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FACTORS ASSOCIATED WITH UNFAVOURABLE BIRTH OUTCOMES IN KENYA

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Summary. Studies addressing factors associated with adverse birth outcomes have almost exclusively been based on hospital statistics. This is a serious limitation in developing countries where the majority of births do not occur within health facilities. This paper examines factors associated with premature deliveries, small baby's size at birth and Caesarean section deliveries in Kenya based on the 1993 Kenya Demographic and Health Survey data. Due to the hierarchical nature of the data, the analysis uses multilevel logistic regression models to take into account the family and community effects. The results show that the odds of unfavourable birth outcomes are significantly higher for first births than for higher order births. Furthermore, antenatal care (measured by frequency of antenatal care visits and tetanus toxoid injection) is observed to have a negative association with the incidence of premature births. For the baby's size at birth, maternal nutritional status is observed to be a predominant factor. Short maternal stature is confirmed as a significant risk factor for Caesarean section deliveries. The observed higher odds of Caesarean section deliveries among women from households of high socio-economic status are attributed to the expected association between socio-economic status and the use of appropriate maternal health care services. The odds of unfavourable birth outcomes vary significantly between women. In addition, the odds of Caesarean section deliveries vary between districts, after taking into account the individual-level characteristics of the woman.

Introduction

Apart from maternal and perinatal mortality, adverse pregnancy outcomes include: fetal loss, premature delivery, low birth weight or small size of the baby at birth and childbirth complications. The principal risk indicators of adverse pregnancy outcomes fall into three broad categories, namely: sociodemographic risk factors, maternal health care factors and the mothers' health status, including her nutritional status.

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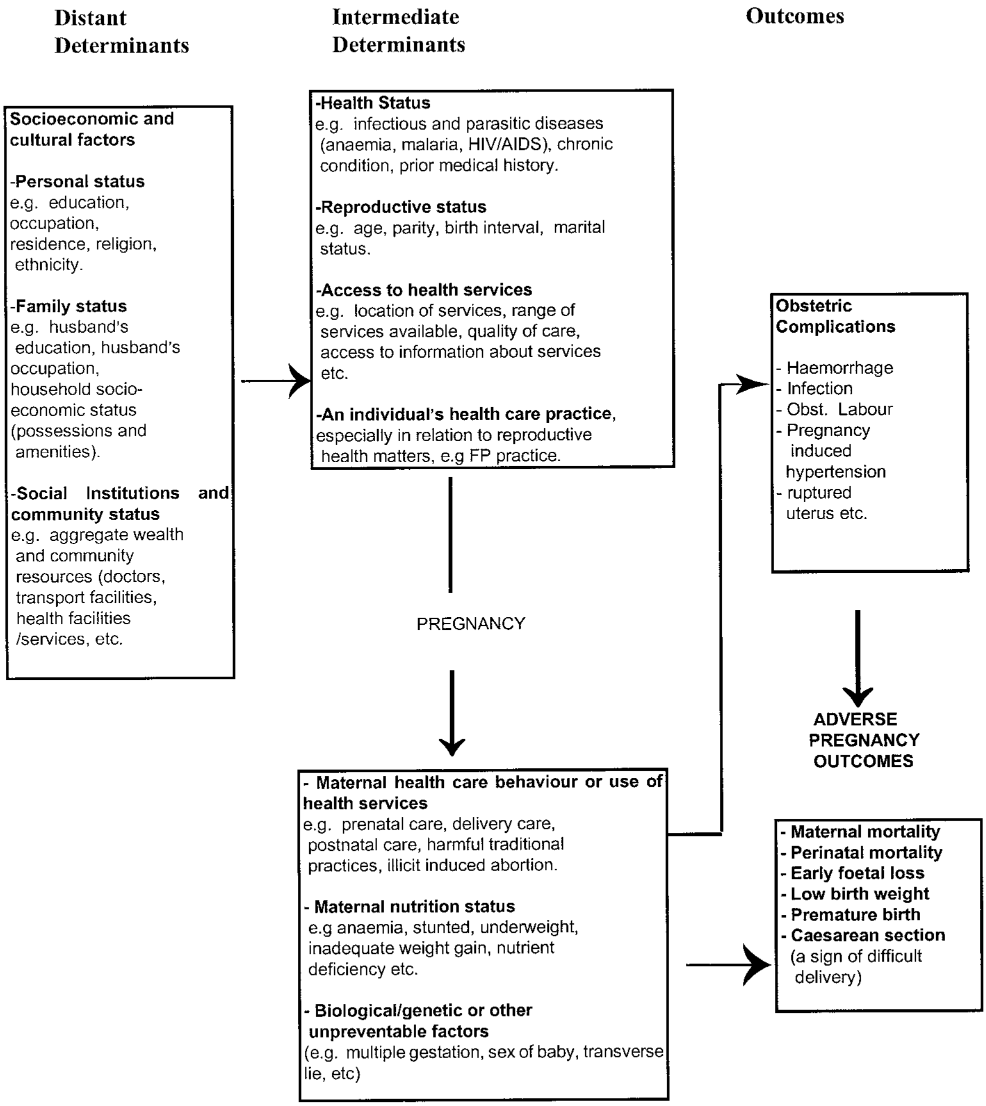

Fig. 1. A conceptual framework for studying determinants of adverse pregnancy outcomes. Source: Magadi (1999), p. 20.

The sociodemographic risk factors are likely to influence the pregnancy outcomes through maternal health care and maternal health status factors as illustrated by the conceptual framework in Fig. 1.

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 pregnancies; for short birth intervals; for women with certain pre-existing health conditions; for poor, malnourished and uneducated women; and for women beyond the reach of adequate health care (WHO, 1994; Herz & Measham, 1987;

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Anandalakshmy *et al.*, 1993; Bhargava, Singh & Saxena, 1991; Gonzalez-Perez & Vega-Lopez, 1996; Population Studies and Research Institute (PSRI) and UNICEF, 1996). For many of these factors, such as age, nothing can be done to alter the risk, but additional care and watchfulness may prevent a complication arising or enable its early detection and effective management.

Appropriate prenatal and delivery care have been identified as important in preventing adverse pregnancy outcomes for both the mother and the baby. In particular, it is important that appropriate delivery care is sought in cases where childbirth complications are likely to develop. Besides maternal mortality, a number of studies have demonstrated an association between antenatal care and other adverse pregnancy outcomes such as perinatal mortality, low birth weight and premature delivery (Llewellyn-Jones, 1974; Sadio, 1991; Ahmed & Das, 1992; NSO & MI, 1993; Coria-Soto, Bobadilla & Notzon, 1996; Hollander, 1997). In addition to maternal health care, general health care behaviour, especially in matters relating to reproduction, is also likely to influence birth outcomes. For instance family planning can reduce the number of adverse pregnancy outcomes by reducing the number of high-risk pregnancies and unsafe abortions.

A woman's health can have a 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 nutritional status. Poor nutrition is one of the factors closely associated with intrauterine growth retardation and premature birth in both developing and developed countries (Berendes, 1993). Several studies in different parts of the world have identified short maternal stature as a risk factor for adverse pregnancy outcomes such as perinatal death, premature birth, low birth weight and Caesarean section deliveries (Voorhoeve, W'ogio & Muller, 1984; Martorell, 1991; NSO & MI, 1993; Mavalankar, Trivedi & Gray, 1994; Achadi *et al.*, 1995). Apart from height, a number of studies have shown that other maternal anthropometric indicators, namely 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; Mavalankar *et al.*, 1994; Sharma *et al.*, 1994; Amal-Nasir, 1995; Achadi *et al.*, 1995; Pelletier *et al.*, 1995).

The literature shows a fairly consistent relationship between some of the sociodemographic risk factors such as age and parity and adverse pregnancy outcomes. However, the relationship between pregnancy outcomes and factors such as birth interval, maternal education and occupation, is not as consistent. While it is expected that short birth intervals would increase the risk of adverse pregnancy outcomes, some studies show a relationship in the reverse direction. Voorhoeve *et al.* (1984) explained that the observed general tendency for perinatal mortality to increase with increasing birth interval 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 apparent later in life when the index child is most vulnerable to malnutrition and infectious diseases. Similarly, although education and occupation are expected to improve birth 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 poor birth outcomes. As a possible explanation for education being a risk factor of prematurity in Burkina Faso, Prazuck

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et al. (1993) suggested that educated mothers were more likely to use motorized transport on bumpy roads, which cause intrauterine vibrations, resulting in preterm delivery. Kramer (1987) pointed out that there is need for research on the effect of maternal work and prenatal care, among other factors, on intrauterine growth retardation and prematurity.

Some studies have used bivariate statistical techniques to establish the association between birth outcomes and individual women's characteristics. However, such techniques do not control for confounding factors that might distort the associations. Even multivariate techniques such as logistic regression may not fully identify the risk factors for adverse birth outcomes, possibly because the causes of adverse birth outcomes may operate at many levels such as household, community or even district. For example, accessibility of health services within a community could contribute to adverse birth outcomes. The effects of such factors may vary both at the woman and community levels. Thus, it is important to acknowledge the many levels at which factors operate to influence adverse birth outcomes, and hence the use of multilevel statistical techniques is appropriate.

Studies that have identified the factors associated with adverse pregnancy outcomes in both the developed and the developing nations are numerous but these have almost exclusively been based on hospital data. This is a serious limitation since the majority of births in developing countries occur outside 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 be generalized to the entire population. In such communities, population-based studies that include women who use modern as well as traditional forms of maternal health care are necessary to identify those factors associated with poor birth outcomes.

This paper examines factors associated, in Kenya, with the last three outcomes in Fig. 1, namely premature delivery, small baby's size at birth and Caesarean section deliveries. It is important to note that information on birth weight is not available for the majority of births in Kenya, and hence the baby's size at birth is used instead. The reliability of reported information on the size of a baby at birth and premature delivery is assessed in preliminary analysis. Strictly speaking, a Caesarean section is not a pregnancy outcome. However, it is considered in this paper as one of the unfavourable conditions that can be influenced directly by various obstetric complications.

Data and methods

The data used in this study are from the individual women's and the household questionnaires of the 1993 Kenya Demographic and Health Survey (KDHS). The household questionnaire provided information to assess household socioeconomic status, based on household possessions and amenities, while the women's questionnaire provided information on individual women's characteristics as well as information relating to specific pregnancies or births that occurred during the 5 years preceding the survey. A total of 6115 births to 3929 women were eligible. However, the analysis is based on only 5295 of these births which had complete information on the variables used in the analysis. The exclusion from the analysis of cases with missing information is unlikely to bias the results since a comparison of the sample with full data with cases with missing data showed that the distributions of the outcome variables in the two samples were fairly similar (within ± 0·2%).

The KDHS used a multi-stage cluster sampling strategy. A description of the sampling procedure is reported elsewhere (National Council for Population and Development, Central Bureau of Statistics and Macro International, 1994). Multilevel models are appropriate for such data since conventional single-level models cannot capture the hierarchy in the data. In addition, the multilevel approach 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 socioeconomic 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. The outcomes are modelled using a three-level logistic regression model of the form:

$$\log\left(\frac{\pi_{ijk}}{1-\pi_{ijk}}\right) = X'_{ijk} + Z'_{ijk}u_{jk} + W'_{ijk}v_k$$

where π_{ijk} is the probability of a given outcome for a particular birth, i, to the j^{th} woman in the k^{th} community (village or district); X'_{ijk} is the vector of covariates, which may be defined at the 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 the family or woman level; W'_{ijk} is a vector of covariates (usually a subset of X'_{ijk}), the effects of which vary randomly at the 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 using the statistical packages MIXOR (Hedeker & Gibbsons, 1996) and MLn (Institute of Education, 1995). Both of the packages fit multilevel models but use different estimation procedures. Yang, Goldstein & Rasbash (1996) and also Rodriguez & Goldman (1998) have indicated that MLn can sometimes underestimate the random variances, especially when the marginal quasi-likelihood (MQL) estimation procedure is used. Even the second-order predictive quasi-likelihood (PQL) procedure, which is less biased, can sometimes underestimate the variance, especially when there are a small number of level-1 units per level-2 unit. In addition, the PQL procedure may sometimes fail to converge. MIXOR uses a maximum marginal likelihood solution using multidimensional quadrature to integrate numerically over the distribution of random effects. This procedure estimates the variances more accurately than either MQL or PQL. However, MIXOR can only fit models up to two levels, while MLn can fit models with many levels.

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

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outcome in the 5 years preceding the survey. However, the preliminary analysis showed that for some outcome variables (for example Caesarean section deliveries), three-level models were appropriate. Consequently, MIXOR was used for two-level models and MLn for three-level models.

Goldstein (1995) suggested the intra-unit correlation coefficient (the ratio of the unit-level variance to total variance) as a good measure of the strength of the correlation between units. To compare birth outcomes between different districts, residuals can be estimated for each district and districts with substantially different residuals identified. 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 for each residual, j, as $u_j \pm c(\text{S.E.})_j$, where the value c is determined so that the average over all possible pairs is equivalent to a given confidence level (Goldstein & Healy, 1995).

Preliminary analysis

Overall, 3·7% of the 5295 births within the 5 years preceding the 1993 KDHS were premature, 15·4% were reported to be small or very small at birth and 5% were by Caesarean section. Although it is also important that the factors associated with fetal loss (namely abortions and stillbirths) are identified, this is not addressed in the study because such information was not collected. The preliminary analysis includes: an assessment of the reliability of reported ‘size of baby at birth’ and ‘premature birth’ information; bivariate analysis; and an examination of the clustering structure of births and outcome variables for individual women.

Reliability of information on the size of the baby at birth and premature births

The analysis presented in this paper is based on the mothers’ reports for the outcome variables: premature birth, small size of the 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. Measurement error is likely to be most critical for the size of the baby at birth, which is subject to personal perceptions and possible systematic errors. In order to assess the reliability of this information, in Table 1 the average weights of babies by the reported sizes for cases where birth weights were available were examined.

The results show close agreement in that babies classified as ‘very small’ had the lowest average birth weight and those classified as ‘very large’ were heaviest, on average. This suggests that the mothers’ reports were fairly reliable. However, it is assumed here that mothers whose babies were not weighed reported using a similar scale as that of mothers whose babies were weighed. It is also assumed that mothers whose babies were weighed assessed the sizes of their babies independently of the birth weights. To find out if cases with birth weights and those without should be treated as two distinct groups, included in the model for the size of baby at birth was an indicator variable to indicate whether or not birth weight was available. Tests were

Table 1. The distribution of reported size of baby at birth by birth weight

Reported size of baby at birth	Birth weight (g)		
		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

performed to check for possible interactions with relevant socioeconomic and demographic variables. There was a significant interaction between this indicator variable and the mother's weight-for-height score. The direction of the interaction suggests that there may be a tendency for mothers with high weight-for-height to report that their babies were small in size, when there was no birth weight information. Such a tendency is likely to have a counter effect on the expected positive association between maternal nutritional status and the size of the baby at birth. Nevertheless, these results for the size of baby at birth should be reliable, since the use of multilevel models will mitigate such woman-level tendencies.

Previous studies have addressed the issue of the reliability of mothers' reports of the size of the baby at birth. Da Vanzo, Habicht & Butz (1984) presented evidence from the Malaysian Family Life Survey that reports by mothers of their babies' birth weights including approximate sizes are fairly reliable and can be used as proxies to examine many biological and socioeconomic correlates of birth weight. A recent study based on data from fifteen cross-sectional surveys in developing countries noted that the sensitivity of the relative size-at-birth indicator to identify low birth weight (LBW) was very small for most surveys, when using only infants reported as 'very small', even though positive predictive value was at least 70% in most surveys. However, when children reported to be either 'very small' or 'small' were used instead to predict LBW, sensitivity improved greatly to a mean of 66% (Boerma *et al.*, 1996). In this paper, the category for 'small size at birth' includes cases where the mothers reported the size as very small, or smaller than average.

For the case of premature births, included in the multilevel logistic model were interactions of relevant predictor variables and an indicator variable for whether or not antenatal care was received. 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. Such an analysis would help to assess whether those who had and those who had not attended antenatal care should be treated as two distinct groups. The fact that none of the interactions was significant increased confidence in the reliability of reporting for premature births.

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Table 2. Percentage distribution of undesirable birth outcomes by socioeconomic factors

Socioeconomic factors	Percentage 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+	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
Socioeconomic 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+	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

Table 2. *Continued*

Socioeconomic factors	Percentage 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
All cases	3·7	15·4	5·0	5295

$^*p<0·5$; $^{**}p<0·01$; $^{***}p<0·001$.
Source: computed from 1993 KDHS data based on births to women respondents during the 5 years preceding the survey.

Bivariate analysis

Associations between socioeconomic characteristics and unfavourable birth outcomes. The socioeconomic factors considered in this analysis include: rural/urban residence, region of residence, maternal education, maternal employment status, household socioeconomic status, partner's education, ethnicity and religion. The distribution of unfavourable birth outcomes reported in the 1993 KDHS for these socioeconomic factors is given in Table 2. Tests of significance are based on chi-square tests.

The socioeconomic and cultural factors that 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 of Nyanza Province.

The region of residence and work status of the woman are observed to have a significant association with the size of the 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 with women who were employed.

Urban/rural residence, region of residence, ethnicity, socioeconomic status of the household, woman's level of education, and her partner's level of education have a significant association with Caesarean section deliveries. Preliminary results show that the highest proportions of Caesarean section deliveries are among those living in urban areas, those living in Nairobi, those with a high level of education, those with high socioeconomic status, and those from the Kikuyu ethnic group.

Association between demographic factors and unfavourable birth outcomes. The demographic factors included in this analysis are: the age of the mother, birth order, marital status, the length of the preceding birth interval, the mother's age at first birth, the desirability of the pregnancy, and the mother's ideal family size. The distribution of poor birth outcomes by the demographic parameters is given in Table 3.

Table 3. Percentage distribution of poor birth outcomes by reproductive factors

Socioeconomic or reproductive factors	Percentage of births			Total cases
	Premature	Small baby	Caesarean	
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	18·0	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	***	**	***	
<2 years	2·6	13·9	3·4	1088
2–3 years	3·0	14·2	3·9	1884
>3 years	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 (monogamous)	3·6	14·5	5·0	4342
Married (polygamous)	4·2	19·5	2·3	215
Previously married	2·4	18·5	3·9	336
Age at first birth			**	
<15	3·7	15·9	3·1	321
15–19 years	3·7	15·2	4·4	3307
20 years+	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
No 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+	3·4	14·9	4·0	530
All cases	3·7	15·4	5·0	5295

*p<0·5, **p<0·01; ***p<0·001.

Source: computed from 1993 KDHS data based on births to women respondents during the 5 years preceding the survey.

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The age of the mother and the birth order of the pregnancy are significantly associated with all birth outcomes. 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 with those aged 20–34 years. The lowest proportion of Caesarean section deliveries is observed among mothers aged 35 years and above. The distribution of unfavourable birth outcomes by birth order appears to follow a more or less similar pattern to the distribution by age. The highest proportion of unfavourable birth outcomes is reported among 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 the baby's size at birth, the lowest proportions of small babies were reported among births of order two to five.

The preceding birth interval is significantly associated with all the indicators of poor birth outcomes. In addition to maternal age, birth order and the length of the preceding birth interval, another factor showing a significant relationship with the size of the baby at birth 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, the length of the preceding birth interval, marital status, the mother's age at first birth and the 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 three children.

Maternal health care behaviour, maternal nutritional status and biological factors associated with unfavourable birth outcomes. Table 4 gives the distribution of undesirable birth outcomes by maternal health care, maternal nutritional status and some biological factors based on the 1993 KDHS.

With respect to health care behaviour, indicators of the quality of antenatal care, such as the frequency of antenatal care visits and the number of 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; assistance during delivery is associated with premature deliveries; and the timing of the first antenatal check is associated with both premature delivery and the size of the baby at birth. The highest proportion of premature births was observed among those who did not have any antenatal health care, those who did not receive any tetanus injections and those who were assisted by a medical doctor during delivery. 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 was 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. It should be noted that Caesarean section services are only available at major hospitals, which may not be accessible to many women living in rural areas.

Maternal nutritional status is associated with the size of the baby at birth and Caesarean deliveries but not premature births. The highest proportion of small babies is observed among mothers with low weight-for-height scores and short stature (less

Table 4. Percentage distribution of undesirable birth outcomes by maternal health care, maternal nutritional status and biological factors

Factors associated with birth outcomes	Percentage 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+	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+	3·4	14·4	5·7	2783
Family planning practice			***	
Never used any method	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
Assistance during delivery	**			
Doctor	6·0	15·0	N/A	646
Nurse	3·8	14·1		1644
TBA	3·8	15·7		1031
Relative or other	2·6	16·1		1406
No one	3·2	16·9		568
Weight-for-height (WHO ref.)		*	***	
<100	4·5	18·5	3·3	942
100–120	3·2	14·9	4·1	2755
>120	3·9	14·3	7·4	1598
Height			***	
<150 cm	3·1	19·2	11·7	291
150–160 cm	3·3	15·6	5·5	2643
>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

Table 4. *Continued*

Factors associated with birth outcomes	Percentage of births			Total cases
	Premature	Small baby	Caesarean	
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

*p<0·5; **p<0·01; ***p<0·001.

than 150 cm). Mothers of short stature also seem more likely to have Caesarean section deliveries. This is not surprising given the expected positive association between maternal height and pelvic size. On the other hand, women with low weight-for-height scores are less likely to have Caesarean section deliveries than women who are heavy, relative to their heights.

Other factors showing significant associations with unfavourable birth outcomes include the type of birth and the sex of the 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 analyses are limited since they do not take into account other possible confounding factors. A number of previous studies that have investigated the factors associated with poor birth outcomes have been based on bivariate analysis. Such analyses can yield spurious relationships, particularly where there are significant associations between the covariates of interest. For example, in a study of the risk factors for preterm delivery in Burkina Faso, Prazuck *et al.* (1993) observed that being single increased the risk of a premature delivery in the bivariate analysis (p<0·01), but this risk vanished in the multivariate analysis. To be able to identify the important risk factors more precisely it is necessary that the analysis takes into account the effect of all important factors at the same time.

Clustering structure

The data analysed in this paper comprise more than one birth per woman. This implies that some observations could be correlated, since births to the same woman are likely to be more similar. For example, some women may be more likely than others to have an unfavourable birth outcome. In this section, the distribution of births and the incidence of unfavourable birth outcomes per woman are examined to assess the degree of potential clustering of births to a particular woman, and hence determine if it is necessary to use multilevel analysis to measure and control for repeated observations within mothers. The distribution of the number of births per woman in the analysis sample is given in Table 5.

Table 5 shows that almost half of the women in the analysis sample contribute more than one birth to this sample. These births constitute 65% of all births included

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Table 5. The distribution of births per woman within the 5 years preceding the 1993 KDHS

Births	Number of women	Per cent
1	1849	53·7
2	1355	39·3
3	230	6·7
4	9	0·3
5	2	0·1
Total	3445	100·0

Table 6. The distribution of premature births, small baby at birth and Caesarean section deliveries per woman within the 5 years preceding the 1993 KDHS

	Premature		Small size		Caesarean	
Births	No. of women	Per cent	No. of women	Per cent	No. of women	Per cent
0	3268	94·9	2713	78·8	3220	93·5
1	160	4·6	656	19·0	189	5·5
2+	17	0·5	76	2·2	36	1·1
Total	3445	100·0	3445	100·0	3445	100·0

in the analysis, implying that there is need to control for potential correlation between births of the same mother. Further analysis of the clustering structure examines the percentage distribution of the outcome variables: premature births, baby's size at birth and Caesarean section deliveries, per woman. These are presented in Table 6.

About 5%, 21% and 7% of the women had at least one premature birth, small baby at birth, or Caesarean section, respectively. Although only a small proportion of women had more than one birth with these specific outcomes in the 5 years preceding the survey, these births constitute more than 15% of all births with the specific outcome. For instance, only 1.1% of the women had experienced more than one Caesarean section birth in the 5 years preceding the survey, but these births make up 28% of all the Caesarean section births. This further supports the need for an analysis that controls for potential correlation between births of the same mother.

Multilevel logistic regression analyses

All the variables included in the bivariate analysis were considered as potential predictors in the multilevel logistic regression models. In addition, interactions were included of relevant factors with dummy variables for the availability of birth weight information and antenatal care attendance in the models for the size of baby at birth and premature birth, respectively. This was done in order to control for possible biases in the reporting of these outcome variables as discussed above. The selection of variables in the final model was based on stepwise selection to retain those variables that were statistically significant. However, some selected variables that were considered crucial were retained in the final model regardless of their significance level. For example, in view of the assumption that there may be similarities in the assessment of the baby's size within ethnic groups or regions, these variables were included in the final model regardless of their *p*-values.

Factors associated with premature delivery

The parameter estimates and odds ratios for the multilevel logistic model are presented in Table 7. The significant factors associated with premature delivery are frequency and timing of antenatal care, tetanus injection, the type of birth, birth order, region of residence and ethnicity.

The quality of antenatal care (measured by the frequency of antenatal visits and tetanus injections) is observed to be particularly important in predicting 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 the incidence of premature delivery, those who start antenatal care late in pregnancy are observed to be associated with lower odds of premature births compared with those who start antenatal care earlier. This result should not be interpreted to imply that late start of antenatal care reduces the chances of premature delivery. It is more likely that early medical care would be sought for pregnancies with complications and such pregnancies are at a higher risk of ending prematurely.

First-order births are observed to be associated with significantly higher odds of premature deliveries. Compared with 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 are about seven times the odds for single births.

Nairobi and Nyanza Provinces are associated with significantly lower odds of premature deliveries than Central Province, with corresponding average odds ratios of 0.30 and 0.16 respectively. The other provinces are not significantly different from Central Province. With respect to ethnicity, the Luos have very high proportions of premature births with average odds about seven times those of the Kikuyu.

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 that 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% of the total unexplained variation in premature births is attributable to unobserved factors relating to the woman or her family.

Table 7. The parameter estimates of premature deliveries from the multilevel logistic regression model

Parameter	Estimate[a]	Standard error	Average odds ratio
Fixed effects			
Constant	− 0·95	0·666	
Frequency of antenatal visits (7 or more visits)†			
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)†			
2nd trimester	− 0·65*	0·310	0·52
3rd trimester	− 1·73*	0·490	0·18
No antenatal care (7 or more antenatal care visits, starting during 1st trimester)†	− 0·29	0·608	0·75
Tetanus injection (no tetanus injection)†			
At least one injection	− 1·12*	0·348	0·32
Birth order (higher order births)†			
First birth	0·82*	0·244	2·27
Type of births (single birth)†			
Multiple birth	1·94*	0·421	6·96
Region (Central Province)†			
Nairobi	− 1·77*	0·878	0·30
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)†			
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
Random effects			
Woman-level standard deviation	2·18*	0·348	

[a]Estimates based on maximum marginal likelihood solution, obtained using MIXOR.
*$p<0{\cdot}05$.
†Represents reference category.

Factors associated with small baby's size at birth

As pointed out earlier, it is important to note that this analysis is based on the mother's perception of the size of the baby at birth, which may be subject to personal bias and systematic or random reporting errors. A dummy variable for whether or not

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birth weight information was available was included, and the interactions with relevant predictor variables were examined, in order to control for possible differences between those cases with and those without birth weights. Table 8 presents the parameter estimates and average odds ratios for factors significantly associated with small baby size at birth.

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 with those whose mothers had no tetanus injection.

Maternal nutritional status, based on the weight-for-height score, was significantly associated with the size of the newborn. Babies born to mothers with low weight-for-height scores are more likely to be small compared with those born to mothers with average or high weight-for-height scores. However, it should be noted that mothers with high weight-for-height scores seemed less likely to report the baby's size as small when birth weight information was available. Maternal height is also observed to be important. Babies born to shorter mothers (less than 150 cm in height) were more likely to be small compared with those born to taller mothers (more than 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 smaller than male babies and single births, with average odds ratios of 1·8 and 3·1 respectively.

None of the socioeconomic and cultural factors, other than region, seems to be significantly associated with 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 that shows a significant influence on 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 on average about 1·8 times more likely to result in small babies than higher order births.

As in the case of premature delivery, there is significant unexplained variation in reports of the size of baby at birth between different women. The intra-woman correlation coefficient for the model of the size of the baby at birth is 0·25, implying that about a quarter of the total unexplained variation in the reported size of the baby at birth is attributable to unobserved factors relating to the mother or the family.

Factors associated with Caesarean section deliveries

The parameter estimates and the odds ratios for variables significantly associated with Caesarean section deliveries are presented in Table 9. The odds of Caesarean section deliveries are influenced by the socioeconomic status of the households. The average odds of Caesarean section deliveries among births to women in households of high socioeconomic status are higher than the odds for women in households of medium socioeconomic status by a factor of 1·9. Compared with births in households of low socioeconomic status, births to women from households of high socioeconomic status have more than twice the odds of Caesarean section deliveries.

Table 8. The parameter estimates of small baby's size at birth from the multilevel logistic model

Parameter	Estimate[a]	Standard error	Average odds ratio
Fixed effects			
Constant	− 1·89	0·230	
Weight-for-height score (100–120)†			
<100	0·38*	0·155	1·46
>120	0·11	0·142	1·12
Height of mother (150–160 cm)†			
<150 cm	0·40	0·208	1·49
>160 cm	− 0·18	0·102	0·83
Birth order (higher order births)†			
First birth	0·59*	0·150	1·80
Tetanus injection (no tetanus injection)†			
At least one injection	− 0·60*	0·143	0·55
Sex of child (male)†			
Female	0·59*	0·093	1·80
Type of birth (single birth)†			
Multiple birth	1·13*	0·208	3·10
Ethnic group (Kikuyu)†			
Other	− 0·26	0·208	0·77
Kisii	− 0·27	0·320	0·73
Luhya	− 0·34	0·256	0·77
Luo	− 0·21	0·276	0·76
Region (Central Province)†			
Nairobi	− 0·15	0·376	0·86
Coast	0·10	0·262	1·11
Eastern	0·22	0·265	1·25
Nyanza	0·03	0·300	1·03
Rift Valley	0·29	0·222	1·34
Western	0·61*	0·288	1·84
Birth weight information (not available)†			
Available	− 0·10	0·141	0·90
Wt–Ht <100*birth weight available	− 0·20	0·252	
Wt–Ht 120*birth weight available	− 0·45*	0·213	
Random effects			
Woman-level standard deviation	1·03	0·132	

[a]Estimates based on maximum marginal likelihood solution, obtained using MIXOR.
*$p<0{\cdot}05$.
†Represents reference category.

Demographic factors observed to have a significant effect on Caesarean section deliveries include birth order and maternal age. Age group 20–24 years is associated with lower odds of Caesarean section deliveries than age group 30–34 years. Mothers

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Table 9. The parameter estimates and average odds ratios for Caesarean section deliveries

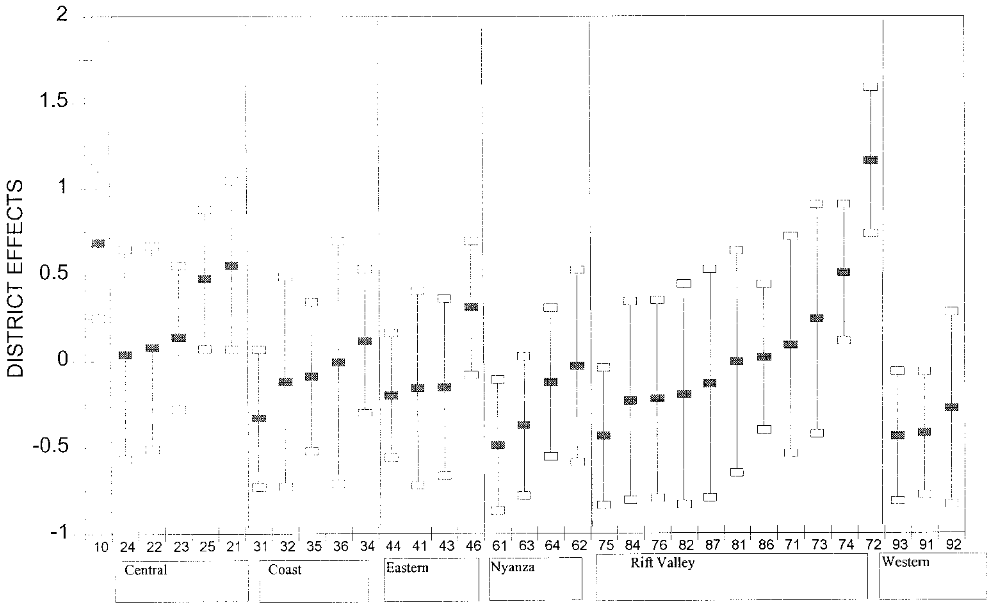
Parameter	Estimate[a]	Standard error	Average odds ratio
Fixed effects			
Constant	− 3·43	0·226	
Household socioeconomic status (medium)†			
Low	− 0·17	0·171	0·84
High	0·63*	0·203	1·88
Age group (20–24 years)†			
13–19	− 0·09	0·223	0·91
25–29	0·32	0·193	1·38
30–34	0·52*	0·224	1·67
35+	− 0·20	0·299	0·82
Birth order (higher order birth)†			
First birth	0·78*	0·202	2·18
Family planning practice (never used any method)†			
Used only traditional	0·23	0·223	1·26
Ever used modern	0·41*	0·157	1·51
Height of mother (150–160 cm)†			
<150 cm	0·93*	0·245	2·53
>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	

[a]Estimates based on first-order MQL approximation, obtained using MLn.
*$p<0·05$.
†Represents reference category.

aged 30–34 years have 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 are also higher among first births. Compared with higher order births, first births have twice the odds of Caesarean section deliveries.

Use of family planning methods is 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 with mothers who have never used any method of family planning. This is also to be expected, as both are dependent on access to health facilities. However one cannot be certain, from these data, of any causality. Maternal height is observed to be strongly associated with Caesarean section deliveries. The odds of 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 strong correlation in the likelihood of Caesarean section deliveries for different pregnancies of the same woman. This is expected since women who have



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.Gisgu
71-Kajiado 73-Laikipia 74-Nakuru 72-Kericho 93-Kakamega 91-Bungoma 92-Busia.

Fig. 2. Simultaneous 95% confidence intervals for district-level residuals for Caesarean section deliveries.

undergone a Caesarean section delivery are at an increased risk of having another in subsequent births. In addition, the probability of Caesarean section deliveries varies significantly between districts.

To illustrate the district variability, simultaneous confidence intervals for district-level residuals are used, after controlling for the observed significant covariates. Any two districts whose confidence intervals do not overlap are associated with different levels of Caesarean section deliveries. The simultaneous confidence intervals for district-level residuals are presented in Fig. 2.

From Fig. 2 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 Caesarean section deliveries while Nairobi and the districts in Central Province are associated with higher observed than expected 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,

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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 significantly higher than expected Caesarean section deliveries compared with Nandi, Trans Nzoia, Narok, Elgeyo Marakwet, West Pokot, Baringo, Uasin Gishu and Kajiado Districts. Nakuru District also has significantly higher than expected Caesarean section deliveries than Nandi District.

Discussion

In general, the results from this analysis are consistent with most previous studies in terms of the risk factors of poor birth outcomes. 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.

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. While the predominant factor in the baby's size at birth is maternal nutritional status, the crucial factor in premature deliveries seems to be the quality of prenatal care. Previous studies from other developing countries also demonstrated a similar association between antenatal care and preterm deliveries (Prazuck *et al.*, 1993; Coria-Soto *et al.*, 1996; Hollander, 1997). 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. In particular, the timing and frequency of antenatal care visits are important for a healthy birth.

With respect to the size of the baby at birth, maternal nutrition appears to be an important factor. The strong link between maternal nutritional status and birth weight has also been demonstrated by other studies. Anderson & Bergstrom (1997) identified maternal weight as the most important independent determinant of birth weight in a western Central African Republic population. Similar results have been observed in Bangladesh, where Das & Khanam (1997) observed the association of maternal weight and birth weight to be of the strongest significance. It is, however, important to note that the maternal weight-for-height and the baby's size at birth association presented in this paper could have been influenced partly by the differences in reporting by the mothers. The regression results suggest that women with high weight-for-height scores were more likely to report that the size of the baby was small when information on birth weight was not available. This is probably a reflection of high expectation by such women. That is, women with higher than average weight-for-height score may expect their babies to be bigger than average. Such a reporting pattern may have weakened the observed association between maternal weight-for-height and baby's size at birth.

The association between various socioeconomic indicators (e.g. maternal education, occupation, socioeconomic status) and either birth weight or prematurity is unclear from previous studies. For example, while some studies have shown a negative association between maternal education and the poor birth outcomes (Ebomoyi, Adetoro & Wickremasinghe, 1991; Karim & Mascie-Taylor, 1997), many studies have failed to detect such associations (Xu *et al.*, 1995; Bener, Abdulrazzaq & Dawodu, 1996; Peabody & Gertler, 1997), and yet some studies have shown a relationship in the reverse direction (e.g. Prazuck *et al.*, 1993). This study has shown no significant associations between the socioeconomic indicators and premature births or the size of the baby at birth. One possible explanation for the significant associations observed in some of the studies may be the type of data used, which is often hospital-based. It is important to note that hospital-based data, especially those 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 have higher than average risks of unfavourable birth 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 the observed associations could be spurious. This probably explains why residence or the work status of a woman, for instance, are significantly associated with premature births and size of baby at birth in the bivariate analysis, but not in the final model. Thus, the apparent high risk of undesirable birth outcomes observed in the bivariate analysis among unemployed mothers may not necessarily be the effect of this factor *per se*, but probably a result of poor maternal health care utilization and/or poor nutritional status among this subgroup of women. Similarly, the apparent high risk of poor birth outcomes observed among teenagers is most likely a result of their poor nutritional status, poor health care or a high proportion of first-order births.

The significant association between ethnicity and premature delivery may indicate the significant role played by cultural practices on pregnancy outcome. Although the Luos are associated with very high odds of a 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 in some categories. However, it was clear that in Nyanza Province, the Kisii had much lower proportions of premature births than the Luos. Some of the Luo customs discourage pregnant women from eating various types of foods (PSRI & UNICEF, 1996), some of which are highly recommended by health and nutrition specialists for the well-being of the mother and her baby. Thus, a qualitative study would be useful in identifying the undesirable cultural practices that need to be discouraged.

The interpretation of the results for Caesarean section deliveries should be undertaken 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 risk factors of difficult delivery leading to Caesarean section deliveries, the socioeconomic indicators are likely to influence Caesarean section deliveries mainly through their association with the utilization of appropriate delivery care services. The association between socioeconomic status and Caesarean section deliveries observed in this study corroborates results from previous studies which had linked higher socioeconomic indicators, such as high maternal education level and urban residence, with increased incidence of Caesarean section deliveries (Webster *et al.*, 1992; Chacham & Perpetuo, 1998).

The observed association between household socioeconomic status and Caesarean section deliveries can be explained by the fact that women from households of high socioeconomic status are more likely to receive appropriate delivery care as opposed to their counterparts from households of low socioeconomic status. Thus, if a delivery is difficult, women of high socioeconomic status are more likely to be at a health facility that offers Caesarean sections. Women from households of low socioeconomic status, on the other hand, may not have access to such care. Similarly, the association between family planning practice and Caesarean section deliveries 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 have never used any family planning method. The regions associated with the lowest odds of Caesarean section deliveries, namely Western, Nyanza, and Coast Provinces, are all known to be associated with the highest infant and maternal mortality levels in the country (NCPD, Central Bureau of Statistics & Macro International, 1994; PSRI & 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.

The results of this study suggest that significant variation in birth outcomes exists between different women after controlling for significant observed factors, implying that there may be unobserved or unobservable personal characteristics of woman which put some at higher risk of unfavourable birth outcomes than others. Such factors could include biological or genetic factors, the woman's health status during pregnancy or other behavioural characteristics. Previous studies have identified factors such as prior pregnancy loss, cigarette smoking and physical work to increase the risk of low birth weight and/or premature birth (Thomson, 1983; McFadyen *et al.*, 1984; Sharma *et al.*, 1994; Bener *et al.*, 1996).

While the statistical significance of the higher level effects are appreciated, it is equally important to acknowledge the fact that the measurements of intra-class correlations, particularly for the size of the baby at birth, may have been influenced by the validity of mothers' assessment. It is possible that some mothers may systematically report their baby's size as 'small' or 'large', depending on their perceived 'average' size, which may be larger or smaller than the actual average. This would inflate the measurements of the intra-woman correlation. On the other hand, some women may report the baby's size relative to the size of another, which would lead to an underestimation of the intra-class correlation. Thus, it is possible that the levels of the intra-class correlations (especially for the baby's size at birth) may be over- or underestimated, depending on the extent of the two possible misreporting patterns. In general it is assumed that the net effect of this will not be large.

More importantly, the possible effect of such misreporting tendencies on the results of the other covariates in the model should be recognized. A comparison of the results presented in this paper with equivalent models that do not control for these higher level effects shows reasonable consistency, except for a few factors (see Magadi, 1999). One difference observed was with respect to maternal age, which showed significant associations with both premature birth and the size of baby at birth in the equivalent single-level logistic model, but not in multilevel analysis. Plausible explanations for these include the likelihood of an association between various unobserved woman characteristics with maternal age or possible selective systematic misreporting by women of specific age-groups.

Another difference that was observed was the non-significance of the association between maternal nutritional status and baby's size at birth in the single-level logistic model. This could be due to the earlier observed tendency of women of higher nutritional status to report the baby's size as small when birth weight information was not available. Because of the expected consistency in the availability of birth weight information among births of the same mother, multilevel analysis would be expected to identify the important factors more accurately since such woman-level tendencies are controlled for.

With respect to Caesarean section deliveries, there was reasonable consistency between the two models with respect to the important factors such as maternal height, birth order, ever-use of family planning methods, maternal age and household socioeconomic status. However, factors such as ethnicity, rural/urban residence, maternal education, health facility accessibility and weight-for-height score were significant in the ordinary logistic model but not the multilevel model. It is likely that these factors are correlated with unobserved factors at the district or woman level, which are controlled for in the multilevel analysis.

Conclusions

Quality antenatal care, measured by the frequency of antenatal care visits and tetanus injections, has been observed to have a negative association with 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. In relation to the baby's size 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 should have special focus on the high-risk groups such as first pregnancies. It is also important that births of first-time mothers or mothers of short stature (less than 150 cm in the case of this study), receive appropriate delivery care, since such pregnancies are more likely to require a Caesarean section during childbirth. The results suggest that Caesarean section deliveries may not be available to all women, particularly those of low socioeconomic status and those living in poorer regions. It is important that accessible and affordable appropriate delivery care is available to all women, including those 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 birth outcomes. Thus, there is need for integrated maternal health programmes that include antenatal care, delivery care and maternal nutrition. In all cases, first-order births are observed to be at particularly high risk of unfavourable birth outcomes. It is, therefore, crucial that first pregnancies receive appropriate maternal health care.

All the indicators of unfavourable birth outcomes addressed in this analysis vary significantly by region. Consequently, programmes aimed at addressing these issues should be sensitive to regional disparities. The observed intra-woman correlations suggest that women who had previously experienced any of the unfavourable birth outcomes should be advised on the need for appropriate nutrition and maternal health care due to the increased possibility of having a repeat incidence. There is need for qualitative studies to identify the unobserved behavioural and cultural factors contributing to unfavourable birth outcomes in specific communities within the country.

Further analyses of the association between the different indicators of poor 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 the baby at birth and Caesarean section deliveries. This implies that factors affecting any of the birth 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 to understand better potential pathways through which various factors might either directly or indirectly influence birth outcomes. This is an important area for further research.

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