, there is little variability between communities.

5.4 Delivery Care in Kenya

Appropriate delivery care is important for both maternal and perinatal health, particularly in cases where childbirth complications arise. It is important that mothers deliver their babies in a health facility, where proper medical attention and hygienic conditions can reduce the risk of complication and infections which may cause death or serious illness to either the mother or the baby. Births that are delivered at home are more likely to occur without assistance from medically qualified person, or from anyone. Despite almost universal antenatal care from medical personnel in Kenya, less than half of all the deliveries take place in a health facility (National Council for Population and Development (NCPD) [Kenya], Central Bureau of Statistics (CBS) [Kenya] and Macro International (MI), 1994). Furthermore, the KDHS data show a significant improvement in antenatal care attendance in Kenya over the recent years from 80 per cent in 1989 to 95 per cent in 1993, while no improvement at all has been observed in delivery care.

This section examines the determinants of delivery care in Kenya based on place of delivery and childbirth attendant. The analysis uses multilevel logistic and multilevel multinomial logistic regression models for place of delivery and childbirth attendant, respectively, applied to the 1993 Kenya Demographic and Health Survey data. The survey collected maternal health care data on births occurring during the five years before the survey. Factors considered in the analysis include socio-economic, demographic, reproductive and health care characteristics relating to specific births, as well as those relating to individual woman and the family or household. Availability and accessibility of delivery care services within communities form an important component of the analysis.

5.4.1 Factors Associated with the Place of Delivery

Preliminary analysis of the data included bivariate analysis of the place of delivery with each of the explanatory variables, as well as an examination of the distribution of births and home deliveries in the last five years per woman, to assess potential correlation between births to particular women. Overall, 58 per cent of deliveries had taken place away from a health facility. The per cent distribution of health facility deliveries by various socio-demographic, reproductive health care behaviour and service accessibility characteristics are presented in Appendix 5.1.

5.4.1.1 Clustering Structure

To determine if it is necessary to use a random effects analysis to control for family/woman effects, it is important to examine the distribution of births in the last five years and the place of delivery per woman, to assess the degree of potential correlation between births to a particular woman. The distribution for the number of births and home deliveries per woman in the analysis sample is presented in Tables 5.5 and 5.6, respectively.

Table 5.5 The distribution of number of births per woman in the last five years preceding the survey, 1993 KDHS

Births	Frequency	Per cent
1	1793	52.6
2	1366	40.1
3	237	7.0
4	11	0.3
5	2	0.1
Total	3409	100.0

Table 5.5 shows that almost half of the women contribute more than one birth to the sample, which implies that there is a need to control for any correlation between births to the same mother. Furthermore, such births account for about 66 per cent of all births in the last five years preceding the survey.

Table 5.6 The distribution of number of home deliveries per woman in the last five years preceding the survey, 1993 KDHS

Home deliveries	Frequency	Per cent
0	1326	38.9
1	1235	36.2
2	713	20.9
3	126	3.7
4	8	0.2
5	1	0.03
Total	3409	100.0

Even though Table 5.6 shows that only about 25 per cent of women in the analysis had more than one delivery at home within the last five years preceding the survey, births to these women accounted for about 60 per cent of all home deliveries, which further implies the need for analysis that controls for any potential correlation of births to the same mother.

The community effect is likely to play a significant role in delivery care. The delivery care of women is influenced by availability and accessibility of delivery care services within the community, as well as non-observable community factors. Thus, it is important that the analysis takes into account both observable and non-observable community effects on delivery care. The significant variables in the multilevel logistic regression analysis were selected by forward selection procedure. Parameter estimates, standard errors and odds ratios of home deliveries for the significant variables are presented in Table 5.7.

Table 5.7 Parameter estimates, standard errors and odds ratios for home deliveries, 1993 KDHS

Parameter	Estimate	Standard error	Average Odds Ratio
Fixed Effects			
Constant	-2.38	0.697	
Education Level (no education)[1]			
incomplete primary	-0.60*	0.226	0.55
complete primary	-1.05*	0.253	0.35
secondary and above	-1.77*	0.269	0.17
Socio-economic Status (Low)[1]			
medium	-0.62*	0.156	0.54
high	-1.67*	0.289	0.19
Area of Residence (urban)[1]			
rural	0.98*	0.364	2.66
Region (Central)[1]			
Nairobi	1.52*	0.691	4.57
Coast	2.31*	0.546	10.1
Eastern	0.98	0.613	2.66
Nyanza	1.80*	0.505	6.05
Rift Valley	1.65*	0.398	5.21
Western	2.63*	0.494	13.9
Ethnic Group (Kalenjin)[1]			
Kamba	1.11	0.568	3.03
Kikuyu	-0.78*	0.378	0.46
Kisii	-0.10	0.459	0.90
Luhya	0.16	0.370	1.17
Luo	-0.60	0.431	0.55
Meru/ Embu	-1.25	0.664	0.29
Mijikenda	0.59	0.600	1.80
Other	0.57	0.462	1.77
Birth Order (first birth)[1]			
2-3	1.22*	0.153	3.39
4-5	0.98*	0.183	2.66
6-7	1.32*	0.221	3.74
8 +	1.40*	0.258	4.06

(1) represents reference category
(*) Significant at 5 per cent level

Table 5.7 Parameter estimates, standard errors and odds ratios for home deliveries, 1993 KDHS (continued)

Parameter	Estimate	Standard error	Average Odds Ratio
Desirability of pregnancy (pregnancy wanted then)[1]			
wanted later	0.37*	0.129	1.45
wanted no more	0.31	0.186	1.36
Family Planning practise (never used any method)[1]			
ever used only traditional	-0.36	0.209	0.70
ever user modern methods	-0.98*	0.157	0.38
Frequency of antenatal visits (7 or more visits)[1]			
none	2.22*	0.438	9.21
1-2	1.51*	0.244	4.53
3-4	0.90*	0.178	2.46
5-6	0.51*	0.183	1.66
Time to nearest health facility with delivery care (less than 1 hour)[1]			
1-2 hours	0.07	0.189	1.07
more than 2 hours	0.54*	0.261	1.72
Distance to nearest health facility with delivery care (less than 5 km)[1]			
5-10 km	0.76*	0.191	2.14
more than 10 km	0.96*	0.235	2.61
Random Effects Variance			
Community level (constant)	0.39*	0.156	
Woman level			
constant	4.24*	0.359	
distance more than 10 km/constant	1.50*	0.456	

(1) represents reference category
(*) Significant at 5 per cent level

5.4.1.2 Fixed effects covariates

The parameter estimates presented in Table 5.7 were obtained by second order PQL estimation. It is important to note that these estimates are significantly larger than estimates obtained by first order MQL estimation. One possible explanation for this is the small number of births in the last five years per woman It has been pointed out that first order MQL estimation may result in severe underestimation of parameter estimates when there are a few level 1 units per level 2 units (See Peterson, 1995:95), as is the case in this analysis.

The background socio-economic and cultural characteristics of the woman and her household appear to play a major role in delivery care. The education of the woman plays a leading role, showing a consistent and significant decrease in home deliveries with increasing levels of education The average odds of delivering at home for women with at least complete primary education is less than half the odds for women with no education. Compared with women with secondary education and above, women with no education have an average odds of delivering at home which is about six times higher The socio-economic status of the household, measured by household possessions and amenities, also plays a significant role in delivery care. A higher socio-economic status is associated with a lower probability of delivering at home.

As expected, home deliveries are significantly more likely to take place in rural areas than in urban areas, with an average odds ratio more than double. Delivery care also varies significantly by region. All regions, except Eastern Province, are associated with significantly higher odds of home deliveries than Central province In particular, women in Western and Coast provinces are considerably more likely to have home deliveries, compared to those in Central Province, with average odds ratios more than ten fold The analysis further showed that the Kikuyu women are significantly less likely to deliver at home compared to the Kalenjin women

There is a general tendency for home deliveries to increase with increasing birth order. The average odds of home deliveries for births of order 8 and above is about four times the odds for first order births Although bivariate analysis had shown a significant positive association between home deliveries and the age of mother at time of childbirth, this association is not significant when the other variables are controlled for. Another important element of reproductive behaviour that appears to have a significant influence on delivery care is the desirability of a pregnancy. Mistimed pregnancies were observed to be associated with significantly higher odds of home deliveries than desired pregnancies.

The general health care behaviour of women on reproductive matters appears to influence her delivery care. Women who have ever used modern family planning methods have about 60 per cent lower odds of home deliveries than those who have never used any family planning method. Home deliveries are observed to reduce consistently with increasing number of antenatal visits. The average odds of home deliveries for pregnancies that did not receive any antenatal care, or those that received only one or two antenatal care visits were higher than for pregnancies which benefited from at least seven antenatal care visits by a factor of 9.2 and 4.5, respectively.

The availability of community based health services does not appear to have a significant effect on delivery care when other significant effects are controlled. However, the accessibility of health services offering delivery care appears to influence delivery care significantly. The odds of home deliveries are observed to increase with increasing time or distance to the nearest health facility offering delivery care. The average odds of home deliveries for births occurring more than two hours away from a delivery service is almost double the odds of births occurring less than one hour away from health facility offering delivery care. For births occurring 5-10 km or more than 10 km away, the average odds are more than double, compared to births occurring within a distance of less than 5 km from a delivery care service.

5.4.1.3 Variations in place of delivery between communities and between women

There is a significant variation in delivery care between communities and between women within communities. A fairly large random variance is observed between women within communities. This variance is observed to vary significantly with distance to a delivery health facility. The significant positive covariance between woman level constant and distance more than 10 km away from a health service offering delivery care, implies that the woman effect on the probability of a home delivery is stronger for women who live a long distance away from a delivery health facility.

The variance at community level, though small, is significant. This implies that even after controlling for observable community factors relating to availability and accessibility of delivery services, there still exists unexplained community factors which have a significant effect on place of delivery. Such factors could range from quality of care and affordability of services at the existing facilities to cultural values and practises within specific communities.

5.4.1.4 Intra-community and Intra-family Correlations

The intra-community and intra-family correlations were used to assess the degree of homogeneity in delivery care between births within a community and within a family, respectively. The total variance at family level is the variance of the sum of the two random variables representing the constant and distance more than 10 km away from a health facility, and is given by: $\sigma_{u0}^2 + \sigma_{u1}^2 Z_{\varphi}^2 + 2\sigma_{u0u1} Z_{\varphi}$, where $\sigma_{u0}^2 = 4.24$, $\sigma_{u1}^2 = 1.50$ $\sigma_{u0u1} = 0$ and Z_{φ} takes a value of 1 for distance greater than 10km away from a delivery care facility, and 0 otherwise. Thus, the woman level variance is 4.24 for distance less than or equal to 10 km and 5.74 for distance greater than 10 km. The intra-cluster correlations are 0.049 and 0.041 for distance less than or equal to 10 km and distance greater than 10 km, respectively, while the intra-family correlations are 0.58 and 0.65 for distance less than or equal to 10 km and distance greater than 10 km, respectively.

As in the case of antenatal care, the coefficients of intra-unit correlations indicate that women are highly consistent in delivery care behaviour for subsequent births, but there is little homogeneity for births occurring to different women but within a community. The cluster effect accounts for less than 5 per cent of total unexplained variation in place of delivery. On the other hand, more than half of the total unexplained variation in place of delivery is attributable to unobservable differences between women or families. This is particularly so in the case of women living more than 10 km away from a delivery care facility, for whom about 65 per cent of the unexplained variation in delivery care is due to unobserved differences between women or families.

The preceding analysis has examined delivery care in terms of 'home' deliveries versus health facility deliveries. Health facility deliveries are more likely to be attended to by a doctor, while 'home' deliveries are likely to be attended to by a traditional birth attendant (TBA), a relative (or other unskilled persons) or no one. It is important to determine factors associated with the different types of delivery attendants so as to be able to identify relevant intervention programmes. For instance, intervention programmes targeting the TBAs are likely to have little impact on births which are more likely to be delivered without any assistance or assisted by relatives or other unskilled persons

5.4.2 Factors Associated with Childbirth Attendant

The assistance a woman receives during childbirth has important implications for both the mother's and the baby's health. Among the 5290 births included in this analysis, 12.1 per cent were assisted by a medical doctor, 30.6 per cent were assisted by a nurse or midwife, 20 per cent were assisted by a Traditional Birth Attendant (TBA), 26.6 per cent were assisted by a relative or others, and 10.8 per cent of the cases had no assistance during delivery. The distribution of delivery attendant for births in the five years preceding the 1993 KDHS, according to various characteristics, is presented in Appendix 5.2

Preliminary analysis of the multinomial regression results showed no significant differences between factors associated with the different categories of medical birth attendants. Thus, the categories of medical doctor and nurse or midwife are combined into one category (qualified medical personnel), which is used as the base category in the multilevel multinomial regression model. The parameter estimates for the significant variables are presented in Appendix 5.3.

The interpretation of the parameter estimates in a multinomial logit regression is not straightforward. The most convenient way to present the effects of the predictor variables on an outcome based on multinomial models is in the form of estimated probabilities (Retherford and Choe, 1993). These probabilities are calculated for each covariate, while holding the remaining covariates and the community and family random effects at their mean values. The covariates considered here are all categorical variables, thus their mean values correspond to the proportions in each category. The estimated probabilities for childbirth attendant are given in Table 5.8.

5.4.2.1 Fixed effects covariates

Factors associated with childbirth attendant are very similar to factors influencing the place of delivery. Rural residence is associated with higher probabilities of TBA assistance or no assistance during delivery, while urban residence is associated with higher probability of medical assistance during childbirth. However, there appears to be no difference in the probability of being assisted by a relative or other unskilled persons during childbirth between rural and urban residents.

It is surprising that Nairobi Province is associated with the highest, while Central Province has the lowest probability of a TBA assisted delivery. The probability of being assisted by a relative is highest in Coast and lowest in Nairobi province. Western and Nyanza provinces have the highest probabilities and Eastern province the lowest probability associated with no assistance during delivery. Births in Central Province are most likely, while those in Western Province are least likely, to benefit from medical assistance.

Table 5.8 The estimated probabilities for childbirth attendant by significant characteristics, 1993 KDHS

Parameter	Childbirth Attendant			
	TBA	Relative	No one	(Medical)[1]
Residence				
(Urban)[1]	0.1013	0.3000	0.0306	0.5681
Rural	0.1882	0.2922	0.0781	0.4414
Region				
Nairobi	0.3246	0.1245	0.0881	0.4628
(Central)[1]	0.0712	0.1773	0.0818	0.6697
Coast	0.1697	0.4051	0.0445	0.3807
Eastern	0.1824	0.2362	0.0286	0.5528
Nyanza	0.1580	0.2732	0.1014	0.4674
Rift Valley	0.2193	0.3004	0.0703	0.4100
Western	0.2023	0.3854	0.1142	0.2981
Education Level				
(No education)[1]	0.2013	0.3748	0.1085	0.3154
Primary incomp.	0.1866	0.3233	0.0743	0.4158
Primary complete	0.1887	0.2693	0.0631	0.4788
Secondary +	0.1250	0.1939	0.0485	0.6326
Socio-economic status				
(Low)[1]	0.2231	0.3272	0.0753	0.3744
Medium	0.1665	0.2945	0.0695	0.4695
High	0.1096	0.1850	0.0660	0.6394
Ethnic Group				
(Kalenjin)[1]	0.2734	0.2394	0.0144	0.4728
Kamba	0.3088	0.3138	0.0934	0.2839
Kikuyu	0.0760	0.2855	0.0667	0.5718
Kisii	0.1529	0.3639	0.0687	0.4146
Luhya	0.1745	0.2787	0.1082	0.4385
Luo	0.1852	0.2371	0.0997	0.4779
Meru /Embu	0.0568	0.2528	0.1109	0.5795
Mijikenda	0.2708	0.2852	0.1296	0.3145
Other	0.2055	0.3927	0.0943	0.3076
Birth Order				
first birth	0.1435	0.2248	0.0153	0.6164
(2-3)[1]	0.1864	0.3275	0.0680	0.4182
4-5	0.1765	0.2973	0.1025	0.4237
6-7	0.1829	0.2687	0.1485	0.3999
8 +	0.1771	0.2962	0.1815	0.3452

(1) represents reference category

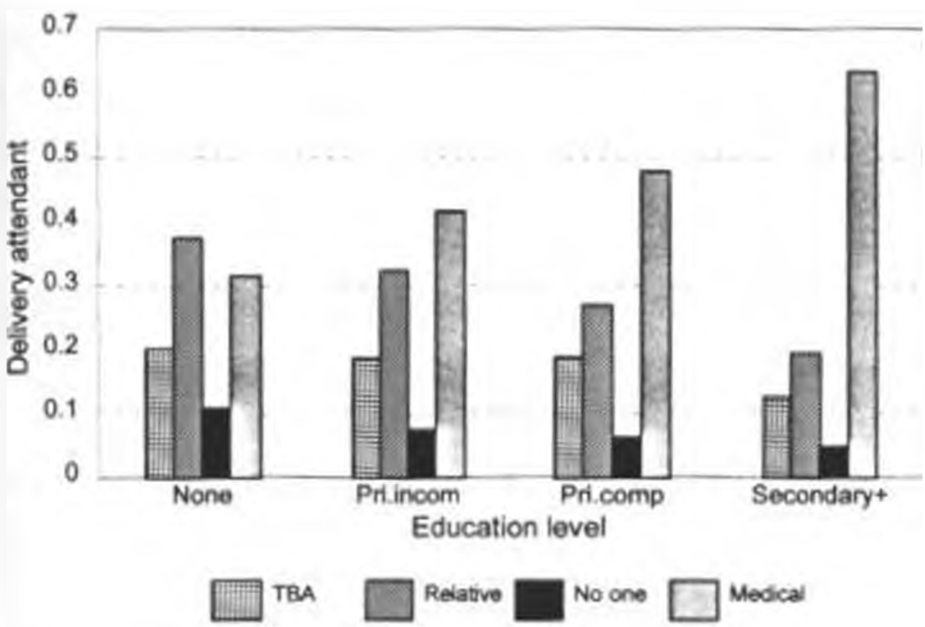
Table 5.8 The estimated probabilities for childbirth attendant by significant characteristics, 1993 KDHS (continued)

Parameter	Childbirth Attendant			
	TBA	Relative	No one	(Medical)[1]
Birth Interval				
(less 2 years)[1]	0.1985	0.3028	0.0776	0.4211
2-3 Years	0.1984	0.2964	0.0649	0.4402
3 Yrs or more	0.1992	0.2485	0.0662	0.4861
first birth	0.1435	0.2248	0.0153	0.6164
Desirability of pregnancy				
(wanted then)[1]	0.1710	0.2883	0.0697	0.4709
wanted later	0.1885	0.3118	0.0725	0.4272
wanted no more	0.1808	0.2769	0.0779	0.4644
Antenatal Visits				
none	0.1745	0.4302	0.1490	0.2463
(1-2 visits)[1]	0.1712	0.3604	0.0968	0.3717
3-4 visits	0.1807	0.3209	0.0732	0.4253
5-6 Visits	0.1863	0.2660	0.0614	0.4863
7 or more	0.1507	0.1983	0.0572	0.5938
FP Ever use				
(never used any)[1]	0.1998	0.3292	0.0839	0.3871
only Traditional	0.1760	0.3057	0.0782	0.4400
ever used modern	0.1538	0.2454	0.0569	0.5439
Distance to Nearest Health Facility				
(less 5km)[1]	0.1628	0.2396	0.0646	0.5330
5-10 km	0.1862	0.3226	0.0712	0.4199
more than 10 km	0.1837	0.3192	0.0798	0.4173
Time to Nearest Facility				
(less than 1 hr)[1]	0.1571	0.3060	0.0620	0.4749
1-2 Hours	0.1802	0.2788	0.0761	0.4649
more than 2 hrs	0.2048	0.3154	0.0761	0.4038
Presence of TBA				
(no)[1]	0.1419	0.3351	0.0720	0.4510
yes	0.1925	0.2815	0.0719	0.4542

(1) represents reference category

As would be expected, higher household socio-economic status is associated with lower probabilities of non-medical assistance (e.g. TBA, relative or no one) and higher probabilities of medical assistance during childbirth. Similarly, the probabilities of non-medical assistance during delivery reduces steadily, while medical assistance increases consistently with increasing educational attainment, as illustrated in Figure 5.3.

Figure 5.3 Estimated probabilities of delivery attendant by maternal educational attainment, 1993 KDHS



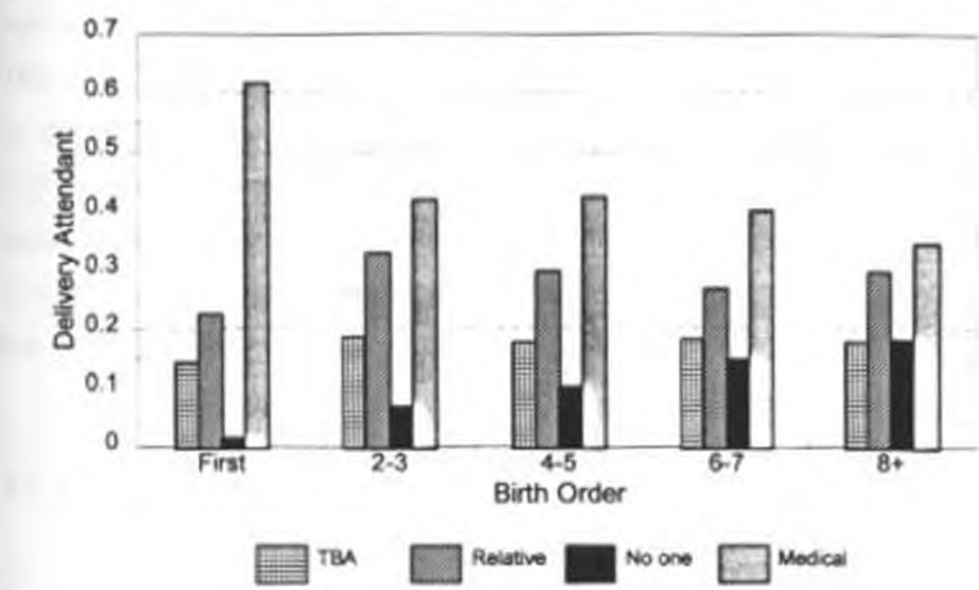
Note: Pri incom - incomplete primary
Pri comp - completed primary

About 11 per cent of births to women with no education, compared to 5 per cent of births to women with at least secondary level education, occur without any assistance. On the other hand, the probability of receiving medical assistance varies from 32 per cent to 63 per cent for births to women with no education and at least secondary level education, respectively

With respect to ethnicity, all ethnic groups are associated with considerably higher probabilities of no assistance during delivery than the Kalenjins. Only about 1 per cent of births to the Kalenjins, compared to at least 10 per cent of births among the Mijikenda, the Meru /Embu, the Luhya and the Luo ethnic groups, occur without any assistance. The Kamba and the Kisii are associated with the highest probabilities of a relative or other unskilled person assisting during delivery. Delivery assistance by a TBA is more likely among the Kamba (31 per cent) and least likely among the Meru/ Embu and the Kikuyu (6 per cent and 8 per cent respectively). On the other hand, the Kikuyu and the Meru/ Embu are associated the highest probability while the Kamba have the lowest probability of medical assistance during childbirth.

Demographic factors observed to influence childbirth attendant significantly include birth order and preceding birth interval. First births are associated with lower probabilities of non-medical assistance and higher probabilities of medical assistance during delivery, as shown in Figure 5.4.

Figure 5.4 Estimated probabilities of delivery attendant by birth order, 1993 KDHS



The probability of having no assistance during delivery for first births is particularly low (about 1.5 per cent). Compared to births of order 2-3, higher order births have probabilities of having no assistance during delivery that are consistently higher. On the other hand, preceding birth interval greater than three years is associated with a lower probability of being assisted by a relative or no one during childbirth, compared to preceding birth interval of less than two years.

Other elements of reproductive behaviour associated significantly with childbirth attendant include desirability of a pregnancy, family planning practise and antenatal care. Mistimed pregnancies are associated with higher probabilities of a TBA or a relative assisting during childbirth, compared to desired pregnancies. Births to women who have ever used modern family planning methods are associated with lower probabilities of non-medical delivery attendant, compared to births among women who have never used any family planning methods. The probabilities of non-medical delivery attendant (especially no one or a relative) reduces steadily with increasing frequency of antenatal care visits during pregnancy.

The accessibility of delivery health care facilities clearly plays an important role in the type of care received during childbirth. The probabilities of having a non-medical delivery attendant are higher for those living more than 5 km away from the nearest health facility providing delivery care. In addition, those who would take more than two hours to get to the nearest delivery health care service have higher probabilities of a TBA or no delivery attendant, compared to those who would take less than one hour to get to the nearest delivery health facility. The presence of a TBA within a community is associated with an increased probability of a TBA assistance and a reduced probability of assistance by a relative or other unskilled person during delivery. However, the presence of a TBA in a community does not seem to influence the probabilities of medical assistance or no assistance during childbirth

5.4.2.2 Variations in delivery attendant between communities and between women

The parameter estimates for the community and the woman random effects on delivery attendant are presented in Table 5.9.

Table 5.9 Parameter estimates for random effects variance for delivery attendant (Standard errors given in brackets), 1993 KDHS

Random Effects Variance	TBA	Relative	No one
Community level constant			
- TBA	0.21 (0.061)*	-	-
- Relative	-0.06 (0.040)	0.08 (0.044)	-
- No one	-0.04 (0.047)	0.04 (0.039)	0.02 (0.061)
Woman level constant			
- TBA	0.87 (0.121)*	-	-
- Relative	-0.54 (0.090)*	0.84 (0.105)*	-
- No one	-0.31 (0.110)*	-0.43 (0.102)*	1.06 (0.162)*

Note: medical attendant is reference category.

The probability of a birth being delivered by a TBA versus a medical attendant varies significantly between communities. A large amount of variation in the probabilities of non-medical versus medical assistance during delivery is observed between women, particularly for the case of no assistance versus medical assistance.

The estimates of community and family level variances can be used to estimate the extent to which communities or families are consistent in delivery care with respect to non-medical versus medical assistance during childbirth. Assuming there is no extra multinomial variation and the level 1 residuals e_{ij} have a standard logit distribution with mean zero and variance $\pi^2/3$, the intra community correlation coefficient for TBA assistance is given by 0.21/(0.21+0.87+3.29) = 0.048, implying little homogeneity in TBA assistance within communities. Only 5 per cent of the unexplained variation in probabilities of TBA versus medical assistance can be attributed to unobserved community factors.

Women seem to be consistent to some extent in the type of delivery care they receive during subsequent births. The intra family correlation coefficient for TBA assistance is given by (0.21+0.87)/(0.21+0.87+3.29) = 0.25. For assistance by a relative or no one, the correlation coefficients are 0.20 and 0.24 respectively. Thus, 25 per cent, 20 per cent and 24 per cent of the total unexplained variation in a TBA, a relative or no one versus medical delivery attendant respectively is attributable to unobserved woman or family factors.

5.4.3 Discussions on Delivery Care

Factors influencing place of delivery are very similar to factors associated with childbirth attendant, and include a wide range of socio-economic, demographic and service accessibility factors. This would be expected, given the high correlation between the two indicators of delivery care. However, a few exceptions are observed. The length of the preceding birth interval has a significant effect on delivery attendant, but not on the type of place of delivery. The effect of a long birth interval (more than 3 years) compared to a short birth interval (less than 2 years) is evident for assistance by a relative or no one, versus medical assistance during childbirth. However, the effect of birth interval on the probability of a TBA versus medical assistance during childbirth is not significant. Another factor observed to have a significant effect on delivery attendant and not place of delivery is the presence of a TBA within a community. The presence of a TBA within a community is associated with an increased probability of TBA assistance and a reduced probability of assistance by a relative or other unskilled persons, while the probabilities associated with no medical delivery assistance remain unchanged. Thus, it would appear that where a TBA is unavailable, the common substitute would be a relative of the pregnant woman or other unskilled persons. This result has important implications for program interventions.

Further analysis on delivery care focussed on specific subgroups to determine if health care behaviour for these subgroups would be determined by a different set of factors. First, determinants of place of delivery for rural residents was examined, paying particular focus on the importance of the presence of a TBA within a community. However, the results showed that the place of delivery for rural residents is determined by the same set of factors that are associated with place of delivery in the overall sample, and the presence of a TBA within a cluster remained non-significant. Secondly, analyses were also carried out separately for first births and higher order births. Again, the set of factors affecting place of delivery for the two subgroups seemed fairly similar to factors identified as important in the overall sample. In particular, results from the analysis for cases of higher birth order was fairly consistent with the results from the overall analysis, leading to the selection of exactly the same set of factors The only factor observed to be important for first order births and not the overall sample is the relationship to the head of the household. For first order births, women who were spouses to the household heads seemed more likely to deliver at home, compared to those who were themselves the household heads. This might partly reflect the autonomy of single mothers with respect to decisions on health care utilization.

5.5 Summary and Conclusions

The regression results show that maternal health care in Kenya is determined by a range of socio-economic and cultural factors associated with the woman or her household, her demographic status or reproductive behaviour relating to a specific birth, and factors relating to availability and accessibility of health services within the community in which the family lives. In addition to these factors, maternal health care is also significantly influenced by unobservable factors relating to a specific pregnancy or birth, the woman herself or her family, as well as the community where she lives.

Among the socio-economic and cultural factors considered, the region of residence, urban/rural residence, household socio-economic status, maternal education, maternal employment status and ethnicity are observed to be important The socio-economic status of the household, measured by household amenities and possessions, is particularly important, influencing frequency and timing of antenatal care visits as well as delivery care. Although previous studies had identified maternal education as an important determinant of maternal health care, this analysis indicates that maternal educational attainment has an important effect on delivery care, but no significant effect of education was observed on either timing or frequency of antenatal care visits. It is possible that maternal educational attainment is a strong determinant of whether or not a mother receives antenatal care. However, for those who receive some antenatal care, education does not play a significant role in determining the timing or frequency of the antenatal care visits.

With respect to demographic factors and reproductive behaviour relating to individual women and specific pregnancies or births, important factors include marital status, birth order, preceding birth interval, age at first birth, desirability of a pregnancy, ideal family size, and family planning practice. In particular, the desirability of a specific pregnancy and family planning practise emerged as very important, being significantly associated with both the frequency and timing of antenatal care visits, as well as delivery care. This supports the arguement that ambivalence towards pregnanacy is an obstacle to receiving appropriate maternal health care. Previous studies had suggested that women with mistimed or unwanted pregnancies are less likely than those with a wanted pregnancy to initiate early antenatal care or to make an adequate number of visits (Weller *et al.*, 1987; Joyce and Grossman, 1990). Another important factor associated with delivery care is the frequency of antenatal care visits during pregnancy. These results have important implications on the integration of family planning services with the maternal health care services.

Both distance and time to the nearest health facility were observed to have an important influence on the frequency of antenatal care visits and delivery care. However, accessibility of services did not seem to influence the timing of the first antenatal care visit. An important factor in timing of the first antenatal visit was the presence of a Community Health Worker (CHW). This implies that the CHWs are playing a positive role in influencing women living in their communities to start antenatal care early in pregnancy.

There is a significant variation in maternal health care behaviour between births to a specific woman, between women within communities, and between communities. In particular, the woman level variances for all measures of maternal health care considered in this study are quite large. The intra-class correlations show that women are highly consistent in maternal health care behaviour, but there is little homogeneity within communities, for births occurring to different women, after controlling for the effect of observed covariates. The total unexplained variation in maternal health care that is attributable to the woman effect is between 50 and 80 per cent, depending on the levels of some of the covariates, while less than 5 per cent of unexplained variation can be attributed to the community effect.

The variations in maternal health care behaviour between communities or between women depend on the levels of some of the observed covariates, which vary randomly at these levels. Specifically, the community effect on the frequency of antenatal care visits reduces with increasing distance of the community to the nearest health facility providing antenatal care. For cases where the distance to the nearest antenatal facility is more than 10 km away, the community effect vanishes. It is possible that health care behaviour by women in communities that are far away from a health facility will be significantly influenced by several unexplained factors, leading to less homogeneity within such communities. The generally low intra-community correlations could be explained by the fact that some of the important community factors influencing maternal health care utilization, such as accessibility of facilities, are already accounted for in the models.

With respect to the variation in maternal health care behaviour between families, the family effect on place of delivery depends on the distance to the nearest health facility providing delivery care. The family effect on the probability of a home delivery is greater for cases where distance to the nearest delivery care facility is more than 10 km away, compared to cases within a distance of 10 km or less. In other words, the family effect on the probability of a health facility delivery is stronger where there is easy access to a health facility. This is consistent with the observed patterns of the family effect on the frequency of antenatal care visits by rural/urban residence. In addition, the family effect on both the frequency and timing of antenatal care depend on the desirability of a pregnancy.

Two major limitations of the data analysed in this paper are worth mentioning. Firstly, a more complete and clearer picture of maternal health care utilization would require analysis of information relating to all pregnancy histories, including those pregnancies which ended up in a foetal loss. It is possible that poor maternal health care would be associated with adverse pregnancy outcomes that do not result in a live birth. However, information available for this analysis only represents cases which resulted in live births.

Secondly, some of the observed covariates relating to the characteristics of the woman, her household and the community in which she lives, refer to the time of the survey and not the time when the woman was pregnant with a particular child. This is particularly a concern with respect to the factors which may have changed during the five years preceding the survey (residence, household socio-economic status, family planning practise, and service availability and accessibility). For this reason, precise causal relationships cannot be accurately established, since some of the information may have changed over the recent years, after the birth in question. Since the data analysed relate to births within the last 5 years before the survey, it is unlikely that these factors would have changed significantly during this period. However, in a strict sense, the relationships should not be considered causal, but mere associations. These limitations would have been minimised if information on the variables which are likely to have changed within the last five years, as well as health care behaviour for all pregnancies during this period, irrespective of pregnancy outcomes, were available in a calender format.

Chapter 6

Factors Associated with Poor Birth Outcomes and Caesarean Section Deliveries in Kenya

6.1 Introduction

The commonly used indicators of poor maternal or foetal outcomes include socio-demographic risk factors, maternal health care and women's health, including her nutritional status. Socio-demographic factors such as low maternal education level, very young or old maternal age, first births and short birth interval have been linked to higher risks of poor pregnancy outcomes (Herz and Measham, 1987; Anandalakshmy *et al.*, 1993; WHO, 1994a; Gonzalez-Perez and Vega-Lopez, 1996). Furthermore, lack of appropriate maternal health care and poor nutritional status have been observed to contribute to poor pregnancy outcomes (Coria-Soto, *et al.*, 1996; Hollander, 1997)

The literature shows a fairly consistent relationship between some of the socio-economic and demographic risk factors, such as age and parity and adverse pregnancy outcomes. However, the relationship between pregnancy outcomes and birth interval, maternal education and occupation, is not as consistent. While it is hypothesised that short birth intervals are likely to increase the risk of adverse pregnancy outcomes, some studies do in fact show a relationship in the reverse direction. Similarly, although education and occupation are expected to improve pregnancy outcomes by improving women's status and access to information and services, some research findings have suggested that more educated women are more likely to experience adverse pregnancy outcomes such as premature delivery (Prazuck, *et al.* 1993). Kramer (1987) pointed out that there is need for research on the effect of factors such as maternal occupation and antenatal care on intra-uterine growth retardation and prematurity

This chapter examines factors associated with premature delivery, small baby size and Caesarean section deliveries in Kenya, based on the 1993 Kenya Demographic and Health Survey (KDHS), using multilevel logistic regression models. Preceding the analysis is an examination of the distribution of undesirable pregnancy outcomes by various factors: the background socio-economic and cultural factors; demographic factors and reproductive behaviour; maternal nutritional status; and the utilization of maternal and other reproductive health care services.

6.2 Data and Methods

The analysis is based on the 1993 Kenya Demographic and Health Survey (KDHS) data. Information obtained in the Household Questionnaire and the Woman's Questionnaire are used. The Household Questionnaire provided information for assessing household socio-economic status, based on household possessions and amenities, while the Woman's Questionnaire provided information on individual women's characteristics as well as information relating to specific pregnancies or births which occurred during the five years preceding the survey. A total of 6115 births, born to 3929 women were eligible. However, this analysis is based on only 5295 of these births which had complete information on the analysis variables. The exclusion from the analysis of cases with missing information is unlikely to bias the results, since the difference in proportions of the outcomes in the analysis sample and the overall sample are quite small (at most 0.2 per cent).

The 1993 KDHS used a multi-stage cluster sampling strategy. Multilevel models are appropriate for such data, since conventional single-level models cannot capture the hierarchy in the data. In addition, the multilevel approach also allows for the estimation of correlations within different levels. For instance, births to the same woman are likely to be correlated because they share the same mother and family environment. Similarly, births to women in the same community (village or district) may be correlated, since they share similar traditional values and are likely to experience similar socio-economic conditions within the community. Thus, multilevel logistic regression models are used to determine factors associated with premature births, small baby size and Caesarean section deliveries. The models allow for the potential correlation between the observed covariates and the random parameters. We model the outcomes using a three-level logistic regression model of the form:

$$Logit\ \pi_{ijk} = X_{ijk}^{\prime}\beta + Z_{jk}^{\prime}u_{jk} + W_{ijk}^{\prime}v_{k}$$

Where:

π_{ijk} is the probability of a given outcome for a particular birth, i, to woman, j, in community (village or district) k;

X'_{ijk} is the vector of covariates which may be defined at birth, woman or community level;

β is the associated vector of fixed parameters;

Z'_{ijk} is a vector of covariates (usually a subset of X'_{ijk}), the effects of which vary randomly at family or woman level,

W'_{ijk} is a vector of covariates (usually a subset of X'_{ijk}), the effects of which vary randomly at community level;

u_{jk} is the vector of women level random effects; and

v_k is the vector of community level random effects

The multilevel regression analyses were carried out in MIXOR (Hedeker and Gibbsons, 1996) and MLn (Yang *et al.*, 1996) statistical packages. Models for premature deliveries and baby's size at birth were based on two-level logistic regression models, fitted in MIXOR. For Caesarean section deliveries, a third level (district) was observed to be significant, which made it necessary to use MLn, capable of handling more than two levels. MIXOR implements a maximum marginal likelihood solution using multidimensional quadrature to integrate numerically over the distribution of random effects. On the other hand, MLn estimates may be based on marginal quasi likelihood (MQL) using only the fixed part of the model, or may involve adding in the higher order estimated residuals to the linear component of the nonlinear function when forming the Taylor expansion (predictive quasi likelihood - PQL). Thus, it is important to note that the random variance estimates presented in this chapter are based on different approximation procedures.

Previous studies have shown that the first order MQL sometimes largely underestimates the random variances and less biased estimates are derived from second order PQL approximation (see Rodriguez and Goldman, 1998). However, when there are a small number of level-1 units per level-2 unit, even the second order PQL may underestimate the level-2 variation (Yang *et al.*, 1996). In this analysis, the number of births per woman is rather small, ranging from one to five. Furthermore only a few women had more than one undesirable pregnancy outcome in the five years preceding the survey.

An important situation may arise when we wish primarily to have information about each individual district in the sample, yet we have a large number of districts, some of which may have rather few observations, resulting in imprecise estimates. In such a case, we may regard the districts as members of a larger population and then use our population estimates of the mean and between-district variation to obtain more precise estimates for each individual district (see Goldstein, 1995).

The sample included in the analysis has a total of 33 districts, with some districts having rather few births occurring during the 5 years preceding the survey. To compare pregnancy outcomes between different districts, residuals can be estimated for each district, and districts with substantially different residuals identified. In terms of significance testing, we would be interested in establishing whether a specific district has a smaller residual than another. Confidence intervals for the residuals are constructed so that the criterion for judging statistical significance at a given level for a pair of residuals is whether their confidence intervals overlap. The procedure adopted defines a given set of confidence intervals (simultaneous confidence intervals) for each residual, j as $u_j \pm c(s.e.)_j$, where the value c is determined so that the average over all possible pairs is equivalent to a given confidence level (Goldstein and Healy, 1995).

6.3 Preliminary Analysis

The preliminary analysis includes: an assessment of the reliability of reported 'size of baby at birth' and 'premature birth' information; and bivariate analysis examining the distribution of poor birth outcomes and Caesarean section deliveries by various factors which are likely to have an influence on the outcomes. Overall, 3.7 per cent of the 5295 births within the five years preceding the 1993 KDHS were premature 15.4 per cent were reported to be small or very small in size and 5 per cent were by Caesarean section deliveries

6.3.1 Reliability of Information on 'Size of Baby at Birth' and 'Premature Birth'

The analysis is based on mother's reports for the outcome variables premature birth, small size of baby at birth and Caesarean section deliveries Whereas reporting for Caesarean section is likely to be reliable, it may be unreliable for the other two outcomes due to the possibility of personal biases The measurement error is likely to be most critical for the 'size of baby at birth' variable, which is subject to personal perceptions and possible systematic errors Information on birth weight was not available for more than half of the cases, thus, the reported baby's size at birth, was used instead. In order to assess the reliability of 'size of baby' information we have examined, in Table 6.1, the distribution of information on 'size of baby at birth' against 'birth weight' information, for cases where birth weight information was available.

Table 6.1 The distribution of reported size of baby at birth by birth weight

Reported size of baby at birth	Birth weight (grams)		
		95% confidence interval for mean	
	Median	Lower bound	Upper bound
Very small	1800	1678	1957
Smaller than average	2500	2456	2575
Average	3000	3150	3205
Larger than average	3800	3728	3827
Very large	4250	4257	4619

The distribution of the 'size of baby at birth' information by the median birth weights or the 95 per cent confidence intervals for mean birth weights presented in Table 6.1 conform to what would be expected, suggesting that the reporting on size of baby at birth is fairly reliable. However, this would be based on the assumptions that: mothers whose babies were not weighed had a similar scale of assessment to those whose babies were weighed; and mothers whose babies were weighed assessed their baby's size independently of the birth weights. To find out if we should be treating those with birth weights and those without as distinct groups, we included in the model for small size of baby at birth, a dummy for whether birth-weight was available or not and checked the interraction with relevant socio-economic and demographic variables. None of the interactions between the birth weight dummy and the socio-economic and demographic variables was significant. Thus, there is no evidence that mothers of specific socio-economic and demographic characteristics had a general tendency to systematically misreport the size of their babies when there was no birth weight information.

Similarly, for the case of premature births, we included in the multilevel logistic model, interactions of a dummy variable for whether antenatal care was received or not, with relevant predictor variables. The basis for this analysis is the assumption that those who had attended antenatal care would have a fairly reliable idea of when the baby was due to be born. The fact that none of the interractions was significant increased our confidence on the reliability of reporting for premature births.

6.3.2 Socio-economic and Reproductive Factors Associated with Poor Birth Outcomes and Caesarean section deliveries

The socio-economic factors considered in this analysis include rural-urban residence, region of residence, maternal education, maternal employment status, household socio-economic status, partner's education, ethnicity and religion; while the reproductive factors include marital status, preceding birth interval, the age at first birth, desirability of a pregnancy and ideal family size, in addition to age at birth and birth order. The distribution of premature births, small baby at birth and caesarean section deliveries reported in the 1993 KDHS by these socio-economic and reproductive factors is given in Table 6.2.

The socio-economic and cultural factors which had a significant association with premature delivery are urban/rural residence and ethnicity. The proportion of premature deliveries is higher among urban than rural residents. With respect to ethnicity, the highest and lowest proportions of premature deliveries are observed among the Luo and the Kisii ethnic groups, respectively. It is interesting to note that these two communities predominantly reside in the same region (Nyanza province).

Region of residence and work status are observed to have a significant association with the size of baby at birth. The Western province has the highest proportion of babies reported to have been small or very small at birth, while the lowest proportion was reported in Nairobi. Unemployed women reported a higher proportion of small babies, compared to the employed women.

Table 6.2 Per cent distribution of premature births, small size of baby at birth, and Caesarean section deliveries by socio-economic and reproductive factors, 1993 KDHS

Socio-economic / Reproductive Factors	Per cent of Births			Total Cases
	Premature	Small Baby	Caesarean	
Residence	*		***	
urban	5.5	14.3	10.5	544
rural	3.5	15.5	4.4	4751
Region		**	***	
Nairobi	2.2	11.6	16.6	138
Central	4.1	14.0	8.8	591
Coast	4.9	14.4	5.3	640
Eastern	2.9	15.8	5.5	765
Nyanza	3.3	12.6	2.3	999
Rift Valley	3.6	16.3	5.5	1318
Western	3.9	18.9	2.1	845
Education Level			***	
no education	3.3	16.6	2.7	912
incomplete primary	3.3	15.4	4.5	2182
complete primary	3.5	14.6	5.1	1108
secondary and above	4.9	14.9	7.7	1093
Work Status		*		
employed	3.8	14.2	4.8	2977
unemployed	3.5	16.8	5.3	2318
Socio-economic Status			***	
low	3.6	15.4	3.6	1820
medium	3.4	15.6	4.7	2877
high	5.2	14.0	10.7	598
Partner's Education			**	
none	3.2	16.8	3.6	506
primary	3.4	15.0	4.3	2641
secondary and above	3.8	14.5	5.9	1746
no partner	5.0	19.4	7.5	402
Ethnicity	**		***	
Kalenjin	2.9	15.6	5.1	855
Kamba	3.1	16.5	4.7	553
Kikuyu	3.6	15.2	10.3	809
Kisii	1.1	12.9	2.5	365
Luhya	4.0	17.5	2.2	982
Luo	6.4	13.1	3.7	753
Meru /Embu	2.6	14.8	7.4	310
Mijikenda	3.7	15.9	3.7	326
other	3.5	15.4	5.0	342

Note: * - p<0.5, ** - p<0.01 *** - P<0.001

Table 6.2 Per cent distribution of premature births, small size of baby at birth and Caesarean section deliveries by socio-economic and reproductive factors, 1993 KDHS (continued)

Socio-economic / Reproductive Factors	Per cent of Births			Total Cases
	Premature	Small Baby	Caesarean	
Religion				
Catholic	3.5	15.3	5.3	1622
Protestant	3.8	15.2	4.9	3268
other	3.5	17.3	4.7	405
Maternal age	*	***	*	
13-19	5.3	19.0	5.6	977
20-24	3.0	13.0	4.6	1617
25-29	4.0	14.8	5.4	1334
30-34	3.2	14.3	6.1	755
35 +	2.8	18.1	2.6	612
Birth order	**	***	***	
1	5.6	19.1	8.1	1061
2-3	3.4	13.7	4.7	1665
4-5	2.8	13.4	4.1	1165
6-7	3.7	16.1	4.4	728
8 +	2.8	16.2	2.8	673
Preceding Birth Interval	***	**	***	
less than 2 yrs	2.6	13.9	3.4	1088
2-3 years	3.0	14.2	3.9	1884
more than 3 yrs	4.0	15.1	5.3	1262
first birth	5.6	19.1	8.1	1061
Marital Status		**	*	
single	5.0	19.4	7.5	402
married (monogamy)	3.6	14.5	5.0	4342
married (polygamy)	4.2	19.5	2.3	215
previously married	2.4	18.5	3.9	336
Age at first birth			**	
below 15	3.7	15.9	3.1	321
15-19 years	3.7	15.2	4.4	3307
20 yrs and above	3.7	15.5	6.5	1667
Desirability of pregnancy				
then	3.6	15.2	4.9	2519
later	4.2	15.8	5.2	1883
o more	2.8	14.8	4.8	893
Ideal Family size			***	
0-3	4.1	15.8	6.6	1790
4	3.7	15.2	4.7	2084
5-6	2.9	15.3	3.0	891
7 or more	3.4	14.9	4.0	530
All Cases	**3.7**	**15.4**	**5.0**	**5295**

Note (*) p<0.5 (**) p<0.01 (***) P<0.001

Urban-rural residence, region of residence, the woman's level of education, her partner's level of education, socio-economic status of the household and ethnicity are all observed to have a significant association with Caesarean section deliveries. The results show that the highest proportions of Caesarean section deliveries are to those living in Nairobi, those with high education, with high socio-economic status and from the Kikuyu ethnic group.

Among the demographic factors and reproductive behaviour, the age of the mother, the birth order and the length of the preceding birth interval are significantly associated with all the undesirable pregnancy outcomes. The pattern of association showing an increase in the proportion of unfavourable pregnancy outcomes with increasing preceding birth interval is surprising, given that a longer birth interval is expected to be associated with better health for the mother and hence a more favourable pregnancy outcome. The observed pattern is possibly due to the effect of maternal age, since births to older women are likely to be more widely spaced.

Apart from maternal age, birth order and the length of the preceding birth interval, another factor showing a significant relationship with the size of the newborn is marital status. The highest proportion of small babies at birth is observed among mothers in polygamous unions. Caesarean section deliveries are significantly associated with the mother's age, birth order, length of the preceding birth interval, marital status, the age at first birth and ideal family size. The highest proportion of Caesarean section deliveries is observed among single mothers, mothers who had their first births at age 20 years or above, and those whose ideal family size is no more than 3 children.

The proportion of premature births is highest among teenage mothers and does not change much for mothers aged 20 years and above. Teenagers also have the highest proportion of small babies at birth. The proportion of small babies at birth is also considerably higher for mothers aged 35 years and above, compared to those aged 20-34 years. The proportion of Caesarean section deliveries falls with age up to age group 20-24, then there is a slight rise with age thereafter, peaking at age group 30-34. The lowest proportion of Caesarean section deliveries is observed among mothers aged 35 years and above. This is probably due to the strong association between age and birth order or because older women are less likely to use modern health care

The distribution of poor birth outcomes and caesarean section deliveries by birth order appears to follow a more or less similar pattern with the highest proportion of the outcomes being reported among the first order births. The proportion of premature or Caesarean section births declines with increasing birth order, except for a slight increase for births of order six to seven. For baby's size at birth, the lowest proportions were reported among births of order two to five

6.3.3 Maternal Health Care Behaviour, Maternal Nutritional Status and Biological Factors Associated with Poor Birth Outcomes and Caesarean Section Deliveries.

Appropriate maternal health care has been identified as important in preventing adverse pregnancy outcomes for both the mother and the baby. Besides maternal mortality, studies have demonstrated the importance of antenatal care in reducing other adverse pregnancy outcomes such as perinatal mortality, low birth weight and premature delivery (Ahmed and Das, 1992, NSO and MI, 1993; Cona-Soto *et al.*, 1996; Hollander, 1997). In addition to maternal health care, the general health care behaviour, especially in matters relating to reproduction, are also likely to influence pregnancy outcomes. For instance, family planning can reduce the number of adverse pregnancy outcomes by reducing the number of high risk pregnancies and unsafe abortions.

The health status of a woman can have a very dramatic impact on her quality of life and productivity, and the life of her newborn. One of the most relevant components of women's health is their nutritional status. Poor nutritional status is one of the factors with the largest impact on intrauterine growth retardation and premature birth in both the developing and the developed countries (Berendes, 1993). Several studies in different parts of the world have identified short maternal stature as a risk factor of adverse pregnancy outcomes, such as, perinatal death, premature birth, low birth weight and Caesarean section deliveries (Voorhoeve, *et al.*, 1984a, Martorell, 1991;

Mavalankar *et al*., 1994; Achadi *et al*., 1995). Apart from height, studies have shown that other maternal anthropometric indicators (pre-pregnancy weight, weight gain in pregnancy, body mass index (BMI) and mid-upper arm circumference) are also significantly associated with perinatal outcomes (Efiong, 1979; Mavalanker *et al*., 1994; Sharma *et al*., 1994; Amal-Nasir, 1995; Achadi *et al*., 1995; Pelletier *et al*., 1995).

The 1993 KDHS took height and weight measurement for women who had births in the 5 five years preceding the survey. The height and weight measurements were used to derive the body mass index (BMI) and weight-for-height scores based on different reference populations. This analysis uses the weight-for-height scores based on the WHO reference population. The weight-for-height scores rather than BMI are used in the analysis because the BMI figures were not adjusted for the expected weight gain for the currently pregnant or recently pregnant women.

In addition to the factors already discussed, some biological factors are also likely to influence pregnancy outcomes. Multiple births may influence both premature delivery and the baby's size at birth, while the sex of the child may have an influence on its size at birth. Table 6.3 gives the distribution of premature births, small size of baby and Caesarean section deliveries by maternal health care, maternal nutritional status and biological factors, based on the 1993 KDHS.

Table 6.3 Per cent distribution of premature births, small baby size and Caesarean section deliveries by maternal health care, maternal nutritional status and biological factors, 1993 KDHS

Factors Associated with Birth Outcomes	Per cent of Births			Total Cases
	Premature	Small Baby	Caesarean	
Timing of first antenatal visit	**	***		
first trimester	4.9	16.1	4.6	732
second trimester	3.5	15.0	4.9	3529
third trimester	2.4	13.8	6.3	848
never	7.0	26.3	2.7	186
Frequency of antenatal visits	*	***	***	
none	7.0	26.3	2.7	186
1-2	5.5	18.1	4.7	530
3-4	3.4	14.8	4.3	2310
5-6	3.4	13.9	4.8	1487
7 or more	3.1	15.2	7.9	782
Tetanus Injection	***	***	*	
none	7.4	23.7	5.8	447
single	3.1	14.8	3.9	2065
two or more	3.4	14.4	5.7	2783
Family Planning practise			***	
never used any	3.6	15.9	3.7	2419
used only traditional	2.8	15.2	5.0	757
ever used modern	4.1	14.8	6.4	2119
Weight-for-Height		*	***	
less than 100	4.5	18.5	3.3	942
100 - 120	3.2	14.9	4.1	2755
more than 120	3.9	14.3	7.4	1598
Height			***	
less than 150 cm	3.1	19.2	11.7	291
150 - 160 cm	3.3	15.6	5.5	2643
more than 160 cm	4.2	14.7	3.6	2361
Nature of Birth	***	***		
single birth	3.4	15.0	5.0	5148
multiple births	12.2	28.6	6.1	147
Sex of child		***		
male	3.5	12.2	5.3	2645
female	3.8	18.5	4.6	2650
All Cases	**3.7**	**15.4**	**5.0**	**5295**

Note: (*) p<0.5 (**) p<0.01 (***) - P<0.001

Table 6.3 shows that the indicators of the quality of antenatal care, such as the frequency of antenatal care visits and receiving tetanus injections, are significantly associated with all the birth outcomes considered. In addition, ever use of family planning methods is associated with Caesarean section deliveries; and timing of the first antenatal check is associated with both premature delivery and size of newborn. The highest proportion of premature births were observed among those who did not have any antenatal health care and among those who did not receive any tetanus injections. Similarly, the highest proportion of small babies was observed among those who never attended antenatal care and those who did not receive any tetanus injections. The highest proportion of Caesarean section deliveries were among those who made seven or more antenatal care visits during pregnancy and those who had at least at one time used modern family planning methods.

Maternal nutritional status is associated with the size of baby at birth and Caesarean deliveries, but not with premature births. The highest proportion of small babies is observed among mothers with low weight-for-height scores and short stature (less than 150 cm). Mothers of short stature also seem more likely to have Caesarean section deliveries, but those with low weight-for-height scores are less likely to have Caesarean section deliveries than their other counterparts.

Other factors showing significant associations with undesirable pregnancy outcomes include the type of birth and the sex of child. Multiple births are more likely to be premature than single births and a higher proportion of small babies are observed among multiple births or female babies.

Bivariate analysis can yield spurious relationships, particularly where there are significant associations between the covariates of interest. To be able to identify the important risk factors more precisely it is necessary that the analysis takes into account the effect of the other important factors at the same time. The next section presents results of such analyses based on multilevel logistic regression models.

6.4 Results of Multilevel Logistic Regression Analyses

For more efficient estimation of parameters in the final regression models, it was desirable to collapse some of the categories of the covariates with fairly similar parameter estimates. This was applicable for the case of ethnicity, birth order and tetanus injection. For ethnicity, estimates for ethnic groups with relatively higher or lower than average probabilities of the outcome variables were obtained separately, while the other groups having more or less average probabilities of the outcome variables were all grouped into one category. With respect to birth order and tetanus injection, only the first order births seemed different from the others and receiving two or more tetanus injections did not seem different from a single tetanus dosage

6.4.1 Factors Associated with Premature Delivery

The parameter estimates and odds ratios for premature delivery are presented in Table 6.4. The estimates show that the quality of antenatal care is a particularly important factor in premature deliveries. Other factors observed to be important include the region of residence, ethnicity and birth order. The socio-economic factors do not seem to have a significant influence on premature deliveries. Although maternal education, for instance, had been observed to be a risk factor for preterm deliveries in Burkina Faso (Prazuck *et al.*, 1993), this study shows no variation in preterm deliveries by maternal education when other socio-demographic and health related factors are controlled for

Table 6.4 The parameter estimates and average odds ratios of premature deliveries, 1993 KDHS

Parameter	Estimate †	Standard error	Average Odds Ratio
Fixed Effects			
Constant	-0.95	0.666	
Region (Central Province)[1]			
Nairobi	-1.77*	0.878	0.17
Coast	0.24	0.595	1.27
Eastern	-0.24	0.637	0.79
Nyanza	-1.83*	0.656	0.16
Rift Valley	-0.07	0.512	0.93
Western	-0.32	0.610	0.73
Ethnic Group (Kikuyu)[1]			
other	-0.39	0.506	0.68
Kisii	-0.14	0.804	0.87
Luhya	0.16	0.550	1.17
Luo	1.96*	0.584	7.10
First Birth (higher order births)[1]	0.82*	0.244	2.27
No antenatal care (7 or more visits, starting in first trimester)[1]	-0.29	0.608	0.75
Frequency of antenatal visits (7 or more visits)[1]			
1-2	1.62*	0.468	5.05
3-4	0.51	0.360	1.67
5-6	0.27	0.347	1.31
Timing of antenatal care (1st trimester)[1]			
2nd trimester	-0.65*	0.310	0.52
3rd trimester	-1.73*	0.490	0.18
Tetanus injection (no tetanus injection)[1]			
at least one injection	-1.12*	0.348	0.32
Multiple Births	1.94*	0.421	6.96
Random Effect			
Woman level standard deviation	2.18*	0.348	

(†) estimates based on maximum marginal likelihood solution , obtained using MIXOR
(1) represents reference category
(*) - significant at 5 per cent level

Nairobi and Nyanza provinces are associated with significantly lower odds of premature deliveries than the Central province, with corresponding average odds ratios of 0.17 and 0.16, respectively. The other provinces are not significantly different from Central Province. With respect to ethnicity, the Luo have very high proportions of premature deliveries, compared to the Kikuyu. The average odds of a premature birth among the Luo is about seven times that of the Kikuyu. Although the Luo are associated with very high odds of premature delivery, they predominantly reside in Nyanza province, a region associated with one of the lowest odds of premature deliveries. An interaction between region and ethnicity was not significant, primarily because of small numbers of observations. However, it was clear that in Nyanza province, there was a clear dichotomy between the Luo, with a high proportion of premature births, and the Kisii, who had a lower proportion of premature births.

The first order births are associated with significantly higher odds of premature deliveries. Compared to higher order births, first births have more than double the odds of a premature birth. A biological factor that has a strong association with premature delivery is multiple births. The average odds of a premature delivery for multiple births is about seven times the odds for single births.

The quality of antenatal care (measured by frequency of antenatal visits, tetanus injections and timing of antenatal care) has a significant influence on premature delivery. The average odds of premature deliveries for those who received only one or two antenatal care visits exceeded the odds for those who received seven or more visits by a factor of five. Receiving at least one tetanus toxoid injection is associated with reduced odds of premature births by a factor of one-third. Even though an early start for antenatal care might be expected to improve maternal health and thus reduce incidence of premature delivery, those who started antenatal care late in pregnancy are observed to be associated with lower odds of premature births compared to those who started antenatal care earlier. This result should not be interpreted to imply that late start of antenatal care reduces the chances of prematurity. It is possible that early medical care would be sought for pregnancies with complications and such pregnancies are at a higher risk of ending prematurely. Furthermore, this observation could be as a result of measurement error in the reporting of prematurity, since it is possible that some women who started antenatal care late in pregnancy may have been unaware that the births were premature

A significant variation in premature births is observed between different women after taking into account the effects of the observed covariates, as evidenced by the multilevel parameter. This implies that there are unobservable factors relating to individual women or their families which put some of them at an increased risk of a premature delivery. The intra-family correlation coefficient for premature deliveries is 0.59, implying that almost 60 per cent of the total unexplained variation in premature births is attributable to unobserved factors relating to the woman or her family.

6.4.2 Factors Associated with the Size of the Baby at Birth

Table 6.5 presents the parameter estimates and average odds ratios for small size of the baby at birth. Despite the strong association between premature delivery and baby's size at birth, the two seem to be influenced by rather different sets of factors.

None of the socio-economic and cultural factors, other than region, seem to be significantly associated with the baby's size at birth when other significant factors are controlled for. Furthermore, of the demographic factors included in the analysis, it is only birth order which shows a significant association with the baby's size. The proportion of babies reported to be small or very small at birth was significantly higher in Western than in Central province. First order births are about 1.6 times more likely to result in small babies than higher order births

Table 6.5 The parameter estimates and the average odds ratios for small size of the baby at birth, 1993 KDHS.

Parameter	Estimate †	Standard error	Average Odds Ratio
Fixed Effects			
Constant	-2.00	0.220	
Region (Central Province)[1]			
Nairobi	-0.29	0.339	0.75
Coast	-0.01	0.189	0.99
Eastern	0.09	0.180	1.09
Nyanza	-0.08	0.182	0.92
Rift Valley	0.22	0.166	1.25
Western	0.46*	0.182	1.58
First birth (higher order births)[1]	0.48*	0.107	1.62
Tetanus injection (No injection)[1]			
at least one injection	-0.65*	0.141	0.52
Height of Mother (150 - 160 cm)[1]			
less than 150 cm	0.41*	0.207	1.51
more than 160 cm	-0.20	0.100	0.82
Weight-for-height score (100 - 120)[1]			
less than 100	0.32*	0.125	0.38
more than 120	-0.10	0.109	0.90
Sex of child (male)[1]			
female	0.59*	0.092	1.80
Multiple births (single birth)[1]	1.10*	0.209	3.00
Random Effects			
Woman level standard deviation	1.03	0.131	

(†) Estimates based on maximum marginal likelihood solution, obtained using MIXOR
(1) represents reference category
(*) significant at 5 per cent level

Among the quality of antenatal care variables, only tetanus injection was significant in this model. Babies whose mothers had received at least one tetanus injection had about half the odds of being small at birth, compared to those whose mothers had no tetanus injection

Maternal nutritional status, based on the weight-for-height WHO percentiles, was associated with the size of the newborn. Babies born to mothers with low weight-for-height score were more likely to be small at birth, compared to those born to mothers with average weight-for-height score. Maternal height is also observed to be important. Babies born to shorter mothers (less than 150 cm in height) were more likely while those whose born to taller mothers (more than 160 cm in height) were less likely to be small at birth, compared to those whose mothers were of medium height (150-160 cm).

Other factors influencing the size of a baby at birth are the sex of the child and the type of birth. Female babies and multiple births are more likely to be small, compared to male babies and single births with average odds ratios of 1.8 and 3.0 respectively.

As in the case of premature delivery, there is a significant unexplained variation in size of baby at birth between different women. The intra-family correlation coefficient for a small baby at birth is 0.25, implying that about a quarter of the total unexplained variation in small baby's size is attributable to unobserved factors relating to the woman or to her family.

6.4.3 Factors Associated with Caesarean Section Deliveries

In the analysis of Caesarean section deliveries, second order PQL using MLn failed to converge, hence, the results presented were based on first order MQL approximations, even though we are aware they could be biased. A comparison of the woman-level random parameters obtained using first order MQL with the MIXOR estimates for the models of premature deliveries and baby's birth size indicated that the MQL estimates were lower by about one-third. However, the parameter estimates for the fixed effects were not significantly different for the two estimation procedures. The apparent underestimation of the woman-level random parameters obtained using the first order MQL is most probably due to the small number of births per woman in the sample (See Goldstein, 1995; Yang *et al.*, 1996). For this reason, estimates of intra-unit correlations are not calculated for Caesarean section deliveries, since they are likely to be biased The parameter estimates and the odds ratios for Caesarean section deliveries are presented in Table 6.6.

The interpretation of the results for Caesarean section deliveries should be done with care, since higher odds of Caesarean section deliveries could have both positive and negative implications. While some of the factors, such as maternal height and birth order, are likely to be associated with an increased risk of difficult delivery leading to Caesarean sections, the socio-economic indicators are likely to influence Caesarean sections mainly through their association with the utilization of appropriate delivery care services. Some of the difficult deliveries requiring Caesarean section deliveries are likely to result in more adverse pregnancy outcomes, such as maternal or perinatal mortality, if appropriate delivery care is not received.

The odds of Caesarean section deliveries are influenced by the socio-economic status of the households The average odds of Caesarean section deliveries among births to women in households of high socio-economic status are higher than the odds for women in households of medium socio-economic status by a factor of 1 88. Compared to births in households of low socio-economic status, births to women from households of high socio-economic status have more than twice the odds of Caesarean section deliveries This observation may be explained by the fact that women from households of high socio-economic status are more likely to receive appropriate delivery care, as opposed to their counterparts from households of low socio-economic status. A substantial proportion of difficult deliveries requiring a Caesarean section among women in households of low socio-economic status are unlikely to receive such care.

Table 6.6 The parameter estimates and average odds ratios for Caesarean section deliveries, 1993 KDHS.

Parameter	Estimate†	Standard error	Average Odds Ratio
Fixed Effects			
Constant	-3.43	0.226	
Socio-economic Status (medium)[1]			
low	-0.17	0.171	0.84
high	0.63*	0.203	1.88
Age Group (20-24 years)[1]			
13-19	-0.09	0.223	0.91
25-29	0.32	0.193	1.38
30-34	0.52*	0.224	1.68
35+	-0.20	0.299	0.82
First birth (higher order births)[1]	0.78*	0.202	2.18
Family Planning Practise (never used any method)[1]			
used only traditional	0.23	0.223	1.26
ever used modern	0.41*	0.157	1.51
Height of Mother (150 - 160 cm)[1]			
less than 150 cm	0.93*	0.245	2.53
more than 160 cm	-0.41*	0.157	0.66
Random Effects Variance			
District level - Intercept	0.25*	0.113	
Woman level - intercept	2.86*	0.381	

(†) estimates based on first order MQL approximation, obtained using MLn
(1) represents reference category
(*) significant at 5per cent level

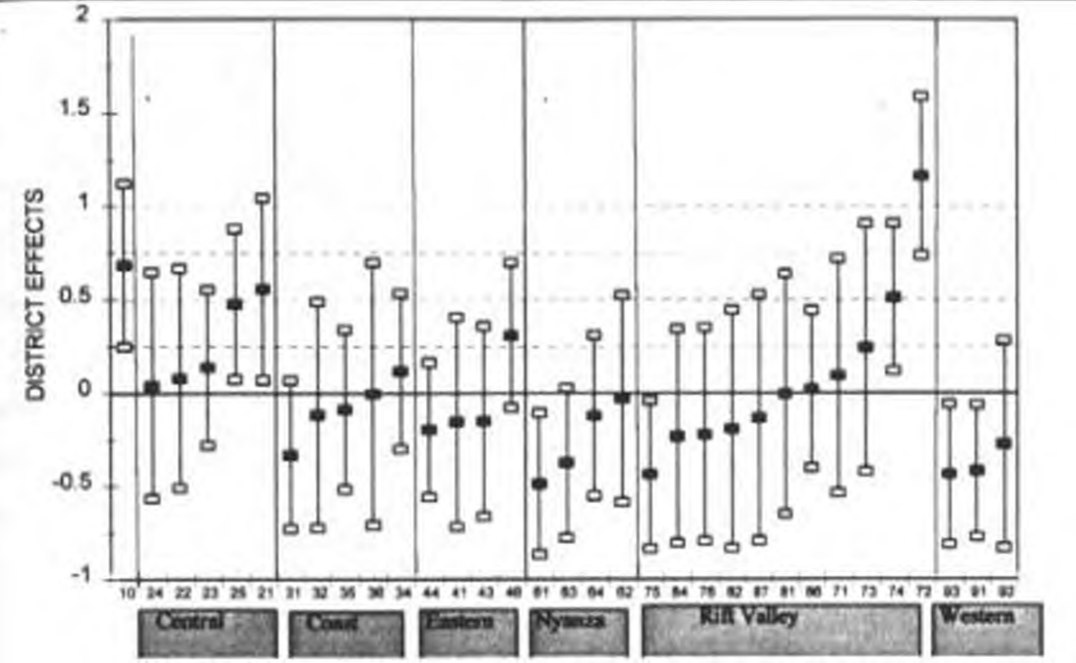
Demographic factors observed to have a significant effect on Caesarean section deliveries include birth order and maternal age. The age group 20-24 years is associated with lower odds of Caesarean section deliveries compared to age group 30-34 years. Mothers aged 30-34 years have an average odds of Caesarean section deliveries exceeding those for mothers aged 20-24 years by a factor of 1.7. The odds of Caesarean section deliveries is also higher among first births. Compared to higher order births, first births have twice the odds of Caesarean section deliveries.

Ever use of family planning appears to be associated with Caesarean section deliveries. Mothers who have ever used a modern family planning method are more likely to have a Caesarean section delivery, compared to mothers who have never used any method of family planning. This result is not surprising, since women who have ever used modern family planning methods are more likely to seek appropriate delivery care, as opposed to their counterparts who had never used any family planning method. It should be noted that family planning practice is used here as an indicator of health care behaviour by women in relation to reproductive matters.

Maternal height is strongly associated with Caesarean section deliveries. The odds of a Caesarean section delivery for mothers who are less than 150 cm tall are greater than for mothers who are 150-160 cm and those who are taller than 160 cm by a factor of 2.5 and 3.8 respectively.

There is a large variation in Caesarean section deliveries between different women. This is expected, since women who have undergone a Caesarean section delivery are at an increased risk of having a repeat in subsequent births. In addition, the probability of Caesarean section deliveries varies significantly between districts. To interpret the district variability, simultaneous confidence intervals for district level residuals are used to compare the district effect on Caesarean section deliveries, after controlling for the observed significant covariates. Any two districts whose confidence intervals do not overlap are associated with different effects on Caesarean section deliveries. The simultaneous confidence intervals for district level residuals are presented in Figure 6.1.

Figure 6.1 Simultaneous 95 per cent confidence intervals for district level residuals for Caesarean section deliveries, 1993 KDHS



District Codes

10-Nairobi 24-Nyandarua 22-Kirinyaga 23-Muranga 25-Nyeri 21-Kiambu 31-Kilifi 32-Kwale 35-Taita Taveta 36-Tana River 34-Mombasa 44-Machakos 41-Embu 43-Kitui 46-Meru 61 Kisii 63 Siaya 64 Homa Bay 62-Kisumu 75-Nandi 84-TransNzoia 76 Narok 82 Elgeyo Marakwet 87-W Pokot 81-Baringo 86-U.Gishu 71-Kajiado 73-Laikipia 74-Nakuru 72-Kericho 93-Kakamega 91-Bungoma 92-Busia

From Figure 6.1, it can be seen that different regions of the country have varying proportions of Caesarean section deliveries. The districts in Western, Nyanza and Coast (except Mombasa) provinces are, on average, associated with lower observed than expected rates of Caesarean section deliveries, while Nairobi and the districts in Central province are associated with higher observed than expected rates of Caesarean section deliveries. Overall, Kericho, Nairobi, Nakuru, Nyeri and Kiambu districts are associated with above average Caesarean section deliveries, while Kisii, Siaya, Nandi, Bungoma and Kakamega districts are associated with below average Caesarean section deliveries. The simultaneous confidence intervals for district level effects, however, show little variation in Caesarean section deliveries between districts within province, except for the Rift Valley province. Within the Rift Valley province, Kericho district has a significantly higher than expected Caesarean section deliveries, compared to Nandi, Trans Nzoia, Narok, Elgeyo Marakwet, West Pokot, Baringo, Uasin Gishu and Kajiado districts. Nakuru district also has a significantly higher than expected Caesarean section deliveries than Nandi district

The regions associated with lowest odds of Caesarean section deliveries (Western, Nyanza and Coast provinces) are all known to be associated with the highest infant and maternal mortality levels in the country (National Council for Population and Development (NCPD) [Kenya], Central Bureau of Statistics (CBS) [Kenya] and Macro International (MI), 1994; Population Studies and Research Institute (PSRI) and UNICEF, 1996) This may imply that appropriate delivery care is not received for a substantial proportion of difficult deliveries in these regions requiring a Caesarean section. Such cases would probably result in more adverse pregnancy outcomes, including stillbirths and maternal morbidity and mortality.

6.5 Discussions

In general, the results from this analysis are consistent with most previous studies in terms of the risk factors of poor birth outcomes and Caesarean section deliveries. In particular, the study confirms an increased risk of poor birth outcomes for first births, for mothers with poor nutritional indicators and for mothers who do not use appropriate reproductive health care, including maternal health care. However, some of the factors previously identified as important, such as maternal educational attainment, do not emerge as statistically significant in the current study.

It is necessary to provide possible explanations to the fact that some factors identified as important risk factors of pregnancy outcomes in previous studies do not show statistical significance in this analysis. Possible explanations may be that the majority of previous studies on birth outcomes have used hospital-based data, and in many cases, these studies have not controlled for correlations between births to the same mother or within the same community. It is important to note that hospital-based data, especially from developing countries, are likely to be selective, since some subgroups of the population are likely to visit the health facilities only when they develop complications. Naturally, such subgroups will have higher than average risks of adverse pregnancy outcomes.

Another possible explanation is in relation to the statistical procedures employed. Analyses that do not take into account confounding factors may be misleading, since some of the observed effects could be spurious. This probably explains why mother's age, for instance, is significant in the bivariate analysis, but not in the multivariate model. Thus, the apparent high risk of undesirable pregnancy outcomes observed among the teenagers in the bivariate analysis may not necessarily be the effect of age per se, but more likely to be a result of the teenagers' poor nutritional status, poor health care or a high proportion of first order births.

It is also possible that some of the background factors may not have direct associations with the birth outcomes, but do influence these outcomes indirectly through the intermediate factors. Further analysis of the association between the different birth outcomes show that these outcomes are significantly associated with each other. For instance, there is a significant association between premature births and both the size of baby at birth and Caesarean section deliveries. This implies that factors affecting any of the pregnancy outcomes may have an indirect influence on the other outcomes as well. Therefore, it is important to explore the association structure between the variables concerned, in order to better understand potential pathways through which various factors might either directly or indirectly influence birth outcomes. This forms the focus of Chapter Seven.

6.6 Conclusions and Recommendations

Quality antenatal care has been observed to play an important role in reducing the incidence of premature deliveries. Appropriate antenatal care is likely to reduce the incidence of premature deliveries through early detection, treatment and effective management of conditions that may cause premature deliveries. It is, therefore, particularly important that pregnancies that are at a high risk of ending prematurely (such as first order births or multiple births) receive appropriate antenatal care. The significant association between ethnic group and premature delivery may indicate the significant role played by cultural practices on pregnancy outcome. Thus, a qualitative study would be useful in identifying undesirable cultural practices that need to be discouraged.

In relation to the size of the baby at birth, the results illustrate that improved maternal nutrition has an important role to play in the development of the unborn baby. Maternal nutrition programmes are, therefore, likely to be beneficial not only for the health of the mother, but for that of the newborn as well. Such programs should have special focus on the high risk groups, such as first pregnancies.

It is important that births involving first pregnancies or mothers who appear to be stunted (less than 150 cm in our case), receive appropriate delivery care. Such pregnancies are more likely to require a Caesarean section during childbirth. The observed associations between the odds of Caesarean section deliveries and the socio-economic indicators suggest the need for accessible and affordable appropriate delivery care, especially in Nyanza, Coast and Western provinces.

In summary, quality antenatal care, appropriate maternal nutrition and appropriate delivery care are all important in reducing the incidence of undesirable pregnancy outcomes. Thus, there is need for integrated maternal health programs that include antenatal care, delivery care and maternal nutrition. For this to be effective, close collaboration would be required between the formal health sector and the informal community based services. For instance, the current efforts to train traditional birth attendants (TBAs) on appropriate maternal health care should include aspects of maternal nutrition. Furthermore, the TBAs should be well informed of cases likely to be at a high risk of a difficult delivery that would need timely referral to appropriate health facilities to avert adverse pregnancy outcomes. All the indicators of unfavourable pregnancy outcomes addressed in this analysis vary significantly by region. As such, programmes aimed at addressing these issues should be sensitive to the regional disparities. In all cases, first order births are observed to be particularly at a high risk of poor pregnancy outcomes and caesarean tiondelivenes. It is, therefore, crucial that first pregnancies receive appropriate maternal health care.

There exists a significant variation in pregnancy outcomes between different women, even after controlling for the significant observable factors, implying that there are unobservable personal woman characteristics which put some women at particularly high risk of poor pregnancy outcomes and Caesarean section delive than others. Women who have already experienced any of these outcomes should be advised on the need for appropriate nutrition and maternal health care due to the increased possibility of having a repeat incidence.

Chapter 7

Pathways of the Determinants of Poor Birth Outcomes and Caesarean Section Deliveries in Kenya

In the previous chapter we found that poor birth outcomes and caesarean section deliveries are influenced primarily by maternal health care and nutritional status. The background socio-economic factors were observed to have a strong effect on the odds of a Cesarean section delivery, but no significant effect was observed on the odds of premature births or small baby size at birth. Maternal educational attainment, for instance, did not show any significant effect on these birth outcomes, contrary to what is expected. It is possible that some of the background socio-economic and demographic factors, such as maternal education, would influence the pregnancy outcomes indirectly, through the intermediate factors. This chapter explores the association structure between the various factors that are likely to contribute to poor birth outcomes so as to establish the indirect paths between these factors and the outcomes. The results will improve our understanding of the determinants of adverse pregnancy outcomes and hence, help us to identify specific elements that need to be targeted by the safe motherhood programmes.

7.1 Methods

The data used is based on births reported to have occurred within the five years preceding the 1993 Kenya Demographic and Health Survey (KDHS). In the two previous chapters we found evidence of a significant correlation between births to the same mother for the variables of interest, such as maternal health care and birth outcomes. Hence, we cannot assume complete independence of the observations.

One way of eliminating potential bias in the results due to multiple births per woman would be to include only one birth per woman, for example: the most recent birth. This would result in a substantial reduction of the sample, which would affect the significance of the associations. Specifically, there would be loss of statistical power to give evidence of a significant association even where an association actually exists. On the other hand, when multiple births per woman are used without controlling for the woman effect, some non-existent associations may appear important, as p-values will be reduced.

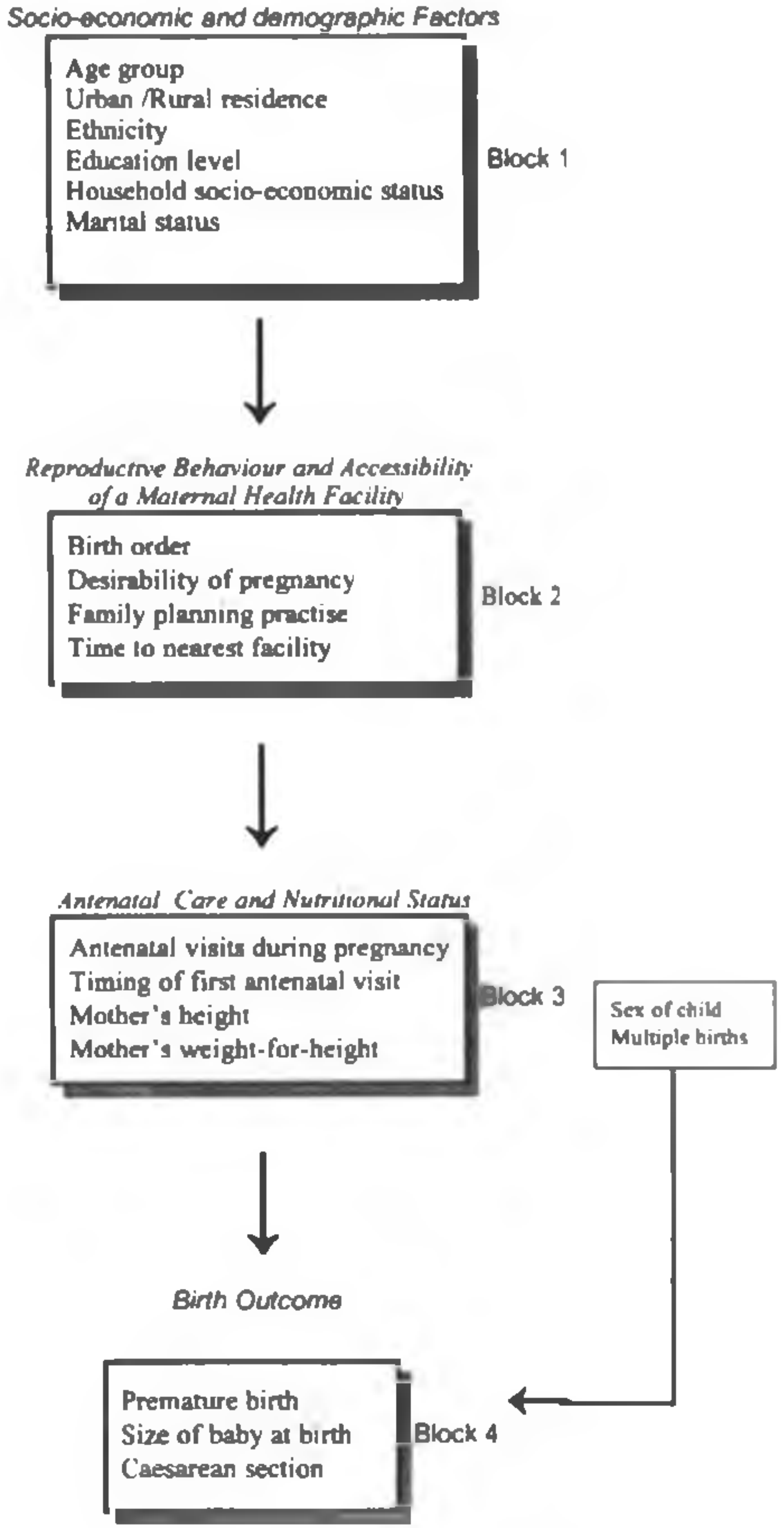
We note the fact that the first option of using only one birth per woman would be appropriate if all births to a woman were perfectly correlated, while the latter option would be ideal if births to the same mother were uncorrelated. Neither of these options is applicable in our case. Since excluding some cases from the analysis is likely to further increase the anticipated problem of sparseness of cells, we choose to include all the births, even though we are aware of the potential bias. A significance level of 0.01 rather than 0.05 is used during model selection to account for the expected reduction in p-values. In order to assess the degree of potential bias in the results, some comparisons are made with models based on only one birth per woman. Furthermore, for selected key variables, comparisons are made with equivalent multilevel models that take into account the woman random effect.

Graphical loglinear models are used to explore the association structure between the various factors which are likely to contribute to adverse pregnancy outcomes, either directly or indirectly. The modelling procedure entails partitioning the variables into blocks, ordered to form a chain, based on possible causal direction. The analysis involves the study of intra-block associations, as well as associations between variables in different blocks, to provide direct and indirect pathways from each of the determinants to the poor birth outcomes. Any association between variables from the same block is assumed to be non-causal, while associations between variables from different blocks are considered as potentially causal. Linking the blocks into a chain gives direct and indirect paths between any variables and their potential determinants (see for example Mohamed, Diamond and Smith, 1998).

The factors included in this analysis are partitioned into four distinct blocks, ordered to form a chain. At the end of the chain is the block consisting of indicators of poor birth outcomes: premature delivery, smallsize of the baby at birth; and Caesarean section delivery. The outcomes are directly influenced by maternal health care and nutritional status, grouped in the third block. Alongside these factors are the biological factors, such as multiple births and sex of child, which may also have a direct influence on the birth outcomes. The second block consists of factors relating to reproductive behaviour and accessibility of health services. These factors may contribute to poor birth outcomes, either directly or indirectly, through the factors in the third block. In the background, we have the socio-economic and demographic factors which are likely to influence birth outcomes through the intermediate factors, but may at the same time have a direct influence on the birth outcomes. The conceptual framework presented in Figure 7.1 shows potential pathways of the determinants of poor birth outcomes and Caesarean section deliveries.

The number of cases included in the analysis ranges from 6107 for the model containing only Block 1 variables to 5336 for the complete model containing variables in all the blocks. The per cent distribution of variables in the complete model is given in Appendix 7.1.

Figure 7.1 Framework for pathways of the determinants of premature births, small baby's size at birth and Caesarean section deliveries.



The final models are selected by stepwise backward elimination procedure. Starting with the model with all edges present, the non-significant edges are excluded, one at a time, starting with the least significant edge, until only the significant edges ($p<0.01$) are left in the model.

7.2 Associations Between the Background Socio-economic and Demographic Factors

The socio-economic and demographic factors included in the analysis are maternal age, maternal education level, urban-rural residence, household socio-economic status, ethnicity and marital status. Some of the important factors such, region and partner's education, were not included due to their strong correlation with some of the variables already in the model. For instance, region is strongly correlated to ethnicity and partners education has a strong correlation with both household socio-economic status and maternal education level. The edge exclusion deviances based on the two-way interactions model are presented in Table 7.1.

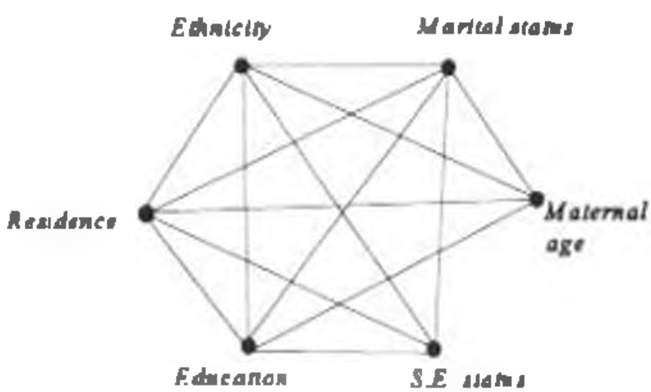
Table 7.1 The edge exclusion deviances for the associations between the socio-economic and demographic factors (The degrees of freedom are given in brackets), 1993 KDHS

Variable	Age	Education	Residence	S-E Status	Ethnicity
Age	-				
Education	290.4 (4)**	-			
Residence	11.0 (2)*	40.9 (2)**	-		
S-E status	1.1 (4)	370.8 (4)**	652.1 (2)**	-	
Ethnicity	48.2 (10)**	158.2 (10)**	153.8 (5)**	193.4 (10)**	-
Mar.status	417.4 (4)**	76.7 (4)**	15.1 (2)**	20.4 (4)**	104.3 (10)**

Note (*) Significant at 1 per cent level ($p<0.01$)
(**) Significant at 0.1 per cent level ($p<0.001$)

The total deviance to explain in Block 1, which is the deviance against complete independence of the six background socio-economic and demographic factors, is 4169 on 957 degrees of freedom. The residual deviance of the two-way model presented in Table 7.1 is 991 on 880 degrees of freedom, implying that a substantial proportion of the variation is accounted for by the two-way interactions. The results show that all the background socio-economic and demographic factors in Block 1, except maternal age and household socio-economic status are dependent on each other, given the rest of the factors. The particularly high edge exclusion deviances for the interactions between age and marital status and between household socio-economic status and both rural/urban residence and education are due to the fact that single mothers are more likely to be young and women of high socio-economic status are more likely to be highly educated and reside in urban areas. The independence graph for the associations between Block 1 variables is presented in Figure 7.2. Any two variables connected with an edge have a significant association, given the rest of the factors in this block, while the absence of an edge implies conditional independence between the factors.

Figure 7.2 Independence graph for background socio-economic and demographic factors, 1993 KDHS



The independence graph shows that household socio-economic status is conditionally independent of maternal age, given ethnicity, urban-rural residence, maternal education level and marital status. The apparent relationship between maternal age and ethnicity is a reflection of regional or cultural differentials in fertility behaviour. For instance, a relatively high proportion of births will occur among younger women in communities where women marry and start child bearing early, as opposed to those where marriage usually occurs at a later age.

It is important to note that some of the associations observed between given factors and ethnicity may not necessarily be the effect of ethnicity per se, but could reflect the association between these factors and region, since region and ethnicity are highly correlated. Specific ethnic groups live predominantly in particular regions of the country and rarely in others, as shown in Table 7.2

Table 7.2 Per cent distribution of ethnicity by region, 1993 KDHS

	Ethnic Group						
Region	Kalenjin	Kamba	Kikuyu	Luhya	Luo	others	**Total cases**
Nairobi/Central	0.3	4.8	77.7	3.8	9.3	4.1	880
Coast	-	8.4	3.7	1.9	7.1	78.9	776
Eastern	0.1	58.7	1.0	0.4	-	39.7	911
Nyanza	0.5	0.4	0.3	3.8	57.8	37.3	1116
Rift Valley	62.7	0.6	14.2	12.1	3.1	7.2	1524
Western	2.9	0.1	1.3	87.2	1.9	6.6	900
All	**16.2**	**10.7**	**15.6**	**17.4**	**13.9**	**26.1**	**6107**

The decision to include only one of the two variables in the analysis was taken since including both would lead to sparse cells which would create problems in the modelling process. In a preliminary analysis, separate models with ethnicity and with region were run and the results compared. The model with ethnicity explained a greater proportion of the total variation, hence the decision to include ethnicity rather than region.

7.3 Reproductive Behaviour and Accessibility of Maternal Health Care Facility

Three factors relating to reproductive behaviour and one factor used as an indicator of the accessibility of a facility offering maternal health care were included in Block 2. The reproductive factors were birth order, desirability of the pregnancy and ever use of family planning, while time to the nearest delivery care facility was used as a measure of accessibility of maternal health care. The loglinear models at this stage included the variables in both Blocks 1 and 2. The analysis of the association structures involved the study of the associations between factors in Blocks 1 and 2 (inter-Block associations), as well as associations between the Block 2 variables (intra-Block associations), conditioned on factors in both Block 1 and Block 2. The edge exclusion deviances for the two-way interactions with the Block 2 variables are presented in Table 7.3.

Table 7.3 Edge exclusion deviances for the factors relating to reproductive behaviour and service accessibility factors (The degrees of freedom are given in brackets), 1993 KDHS

Variable	Birth order	Desirability of pregnancy	FP use	Facility access
Birth order	-			
Desir. Preg	191.4 (2)**	-		
FP use	30.75 (2)**	38.73 (1)**	-	
Facility access	3.93 (2)	0.07 (1)	5.19 (1)	-
Age	2584 (4)**	22.26 (2)**	9.51 (2)*	1.45 (2)
Education	268.3 (4)**	16.05 (2)**	131.5 (2)**	9.61 (2)*
Residence	24.61 (2)**	13.47 (1)**	39.99 (1)**	330.1 (1)**
S-E status	19.25 (4)**	3.20 (2)	90.18 (2)**	10.16 (2)*
Ethnicity	59.6 (10)**	67.73 (5)**	170.2 (5)**	28.59 (5)**
Mar.status	291.1 (4)**	213.9 (2)**	12.79 (2)*	1.63 (2)

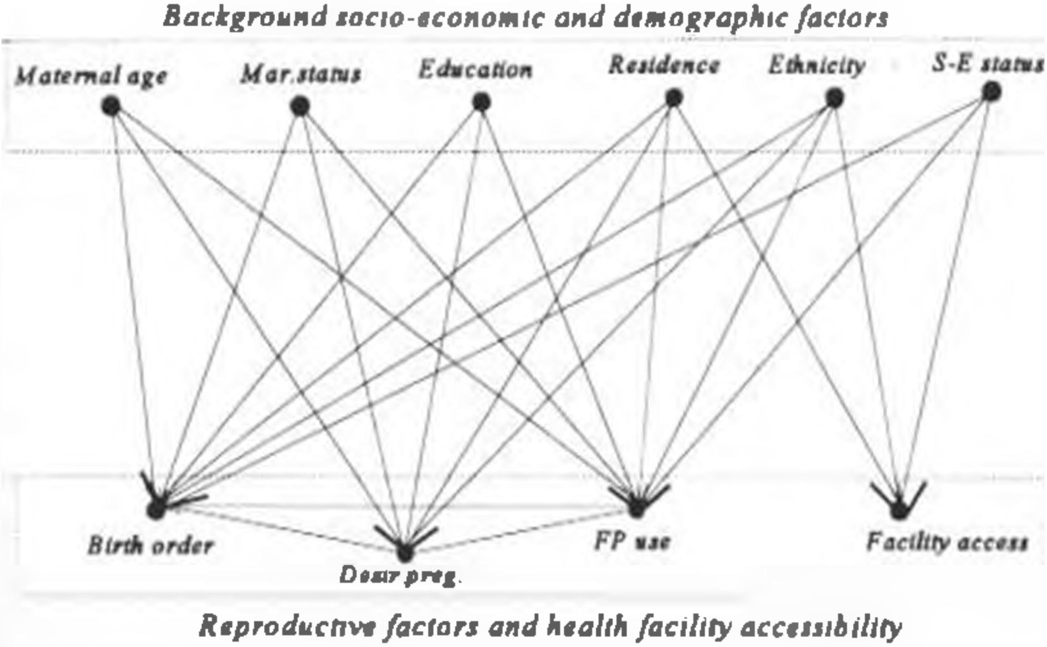
Note (*) Significant at 1 per cent level ($p<0.01$)
(**) Significant at 0.1 per cent level ($p<0.001$)

The strikingly large edge exclusion deviance for the association between age and birth order is expected, since higher birth orders are more likely to occur among the older than younger women. The other associations with fairly large edge exclusion deviances are between birth order and desirability of a pregnancy, marital status and the level of maternal education; between desirability of a pregnancy and marital status; between family planning use and ethnicity; and between health facility accessibility and urban-rural residence. The conditional probabilities show that women with high education or those who are single are less likely to have higher order births, compared to their counterparts with lower education or those who are married. The strong association between ethnicity and ever use of modern family planning methods is a reflection of the regional and/or cultural disparities in the use of modern family planning methods. As would be expected, urban residents have better access to maternal health care services than rural residents.

The independence graph for the intra-block associations of reproductive behaviour and service accessibility, as well as the associations with the background socio-economic and demographic characteristics is given in Figure 7.3.

The independence graph in Figure 7.3 shows that ever use of family planning, desirability of a pregnancy and birth order are mutually dependent given background socio-economic and demographic characteristics and accessibility of a maternal health facility. However, each of these three factors is conditionally independent of maternal health facility accessibility given urban-rural residence, ethnicity and household socio-economic status.

Figure 7.3 Reproductive behaviour and service accessibility factors (intra-block and inter-block associations), 1993 KDHS



The graph further shows that birth order and ever use of modern family planning methods are dependent on all the socio-economic and demographic factors included in the analysis, given the rest of the factors in Blocks 1 and 2. The desirability of a pregnancy is also dependent on all, except household socio-economic status. Accessibility of maternal health facilities is dependent on urban/rural residence, household socio-economic status and ethnicity. The association between maternal health facility accessibility and ethnicity is a reflection of the regional disparities in the distribution of health facilities in the country.

As mentioned earlier, this analysis uses multiple births per woman, which might create spurious associations, since births to the same mother are likely to exhibit some similar characteristics. For instance, some women may be more likely to have unintended (unwanted or mistimed) pregnancies than others. One way of assessing the degree of potential bias resulting from use of multiple births per woman is through a comparison of the results obtained in the loglinear analysis with results based on multilevel logit models that controls for correlation between births to the same mother.

When all explanatory variables are categorical, logit models have corresponding loglinear models. Agresti (1996) illustrates that a main effects logit model with no interaction corresponds to a two-way loglinear model of homogenous association. The same estimated effect of an explanatory variable on a given response variable results from logit or loglinear parameters. In this analysis, we used logit models to examine the factors in Blocks 1 and 2 associated with unintended pregnancies, taking into account the woman random effect. The results of the multilevel logistic model for unintended (mistimed or unwanted) pregnancy are presented in Table 7.4.

The results of the multilevel logistic regression are fairly consistent with the results of the loglinear analysis. All the variables which showed a significant association with desirability of pregnancy in the loglinear analysis are significant in the multilevel logistic regression analysis. The loglinear analysis had shown that desirability of a pregnancy is independent of household socio-economic status and maternal health facility accessibility. These results are confirmed by the multilevel logistic analysis, which shows that these variables are not significantly associated with the odds of an unintended pregnancy.

In addition to the observed covariates, the odds of unintended pregnancies are also significantly influenced by unobservable characteristics of the woman. The variation in odds of unintended pregnancies between women is fairly large. The intra-woman correlation, derived from the estimate of the woman random effect, implies that almost half of the total unexplained variation in unintended births is attributable to unobserved characteristics of the woman.

Table 7.4 Parameter estimates and average odds ratios for unintended pregnancies, 1993 KDHS

Parameter	Estimate†	Standard error	Average odds ratio
Fixed Effects			
Constant	1.01	0.273	
Rural residence (urban residence)[1]	0.56*	0.171	1.75
Ethnic Group (Kalenjin)[1]			
Kamba	0.74*	0.195	2.10
Kikuyu	0.01	0.171	1.01
Luhya	0.01	0.163	1.01
Luo	-0.39*	0.170	0.68
other	-0.37*	0.152	0.69
Maternal education (none /pri.incomplete)[1]			
primary complete	0.43*	0.125	1.54
secondary and above	0.03	0.134	1.03
Household Socio-economic Status (low)[1]			
medium	0.11	0.106	1.12
high	-0.01	0.183	0.99
Maternal Age (below 20 years)[1]			
20-34 years	-0.57*	0.133	0.57
35 years and above	-0.46*	0.198	0.63
Marital Status (single)[1]			
married	-2.70*	0.202	0.07
previously married	-2.39*	0.249	0.09
Birth Order (1st birth)[1]			
2-4	0.95*	0.126	2.59
5 +	2.11*	0.171	8.25
Ever used modern family planning methods (never used modern methods)[1]	0.57*	0.103	1.77
Time to Nearest Maternal Health Facility more than 1 hour (less than 1 hour)[1]	0.02	0.105	1.02
Random Effect			
Woman level (standard deviation)	1.75*	0.105	

(†) Estimates based on maximum marginal likelihood solution, obtained using MIXOR
(*) significant at 5 per cent level
(1) represents reference category

7.4 Antenatal Care and Maternal Nutritional Status

Antenatal care and maternal nutritional status are likely to have a direct influence on birth outcomes such as premature delivery, size of the baby at birth and Caesarean section deliveries. Appropriate antenatal care is measured in terms of the frequency of visits during pregnancy and the timing of the first visit. These two variables were combined into one in order to retain those who never attended any antenatal in the analysis, while at the same time ensuring we do not have structural zero cells, since this might create problems in the modelling process. Maternal nutritional status is based on maternal height and weight-for-height. These three variables make up the third set of factors (Block 3). The edge exclusion deviances for the two-way associations between these variables with Blocks 1 and 2 variables are presented in Table 7.5.

Table 7.5 Edge exclusion deviances for the factors relating to antenatal care and maternal nutritional status (The degrees of freedom are given in brackets), 1993 KDHS

Variable	Timing /frequency of antenatal care	Height	Weight-for-height
Ante.time/freq.	-		
Height	25.55 (12)	-	
wt-for-ht	42.79 (12)**	268.7 (4)**	-
Birth order	24.35 (12)	9.13 (4)	7.87 (4)
Desir. preg	42.12 (6)**	1.20 (2)	6.74 (2)
FP use	91.70 (6)**	2.57 (2)	128.4 (2)**
Facility access	22.85 (6)**	0.31 (2)	24.91 (2)**
Age	40.51 (12)**	5.66 (4)	23.35 (4)**
Education	149.9 (12)**	61.1 (4)**	29.38 (4)**
Residence	36.40 (6)**	8.54 (2)	63.40 (2)**
S-E status	144.6 (12)**	12.76 (4)	120.6 (4)**
Ethnicity	210.1 (30)**	368.9 (10)**	113.3 (10)**
Mar status	38.18 (12)**	7.70 (4)	10.09 (4)

Note: (*) Significant at 1 per cent level ($p<0.01$) (**) Significant at 0.1 per cent level ($p<0.001$)

The edge exclusion deviances in Table 7.5 suggest that the association of antenatal care with ethnicity, the level of education and household socio-economic status are fairly strong. An examination of the conditional probabilities reveal that the Luo have the highest probability of having no antenatal care. On the other hand, the Kikuyu have the lowest probability of having no antenatal care, but at the same time more likely to start antenatal care late in pregnancy. Those with at least secondary level education or in households of high socio-economic status have significantly higher probabilities of starting antenatal care early (in the first trimester) and of receiving at least four antenatal care visits during pregnancy.

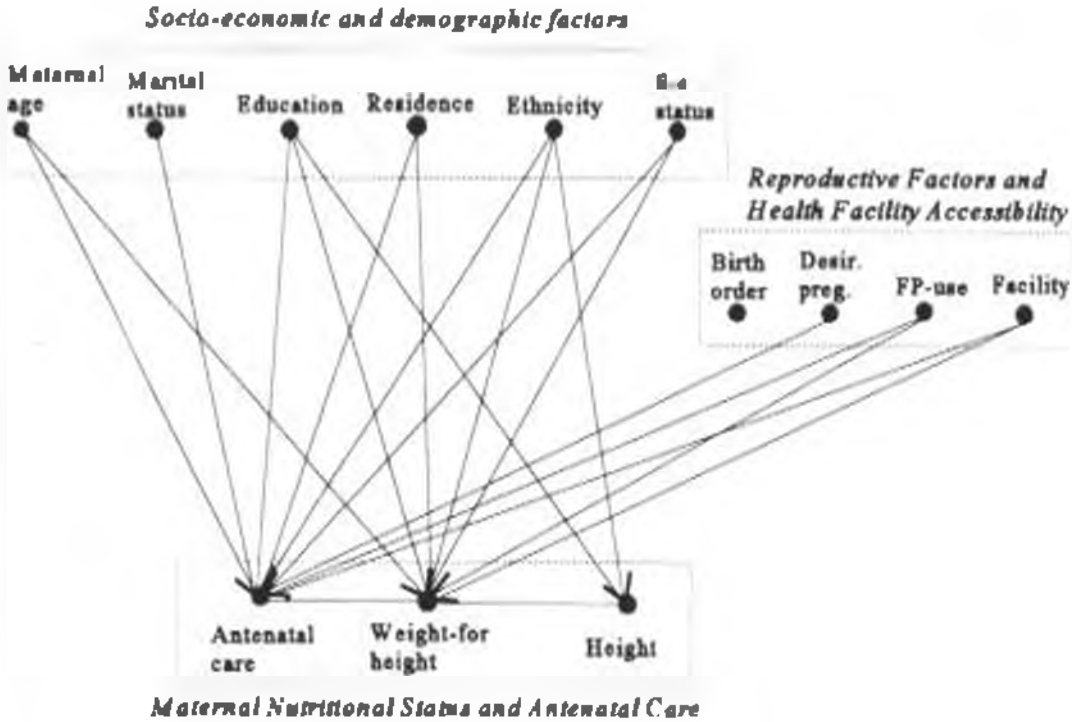
The indices of nutritional status (namely height and weight-for-height), are strongly associated with each other, as illustrated by the large edge exclusion deviance. The conditional probabilities show that short women are likely to have high weight-for-height. Like antenatal care, maternal nutritional status, measured in terms of weight-for-height, has significant associations with almost all the factors in the first and second blocks. The relationships with household socio-economic status and ever use of family planning are particularly strong. The conditional probabilities of weight-for-height score indicate that high household socio-economic status and ever use of modern family planning methods are associated with high weight-for-age score.

On the other hand, height has significant associations only with ethnicity and education level. Even though height is a measure of nutritional status, the strong association between height and ethnicity can partly be attributed to genetic differences between the various ethnic groups. Members of specific ethnic groups tend to be shorter or taller than others, even when they are exposed to the same environment. However, the fact that conditional probabilities of height, given education, show that those with low education are more likely to be shorter than those with higher educational attainment is probably an indication of higher nutritional status for the later. Figure 7.4 illustrates the intra-block associations of the variables in the third block as well as inter-block associations with factors in Blocks 1 and 2.

Figure 7.4 summarises the direct associations with Block 3 factors based on inter-block and intra-block associations. Antenatal care is associated with all the factors in

Blocks 1 and 2, except birth order. Weight-for-height is also associated with all these factors, except marital status, birth order and the desirability of a pregnancy. On the contrary, height is only associated with ethnicity and education level, but is conditionally independent of all the other factors. The intra-block associations show that weight-for-height is associated with both antenatal care and height. However, antenatal care is independent of height, given weight-for-height and the rest of the factors in the first two blocks.

<u>Figure 7.4 Antenatal care and maternal nutritional status (intra-block and inter-block associations), 1993 KDHS</u>



7.5 Associations with Poor Birth Outcomes and Caesarean section deliveries

The outcomes included in this analysis (premature delivery, small baby's size at birth and Caesarean section deliveries) may be influenced directly or indirectly by the factors in the three blocks discussed in the previous sections. In addition to these factors, birth outcomes may also be directly influenced by some biological factors, such as multiple births or the sex of child. The direct associations between the outcomes and the potential determinants are shown by the edge exclusion deviances given in Table 7.6.

Table 7.6 Edge exclusion deviances for the associations with premature births, small baby at birth and Caesarean section delivery (The degrees of freedom are given in brackets), 1993 KDHS

Variable	Premature birth	Small baby	Caesarean section
Premature birth	-		
Small baby	219.0 (1)**	-	
Caesarean section	10.65 (1)*	2.97 (1)	-
Antenatal care	40.28 (6)**	25.95 (6)**	10.80 (6)
Height	4.82 (2)	3.49 (2)	31.39 (2)**
wt-for-ht	2.96 (2)	5.14 (2)	29.54 (2)**
Birth order	15.45 (2)**	22.63 (2)**	29.47 (2)**
Desir preg	0.15 (1)	0.04 (1)	0.12 (1)
FP use	2.92 (1)	1.02 (1)	17.44 (1)**
Facility access	1.97 (1)	0.57 (1)	10.80 (1)*
Maternal age	11.27 (2)*	18.69 (2)**	10.54 (2)*
Education	8.01 (2)	1.18 (2)	20.95 (2)**
Residence	6.49 (1)	0.46 (1)	29.77 (1)**
S-e status	7.52 (2)	0.33 (2)	40.69 (2)**
Ethnicity	18.95 (5)*	8.34 (5)	65.45 (5)**
Mar status	4.81 (2)	8.86 (2)	6.69 (2)
Sex of child	0.27 (1)	38.45 (1)**	2.16 (1)
Multiple births	25.01 (1)**	20.87 (1)**	0.52 (1)

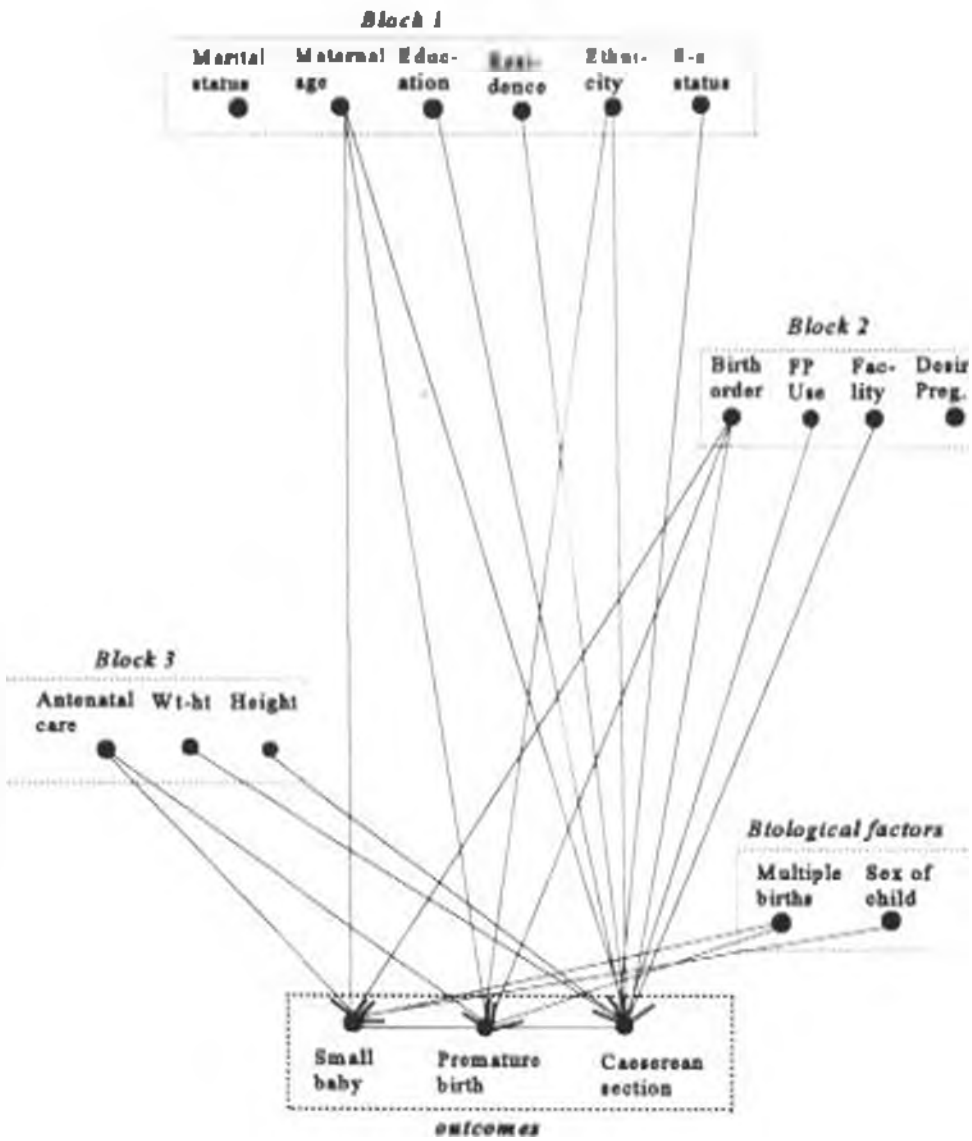
Note: (*) Significant at 1 per cent level ($p<0.01$)
(**) Significant at 0.1 per cent level ($p<0.001$)

The large edge exclusion deviance for the association between the small size of the baby at birth and premature deliveries is not surprising, since premature babies usually have low birth weights. Other relatively large edge exclusion deviances are also observed in the associations of Caesarean section deliveries with ethnicity, household socio-economic status and maternal height. The highest probabilities of Caesarean section deliveries are observed among the Kikuyu women, those in households of high socio-economic status and among short mothers. With respect to the baby's size at birth, the most important factors include sex of child, multiple births and birth order. The intra-block and inter-block associations of the undesirable birth outcomes are presented in Figure 7.5.

Figure 7.5 shows that the size of baby at birth and Caesarean section delivery are independent, given the timing of birth (premature or full term) and the rest of the factors. However, both the size of the baby at birth and Caesarean section delivery are associated with the timing of birth. Premature babies are more likely to be small at birth, and also more likely to be by Caesarean section delivery, compared to full term babies.

The factors which have a direct influence on premature delivery include maternal age, ethnicity, birth order, antenatal care and multiple births. The small size of the baby at birth is influenced by the same set of factors, except ethnicity. In addition to the above factors, the sex of the child also influences the baby's size. A number of factors have a direct influence on Caesarean section deliveries. These include socio-economic and cultural factors, such as maternal education level, urban-rural residence, household socioeconomic status and ethnicity, demographic factors (maternal age and birth order); health care factors, such as service accessibility and ever use of modern family planning methods; and maternal nutritional status, measured in terms of maternal height and weight-for-height.

Figure 7.5 The direct associations with premature births, small baby at birth and Caesarean section delivery, 1993 KDHS

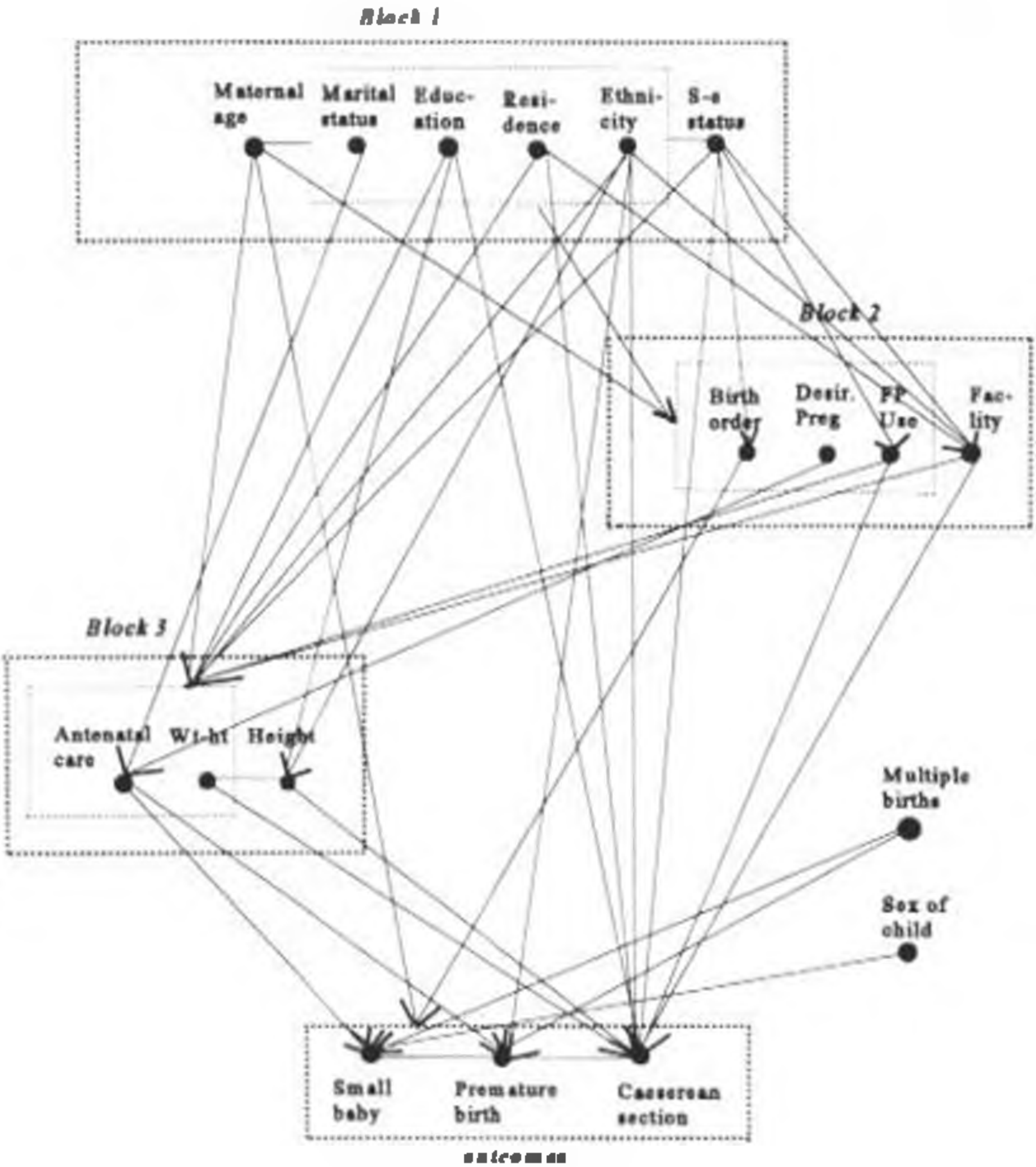


Some of the variables do not have a direct association with the birth outcomes, but may influence these outcomes indirectly through some other factors For instance, even though the desirability of a pregnancy and marital status have no direct association with poor birth outcomes, namely, premature births and size of baby at birth, these factors are likely to influence these outcomes through antenatal care. Possible paths in the system are numerous and difficult to present clearly in a single graph. Hence, the variables are re-arranged such that variables which are dependent on each other, and have given common associations, are put in sub-blocks. The set of edges connecting each of the variables in a sub-block to a particular variable may then be replaced with a single edge connecting the variable to the sub-block. However, if the associations are only with some of the variables in a sub-block, then edges are drawn to these particular variables (see for example, Mohamed, Diamond and Smith, 1998) The intra-block and inter-block associations for the whole framework, presented in Figure 7.6, gives both direct and indirect associations of various factors with the poor birth outcomes and Caesarean section delivery

Figure 7.6 demonstrates that all the factors in Block 1 have a direct or an indirect association with premature birth, baby's size at birth and Caesarean section deliveries Marital status has no direct link with these birth outcomes, but may influence them through its association with birth order and antenatal care. Maternal age, on the other hand, has both direct and indirect associations with all these birth outcomes. The socio-economic indicators (the level of maternal education, urban-rural residence and household socio-economic status) all have direct associations with Caesarean section delivery and may influence premature deliveries and the size of the baby at birth through the factors in the second and third blocks. Ethnicity has a direct association with premature births and Caesarean section deliveries, and may influence baby's size through birth order and antenatal care

Among the variables in Block 2, birth order has a direct link with all the birth outcomes. Ever use of modern family planning methods and maternal health facility accessibility have a direct association with Caesarean section deliveries and an indirect link with both premature delivery and baby's size at birth through antenatal care. The desirability of a pregnancy has no direct association with the poor birth outcomes, but is linked to premature delivery and the size of the baby at birth through antenatal care.

Figure 7.6 The direct and indirect pathways of the determinants of premature births, baby's size at birth and Casarean section births, 1993 KDHS



An important variable in this analysis, worth singling out, is antenatal care. Figure 7.7 illustrates the links between all the factors in the framework and antenatal care, ignoring all the other links

Figure 7.7 Direct associations with antenatal care, 1993 KDHS

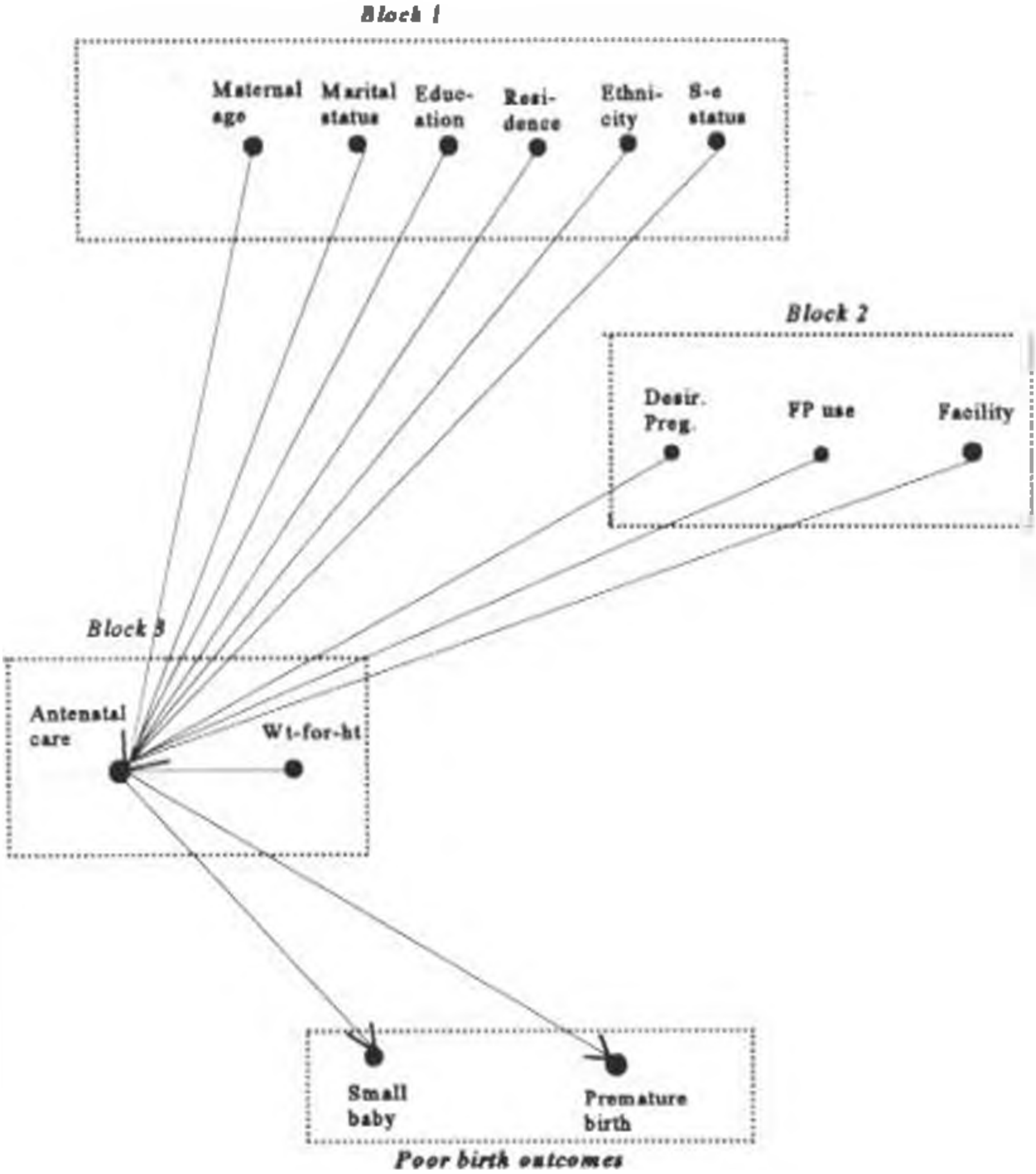


Figure 7.7 illustrates that antenatal care constitutes a central link through which many of the socio-economic and reproductive factors might influence birth outcomes. All the socio-economic and demographic factors in Block 1 and the factors relating to reproductive behaviour (except birth order) and facility access in Block 2 influence the size of the baby at birth and premature births through antenatal care, even though some of these factors also have direct associations with the poor birth outcomes.

7.6 Discussions

Apart from providing a comprehensive picture of the determinants of poor birth outcomes and Caesarean section deliveries, the analysis in this chapter sheds some light on possible explanations of some of the inconsistencies in previous studies. For example, the effect of maternal education on premature births is unclear from previous studies. It is likely that studies based on models which include factors such as antenatal care, through which education is likely to influence premature births, would conclude that education has no effect on prematurity. On the other hand, if the intermediate factors, through which education influences prematurity, are not included in the model, education would then appear to be associated with prematurity. Careful selection of variables to be included in the models would help minimise spurious association and hence lead to a more accurate identification of the important factors

As mentioned earlier, one of the major limitations of this analysis is the use of multiple births per woman, without controlling for possible correlations of outcomes between births of the same woman. One way of assessing the extent of the potential bias in the associations due to these correlations is through comparisons with equivalent multilevel logit models that take into account the woman level homogeneity. One such comparison with unintended births as the outcome variable identified exactly the same set of important factors, suggesting that it is unlikely that correlations between births to the same woman could have affected our results significantly.

Further comparisons of the direct associations with poor birth outcomes and Caesarean section deliveries, with the multilevel logit models of the same outcomes in Chapter six also suggest high consistency in the identification of important factors, with a few exceptions. One noticeable difference is with respect to maternal age, which is observed to have a significant association with both premature births and small baby's size at birth in the loglinear analysis, but not in the equivalent multilevel analysis. It is likely that the unobservable woman characteristics, which are taken into account by the multilevel models, are correlated with maternal age. As such, the models which do not control for the woman random effect would tend to identify age as an important factor. Another noticeable difference is the non-significance of the associations between the indicators of maternal nutritional status, such as weight-for-height or height and the size of the baby at birth in the loglinear analysis. It is possible that the presence of other factors, correlated with maternal nutritional status, in the loglinear model might weaken the net effect of nutritional status on the size of the baby at birth, even if they are only weakly associated with the size of the baby.

With respect to Caesarean section deliveries, again there is reasonable consistency in terms of the important factors, such as maternal height, birth order, ever use of modern family planning methods, maternal age and household socio-economic status. However, other factors sich as ethnicity, rural-urban residence, maternal education, health facility accessibility and weight-for-age score are significant in the loglinear analysis, but not in the multilevel logistic regression analysis. These factors are likely to be correlated with unobservable factors at the district or woman level which, are taken into account in the multilevel analysis.

7.7 Summary and Conclusions

This chapter has examined the associations between various sets of factors that can contribute to poor birth outcomes and Caesarean section delivenes, either directly or indirectly, through other factors. The results show a wide range of significant associations both within and between the various sets of factors. The intra-block associations show that all the socio-economic and demographic factors are associated with each other, with the exception of maternal age and household socio-economic status, which are independent, given the other factors. With respect to the variables in the second block, the factors relating to reproductive behaviour (birth order, the desirability of a pregnancy and ever use of modern family planning methods) are all associated with each other. However, these factors are independent of maternal health facility accessibility, given the rest of the factors in Blocks 1 and 2. The factors in Block 3 relating to antenatal care and maternal nutritional status are associated with each other, apart from maternal height and antenatal care, which are independent, given the rest of the factors in the first three blocks. Finally, for the birth outcomes, premature delivery is associated with both baby's size at birth and

Caesarean section delivery, but the later two variables are independent, given the rest of the factors.

The inter-block associations are perhaps more important in identifying the potential pathways of the determinants of poor birth outcomes and Caesarean section deliveries. There are a number of associations between the variables in Block 1 and those in Block 2. Similarly, a large number of significant associations are observed between the variables in Block 3 and those in both Block 1 and Block 2. Some of the variables in Block 3 are further linked to the Block 1 variables through some variable in Block 2. Finally, the poor birth outcomes, and Caesarean section delivery in the last block have direct associations with some of the variables in the three blocks. Some of the variables in Block 2 contribute to the birth outcomes through factors in Block 3, while some factors in Block 1 contribute to the birth outcomes through factors in the second or third block. Clearly, there is an enormous number of potential pathways of the determinants of poor birth outcomes and Caesarean section deliveries, considering the observed associations between factors in all the four blocks. Some of these pathways deserve particular mention.

When considering only the direct associations with birth outcomes, we would conclude that reproductive factors, such as marital status and desirability of a pregnancy, have no effect on poor birth outcomes, such as prematurity or small baby's size at birth. However, an examination of possible pathways of the determinants of these birth outcomes shows that both marital status and the desirability of a pregnancy have an indirect contribution through antenatal care. Conditional probabilities, for example, show that unintended births or births to single mothers are both associated with poor antenatal care (late start of antenatal care and inadequate number of visits), which is in turn associated with higher probabilities of a premature birth.

Results from a single model on the determinants of premature births, that includes all the factors considered in this analysis, are likely to lead to the conclusion that socio-economic factors, such as maternal education, urban-rural residence and household socio-economic status, have no significant contribution to prematurity. However, the analysis in this chapter illustrates that even though these factors have no direct association with premature births, they do have an indirect contribution through some of the intermediate factors For instance, all these factors contribute to premature births through their association with antenatal care, which in turn has a direct influence on prematurity The contribution of some of these factors could take a longer path. For example, urban-rural residence has a direct association with health facility accessibility, which in turn influences antenatal care, that is directly associated with premature births. More or less similar pathways would be applicable in the case of determinants of small baby's size at birth.

In terms of policy implications, an important finding relates to the important role of antenatal care. Antenatal care constitutes the link between many of the socio-economic factors, as well as reproductive factors, with poor birth outcomes such as prematurity and small baby's size at birth. Emphasis on appropriate antenatal care, with respect to both timing and frequency of the visits should, thus, be given priority by safe motherhood programs in Kenya Such programs should have special focus on the subgroups which have been identified to be at a higher risk of not receiving adequate antenatal care, such as women of low socio-economic status, women living in rural areas and single mothers, paying particular attention to the regional disparities

Chapter 8

Conclusions and Recommendations

8.1 Summary and Conclusions

The overall aim of this study was to improve our understanding of factors associated with poor maternal health care and adverse pregnancy outcomes in Kenya. The specific objectives were to: examine factors associated with maternal mortality in Kenya, establish determinants of maternal health care in Kenya; and identify the direct and the indirect determinants of poor birth outcomes and Caesarean section deliveries in Kenya. The conceptual framework adopted for the study is a modified version of the framework described by McCarthy and Maine (1992) on determinants of maternal mortality. The bulk of the analysis was based on the 1993 Kenya Demographic and Health Survey data. However, the chapter on maternal mortality used information from the 1994 Kenya Maternal Mortality Baseline Survey. The main statistical methods used were multilevel models, loglinear models and graphical chain models

Most previous studies on maternal outcomes in Kenya have been based on hospital data or data from specific communities and, therefore, produced results applicable only to subgroups of the population. In this study, we examined factors associated with poor maternal health care and adverse pregnancy outcomes in Kenya using data from two national surveys: the Kenya Maternal Mortality Baseline Survey of 1994; and the 1993 Kenya Demographic and Health Survey. The study acknowledges limitations in the data analysed, especially for the analysis of maternal mortality. However, the cost of comprehensive surveys providing reliable data on this subject would be substantial, hence, it is necessary to derive maximum output from existing data. It was not possible to collect population-based data specific to our study requirements due to financial constraints. The findings should be interpreted in light of the data limitations, discussed in Chapter three.

In general, the study has confirmed findings from previous studies of factors associated with maternal health care and adverse pregnancy outcomes. In addition, the use of refined statistical procedures has permitted a more comprehensive investigation of the factors involved and how they contribute to poor maternal health care and adverse pregnancy outcomes. The use of multilevel models has helped to better explain the different levels at which various factors do influence the outcomes at individual pregnancy level, at woman/family level, and at community level for population based data; or at the hospital level, for hospital-based data. Secondly, the application of graphical chain models has enabled a better understanding of the pathways through which given factors may indirectly influence the birth outcomes.

8.1.1 Factors Associated with Maternal Mortality in Kenya

The analysis of factors associated with maternal mortality in Kenya, discussed in Chapter four, used both the hospital-based and the household survey data from the 1994 Kenya Maternal Mortality Baseline Survey. The first section used the hospital in-patient data to investigate the factors influencing maternal mortality in Kenyan hospitals, using a 2-level logistic regression model. The results showed that the probability of maternal mortality depends on both the socio-economic and demographic characteristics of a particular woman and a hospital effect that was not explained by any of the variables in our data. Possible causes of the hospital effect include availability of supplies, equipment and qualified personnel, as well as hospital administration. The hospital effect on maternal mortality was observed to be stronger for women with least favourable socio-economic and demographic characteristics, such that, the risk of a maternal death for a woman aged 35 years and above who had low education (no education or only primary level education) and did not attend antenatal care was extremely high in hospitals associated with high maternal mortality levels. Consequently, attempts to reduce maternal mortality in the country should aim at reducing the incidence of high risk pregnancies and improving quality of obstetric care at the hospitals.

The second section of Chapter four examined the interrelationships between pre-disposing factors, maternal health care factors and circumstances of maternal deaths, based on the household survey data on maternal deaths among sisters of the survey respondents. An examination of the characteristics of maternal deaths suggested that the risk of a maternal death is higher for women aged 35 years and above and for first pregnancies. The results from the loglinear analysis showed pairwise associations between distance to the nearest health facility, antenatal care and place of death. Maternal deaths occurring outside the hospital were associated with long distance to a health facility and lack of antenatal care. Women who had not received any antenatal care were about three times more likely to die outside a health facility, compared to those who had received some antenatal care. Antenatal care was also associated with the use of family planning and the desirability of a pregnancy, which was in turn associated with the survival of the index child. Unintended pregnancies were less likely to receive antenatal care or result in a live birth, compared to desired pregnancies. These results have important implications for the integration of maternal health care and family planning services to achieve improved maternal outcomes for both the mother and the newborn.

8.1.2 The Determinants of Maternal Health Care in Kenya

In Chapter five, the determinants of maternal health care in Kenya were investigated using multilevel models applied to the 1993 Kenya Demographic and Health Survey data. The analysis of antenatal care, based on frequency of visits and timing of the first antenatal care visit used three-level linear regression models, while the analysis of determinants of delivery care was based on multilevel logistic and multilevel multinomial models for place of delivery and childbirth attendant, respectively.

The results showed that maternal health care in Kenya is determined by a range of socio-economic and cultural factors relating to the woman or her household; her demographic status and reproductive behaviour relating to a specific birth, and factors relating to availability and accessibility of health services within her community. Among the socio-economic and cultural factors, the region of residence, urban-rural residence, household socio-economic status, maternal education, maternal employment status and ethnicity emerged as important. The household socio-economic status was observed to be particularly important, influencing all the indicators of antenatal and delivery care, with higher household socio-economic status being associated with improved maternal health care. Maternal education had a strong effect on delivery care, showing a consistent reduction in the probability of a home delivery or non-medical delivery assistance with increasing education level

Of the demographic factors and factors relating to reproductive behaviour, important factors included marital status, birth order, preceding birth interval, age at first birth, desirability of a pregnancy, ideal family size and family planning practise. In particular, the desirability of a pregnancy and ever use of family planning methods were significantly associated with all the indicators of maternal health care. Unintended pregnancies and pregnancies to women who had never used any family planning methods were associated with late start of antenatal care, fewer antenatal care visits and higher probabilities of home deliveries and non-medical delivery attendant. This result further supports the need for improved integration of maternal health care and family planning services, which should incorporate the community based services.

The accessibility and availability of health services within communities were observed to be important in both antenatal and delivery care. An increase in the distance or time to the nearest maternal health care facility was associated with fewer antenatal care visits and higher chances of home deliveries and non-medical childbirth attendant. An important factor in the timing of the first antenatal care visit was the presence of a community health worker within a community. The presence of a traditional birth attendant (TBA) was associated with an increased probability of a TBA assistance and a reduced probability of assistance by a relative or other unskilled persons. This suggests that in communities where a TBA is not available, the common subsititute would be unskilled persons, usually a relative

In addition to the observed covariates, maternal health care was observed to be influenced by unobservable factors relating to a specific pregnancy, the woman herself and the community where she lived. The significant community effect suggested that there were unexplained factors at community level which influenced maternal health care, after taking into account the availability and accessibility of maternal health care facilities. However, the community effect on the frequency of antenatal care visits diminished for cases more than 10 km away from the nearest health facility, implying that lack of access to services reduces the homogeneity in frequency of antenatal care visits within communities. The woman or family effect on maternal health care was observed to be particularly strong, but varied depending on the levels of some of the observed covariates. Specifically, the family effect on the frequency of antenatal care visits was stronger for urban than rural residents; the family effect on both the frequency and timing of antenatal care was reduced for mistimed pregnancies; and the family effect on the probability of a home delivery was greater for cases more than 10 km away from the nearest health facility. These results imply that even though women are generally consistent in maternal health care behaviour, this consistency is reduced in cases of unplanned pregnancies or poor accessibility of services.

8.1.3 Direct and Indirect Determinants of Poor Birth Outcomes and Ceasarean Section Deliveries

Chapter six focused on factors associated with poor birth outcomes (premature delivery, small size of baby at birth) and Caesarean section deliveries in Kenya. Multilevel logistic regression models were applied to the 1993 Kenya Demographic and Health Survey data to identify factors associated with these outcomes. The results showed that the risk of a poor birth outcome or Caesarean section delivery was higher among first births than the higher order births. In addition, the quality of antenatal care received during pregnancy was observed to play an important role in premature births, while the mothers' nutritional status was significantly associated with the size of the newborn. With respect to Caesarean section deliveries, short maternal height was confirmed to be a significant risk factor. However, the observed associations between the socio-economic indicators and Caesarean section deliveries was attributed to the expected association between high socio-economic status and the use of appropriate health care

The risks of the poor birth outcomes and Caesarean section deliveries were observed to vary significantly between women, indicating that there were unexplained factors relating to individual women which put some at a higher risk of having these outcomes. Such factors may include biological factors such as genetic factors and the general health status of individual women. The likelihood of Caesarean section deliveries was also observed to vary significantly between districts. The fact that regions associated with low levels of Caesarean section deliveries are known to have the highest maternal and infant mortality levels in the country might suggest that appropriate delivery care is not received for a substantial proportion of difficult deliveries in these regions, requiring specialised obstetric care. Such cases would most probably result in a perinatal and/or a maternal death

Chapter seven extended the analysis of the determinants of poor birth outcomes and Caesarean section deliveries to establish indirect pathways of the determinants. Graphical loglinear models were used to explore the association patterns between the various factors that are likely to contribute to these outcomes. The factors were partitioned into subsets (blocks), ordered to form a chain, based on possible causal relationships An examination of both intra-block and inter-block associations showed a vast number of potential pathways of the determinants of premature births, size of baby at birth and Caesarean section deliveries The analysis showed that even though factors such as the desirability of a pregnancy, marital status, maternal education and socio-economic status have no direct association with poor birth outcomes such as premature births and small baby's size at birth, they have an indirect contribution to these outcomes through some intermediate factors In particular, antenatal care was identified as constituting an important link through which many of the socio-economic and reproductive factors would influence premature births or the size of the baby at birth.

The analysis in Chapter seven not only provided a comprehensive picture of the determinants of the birth outcomes, but also shed some light on possible explanations to some of the inconsistencies on determinants of poor birth outcomes observed in previous studies. For example, the effect of maternal education on premature births is unclear; some previous studies have shown that maternal education has no association with premature births. This study suggests that the association between education and prematurity may operate through intermediate factors such as antenatal care. As a result, the significance of maternal education in a statistical model may depend on whether or not these intermediate factors are included.

8.2 Policy Implications

Among the important findings, one key factor which cuts across all the analysis chapters is the important role of antenatal care in maternal outcomes. Lack of adequate antenatal care was identified as a principal contributing factor to maternal deaths, home deliveries, premature births and small size of the baby at birth. The other important factors such as the desirability of a pregnancy and accessibility of maternal health care were observed to influence maternal outcomes mainly through their association with antenatal care. The analysis based on graphical chains model further illustrated the central link that antenatal care constitutes between various socio-economic and demographic factors and poor birth outcome.

The inaccessibility of maternal heath care services is a major obstacle to receiving appropriate health care during pregnancy, childbirth or when obstetric complications develop. The importance of accessibility of health care services was demonstrated in the analysis of maternal deaths in the population based data, which showed that long distance to a maternal health care facility was associated with lack of antenatal care and maternal deaths occurring outside a health facility. Furthermore, the analysis of factors associated with maternal health care confirmed that the accessibility of maternal health care services is a significant factor in the frequency of antenatal care visits during pregnancy and the type of delivery care a woman receives.

In all the analyses, it is clear that there are significant unobservable factors at different levels which affect maternal health care and pregnancy outcomes. Unobservable factors relating to individual women/families and the communities (village or district) where these women live have a significant effect on their maternal health care behaviour and birth outcomes. The effect of the unexplained family-level factors was observed to be particularly strong. Such factors may include the individual families cultural values and practises, as well as biological factors directly linked to birth outcomes. For the hospital-based data, hospital factors such as administration and management of resources, qualified personnel, adequate supplies and equipment, may determine how well the hospitals deal with obstetric complications and this may make a difference between a successful outcome or a maternal death.

Most of the major findings of this study are of direct relevance to policy, mainly in relation to the provision and utilization of appropriate maternal health care services. The issues that need to be addressed include the provision of essential obstetric care at the health facilities; public awareness on the need for timely and appropriate antenatal and delivery care; better access to affordable maternal health care; and improvements in the integration of maternal health care with other reproductive health care services. The marked regional disparities in maternal outcomes and the use of maternal health care should be taken into account when addressing these issues.

The analysis of maternal mortality based on hospital data observed that the hospital effect on maternal mortality is stronger for women with less favourable socio-economic and demographic characteristics, such as low education and lack of antenatal care. Therefore, the provision of affordable essential obstetric care, particularly for the deprived groups, would have a major contribution to the reduction of maternal deaths at the hospitals. This recommendation is supported by the observed low odds of Caesarean section deliveries among women of low socio-economic status, implying that these women are less likely to receive appropriate delivery care. The need for the provision of essential obstetric care is further strengthened by the result that, even though antenatal care attendance was associated with a reduced probability of a maternal death, a significant number of maternal deaths still occurred at the hospitals among women who had received antenatal care. Hence, there is a considerable number of women who appreciate modern health care in dealing with problems relating to maternity and for whom improving quality of care at the existing facilities is likely to make a substantial contribution in reducing the incidence of maternal mortality.

In addition to the provision of essential obstetric care, ensuring appropriate antenatal care and delivery care should rank high in terms of priorities for safe motherhood programs in Kenya. There is need to raise public awareness on the importance of timely and appropriate antenatal and delivery care. Antenatal care is particularly important, given its central role in maternal outcomes. The fact that women who had never used modern family planning methods were consistently observed to receive antenatal care less often and were, as a result, more likely to have poor maternal outcomes, suggests the need for community-based reproductive health services to reach the group of women who are unlikely to visit health facilities for any reproductive matters, such as family planning, antenatal care or the management of obstetric complications.

The observed associations between the use of family planning, antenatal care and obstetric care illustrate the need for improved integration of maternal health care and family planning services. Even though there is reasonable integration of maternal health care and family planning services in Kenya, there is certainly room for improvement. The providers of these services should see the services as complementary, sharing the primary goal of improved maternal and child health and, as such, avoid focussing on one component at the expense of the other. The integration should include maternal nutrition programmes. Integration of services can greatly improve cost effectiveness, but requires careful balance so that no component is disadvantaged as a result of over-emphasis on the other. For the integration of services to be effective, close collaboration would be required between the formal health sector and the informal community based services. For example, the current efforts in Kenya to train traditional birth attendants (TBAs) should improve the TBAs' skills in identifying high risk pregnancies for which timely referral for specialised obstetric care is critical to avert adverse pregnancy outcomes for both the mother and the newborn. In addition, basic knowledge in other reproductive health issues such as family planning should be enhanced to enable TBAs be able to advise their clients effectively on seeking related reproductive health care. Similarly, the other community-based workers such as the community health workers, and the community-based distribution agents for family planning services, should be informed of appropriate maternal health care and the basic symptoms of common obstetric complications to enable them effectively advise women in their communities, especially those requiring specialised care, to seek appropriate maternal health care.

Another issue that needs to be addressed is the improvement in access to maternal health care. Long distance and/or time to the nearest maternal health care facility have been identified as obstacles in seeking appropriate maternal health care, leading to poor maternal outcomes. For example, long distance to the nearest health care facility has been observed to be associated with maternal deaths occurring outside a health facility. Communities with poor access to maternal health facilities should be well served with outreach health services, such as mobile clinics and community based services.

Apart from being accessible, the health services should be affordable to the women who need to use them. The consistent positive association between high household socio-economic status and the use of appropriate maternal health care suggests that poverty is an impediment to the use of appropriate maternal health care. Programs aimed at alleviating poverty levels in Kenya are, therefore, likely to make a significant contribution to the improvement of maternal and child health in the country.

Finally, it is important that programs aimed at improving maternal outcomes in Kenya be sensitive to the regional disparities. All the indicators of maternal health care and pregnancy outcomes have been observed to vary significantly by region. The fact that regions with the lowest levels of Caesarean section deliveries (Western, Nyanza and Coast provinces) are known to be associated with the highest maternal and infant mortality levels in the country implies that appropriate delivery care is not received for a substantial proportion of difficult deliveries in these regions. Such cases are likely to result in adverse pregnancy outcomes such as stillbirths and maternal morbidity or mortality. This result, together with the observed association between the likelihood of Caesarean section deliveries and socio-economic indicators, suggest the need for accessible and affordable delivery care, particularly in Nyanza, Coast and Western provinces

8.3 Future Research

This study has made an important contribution to a better understanding of factors associated with poor maternal health care and adverse pregnancy outcomes in Kenya. At the same time, the study has highlighted gaps in methodology as well as data sources. There is need for a more extensive population-based study that includes other adverse pregnancy outcomes, such as foetal loss (both induced and spontaneous abortions), still births and maternal morbidity, to be able to fully understand the important factors in maternal outcomes. These outcomes have not been addressed in the present study and, also, maternal mortality could not be studied more comprehensively because of lack of data. An even better understanding of the scenario would be made possible if data on time-varying factors were available at specific times when the events of interest occurred, to be able to establish precise causal relationships. The cost of such a study would no doubt be substantial, but the results would make a major contribution towards the build-up of a complete picture of safe motherhood in Kenya, which is crucial for the implementation of a successful safe motherhood programme in the country.

Even though a comprehensive study addressing the different elements of safe motherhood in Kenya would be the ideal in providing a complete picture of safe motherhood in the country, smaller scale studies addressing specific important aspect would certainly make an important contribution. Areas lacking reliable population-based data include factors associated with induced abortions and maternal morbidity and mortality.

This study has shown that there are factors at the community level, family level or hospital level, unexplained by the data analysed, which have a significant contribution to poor maternal health care and adverse pregnancy outcomes in Kenya. The hospital-based data is particularly limited, as discussed in Chapter 4. A detailed study focussing on the hospitals associated with high maternal mortality risks is necessary to help better understand specific factors at these hospitals that need to be addressed in order to reduce the maternal mortality levels. For the population-based data, it is important to better understand the community factors affecting the use of maternal health care services. This study addressed factors relating to availability and accessibility of maternal health care services within communities. However, quality of care at the existing facilities, though recognised as an important factor, was not addressed because such information was not available. Collecting detailed information on quality of care, may not be practical in a large scale population-based survey, but some information on basic indicators of quality of care such as whether qualified personnel, equipment and supplies are adequate, would help uncover some of the unexplained community factors influencing the use of maternal health care.

There are specific regions of the country which certainly require more attention. There are wide regional variations with respect to safe motherhood in Kenya, with regions such as Nyanza, Coast and Western provinces being linked to high rates of poor outcomes. In particular, the situation in Nyanza calls for urgent attention, since the region had also recorded the highest infant and child mortality rates in the country over the last few decade, with very little improvement over the years. Furthermore, the Luo ethnic group, which predominantly live in Nyanza province, were observed to have a very high rate of premature births, which calls for qualitative studies to identify any cultural practices that need to be discouraged. Studies focussing on the high risk communities would aid the development and implementation of effective intervention programmes that would have a great impact on improved maternal outcomes for the mother and the newborn in the country as a whole and, at the same time, reduce the regional disparities

This study has raised some methodological issues. In particular, the need to control for intra-unit correlations in graphical models is apparent. The graphical models have proved quite effective in providing a comprehensive picture of the determinants of an outcome, but there is evidence that some of the associations may be significantly influenced by the intra-unit correlations. Hence, further research in the development of multilevel graphical models would certainly be useful

Finally, while this study was successful in disclosing factors associated with maternal health care and adverse pregnancy outcomes in Kenya, qualitative studies focussing on cultural values and practises would contribute to further understanding of the issues. This would help towards designing more appropriate regional or community specific programmes aimed at improving maternal outcomes in the country.

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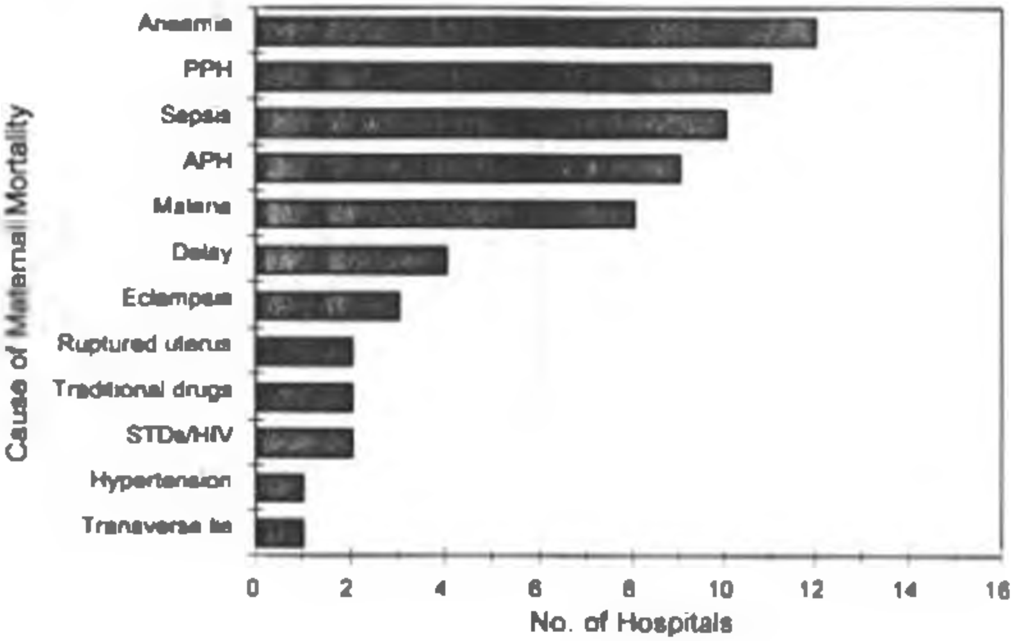
APPENDICES

Appendix 4.1 Hospital Staff Reports on the Maternal Mortality Situation at the Hospitals

The hospital staff reports indicated that the predominant causes of maternal mortality were anaemia, post partum haemorrhage (PPH), sepsis, antepartum haemorrhage (APH) and malaria, as illustrated in Figure A.1.

Figure A.1: Reported major causes of maternal mortality at the hospitals, 1994 KMMBS



Anaemia, mentioned as a major cause of maternal mortality in 12 of the hospitals, was mainly attributed to malaria, worm infestation and malnutrition, while sepsis was mainly puerperal, following Caesarean sections or home deliveries. Other causes of maternal mortality mentioned included delay in arriving at the hospitals; undiagnosed eclampsia; use of harmful traditional drugs, which often resulted in ruptured uterus or intrauterine foetal death; sexually transmitted infections, including HIV; hypertension; and delivery complications resulting from the baby lying in a transverse position.

The hospital staff reports indicated marked regional differentials in major causes of maternal mortality in Kenya. Hospitals situated in the western parts of the country, including Nyanza province (e.g. Busia, Siaya, Homabay, Kisii), and the Coastal region, including neighbouring districts in Eastern province (e.g Kilifi, Taita Taveta, Kitui), reported anaemia, malaria and delay in arrival at the hospitals as the major causes of maternal deaths at the hospital. For hospitals in the Central parts of the country and some parts of the Rift Valley with low malaria prevalence (e.g Nyeri, Embu, Baringo and Uasin Gishu), haemorrhage and sepsis were reported as the leading causes.

On maternal health care, antenatal clinic attendance was reported to be satisfactory, while postnatal care was reported to be very poor. It was reported that only women who delivered by Caesarean section usually received postnatal care. There were no established post-natal clinics in some of the hospitals and women visiting these health facilities for post-natal care were seen either in the gynaecology ward or advised to visit the family planning clinics. Factors hindering clinic attendance were identified by hospital staff as long distance to health facilities, coupled with lack of means of transport and poor communication networks; ignorance on availability and importance of maternal health care services; traditional beliefs; poverty; and the unfriendly attitude of nurses at the clinics.

Suggestions made by the hospital staff on how maternal mortality could be reduced included intensifying primary health care education, mentioned in about 80 per cent of the cases; improving accessibility of services, mentioned in about three-quarters of the cases; and improving quality of services provided, cited in about half the cases. It was suggested that primary health care education should address both preventive and curative health care and should create awareness on availability and importance of services. Suggested communication channels included public campaigns, home visits and involving community based workers in disseminating information. Specific information that was thought to be important included appropriate antenatal and post-natal care; the need to seek timely and appropriate delivery care; appropriate diet during pregnancy; and the dangers of using herbal drugs. An important factor commonly mentioned is improving accessibility of health services and taking services close to the people, through outreach services. There was need to introduce post-natal clinics where they were non-existent. It was felt that the quality of services at the facilities could be improved by training more health workers, improving quality of antenatal care to ensure timely identification of high risk cases, ensuring good labour management, improving referral system and ensuring infection control procedures. It was further pointed out that there is need to ensure improved attitude of health personnel, so that services are provided in a friendly atmosphere and the client-provider relationship improved. Furthermore, there is need for the hospital staff to liaise with the Traditional Birth Attendants (TBAs).

About half of the surveyed hospitals were reported to handle referrals from TBAs often, while others handled referrals only occasionally or not at all. Lack of appropriate means of transport was cited as a major hindrance to timely referral. In general, the hospital staff felt that the TBAs provided useful services, especially in instances where hospitals were far away and no delivery complications were involved. Trained TBAs, in particular, were reported to do a commendable job. Some were very committed to their jobs and accompanied their clients to the hospitals, where they provided useful observational histories of the clients and were always willing to learn more by asking questions. The hospital staff felt that although the TBAs provided an important service, their skills were limited and there was a need for further training. It was suggested that training could take the form of seminars and should address issues relating to hygiene, diagnosis of complications and the importance of referral.

Appendix 4.2 Loglinear Models Showing Significant Associations Between Predisposing Conditions, Antenatal Care and Circumstances of Maternal Deaths, 1994 KMMBS.

Factors in Model	Parsimonious model	Scaled deviance (residual DF)
Age group (G) Antenatal care (A) Place of death (P)	(G, AP)	12.734 (6)
Parity (R) Antenatal care (A) Place of death (P)	(R, AP)	10.906 (9)
Birth interval (B) Antenatal care (A) Place of death (P)	(B, AP)	8.9992 (6)
Major illness in lifetime (M) Antenatal care (A) Place of death (P)	(M, AP)	7.2709 (3)
History of stillbirths /abortions (H) Antenatal care (A) Place of death (P)	(H, AP)	2.6977 (3)
Previous obstetric complications(C) Antenatal care (A) Place of death (P)	(C, AP)	2.9577 (3)
Wanted pregnancy (W) Antenatal care (A) Place of death (P)	(WA, AP)	5.4069 (2)
FP practise (F) Antenatal care (A) Place of death (P)	(FA, AP)	4.6590 (2)
Place of previous deliveries (D) Antenatal care (A) Place of death (P)	(DP, AP)	6.1491 (4)
Distance to nearest facility (D) Antenatal care (A) Place of death (P)	(DA, DP, AP)	0.2769 (2)
Desirability of pregnancy (W) Antenatal care (A) Cause of death (C)	(C, AW)	7.3778 (6)
Previous complications (P) Antenatal care (A) Cause of death (C)	(A, PC)	8.1552 (5)
Place of prev. deliveries (D) Antenatal care (A) Cause of death (C)	(AD, CD)	5.779 (6)
Desirability of pregnancy (W) Antenatal care (A) Status of index child (S)	(AW, SW)	1.307 (4)

The models presented in Appendix 4.1 fit the data reasonably well since in all cases, except the first model with age group, the scale deviance is not significant at 5 per cent level, implying that the models are not significantly different from corresponding saturated models. For the model with age group, the scale deviance is significant at 5 per cent level but not at 1 per cent level.

Appendix 5.1: Per cent distribution of home deliveries by socio economic and demographic, reproductive health care behaviour and service accessibility characteristics, 1993 KDHS

Socio-economic /Cultural Factors	Home Deliveries (per cent)	Number of Cases	Significance
Residence			
- Urban	26.7	486	***
- Rural	61.3	4804	
Region			
- Nairobi	23.0	135	
- Central	24.2	559	
- Coast	68.4	621	
- Eastern	54.4	765	***
- Nyanza	62.4	1041	
- Rift Valley	63.0	1332	
- Western	69.3	837	
Education Level			
- No education	78.6	936	
- Incomplete primary	65.0	2173	***
- Complete primary	51.9	1105	
- Secondary and above	32.9	1076	
Work Status			
- employed	54.6	2989	***
- unemployed	62.7	2301	
Socio-economic Status			
- Low	71.2	1865	
- Medium	56.8	2854	***
- High	27.6	571	
Partner's Education			
- none	76.8	516	***
- primary	65.6	2648	
- secondary and above	42.5	1716	
- no partner	53.2	410	
Ethnicity			
- Kalenjin	66.8	841	
- Kamba	66.3	555	
- Kikuyu	29.6	810	
- Kisii	59.4	399	
- Luhya	67.5	969	
- Luo	56.2	747	***
- Meru /Embu	34.9	304	
- Mijikenda	78.9	317	
- Other	68.7	348	
Religion			
- Catholic	55.8	1607	***
- Protestant	57.8	3279	
- Other	70.5	404	
Position in Household			
- head	58.0	1015	*
- spouse	59.4	3111	
- other	56.7	1164	

Note: *** - $p<0.01$, ** - $p<0.05$, * - $p<0.1$, ns - not significant

Appendix 5.1 Per cent distribution of home deliveries by socio-economic and demographic, reproductive health care behaviour and service accessibility characteristics, 1993 KDHS (continued)

Demographic Factors	Home Deliveries (per cent)	Number of Cases	Significance
Marital Status			
- single	53.2	410	
- married (monogamous)	58.0	4309	
- married (polygamous)	67.6	219	***
- previously married	59.9	362	
Age group			
- 13-19	53.6	976	
- 20-24	56.2	1574	***
- 25-29	56.7	1334	
- 30-34	60.9	764	
- 35 +	69.6	642	
Birth order			
- 1	41.8	1072	
- 2-3	56.3	1620	
- 4-5	59.9	1166	***
- 6-7	68.6	739	
- 8 +	73.7	693	
Preceding Birth Interval			
- less than 2 yrs	63.2	1091	***
- 2-3 years	65.6	1888	
- more than 3 yrs	56.7	1239	
- first birth	41.8	1072	
Age at first birth			
- below 15	73.5	317	
- 15-19 years	61.7	3293	***
- 20 yrs and above	48.3	1680	
Desirability of pregnancy			
- Then	55.8	2538	
- Later	60.0	1864	***
- No more	61.0	888	
Ideal Family size			
- 0-3	46.9	1769	
- 4	59.0	2071	***
- 5-6	68.2	889	
- 7 or more	74.7	561	
Health Care Behaviour on reproduction matters			
Timing of first antenatal visit			
- first trimester	49.5	729	***
- second trimester	57.5	3518	
- third trimester	61.5	841	
- never	86.1	202	

Note: *** - p<0.01, ** - p<0.05, * - p<0.1, ns - not significant.

Appendix 5.1 Per cent distribution of home deliveries by socio-economic and demographic, reproductive health care behaviour and service accessibility characteristics, 1993 KDHS (continued)

Health Care Behaviour on reproduction matters	Home Deliveries (per cent)	Number of Cases	Significance
Frequency of antenatal visits			
- none	86.1	202	
- 1-2	71.1	536	***
- 3-4	61.0	2306	
- 5-6	53.4	1474	
- 7 or more	42.4	772	
Family Planning practise			
- never used any method	69.5	2455	***
- used only traditional	60.1	781	
- ever used modern	43.9	2054	
Available forms of health care within community			
Traditional Birth Attendants			
- not available	44.6	1317	***
- available	62.6	3973	
Community Health Workers			
- not available	56.8	2521	*
- available	59.4	2769	
Community Based Distributors			
- not available	57.9	2260	ns
- available	58.3	3030	
Mobile clinic			
- not available	57.0	3891	***
- available	61.3	1399	
Accessibility of health facilities with delivery care			
Distance to nearest health facility with delivery service			
- less than 5 km	46.0	1660	
- 5-10 km	59.9	1942	***
- more than 10 km	68.1	1688	
Time to nearest health facility with delivery service			
- less than 1 hour	48.2	1470	***
- 1-2 hours	57.0	2655	
- more than 2 hours	73.3	1165	
ALL	58.1	5290	

Note: *** - p<0.01, ** - p<0.05, * - p<0.1, ns - not significant.

Appendix 5.2 Per cent distribution of childbirth attendant by socio-economic and demographic characteristics, reproductive health care behaviour and service availability and accessibility characteristics, 1993 KDHS

Socio-economic /Cultural Factors	Childbirth Attendant					
	Doctor	Nurse / midwife	TBA	Relative	No one	No of cases
Residence						
- Urban	24.9	49.8	6.8	15.8	2.7	486
- Rural	10.8	28.7	21.3	27.7	11.6	4804
Region						
- Nairobi	30.4	48.1	10.4	8.1	3.0	135
- Central	24.7	51.3	2.3	14.1	7.5	559
- Coast	14.3	18.4	19.8	39.3	8.2	621
- Eastern	9.9	35.7	23.8	24.2	6.4	766
- Nyanza	11.0	27.6	17.2	26.2	18.2	1041
- Rift Valley	9.6	28.2	29.3	27.7	5.3	1332
- Western	6.2	26.2	18.5	29.3	19.8	837
Education Level						
- No education	6.2	15.6	24.3	34.3	19.7	936
- Incomplete primary	9.3	26.0	22.8	30.5	11.4	2173
- Complete primary	14.8	34.8	19.3	23.6	7.7	1105
- Secondary and above	19.9	48.7	11.2	15.1	5.1	1076
Work Status						
- employed	12.9	33.1	17.2	24.2	12.5	2989
- unemployed	11.0	27.3	23.5	29.7	8.5	2301
Socio-economic Status						
- Low	7.6	21.6	27.7	30.6	12.6	1865
- Medium	12.6	32.6	17.3	26.6	10.8	2854
- High	23.6	50.3	7.9	13.3	4.9	571
Partner's Education						
- none	6.0	18.4	25.2	36.2	14.1	516
- primary	9.9	24.9	22.0	29.5	13.7	2648
- secondary and above	16.6	42.7	14.7	19.0	7.1	1716
- no partner	14.9	32.4	22.2	27.3	3.2	410
Ethnicity						
- Kalenjin	8.4	25.7	37.7	25.9	2.3	841
- Kamba	9.7	23.8	33.9	26.3	6.3	556
- Kikuyu	24.8	46.2	3.6	16.5	6.9	810
- Kisii	15.0	26.1	14.3	31.1	13.5	389
- Luhya	6.3	28.0	18.7	28.2	18.9	969
- Luo	10.7	33.9	16.9	21.3	17.3	747
- Meru /Embu	11.2	54.3	5.6	21.4	7.6	304
- Mijikenda	6.3	15.5	25.2	41.3	11.7	317
- Other	16.4	15.8	17.5	40.2	10.1	348
Religion						
- Catholic	12.9	31.6	20.3	24.1	11.1	1607
- Protestant	11.7	31.5	19.6	26.3	10.9	3279
- Other	11.6	19.1	21.0	38.1	9.2	404

Appendix 5.2 Per cent distribution of childbirth attendant by socio economic and demographic characteristics, reproductive health care behaviour and service availability and accessibility characteristics, 1993 KDHS(continued)

Socio-economic /Cultural Factors	Childbirth Attendant					
	Doctor	Nurse / midwife	TBA	Relative	No one	No.of cases
Position in Household						
- head	12.0	33.4	18.7	22.9	13.0	1015
- spouse	11.3	30.0	19.6	27.4	11.8	3111
- other	14.3	29.9	21.9	27.7	6.3	1164
Demographic Factors						
Marital Status						
- single	14.9	32.4	22.2	27.3	3.2	410
- married (monogamous)	12.0	30.9	19.5	27.1	10.6	4309
- married (polygamous)	5.9	27.4	22.4	20.5	23.7	219
- previously married	13.6	27.3	21.6	23.3	14.2	352
Age group						
- 13-19	12.9	34.8	21.2	26.8	4.2	976
- 20-24	12.1	33.0	17.9	28.7	8.4	1674
- 25-29	13.9	29.9	21.1	24.4	10.6	1334
- 30-34	9.8	29.6	20.7	26.2	13.7	764
- 35 +	9.3	21.0	20.1	26.0	23.5	542
Birth order						
- 1	18.1	41.5	16.1	22.2	2.1	1072
- 2-3	12.0	33.4	19.5	27.8	7.2	1620
- 4-5	11.5	28.2	20.8	27.7	11.7	1166
- 6-7	8.4	23.8	21.3	26.3	18.4	739
- 8 +	7.6	18.5	22.1	28.9	22.9	693
Preceding Birth Interval						
- less than 2 yrs	10.4	27.1	20.0	28.5	14.0	1091
- 2-3 years	8.8	26.3	21.9	29.8	13.1	1888
- more than 3 yrs	13.2	30.8	20.3	23.7	11.9	1239
- first birth	18.1	41.5	16.1	22.2	2.1	1072
Age at first birth						
- below 15	7.6	18.9	23.7	34.1	15.8	317
- 15-19 years	11.0	28.1	20.6	28.3	12.1	3293
- 20 yrs and above	15.1	37.8	18.1	21.7	7.3	1680
Desirability of pregnancy						
- Then	12.5	32.5	19.0	26.4	9.7	2538
- Later	11.6	29.3	21.2	28.4	9.5	1864
- No more	11.7	27.9	20.2	24.4	16.8	886
Ideal Family size						
- 0-3	16.4	38.3	16.3	21.1	7.8	1769
- 4	11.9	29.9	19.9	26.6	11.7	2071
- 5-6	8.2	23.5	23.3	32.1	12.9	889
- 7 or more	5.2	20.0	26.4	35.1	13.4	561

Appendix 5.2 Per cent distribution of childbirth attendant by socio economic and demographic characteristics, reproductive health care behaviour and service availability and accessibility characteristics, 1993 KDHS (continued)

Health Care Behaviour on reproduction matters	Childbirth Attendant					
	Doctor	Nurse / midwife	TBA	Relative	No one	No of cases
Timing of first antenatal visit						
- first trimester	16.6	35.3	21.8	18.5	7.8	729
- second trimester	11.6	31.8	19.9	26.2	10.5	3518
- third trimester	12.1	26.5	18.0	31.3	12.1	841
- never	4.0	10.4	22.3	43.1	20.3	202
Frequency of antenatal visits						
- none	4.0	10.4	22.3	43.1	20.3	202
- 1-2	9.1	21.1	20.3	32.8	16.8	536
- 3-4	10.6	28.9	20.2	29.4	10.9	2306
- 5-6	12.9	34.4	21.3	22.8	8.5	1474
- 7 or more	19.0	40.3	15.8	16.7	8.2	772
Family Planning practise						
- never used any method	7.5	23.8	24.8	31.4	12.5	2455
- used only traditional	11.8	29.3	21.0	27.5	10.4	781
- ever used modern	17.6	39.2	13.8	20.4	8.9	2054
Available forms of health care within community						
Traditional Birth Attendants						
- not available	16.6	39.2	11.0	25.3	7.9	1317
- available	10.5	27.8	22.9	27.0	11.8	3973
Community Health Workers						
- not available	12.9	30.9	20.1	26.4	9.6	2521
- available	11.3	30.3	19.9	26.7	11.8	2769
Community Based Distributors						
- not available	13.1	29.8	20.5	27.5	9.2	2260
- available	11.4	31.2	19.5	25.9	12.0	3030
Mobile clinic						
- not available	13.3	30.6	19.9	26.0	10.2	3891
- available	8.6	30.7	20.2	28.1	12.4	1399
Accessibility of health facilities with delivery care						
Distance to nearest health facility with delivery service						
- less than 5 km	14.9	39.6	14.9	21.3	9.2	1660
- 5-10 km	12.0	29.0	19.5	27.9	11.6	1942
- more than 10 km	9.3	23.5	25.5	30.2	11.4	1688
Time to nearest health facility with delivery service						
- less than 1 hour	14.7	37.4	15.3	24.1	8.5	1470
- 1-2 hours	12.5	31.6	19.4	25.0	11.5	2655
- more than 2 hours	7.6	19.8	27.1	33.2	12.2	1165
ALL	12.1	30.6	20.0	26.6	10.8	5290

Appendix 5.3 Parameter estimates for delivery attendant (standard errors are given in brackets), 1993 KDHS

Parameter	Parameter Estimate for Childbirth Attendant (vs qualified medical attendant)		
	TBA	Relative	No one
Fixed Effects			
Constant	-1.88 (0.518)	0.20 (0.358)	-3.38 (0.678)
Education Level (no education)[1]			
- incomplete primary	-0.35 (0.121)*	-0.42 (0.109)*	-0.66 (0.131)*
- complete primary	-0.48 (0.144)*	-0.76 (0.130)*	0.86 (0.169)*
- secondary and above	-1.17 (0.167)*	-1.36 (0.148)*	-1.51 (0.203)*
Household Socio-economic Status (Low status)[1]			
- Medium	-0.52 (0.090)*	-0.33 (0.082)*	-0.31 (0.108)*
- High	-1.25 (0.200)*	-1.11 (0.170)*	0.67 (0.237)*
Area of Residence (urban)[1]			
- Rural	0.87 (0.278)*	0.23 (0.203)	1.19 (0.380)*
Region (Central)[1]			
- Nairobi	1.89 (0.566)*	0.02 (0.455)	0.44 (0.706)
- Coast	1.43 (0.441)*	1.39 (0.295)*	-0.04 (0.426)
- Eastern	1.13 (0.467)*	0.48 (0.344)	-0.86 (0.483)
- Nyanza	1.16 (0.435)*	0.79 (0.291)*	0.57 (0.389)
- Rift Valley	1.62 (0.378)*	1.02 (0.223)*	0.34 (0.303)
- Western	1.86 (0.423)*	1.59 (0.277)*	1.14 (0.362)*
Ethnic Group (Kalenjin)[1]			
- Kamba	0.63 (0.340)	0.78 (0.306)*	2.38 (0.484)*
- Kikuyu	-1.47 (0.283)*	-0.01 (0.204)	1.34 (0.345)*
- Kisii	-0.46 (0.298)	0.66 (0.252)*	1.69 (0.380)*
- Luhya	-0.37 (0.217)	0.23 (0.193)	2.09 (0.306)*
- Luo	-0.40 (0.274)	0.02 (0.238)	1.92 (0.361)*
- Meru/ Embu	-1.78 (0.450)*	-0.15 (0.363)	1.84 (0.547)*
- Mijikenda	0.40 (0.341)	0.58 (0.288)*	2.60 (0.452)*
- Other	0.14 (0.258)	0.92 (0.222)*	2.31 (0.341)*
First Birth (birth order 2-3 with preceding interval less 2 years)[1]	-0.65 (0.133)*	-0.76 (0.119)*	-1.88 (0.253)*
Birth Order (order 2-3)[1]			
- 4-5	-0.07 (0.108)	-0.11 (0.097)	0.40 (0.139)*
- 6 7	0.03 (0.130)	-0.15 (0.119)	0.83 (0.153)*
- 8 +	0.14 (0.143)	0.09 (0.130)	1.17 (0.161)*

1 - represents reference category
* - Significant at 5 per cent level

Appendix 5.3 Parameter estimates for delivery attendant (standard errors are given in brackets), 1993 KDHS (continued)

Parameter	TBA	Relative	No one
Birth interval (less than 2 yrs)[1]			
-2-3 years	-0.04(0.103)	-0.07(0.093)	-0.22(0.116)
- greater than 3 years	-0.14(0.116)	-0.34(0.106)*	0.30(0.130)*
Desirability of pregnancy (pregnancy wanted then)[1]			
- wanted later	0.19 (0.088)*	0.18 (0.079)*	0.14 (0.110)
- wanted no more	0.07 (0.125)	-0.03 (0.114)	0.13 (0.136)
Family Planning practise (never used any method)[1]			
- ever used only traditional	-0.25 (0.121)*	-0.20 (0.111)	-0.19 (0.150)
- ever used modern FP	-0.60 (0.099)*	0.63 (0.088)*	-0.73 (0.118)*
Frequency of antenatal visits (1-2 visits)[1]			
- none	0.43 (0.221)	0.59 (0.195)*	0.84 (0.220)*
- 3-4	-0.08 (0.132)	-0.25 (0.116)*	-0.41 (0.145)*
- 5-6	-0.18 (0.141)	-0.57 (0.126)*	-0.72 (0.164)*
- 7 +	-0.60 (0.168)*	-1.07 (0.151)*	-0.99 (0.194)*
Time to nearest health facility with delivery care (less than 1 hour)[1]			
- 1-2 hours	0.16 (0.127)	-0.07 (0.105)	0.23 (0.138)
- more than 2 hours	0.43 (0.154)*	0.19 (0.129)	0.37 (0.168)*
Distance to nearest health facility with delivery care (less than 5 km)[1]			
- 5-10 km	0.37 (0.131)*	0.54 (0.109)*	0.34 (0.138)*
- more than 10 km	0.37 (0.143)*	0.53 (0.121)*	0.46 (0.156)*
Presence of TBA within community (No TBA)[1]			
- TBA	0.30 (0.132)*	0.18 (0.104)	-0.01 (0.141)
Random Effects Variance			
Cluster level constant			
- TBA	0.21 (0.061)*	-	-
- Relative	0.06 (0.040)	0.08 (0.044)	-
- No one	-0.04 (0.047)	0.04 (0.039)	0.02 (0.061)
Woman level constant			
- TBA	0.87 (0.121)*	-	-
- Relative	-0.54 (0.090)*	0.84 (0.105)*	-
- No one	-0.31 (0.110)*	-0.43 (0.102)*	1.06 (0.162)*

1 - represents reference category

* Significant at 5 per cent level

Appendix 7.1 The per cent distribution of variables in the complete loglinear model, 1993 KDHS

Variable Category	Per cent	Number of cases
Urban / Rural Residence		
urban	10.6	564
rural	89.4	4772
Ethnicity		
Kalenjin	15.8	843
Kamba	9.7	515
Kikuyu	15.3	819
Luhya	18.9	1006
Luo	14.5	775
other	25.8	1378
Maternal Education Level		
none / primary incomplete	58.6	3127
primary complete	20.9	1115
secondary and above	20.5	1094
Household Socio-Economic Status		
low	34.7	1853
medium	53.7	2867
high	11.5	616
Maternal Age		
below 20 years	18.4	984
20-34 years	70.0	3736
35 years and above	11.6	616
Marital Status		
single	7.7	409
married	85.3	4552
previously married	7.0	375
Birth Order	20.2	1077
1st	43.2	2303
2-4	36.7	1956
5+		
Desirability of the Pregnancy		
wanted then	47.9	2554
wanted later /no more	52.1	2782
Ever use of Family Planning		
never used modern methods	60.3	3216
ever used modern methods	39.7	2120
Time to Nearest Maternal Health Facility		
less than 1 hour	28.7	1533
1 hour or more	71.3	3803

Appendix 7.1 The per cent distribution of variables in the complete loglinear model, 1993 KDHS (Continued)

Variable Category	Per cent	Number of cases
Timing of 1st Antenatal Care Visit, and Frequency of Visits		
no antenatal care	3.8	203
3rd trimester, less than 4 visits	11.5	615
2nd trimester, less than 4 visits	17.5	933
1st trimester, less than 4 visits	0.6	33
3rd trimester, 4 or more visits	4.4	234
2nd trimester, 4 or more visits	48.9	2607
1st trimester, 4 or more visits	13.3	711
Height		
less than 150 cm	5.4	290
150-160 cm	49.6	2648
more than 160 cm	44.9	2398
Weight-for-Height		
low (less than 100)	18.0	959
average(100-120)	51.9	2769
high (more than 120)	30.1	1608
Sex of Child		
male	49.9	2664
female	50.1	2672
Multiple Births		
single birth	97.0	5176
multiple births	3.0	160
Baby's Size at Birth		
normal /big	84.7	4518
small /very small	15.3	818
Premature Delivery		
full term	96.2	5134
premature	3.8	202
Delivery by Caesarean		
no	95.0	5069
yes	5.0	267
All	**100**	**5336**