UNIVERSITY OF SOUTHAMPTON

An Analysis of Fertility Differentials in Liberia and Ghana Using Multilevel Models.

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ABSTRACT

FACULTY OF SOCIAL SCIENCES

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AN ANALYSIS OF FERTILITY DIFFERENTIALS IN LIBERIA AND GHANA USING MULTILEVEL MODELS

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This thesis investigates differentials in the levels of fertility, nuptiality and contraceptive use in Liberia and Ghana, using data from the recent Demographic and Health Surveys in these countries. Of particular interest is the effect of the community in which a woman lives on her current and past fertility, her marital status and her use of contraception. This interest stems from the fact that, although the community in which a woman lives is integral to anthropological explanations of fertility, statistical models of fertility have rarely included an assessment of community effects.

The method of analysis used is multilevel modelling. This involves fitting variables measured at the woman level, variables measured at the community level and also includes the use of random effects to assess the extent to which community effects have not been captured by the fixed explanatory variables. Multilevel log-linear models are used in the analyses of fertility and multilevel logistic models are used in the analyses of nuptiality and contraceptive use.

This thesis demonstrates not only that there is significant variation between communities in both Liberia and Ghana for number of births 0-4 years before survey, children ever born, marital status and use of contraception but also that in each case significant community effects are found even after controlling for woman's age, education, religion and ethnicity.

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0 INTRODUCTION

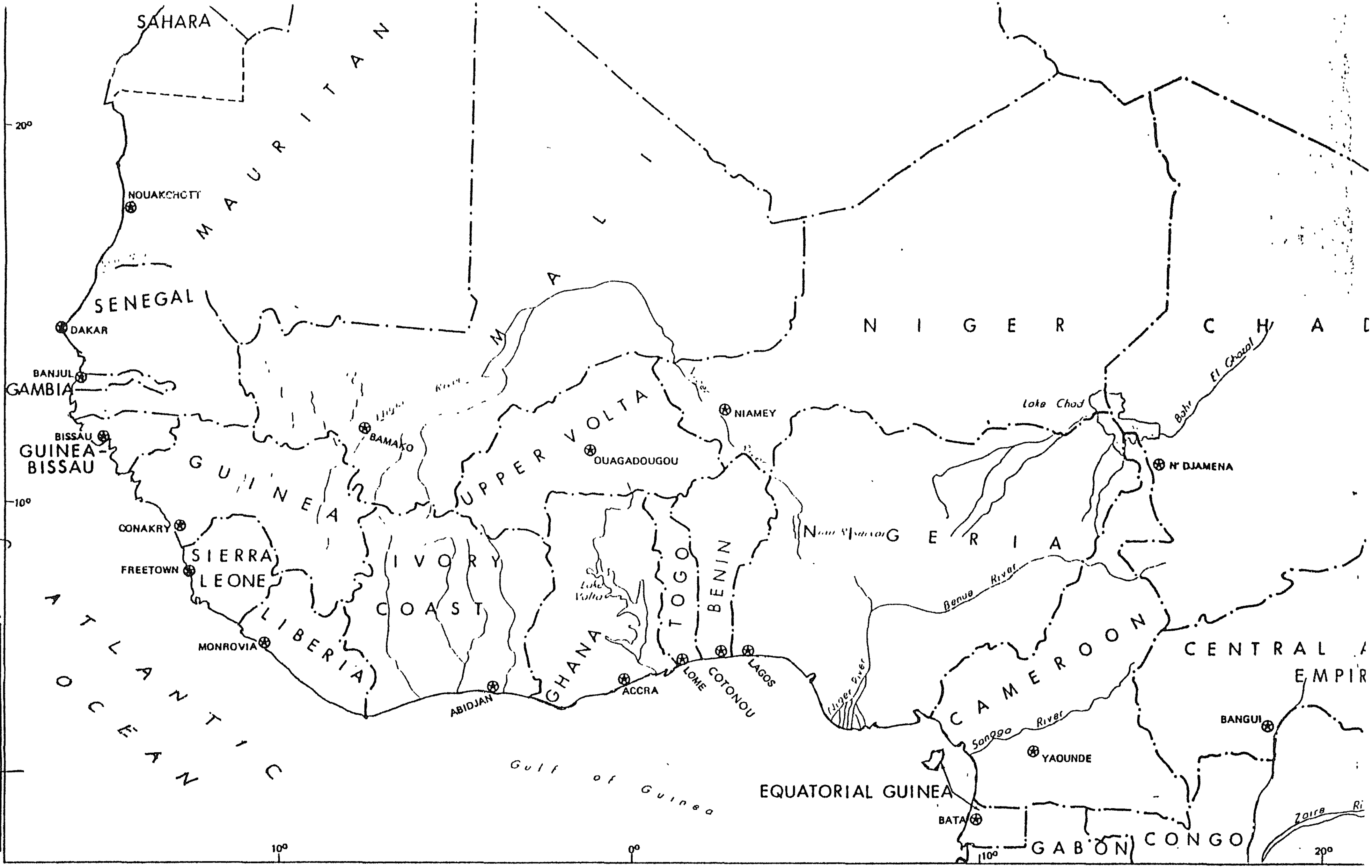
0.1 Background

It would seem to be more than a coincidence that sub-Saharan Africa currently has both the lowest levels of economic development and the fastest rate of population growth of any region of the World. This rapid population growth is primarily due to levels of fertility, which are currently the highest in the World.

Liberia and Ghana, two countries in sub-Saharan Africa, have geographical, economic and cultural similarities, both being located on the coast of West Africa (see Map 0.1). Both are peopled by negro tribes and both are predominantly Christian. Both are underdeveloped. However, the two have contrasting histories with Liberia, uniquely among sub-Saharan African countries, having a non-colonial past; it has been ruled for most of its history by the descendants of freed slaves from the U.S.A. Ghana, however, is a former British colony. Among sub-Saharan African countries Ghana is distinguished by having one of the most educated populations.

0.2 Aims of This Thesis

This thesis analyses fertility in Liberia and Ghana. The data used come from recent Demographic and Health Surveys (DHS) in these countries. The principal aim of the thesis is to examine the variation of fertility between socioeconomic and cultural subgroups of these populations and between different communities. As well as analysing variation in current and cumulative fertility



Map 0.1 West Africa

between subgroups of each population, variation in levels of marriage and contraceptive use between these subgroups will also be examined.

In investigating fertility in Liberia and Ghana, a recently developed method of statistical analysis, multilevel modelling, will be employed. This will allow the effects of communities to be incorporated concisely into the analyses. Hence, a secondary aim of this thesis is to offer an appraisal of this new methodology as a tool for analysing fertility data.

Since multilevel modelling has only recently been developed issues regarding the approach to model selection for multilevel models have not been addressed. Hence, a third aim of this thesis is to address model selection with multilevel models.

0.3 Summary of Existing Knowledge

Prior to the 1986 Liberia Demographic and Health Survey (LDHS), reliable and comprehensive nationally representative data on fertility in Liberia were not available, with the only information being unreliable and limited census data and a few small-scale survey investigations. On the other hand Ghana has been relatively well served. The 1988 Ghana Demographic and Health Survey (GDHS) data can be contrasted to data obtained from another comprehensive and nationally representative survey, the 1979-80 Ghana Fertility Survey (GFS) as well as with findings from numerous anthropological investigations of Ghanaian fertility.

Multilevel models have been used to incorporate the effects of "country" into analyses of children ever born to women aged 35-39 and 40-44 using data from various surveys carried out by the World Fertility Survey (WFS) (e.g. Mason, Wong and Entwisle (1983), Entwisle and Mason (1985) and Wong and Mason (1991)) and into analyses of "ever-use of contraception" (Wong and Mason (1985)). In these analyses of children ever born it is assumed that a normal distribution is appropriate for the response variable. However, because this response is valued on the non-negative integers only, at least in natural fertility populations, a Poisson-type distribution is more appropriate (e.g. Little (1978), Mason (1989)). Prior to this thesis no investigation the use of Poisson-type multilevel models to investigate fertility has been attempted. There have been a number of attempts to incorporate the effects of "community" into analyses of fertility or contraceptive use (e.g. Casterline (1985), Billsborrow and Guilkey (1987)). However, most of these used only fixed effects and so were not "multilevel" in the sense of estimating random variation at more than one level. An exception is Entwisle *et al* (1989), although details of the random effect(s) were not published.

0.4 Outline of Thesis

Chapter 1 begins by detailing the biological and behavioural factors which determine fertility and by setting out a conceptual framework within which fertility can be analysed. The bulk of this chapter, however, is concerned with presenting an overview of fertility patterns in sub-Saharan Africa as a whole. The purpose of Chapter 1 is twofold, firstly, to outline the conceptual framework for the analyses of fertility in Liberia and Ghana and, secondly, to provide a context, namely fertility in sub-Saharan Africa, in the light of which the investigations of fertility in Liberia and Ghana can be compared.

Chapter 2 outlines the statistical method used in the analyses, multilevel modelling. Chapter 3 addresses a methodological issue to which little or no attention has previously been paid, namely model selection for multilevel models.

Chapter 4 argues that both theoretical models and empirical models of fertility should relate to both the individual level and to higher levels, and in particular the community and the nation. In other words this chapter argues that models of fertility should be multilevel.

Chapters 5 and 6 run parallel to each other. Chapter 5 analyses fertility in Liberia and Chapter 6 analyses fertility in Ghana. Each chapter contains three main components; a review of existing studies of fertility in the country, a descriptive analysis of fertility in that country using DHS data and multivariate, multilevel analyses of fertility using DHS data.

Chapter 7 compares and contrasts fertility in the two countries studied using the findings of the previous two chapters. Finally, Chapter 8 summarizes the main findings and outlines suggestions for further research.

1 FERTILITY IN SUB-SAHARAN AFRICA

1.0 Introduction

The term "fertility" is used by demographers to describe actual human procreation. The term "fecundity" is used by demographers to describe the biological capacity to procreate. In this chapter I draw from the literature to describe both the levels of and the determinants of fertility in sub-Saharan Africa. Before such descriptions can be undertaken meaningfully, it is necessary to set out a framework for the analysis of fertility. Such a framework is described in Section 1.1. In Section 1.2 I describe the levels of fertility which are found in sub-Saharan Africa and in Section 1.3 I describe factors which determine fertility levels in sub-Saharan Africa.

1.1 A Framework for the Analysis of Fertility

1.1.1 The Determinants of Fertility

The number of children born to a woman is determined by both her reproductive life span and her rate of childbearing during her reproductive life span. The most important events which determine a woman's reproductive life span and her rate of childbearing during this period are:

1) Menarche. The first menstruation of a woman's life indicates the onset of her biological capacity to produce children (i.e. that she is fecund). Menarche does not necessarily indicate the onset of ovulation and there is evidence that a high proportion of the cycles following menarche are anovular (e.g. Gray (1979,

p221).

2) Marriage. This term is used to refer to relatively stable sexual unions within which childbearing is socially sanctioned. Entry into such unions usually indicates the onset of a woman's actual reproductive life, although it should be noted that in all societies childbirth will occur to unmarried women. In most societies only a minority of births occur to unmarried women, although in a number of societies extra-marital childbearing is widespread. In some cases the woman's actual reproductive life will be interrupted by the breakdown of one (or more) marriage(s) through separation, divorce or widowhood in which case(s) it will resume with a subsequent remarriage.

3) i) First birth.

ii) Second birth

iii) Third birth

etc.

The period between successive live births is known as the birth interval. A birth interval contains the following stages:

a) The postpartum infecund interval. Following a birth there is a temporary absence of menstruation and ovulation which can be prolonged as a result of breastfeeding. Abstinence from sexual relations following a birth can also prolong this interval.

b) The waiting time to conception. This is the interval between first ovulation and conception. The length of this interval will reflect, firstly, whether sexual abstinence is observed beyond the return of ovulation; and, secondly, once sexual relations have resumed, the frequency of sexual intercourse and the the use and effectiveness of contraception.

c) A full-term pregnancy. That is a pregnancy which leads to a live birth. It will usually last around 9 months.

In some cases an intrauterine death(s) will occur. According to Gray (1979, p233) the most reliable recorded estimate is that fetal loss accounts for 23.7% of pregnancies over 4 weeks. In cases where intrauterine death occurs additional time will be added to the birth interval due to the gestation of the intrauterine death(s), the infecundable interval(s) following the intrauterine death(s) and the waiting time(s) until the subsequent conception(s).

4) Menopause or the onset of permanent sterility. This is the termination of a woman's biological capacity to reproduce.

A set of biological and behavioural factors known as the intermediate fertility variables (or the proximate determinants of fertility) which directly affect the number of live births a woman has was set out by Davis and Blake (1956) as follows:

I <u>Factors Affecting Exposure To Intercourse ("Intercourse Variables")</u>

A. Those governing the formation and dissolution of unions in the reproductive period.

1. Age of entry into sexual union.

2. Permanent celibacy: proportion of women never entering sexual unions.

3. Amount of reproductive period spent after or between unions.

a. When unions are broken by divorce, separation or desertion.

b. When unions are broken by death of husband.

B. Those governing exposure to intercourse within unions.

4. Voluntary abstinence.

5. Involuntary abstinence (from impotence, illness, unavoidable but temporary separations).

6. Coital frequency (excluding periods of abstinence).

II. Factors Affecting Exposure to Conception ("Conception Variables").

7. Fecundity or infecundity, as affected by involuntary causes.

8. Use or non-use of contraception.

a. By mechanical and chemical means.

b. By other means.

9. Fecundity or infecundity, as affected by voluntary causes (sterilization, subincision, medical treatment, etc.).

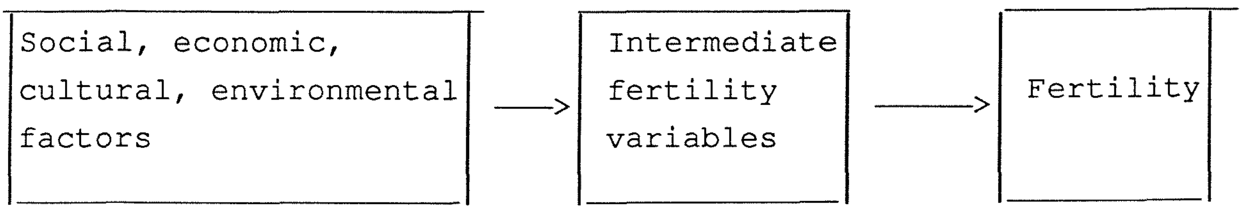
III. Factors Affecting Gestation and Successful Paturition ("Gestation Variables").

10 Foetal mortality from involuntary causes.

11 Foetal mortality from voluntary causes.

Variation in the eleven intermediate fertility variables (directly) causes variation in fertility. Social, economic, cultural and environmental factors can only influence fertility through influencing one or more of these intermediate fertility variables. The relationships among the determinants of fertility are summarized by Figure 1.1.1:

Figure 1.1.1



1.1.2 Bongaarts' Model

In Section 1.1.2, I argued that social, economic, cultural and environmental factors could indirectly effect fertility through influencing one or more of the intermediate fertility variables. A study which relates fertility directly to such social, economic, cultural and environmental factors without considering the intermediate fertility variables could miss the subtlety of the relationships described. However, a more subtle approach would involve not only relating social, economic, cultural and environmental factors to the intermediate fertility variables but also quantifying the effects of the intermediate fertility variables on fertility. In this section I introduce Bongaarts' model (e.g. Bongaarts (1981), Bongaarts and Potter (1983)). This model is currently the most prominent framework for quantifying the effects of changes in the intermediate fertility variables on fertility levels.

In formulating his model, Bongaarts adopted a different, more readily quantifiable set of intermediate fertility variables, which closely overlaps those of Davis and Blake. This set of variables, which Bongaarts refers to as the "proximate determinants of fertility", is as follows:

The Proximate Determinants of Fertility

A. Exposure factors

1. Proportion of reproductive period spent in marriage (i.e. stable sexual union).

B. Deliberate marital fertility control factors

2. Contraception.
3. Induced abortion.

C. Natural marital fertility factors

4. Postpartum non-susceptibility.
5. Frequency of intercourse.
6. Sterility.
7. Spontaneous intrauterine mortality.
8. Duration of viability of ova and sperm.

Bongaarts stated that, although variation in the eight proximate determinants of fertility will explain variation in the fertility levels of individual women, when fertility levels of populations of women are compared only the first four variables listed (i.e. marriage, contraception, induced abortion and postpartum non-susceptibility) are important. This was because population differences of the remaining factors were (with the exception of a few populations with high levels of sterility or spousal separation) not large enough to make a substantial contribution to fertility differences.

Bongaarts produces indices in a deterministic model which measures the fertility inhibiting impacts of the four most important intermediate fertility variables. These indices are as follows:

C_m = index of proportion married (equals 1 in the absence of celibacy and 0 in the absence of marriage).

C_c = index of contraception (equals 1 in the absence of contraception and 0 if all fecund women use 100% effective contraception).

C_a = index of induced abortion (equals 1 in the absence of induced abortion and 0 if all pregnancies are aborted).

C_i = index of postpartum non-susceptbility (equals 1 in the absence of lactation and postpartum abstinence and 0 if postpartum non-susceptibility has infinite duration).

These indices are estimated as follows:

i) $$C_m = \frac{\sum_a [\ m(a) \times g(a)\ ]}{\sum_a g(a)}$$

where

m(a) = age specific proportions of women currently married.

g(a) = age specific marital fertility rates.

ii) $$C_c = 1 - [\ 1.08 \times u \times e\ ]$$

where u is the average proportion of women using contraception and e is the average use effectiveness of contraception (i.e. the proportionate reduction in the monthly probability of conception among those actually practising contraception).

iii) $$C_a = \frac{\text{Total fertility rate}}{\text{Total fertility rate + births averted by abortion}}$$

$$= \frac{TFR}{TFR + [\ 0.4 \times TA \times (\ 1 + u\ )\ ]}$$

where

TA is the total abortion rate

TFR is the total fertility rate

u is as in (ii)

The denominator is derived as follows. For women not using contraception after an abortion, Bongaarts assumes the abortion will only have averted 0.4 births on average. This figure comes from work by Potter (1972) and reflects that without an abortion the expected number of additional live births is less than one because of the risk of spontaneous abortion or still birth and the earlier return of ovulation after abortion compared to live birth. The number of births following an abortion has been shown to be strongly related to the use of contraception following the abortion and hence Bongaarts adjusts this estimate to allow for the prevalence of contraception.

iv) C_i = $\dfrac{\text{Average birth interval in the absence of lactation and postpartum abstinence}}{\text{Average birth interval including the effect of lactation and postpartum abstinence}}$

$$= \frac{20}{18.5 + i}$$

where i is the duration (in months) of the postpartum non-susceptible period defined for each woman as the maximum of the duration of amenorrhea and the duration of abstinence.

(This assumes the average birth interval is made up of:

a) 9 months gestation,

b) an average 7.5 months waiting time to conception (while the woman is susceptible to conception),

c) an assumed addition to birth intervals as a result of spontaneous intrauterine mortality of 2 months,

d) the postpartum non-susceptible period, i. For women who neither breastfeed nor abstain this is assumed to last on average 1.5 months.

Bongaarts estimated that the total fecundity rate (i.e. the total fertility rate after the fertility inhibiting effects of non-marriage, contraceptive use, induced abortion and postpartum infecundability have been removed) to be 15.3 (with a standard error of about 5 percent). This total fecundity rate represents the reduction in fertility below the theoretical biological maximum fertility rate as a result of the incidence of sterility, intrauterine mortality, the frequency of intercourse and the durations of the viable periods of ova and sperm. The total fecundity rate can be reduced by the fertility inhibiting effects of the practice of breastfeeding and postpartum abstinence to give a total natural marital fertility rate. The total natural marital fertility can be reduced by the fertility inhibiting effects of contraception and induced abortion to give a total marital fertility rate, and this total marital fertility rate can be reduced by the fertility inhibiting effect of celibacy to give the total fertility rate. Because of low variation in the population values of frequency of intercourse, sterility, spontaneous intrauterine mortality and duration of viability of ova and sperm, Bongaarts expressed the total fertility rate in terms of the

(estimated) total fecundity rate (i.e. 15.3) and the indices for the fertility inhibiting effects of the four intermediate fertility variables for which population variation was appreciable. That is:

$$TFR = 15.3 \times C_m \times C_c \times C_a \times C_i \quad (1.1.2)$$

In summary, Bongaarts' model is the most widely used method for quantifying the effects of changes/differentials in intermediate fertility variables on fertility. Its widespread use partly reflects both the simplicity and the generality of its network of analytical formulae and the empirical agreement between TFRs estimated by the equation (1.1.2) and actual TFRs.

1.2. Fertility Levels In Sub-Saharan Africa

1.2.0 Introduction

Fertility levels in sub-Saharan Africa are currently among the highest in the world. The total fertility rate (TFR) (i.e. the expected number of births a woman currently at the start of her reproductive life would have if the current fertility rate for each age group were to prevail throughout her reproductive period) for countries in this region is typically between 6 and 7.5 births. This contrasts with Western European countries where TFRs are typically between 1.5 and 2 births. Furthermore, for the vast majority of sub-Saharan African countries there is little or no evidence of a sustained decline in fertility (e.g Van de Walle and Foster (1990)). Table 1.2.0.1. shows the TFRs for selected countries from sub-Saharan Africa and selected countries from the rest of the World.

Table 1.2.0.1: Total Fertility Rates For Selected Countries

Country	Total Fertility Rate (estimated 1990)
Benin	7.0
Cameroon	5.8
Ethiopia	6.2
Ghana	6.3
Guinea	6.2
Ivory Coast	7.4
Kenya	6.7
Liberia	6.4
Nigeria	6.5
Senegal	6.4
Sierra Leone	6.5
Togo	7.2
Zaire	6.2
Zambia	7.2
Australia	1.8
Brazil	3.3
China	2.3
France	1.8
India	4.2
Italy	1.3
Japan	1.6
Mexico	3.8
Pakistan	6.7
Thailand	2.6
U.K.	1.8
U.S.A.	2.0
U.S.S.R.	2.5

Source: Population Reference Bureau (1990). *World Population Data Sheet.*

The high fertility levels in sub-Saharan Africa reflect that children are greatly valued, that a woman's status is enhanced by the regular birth of children and that childlessness is abhorred (e.g. Acsadi and Johnson-Acsadi (1990a), Caldwell (1982), Caldwell and Caldwell (1987), (1990)). The high value of children reflects their importance both as the means of the perpetuation of the lineage or clan and as a source of security for old age (e.g. Gaisie (1981a, p96), Acsadi and Johnson-Acsadi (1990a, p155)). High levels of infant mortality in sub-Saharan Africa serve to reinforce desires for high fertility because parents want to ensure that the risk of being left without surviving children is negligible (Caldwell and Caldwell (1987), (1990)). Furthermore, birth intervals tend to be shorter when the previous child has died (Cantrelle et al. (1978)). In traditional African societies children are regarded as an economic asset. Caldwell ((1976) and (1982)) stresses the economic benefits of having children in traditional African societies and hypothesises that there may be some economic rationality behind desires for high fertility. Furthermore, belief systems in tropical Africa serve to reinforce the value attached to children (Caldwell and Caldwell (1987), (1990)). According to the Caldwells (1987), in tropical Africa:

" . . .high fertility (and a considerable number of surviving children) is associated with joy, the right life, divine approval, and approbation by both living and dead ancestors. Conversely, low fertility is only too easily interpreted as evidence of sin and disapproval." (p416)

Data from the World Fertility Survey (WFS) show that high numbers of children were desired by married women in all the various sub-Saharan African countries surveyed. This is shown in Table 1.2.0.2. It is to be noted that the mean desired family sizes in Table 1.2.0.2 are based on numerical answers only and so do not take into account that many of the women in each of the countries surveyed responded that they want "as many children as possible" or that such matters are "up to God":

Table 1.2.0.2: Mean Desired Family Size in Sub-Saharan Africa

Country	Mean Desired Family Size (*)
Benin (1982)	7.5
Cameroon (1978)	8.0
Ghana (1979-80)	6.1
Ivory Coast (1980-81)	8.5
Kenya (1978)	7.2
Lesotho (1977)	6.0
Nigeria (1981-82)	8.4
Senegal (1978)	8.4

(*) Currently Married Women Only.

Source: World Fertility Survey (1984b). *Major Findings and Implications*.

1.2.1 Fertility Differentials

Within a sub-Saharan African population fertility levels differ according to the social, economic, cultural and environmental characteristics of the women. In this section I draw together findings on fertility differentials between subgroups of sub-Saharan African populations.

Differentials in fertility by ethnic group and region have been observed in most countries studied. However the nature of such subsections of African populations makes it difficult to present an overview of these findings. Consequently, the following sections address only fertility differentials for which an overview can reasonably be presented.

1.2.1.1 Urban-Rural Residence

Compared to rural areas, urban areas, generally, offer more facilities for such things as family planning, education and health, as well as a different set of economic opportunities and costs (e.g. Cochrane (1983)). In most sub-Saharan African societies fertility levels of women living in urban areas tend to be lower than those of women living in rural areas. In particular, in most countries fertility levels of women in the larger urban areas tend to be considerably lower than in other parts of the country. For example, data from the Ghana Fertility Survey show a higher TFR for rural areas (6.9) than for urban areas (5.8) and that the TFR for Greater Accra (the capital and largest urban area in Ghana) at 5.0 is substantially below those for other regions (Shah and Singh (1985, p63)). Likewise, the Cameroon Fertility Survey reported TFRs of 5.9 for rural areas, 5.8 for urban areas (excluding the capital) but only 4.9 in Yaoundé-Douale (the capital) (WFS (1983a, p8)). The Senegal Fertility Survey reported a TFR of 7.5 in rural areas but only 6.5 in urban areas (WFS (1981c, p10)), while the Kenya Fertility Survey reported that Nairobi and Mombassa (the two largest urban areas) had a TFR which was 2.5 births lower than that of rural areas (WFS (1981a, p8)). The more recent Demographic and Health surveys (DHS) also confirm the tendency for urban areas to have lower fertility than rural areas in sub-Saharan Africa. For example, TFRs for urban areas and rural areas are: 4.1 and 5.4 respectively in Botswana (Botswana (1989)), 5.9 and 6.6 in Liberia (Liberia (1988)), and 4.1 and 6.2 in Zimbabwe (Zimbabwe (1989)). Lower fertility in urban areas and, in particular, in large urban areas reflects the smaller family sizes desired in such areas (Acsadi and Johnson-Acsadi (1990a)).

1.2.1.2. Woman's Education

In most sub-Saharan African societies highly educated women (i.e. women who have had secondary level or higher education) tend to have lower fertility levels than less educated women. This is in part because highly educated women delay marriage and first birth in order to pursue education. It also reflects a selection effect whereby young women who have become pregnant cease attending school. Lower fertility among more educated women also reflects that they tend to have smaller desired family sizes (Acsadi and Johnson-Acsadi (1990a)) and that they tend to be more knowledgeable of and make more use of contraception.

The pattern of fertility between partially educated women (i.e. women who attended primary school only) and uneducated women, however, varies amongst sub-Saharan African societies. In some, women with primary education have higher fertility levels than uneducated women whereas in others uneducated women have the higher fertility levels. The presence of "curvilinear" and "inverse" relationships between fertility and individual-level female education (using the terminology of Cochrane (1979)) in different parts of sub-Saharan Africa indicates a need for the context in which a relationship is found to be analysed. The "curvilinear" relationship between a woman's level of education and her fertility has been found for Lesotho, with TFRs of 5.8, 6.1, 5.6, and 4.5 for no schooling, lower primary, upper primary and secondary or higher categories respectively (WFS (1981b, p7)), Burundi, with TFRs of 6.8, 7.2 and 5.5 for women with no education, primary education and secondary or above education respectively (Burundi (1988)), and Ondo State, Nigeria, with TFRs of 6.7, 7.1 and 5.4 for women with no education, primary education and secondary education respectively (Nigeria (1989)). Shah and Singh also found a curvilinear relationship between highest level of education of wife and level of cumulative fertility to age 35 for Ghana with TFRs of 4.9, 5.0, 4.3 and 4.1 for women with no schooling, primary schooling, incomplete middle schooling and complete middle and above schooling respectively (Shah and Singh (1985, p66)). The explanations offered by Shah and Singh for this pattern are that the partially educated women are more likely to benefit from improvements in fecundity as a result of improvements of health and medical services and that these women are more likely to be affected by the breakdown of traditional practices of child-spacing such as postpartum sexual abstinence and breastfeeding. However, when TFRs (ages 15-44) were used to measure fertility for this survey an inverse relationship was found with TFRs of 6.8, 6.6, 5.6, and 3.9 for no schooling, primary schooling (1-6 years schooling), 7-10 years schooling and 11+ years schooling respectively (WFS (1983c, p51)). Likewise, an inverse relationship between female education and fertility has been found in Cameroon, with TFRs of 6.4, 5.9, 4.8 and 4.7 for no schooling, incomplete primary, complete primary, and secondary or higher categories respectively (WFS (1983a, p8)), Botswana, with TFRs of 6.0, 5.2, 4.6, and 3.3 for no education, incomplete primary, complete primary and secondary or higher categories of education respectively (Botswana (1988)), and Zimbabwe, with TFRS of 7.0, 6.0, and 3.8 for no education, primary, and secondary or higher categories of education respectively (Zimbabwe (1989)).

1.2.1.3 Religion

The main religious groups in sub-Saharan Africa can be classified as Christians, Muslims and traditional/animist. The traditional beliefs tend to be strongly pronatalist (Caldwell and Caldwell (1987), (1990)). Fertility levels of Christians tend to be lower than those of the other two groups. For example, data from the WFS show lower fertility levels for Christians in Ivory Coast and Ghana (WFS (1984b), Shah and Singh (1985, p69)). An exception to this pattern has been found in Cameroon where the WFS found Muslims to have the lowest fertility level (WFS (1983a)).

1.3 The Determinants of Fertility in Sub Saharan Africa

1.3.0 Introduction

The previous section demonstrated that high levels of fertility exist in sub-Saharan Africa and that there are fertility differentials within sub-Saharan African populations. In Section 1.1 I showed that fertility levels reflect levels of the intermediate fertility variables. In this section I discuss the levels of the intermediate fertility variables in sub-Saharan

Africa and how these vary according to social, economic, cultural and environmental characteristics.

Broadly speaking, sub-Saharan fertility patterns tend towards those of natural fertility as defined by Henry (1972). That is, there is an absence of parity dependent family limitation. This is reflected by low levels of induced abortion and contraceptive use. Generally, in sub-Saharan Africa, it appears that only the need to achieve a degree of birth spacing has a large fertility inhibiting effect apart from a few (largely Central African) populations in which the impact of sterility is large (e.g. Page and Lesthaeghe (1981, p5)). I now discuss the impact of each of the main intermediate fertility variables in sub-Saharan Africa in greater length.

1.3.1 Marriage

The term marriage is used to refer to a relatively stable sexual union within which childbearing is socially sanctioned. In all societies women who are married will tend to have higher fertility than women who are not married. This reflects women who are not married tending to have lower exposure to sexual intercourse than married women and also tending to have less desire to be impregnated and to give birth than married women. Hence the age at entry into first marriage, the proportion of women who never marry, the time spent out of marriage as a result of divorce, separation or widowhood and the type of marriage are important determinants of fertility levels.

The criteria as to what constitutes a marriage will differ in different types of society. In sub-Saharan Africa, traditional marriage is often a developmental process which may lack a clearly defined point of finalization (e.g. Ayree (1985, p17)). As well as traditional African forms of marriage (usually involving payment of bride wealth to the wife's family), Christian and Islamic forms of marriage are also common. African marriages are characterized by weak bonds between spouses with spouses usually retaining strong lineage links (Caldwell *et al.* (1989, p188)). Furthermore in many African societies polygyny (i.e. a man having more than one wife at a time) is widespread. In African marriages it is widely regarded as a duty of the wife to produce children for her husband, and failure to do so may often lead to her parents having to return the bridewealth or provide a substitute (e.g. a younger sister) to bear the children (e.g. Caldwell and Caldwell (1990, p202)). Although marriage is seen as the respected institution for fruitful sexual relations, in tropical Africa sexual relations outside marriage are also widespread (e.g. Orubuloye *et al.* (1991)). When describing prevailing attitudes to premarital and extramarital relations Caldwell et al. (1989) report:

" a fair degree of permissiveness toward premarital relations that are not too blatantly public, and a degree of acceptance that surreptitious extramarital relations are not the high point of sin." (p197)

The differing criteria for what constitutes a marriage create problems for assessing the impact of marriage on fertility levels. For the convenience of being able to use *some* measurement of marriage, in subsequent data a woman is categorised as married if she is regarded as married by local custom or if she cohabits with a partner.

1.3.1.1 Proportions Ever Married

Marriage in sub-Saharan Africa is near universal and, hence, permanent celibacy has little effect on fertility levels. Spinsterhood is frowned upon (e.g. Caldwell (1968, ch. 5)). Data from the WFS and DHS show that, typically, in sub-Saharan Africa countries fewer than 3% of women at the end of their reproductive lives (i.e. aged between 45 and 49 years) report that they have never married. A notable exception is Botswana where a skewed sex ratio caused by men going to work in South Africa and an absence of polygyny has lead to a substantial proportion of women never marrying (e.g. Lesthaeghe (1986, p231)). The proportions of women aged 45-49 who have ever married or lived with a man recorded by the WFS or DHS for various sub-Saharan African countries are shown in Table 1.3.1.1:

Table 1.3.1.1: Percent Ever Married in Sub-Saharan Africa

Country	% of Women Aged 45-49 Ever Married
WFS	
Cameroon (1978)	98.2
Ghana (1979-80)	99.8
Ivory Coast (1980-81)	100.0
Lesotho (1977)	98.6
Nigeria (1981-82)	99.4
DHS	
Botswana (1988)	79.2
Burundi (1987)	98.0
Ghana (1988)	100.0
Kenya (1989)	97.6
Liberia (1986)	99.5
Nigeria (Ondo) (1986)	100.0
Senegal (1986)	100.0
Togo (1988)	100.0
Zimbabwe (1988)	98.6

Sources: World Fertility Survey (1983b) *Enquête Nationale sur la Fécondité du Cameroun 1978.* World Fertility Survey (1983c). *The Ghana Fertility Survey 1979-80: First Report.*
World Fertility Survey (1984c). *Enquete Ivoirienne sur la Fécondité 1980-81.*
World Fertility Survey (1981b). *The Lesotho Fertility Survey 1977: First Report.*
World Fertility Survey (1984d). *The Nigerian Fertility Survey 1981-82: A Summary of the Findings.*
Botswana (1989). *Botswana Family Health Survey II.*
Burundi (1988). *Enquete Démographique et de Santé au Burundi 1987.*
Ghana (1989). *Ghana Demographic and Health Survey 1988.*
Liberia (1988). *Liberia Demographic and Health Survey 1986.*
Kenya (1989). *Kenya Demographic and Health Survey 1989.*
Nigeria (1989). *Ondo State, Nigeria Demographic and Health Survey 1986.*
Senegal (1988). *Enquête Démographique et de Santé au Sénégal 1986.*
Togo (1989). *Enquête Démographique et de Santé au Togo 1988.*
Zimbabwe (1989). *Zimbabwe Demographic and Health Survey 1988.*

1.3.1.2 Age at First Marriage

In sub-Saharan Africa age at first marriage for women tends to be fairly young, with women usually marrying soon after puberty (e.g. Ayree (1985, p23) for Ghana). Indeed, in some sub-Saharan African societies child marriage is not unusual (Acsadi and Johnson-Acsadi (1990b)). The low ages at first marriage of women in sub-Saharan Africa are shown by data from the various surveys in sub-Saharan Africa carried out as part of the WFS and DHS projects (see Table 1.3.1.2). Ages at first marriage tend to be lower in West Africa than in other parts of sub-Saharan Africa. An exception to the general pattern of low age at first marriage is Botswana (for the reasons mentioned in Section 1.3.1.1). Teenage marriage for women is common in many countries in sub-Saharan Africa (notable exceptions are Botswana and Burundi), but higher median ages at first marriage among younger cohorts of women indicate a trend towards later marriage in many of the countries in sub-Saharan Africa and there is evidence that in many countries teenage marriage is now less common than in the past. In sub-Saharan Africa, husbands are usually much older than their wives (Caldwell *et al.* (1989, p188)). Median ages at first marriage for women and the proportions of women aged 15-19 who have ever married for WFS and DHS surveys in sub-Saharan Africa are presented in Table 1.3.1.2:

Table 1.3.1.2: Age at First Union in Sub-Saharan Africa

Country	Median Age at First Union	% Aged 15-19 Ever Married
WFS		
Benin (1982)	18	43.8
Cameroon (1978)	17	53.1
Ghana (1979-80)	18	30.9
Ivory Coast (1980-81)	17	56.0
Kenya (1978)	18	27.4
Lesotho (1977)	19	31.5
Nigeria (1981-82)	17	40.3
Senegal (1978)	16	59.3
DHS		
Botswana (1988)	24	6
Burundi (1987)	20	7
Ghana (1988)	18	24
Kenya (1989)	19	20
Liberia (1986)	18	36
Nigeria (Ondo) (1986)	20	11
Senegal (1986)	17	43
Togo (1988)	18	27
Zimbabwe (1989)	19	20

Sources: Ebanks, G.E. and Singh, S. (1984). Socio-economic Differentials in Age at Marriage. *WFS Comparative Studies: Cross-National Summaries.*
World Fertility Survey (1984e). *Major Findings and Implications.*
Botswana (1989). *Botswana Family Health Survey II.*
Burundi (1988). *Enquete Démographique et de Santé au Burundi 1987.*
Ghana (1989). *Ghana Demographic and Health Survey 1988.*
Kenya (1989). *Kenya Demographic and Health Survey 1989.*
Liberia (1988). *Liberia Demographic and Health Survey 1986.*
Nigeria (1989). *Ondo State, Nigeria Demographic and Health Survey 1986.*
Senegal (1988). *Enquête Démographique et de Santé au Sénégal 1986.*
Togo (1989). *Enquête Démographique et de Santé au Togo 1988.*
Zimbabwe (1989). *Zimbabwe Demographic and Health Survey 1988.*

1.3.1.3 Marital Dissolution and Remarriage

Marriages may be disrupted by divorce, separation or the death of either partner. The termination of a marriage and ,in particular, the time until a subsequent remarriage will influence fertility through their effects on the exposure to sexual intercourse. Data from the WFS show that marital dissolution tends to be fairly common in sub-Saharan Africa, although its extent can vary considerably between societies with the proportion of ever married women whose first marriages have been dissolved ranging from 15% in Lesotho and Nigeria to 29% in Senegal (see Table 1.3.1.3.). The variation between countries would at least in part reflect the varying types of marriage practised in different African populations.

Table 1.3.1.3: Marital Dissolution in Sub-Saharan Africa

Country	% of First Marriages Dissolved at Survey (women aged 15-49)
Benin (1982)	20
Cameroon (1978)	20
Ghana (1979-80)	28
Ivory Coast (1980-81)	26
Kenya (1978)	16
Lesotho (1977)	15
Nigeria (1981-82)	15
Senegal (1978)	29

Source: Singh, S. Owusu, J.Y. and Shah, I.H. (1985, p32). *Demographic Patterns in Ghana: Evidence from the Ghana Fertility Survey.*

1.3.1.4 Polygyny and Monogamy

Polygyny is widespread in some parts sub-Saharan Africa (e.g. Lesthaeghe (1986)). Data from the WFS and DHS show that in West Africa more than one currently married women in three is in a polygynous union, but that in Burundi and Kenya, countries in East Africa and in Lesotho and Zimbabwe, countries in Southern Africa, polygyny is less common. This is shown in Table 1.3.1.4:

Table 1.3.1.4: Polygyny in Sub-Saharan Africa

Country	% of Current Marriages Which are Polygynous
WFS	
Benin (1982)	35
Cameroon (1978)	42
Ghana (1979-80)	35
Ivory Coast (1980-81)	41
Kenya (1978)	30
Lesotho (1977)	9
Nigeria (1981-82)	43
DHS	
Burundi (1987)	12
Ghana (1988)	33
Kenya (1989)	23
Liberia (1986)	38
Nigeria (Ondo) (1986)	46
Senegal (1988)	47
Togo (1988)	52
Zimbabwe (1988)	17

Sources: World Fertility Survey (1984a). *Enquête Fécondité au Benin, 1982: Résumé de Résultats.*
World Fertility Survey (1983a). *The Cameroon Fertility Survey 1978: A Summary of Findings.*
World Fertility Survey (1983c). *The Ghana Fertility Survey 1979-80: First Report.*World Fertility Survey (1984b). *Enquete Ivorienne sur la Fécondité, 1980-81: Résumé des Résultats.*
World Fertility Survey (1981a). *The Kenya Fertility Survey, 1978: A Summary of Findings.*
World Fertility Survey (1981b). *The Lesotho Fertility Survey 1977: First Report.*
World Fertility Survey (1984d). *The Nigerian Fertility Survey 1981-1982: A Summary of Findings.*
Burundi (1988). *Enquete Démographique et de Santé au Burundi 1987.*
Ghana (1989). *Ghana Demographic and Health Survey 1988.*
Kenya (1989). *Kenya Demographic and Health Survey 1989.*
Liberia (1988). *Liberia Demographic and Health Survey 1986.*
Nigeria (1989). *Ondo State, Nigeria Demographic and Health Survey 1986.*
Senegal (1988). *Enquête Démographique et de Santé au Sénégal 1986.*
Togo (1989). *Enquête Démographique et de Santé au Togo 1988.*
Zimbabwe (1989). *Zimbabwe Demographic and Health Survey 1988.*

The impact of polygyny on fertility levels is unclear. Polygynously married women may compete jealously with each other to have a large number of children (e.g. Lesthaeghe *et al.* (1981, p5)). However, in a polygynous marriage the time the husband spends with his other wife/wives may reduce each wife's fertility by reducing their exposure to sexual intercourse. A difficulty inherent in making comparisons of the fertility levels of monogamously and polyynously married women stems from the fact that any currently monogamous marriage may subsequently become a polygynous marriage. The evolution from monogamy to polygyny means that women in polygynous marriages tend to have higher average ages than women in monogamous marriages. Evidence from the 1979-1980 Ghanaian Fertility Survey (GFS) shows that polygyny is more widespread among Muslims and followers of traditional African beliefs than among Christians (WFS (1983c, p41). This would at least in part reflect the Christian churches' disapproval of polygyny. The GFS found that polygyny is more widespread in rural areas than in urban areas. This would be in part because in cities men turn to "outside wives" or mistresses (e.g. Caldwell *et al.* (1989, p202)). The GFS also found that polygyny is less common among more educated women than among uneducated women.

1.3.2. Contraception

Contraception (i.e. any practice which is used to prevent pregnancy occurring) is now used by a majority of childbearing couples in the developed world and by two-fifths of those in the Third World (Tsui (1985)). Practising family planning has benefits for both maternal and child health (see e.g. National

Research Council (1989)). The main advantages of using contraception effectively are that it allows sexual activity to continue when one or both of the partners does not want a child (from that particular union) and that it removes the need to resort to abortion, infanticide, abandonment of children or having children fostered. All currently existing methods of contraception have a degree of fallibility (see e.g. Trussell and Kost (1987) for estimates of failure rates associated with each method of contraception in the context of a developed country (USA)), and the distinction is usually made between the "efficient" or "modern" methods of contraception (i.e. the pill, IUD, condom, injectables, male or female sterilization, and female barrier methods such as the diaphragm) and other methods of contraception which are less efficient, such as the rhythm method, withdrawal and folk remedies. Hence, the effect of contraceptive use is to reduce (and usually to virtually nullify) the monthly probabilities of conception of women who are sexually active and ovulating (Lesthaeghe *et al.* (1981) state that in the absence of sterility or sub-fecundity or the use of contraception the monthly probability of conceiving for women aged 20 to 30 years who are ovulating and sexually active is in the range 0.12 to 0.17 and that this implies average waiting times to conception of 6 to 8 months).

In sub-Saharan Africa a number of traditional or folk methods of contraception,many of which involve magic or spells, finger and/or waist rings, womb turning and/or herbal preparations are practised (e.g. Caldwell and Caldwell (1990, p210). The efficiency of such methods is highly doubtful. Nonetheless, in data presented in the following sections, such methods of contraception have been categorised as inefficient methods of contraception.

1.3.2.1 Knowledge of Contraception

Data from the WFS and DHS show that most women in sub-Saharan Africa know of at least one method of contraception, although there is considerable variation in the levels of knowledge of contraception between countries. In some countries (Botswana, Kenya, Togo, and Zimbabwe) knowledge of at least one method of contraception is near universal whilst in Nigeria it appears that only a minority of women know of a method of contraception. The percentages of women who know of at least one method of contraception from various WFS and DHS surveys in sub-Saharan Africa are shown in Table 1.3.2.1:

Table_1.3.2.1:_Knowledge_of_Contraception_in_Sub-Saharan_Africa

Country	% Aware of Any Contraceptive Method
WFS	
Benin(*) (1982)	40
Cameroon(*) (1978)	34
Ghana(*) (1979-80)	69
Ivory Coast(*) (1981-82)	85
Kenya(*) (1978)	93
Lesotho(*) (1977)	65
Nigeria(*) (1981-82)	33
Senegal(*) (1978)	60
DHS	
Botswana(**) (1988)	95
Burundi(**) (1987)	70
Ghana(**) (1988)	76
Kenya(**) (1989)	90
Liberia(**) (1986)	72
Nigeria (Ondo)(**) (1986)	48
Senegal(**) (1986)	90
Togo(**) (1988)	94
Zimbabwe(**) (1988)	96

(*) Ever-married women only

(**) All women surveyed.

Sources: WFS (1984e). *Major Findings and Implications.*
Botswana (1989). *Botswana Family Health Survey II.*
Burundi (1988). *Enquete Démographique et de Santé au Burundi 1987.*
Ghana (1989). *Ghana Demographic and Health Survey 1988.*
Kenya (1989). *Kenya Demographic and Health Survey 1989.*
Liberia (1988). *Liberia Demographic and Health Survey 1986.*
Nigeria (1989). *Ondo State, Nigeria Demographic and Health Survey 1986.*
Senegal (1988). *Enquête Démographique et de Santé au Sénégal 1986.*
Togo (1989). *Enquête Démographique et de Santé au Togo 1988.*
Zimbabwe (1989). *Zimbabwe Demographic and Health Survey 1988.*

1.3.2.2 Contraceptive_Use

Despite sizeable proportions of African women knowing of a method of contraception it appears that, with the exception of a few countries (i.e. Botswana, Kenya and Zimbabwe), levels of contraceptive use in sub-Saharan Africa are very low. Data from the WFS show that, in general, the proportions of ever married women who had ever used (or, perhaps more correctly, were willing to admit having ever used) a method of contraception were only between 10% and 40%. Data from the more recent DHS show proportions of all women surveyed who have ever used a method of contraception ranging from 15% in Ondo State, Nigeria to 60% in Zimbabwe. Furthermore, the proportions of currently married who were currently using "efficient" methods of contraception in the various sub-Saharan African countries surveyed as part of the WFS were negligible. Evidence from a few of the countries surveyed as part of the DHS (Botswana, Kenya and Zimbabwe) shows the use of modern methods of contraception has become moderately widespread, but in West Africa the use of modern methods of contraception is still negligible. Of the countries for which the results of the WFS and the more recent DHS surveys can be compared, in Kenya contraceptive use has increased noticeably (this is also supported by data from the 1984 Contraceptive Prevalence Survey (CPS) in Kenya which found that 17% of currently married women were currently using a method of contraception), however, in both Ghana and Senegal levels of current use of contraception are virtually unchanged.

Table 1.3.2.2 shows the proportion of women who have ever used contraception and the proportion of women who are currently using contraception recorded by the WFS and DHS in various sub-Saharan African countries:

Table 1.3.2.2: Contraceptive Use in Sub-Saharan Africa

Country	% Ever Used Any Method	% Currently Using Any Method	% Currently Using Efficient Method
WFS			
Benin (1982)	36(*)	20(**)	1(**)
Cameroon (1978)	11(*)	3(**)	1(**)
Ghana (1979-80)	40(*)	10(**)	6(**)
Ivory Coast(1982)	71(*)	2(**)	0(**)
Kenya (1978)	32(*)	6(**)	4(**)
Lesotho (1977)	23(*)	5(**)	2(**)
Nigeria (1981-82)	14(*)	5(**)	1(**)
Senegal (1978)	11(*)	4(**)	1(**)
DHS			
Botswana (1988)	56(***)	30(***)	29(***)
Burundi (1987)	22(***)	6(***)	1(***)
Ghana (1988)	34(***)	12(**)	5(**)
Kenya (1989)	39(***)	23(***)	15(***)
Liberia (1986)	22(***)	8(***)	7(***)
Nigeria (Ondo)(1986)	15(***)	9(***)	6(***)
Senegal (1986)	32(***)	10(***)	3(***)
Senegal (1986)	38(**)	11(**)	2(**)
Zimbabwe(1988)	60(***)	32(***)	27(***)

(*) Ever Married Women only.

(**) Currently married women only

(***) All women.

Sources: WFS (1984e). *Major Findings and Implications.*
Botswana (1989). *Botswana Family Health Survey II.*
Burundi (1988). *Enquete Démographique et de Santé au Burundi 1987.*
Ghana (1989). *Ghana Demographic and Health Survey 1988.*
Kenya (1989). *Kenya Demographic and Health Survey 1989.*
Liberia (1988). *Liberia Demographic and Health Survey 1986.*
Nigeria (1989). *Ondo State, Nigeria Demographic and Health Survey 1986.*
Senegal (1988). *Enquête Démographique et de Santé au Sénégal 1986.*
Togo (1989). *Enquête Démographique et de Santé au Togo 1988.*
Zimbabwe (1989). *Zimbabwe Demographic and Health Survey 1988.*

The low levels of contraceptive use found in most of sub-Saharan Africa reflect a lack of demand for contraception in societies in which children are greatly valued (e.g. Frank (1987), Van de Walle and Foster (1990), - see Section 1.2.0 for a discussion of the value placed on having children in sub-Saharan Africa). Moreover, the option of having an inconvenient/unwanted child fostered is widely available with the practise of fostering children being widespread (e.g. Frank (1987, p195). In sub-Saharan Africa modern methods of birth control are widely regarded as unnatural and it is widely rumoured that their use will have harmful effects on the woman, her reproductive capacity and her children (Caldwell and Caldwell (1987), (1990)). Fear of female adultery is a further reason for male opposition to contraception. Moreover, African governments tend to be faint-hearted or apathetic towards encouraging family planning (Caldwell and Caldwell (1990, p205)).

In sub-Saharan Africa, when contraception is adopted, it is usually as an alternative to traditional practices involving sexual abstinence as a way of helping to space births (Caldwell and Caldwell (1981, p190)) (this contrasts with Western Europe where contraception is used to limit family size as well as to affect the timing of births). The Caldwells found that among contraceptive users in Nigeria only a minority (roughly only one in five) consciously aimed to limit their ultimate family size. Other reasons given for adopting contraception were marital problems or being unmarried. WFS data from sub-Saharan Africa show that only a minority of women using contraception do not want to have any more children (Frank (1987)).

In summary, at present the impact of contraception on fertility levels in most of sub-Saharan Africa is likely to be slight.

1.3.2.3 Patterns of Contraceptive Use

In sub-Saharan African the use of contraception is more common among urban women than among rural women. This was found in all the sub-Saharan African countries surveyed by the DHS for which results are available except for Togo (Rutenburg *et al.* (1991, p25)). Moreover, contraceptive use is increasingly common with increasing levels of female education, with the only exception to this rule among countries surveyed by DHS being Togo (Rutenburg et al. (1991, p26)). Educated women are more likely to use efficient methods of contraception than inefficient methods (e.g. Appiah (1985, p101) for Ghana). Contraception is comparatively widely used by students, largely in order to avoid disruption of education caused by pregnancy/birth (e.g. Nichols *et al.* (1987) for Liberia).

1.3.3 Abortion

After conception has occurred, the major means of controlling fertility is by terminating the pregnancy through induced abortion. The practice of abortion is highly controversial and is condemned by some religious groups, most notably the Catholic church and Islam.

Assessment of the impact of induced abortion on fertility in sub-Saharan Africa is hampered by a lack of reliable data. This reflects induced abortion being either completely illegal or legal only on very restictive criteria (e.g. pregnancy as a threat to a woman's health, known genetic or other impairment of the fetus, rape, incest or a narrow range of social-medical reasons) throughout Africa (e.g. Caldwell (1975, p82), Frank (1987, pp190-195)). Despite its illegality, abortion does occur (e.g. Caldwell (1975, p82) reports a survey in which 4.5% of females aged 15 and over in Lagos, Nigeria said they had had a medically induced abortion, and Frank (1987) summarizes seven studies of induced abortion in Africa). Abortion may be sought to avoid the disruption of education by pregnancy (e.g. Frank (1987)). Indeed, Caldwell *et al.* (1989, p210) claim that schoolgirl pregnancy is the major cause of induced abortion. However, the Caldwells (1987) assert that abortions to married women are still rare and, in view of the strong motivation of most African women to produce children (see Section 1.3.0), it would seem likely that, overall, the impact of abortion on fertility in sub-Saharan Africa is slight.

1.3.4 Postpartum Non-Susceptibility

The temporary cessation of ovulation and menstruation after every birth (postpartum amenorrhea) is prolonged when a woman breastfeeds. If a woman does not breastfeed the average duration of amenorrhea is between 1.5 and 2 months. As the duration of breastfeeding increases so does the duration of amenorrhea, but at a declining rate (e.g. Bongaarts (1983, p109)). If a woman breastfeeds, the duration of postpartum amenorrhea lasts on average between 60 and 75% of the duration of breastfeeding (Lesthaeghe *et al.* (1981, p7)).

Many sub-Saharan African societies operate a postpartum taboo on female sexual intercourse. The duration of abstinence can be substantial. Schoenmaeckers *et al.* (1981) found taboos with durations greater than a year in over half the African societies they studied. The combined effect of postpartum amenorrhea and postpartum abstinence is to produce a period during which a woman is not susceptible to pregnancy. This, in turn, has the effect of lengthening birth intervals.

In the following sections I examine the durations of breastfeeding practised in sub-Saharan Africa (Section 1.3.4.1) and the effects of postpartum amenorrhea and postpartum abstinence on fertility both separately (Sections 1.3.4.2 and 1.3.4.3 respectively) and combined (Section 1.3.4.4).

1.3.4.1. Breastfeeding

Compared with the alternative of bottle-feeding using infant formulas, breastfeeding is a healthy, cheap and emotionally bonding method of feeding infants (e.g. Jelliffe and Jelliffe (1988), WHO (1981)). In societies such as those in sub-Saharan Africa, where water supplies are often contaminated, the greater protection against infections afforded by breastfeeding is particularly important.

Breastfeeding (i.e. whether a child is *ever* breastfed) of children is near universal in sub-Saharan Africa. Data from the WFS indicate that in each of the sub-Saharan African countries surveyed over 90% of children are breastfed. Furthermore, a long mean duration of breastfeeding was calculated from WFS data in each of the sub-Saharan African countries surveyed. These mean durations of breastfeeding range from 15.7 months in Kenya to 19.5

months in Lesotho.

Women in sub-Saharan Africa often carry their infants strapped to their backs and are less concerned about the need for privacy while breastfeeding than their European counterparts (WHO (1981, p46)). In many cases women who are breastfeeding may often be using infant formulas as well (e.g. Kigondu (1988) for Kenya). Infant formulas are widely available in sub-Saharan Africa, particularly in urban areas (e.g. WHO (1981)).

The proportions of women who ever breastfed their last child and the mean durations of breastfeeding for various sub-Saharan African countries are presented in Table 1.3.4.1:

Table 1.3.4.1: Breastfeeding in Sub-Saharan Africa

Country	% Ever Breastfed Last Child	Mean Duration of Breastfeeding (months)
Benin (1982)	97	19.3
Cameroon (1978)	98	17.6
Ghana (1979-80)	92	17.9
Ivory Coast(81-82)	98	17.5
Kenya (1978)	98	15.7
Lesotho (1977)	95	19.5
Senegal (1978)	98	18.5

Source: Singh ,S. and Ferry, B. (1984). *Biological and Traditional Factors that Influence Fertility: Results from WFS Surveys*. WFS Comparative Studies No. 40.

There is evidence that more educated African women practise a shorter duration of breastfeeding (see Lesthaeghe, Page and Adegbola (1981, p159) for Lagos, Nigeria; and Gaisie (1981b, p247) for Ghana). Interestingly, these studies also show shorter periods of breastfeeding among contraceptive users.

A study by WHO (1981, ch.4)) found that in both Nigeria and

Zaire durations of breastfeeding were shortest among economically advantaged, urban women and longest among rural women. WHO also found that women from the urban élite are more likely to breastfeed according to a schedule as opposed to "on demand" than are poor urban women and rural women.

1.3.4.2 Amenorrhea

A consequence of the long durations of breastfeeding practised in sub-Saharan Africa (see Section 1.3.4.1) is that durations of postpartum amenorrhea in this region tend to be long. Data from the WFS show mean durations of amenorrhea to be between 9.5 months and 12.5 months. Durations of amenorrhea tend to be longer in West Africa than in other parts of Africa. This is shown in Table 1.3.4.2:

Table 1.3.4.2: Duration of Amenorrhea in Sub-Saharan Africa

Country	Mean Duration of Amenorrhea
Benin (1982)	11.9
Cameroon (1978)	11.8
Ghana (1979-80)	12.4
Ivory Coast (1981-82)	10.4
Kenya (1978)	9.9
Lesotho (1977)	9.6

Source: Singh, S. and Ferry, B. (1984). *Biological and Traditional Factors that Influence Fertility: Results from WFS Surveys.* WFS Comparative Studies No. 40.

Singh and Ferry (1984) found evidence of shorter durations of amenorrhea among younger women. This indicates that the traditional pattern of achieving child spacing is being eroded over time.

1.3.4.3 Abstinence

Various types of *female* marital sexual abstinence are practised in sub-Saharan Africa, including abstinence during pregnancy and menstruation, postpartum abstinence and terminal abstinence (e.g. Caldwell and Caldwell (1981b, p76)). However, in this section I describe only those types of abstinence which have an impact on fertility; postpartum abstinence (Section 1.3.4.3.1) and terminal abstinence (Section 1.3.4.3.2).

1.3.4.3.1 Postpartum Abstinence

As mentioned earlier, many sub-Saharan African societies operate a long postpartum sexual taboo for females, although this practise is not universal. Data from the WFS show mean durations of postpartum abstinence ranging from only 2.9 months in Kenya to 15.5 months in Benin. This is shown in Table 1.3.4.3:

Table 1.3.4.3: Duration of Abstinence in Sub-Saharan Africa

Country	Mean Duration of Postpartum Abstinence
Benin (1982)	15.5
Cameroon (1978)	13.9
Ghana (1979-80)	10.0
Ivory Coast (1981-82)	13.1
Kenya (1978)	2.9
Lesotho (1977)	15.0

Source: Singh, S. and Ferry, B. (1984). *Biological and Traditional Factors that Influence Fertility: Results from WFS Surveys.* Comparative Studies No. 40.

WFS data show that durations of abstinence tend to be shorter among younger women (see also Santow and Bracher (1981, p205) for

Ibadan, Nigeria). This suggests the postpartum sexual taboo is being eroded over time. Periods of abstinence tend to be shorter among women who have spent longer periods in education (e.g. Caldwell and Caldwell (1981a, p186), Santow and Bracher (1981, p207), Orubuloye (1981, p230) and Gaisie (1981b, p248)). The Caldwells suggest that this is because better educated women are more aware of Western family types, more aware of the shortcomings of traditional justifications for abstinence (such as the belief among the Yoruba that sperm poison the mother's milk) and are more knowledgable of, and make better use of, contraception. There is evidence that shorter periods of abstinence occur among users of contraception than among non-users of contraception (see e.g. Caldwell and Caldwell (1981, p186), Santow and Bracher (1981, p207) and Gaisie (1981 p248)). As contraceptive users tend to be better educated, this could explain the better educated women having both shorter durations of abstinence and lower levels of fertility. Within a society, Moslem women tend to abstain for longer durations than their Christian counterparts (see e.g. Caldwell and Caldwell (1981, p186), Santow and Bracher (1981, p207) and Orubuloye (1981, p230)). One factor facilitating this would be the more widespread polygyny among Muslims. A cautionary note on the value of data on durations of abstinence should be added. For example, among the tribes of the Kivu of Zaire sexual relations are obligatory roughly one week after a birth but nonetheless mean birth intervals are 2-3 years (Carael (1981, p278), Sala-Diakanda *et al.* (1981, p289)).

1.3.4.3.2 Terminal (Permanent) Abstinence

In sub-Saharan Africa the woman's reproductive life may end by the observance of permanent sexual abstinence. It may be considered inappropriate for a woman who has become a grandmother to continue to produce children (Lesthaeghe *et al.* (1981, p5)). Caldwell and Caldwell ((1981b, p76)) report that this practise of terminal or permanent abstinence is more common among less educated women.

1.3.4.4 Post-Partum Non-Susceptibility

The postpartum non-suceptibile period is defined for each woman as whichever is longer - amenorrhea or abstinence. The data from the WFS reported in the previous two sections show that it is usually abstinence which determines the duration of non-susceptibility. Durations of non-susceptibility tend to be long in sub-Saharan Africa. Table 1.3.4.4 shows that the mean durations of post-partum non-susceptibility recorded by WFS range from 10.3 months in Kenya to 17.2 months in Benin:

Table 1.3.4.4 Postpartum Non-Susceptibility in Sub-Saharan Africa

Country	Mean Duration of Non-Susceptible Period
Benin (1982)	17.2
Cameroon (1978)	15.9
Ghana (1979-80)	14.6
Ivory Coast (1980-81)	14.7
Kenya (1978)	10.3
Lesotho (1977)	16.5

Source: Singh, S. and Ferry, B. (1984). *Biological and Traditional Factors that Influence Fertility: Results from WFS Surveys.* WFS Comparative Studies No. 40.

In most sub-Saharan African countries the durations of the postpartum non-susceptible period are shorter among younger women (Singh and Ferry (1984)), suggesting that traditional practices of achieving child-spacing are being eroded over time. Nonetheless, the non-susceptible periods that result from these child-spacing practises still appears to be the major fertility inhibiting factor in most of sub-Saharan Africa.

1.3.5 Sterility

Sterility is the physiological incapacity to produce a live birth and may take the form of either primary sterility (i.e. when a woman is never able to have children) or secondary sterility (i.e. when a woman becomes sterile after having one or more children). Primary sterility in a developing country normally results in about 3% of married women remaining childless (Frank (1983)).

Sterility is considered abhorrent in all African societies (e.g. Caldwell and Caldwell (1987, p412)). Levels of sterility are high in many parts of Africa, but vary considerably between areas and ethnic groups (Romaniuk (1968), Frank (1983)). In particular, Central Africa is afflicted by very high levels of sterility. Levels of childlessness (which indicates primary sterility) in various sub-Saharan African countries are shown in Table 1.3.5:

Table 1.3.5 Infertility in Sub-Saharan Africa

Country	Population (million)	% of Women Childless At End of Childbearing
Angola	7.1	11.5
Cameroon	8.4	17.2
Central African Republic	2.3	17.3
Chad	4.5	11.0
Congo	1.5	20.5
Gabon	0.5	32.0
Guinea	5.0	6.0
Ivory Coast	8.0	9.9
Mali	6.9	7.7
Mozambique	10.5	13.8
Niger	5.3	8.9
Senegal	5.7	4.0
Sudan	18.4	8.7
Tanzania	17.9	11.4
Upper Volta	6.9	5.9
Zaire	28.3	20.5
Zambia	5.8	14.0

Source: Frank, O. (1983). Infertility in Subsaharan Africa :Estimates and Implications. *Population and Development Review.* Vol 9. No. 1.

Possible causes of sterility are:

i) the reduction in fecundability through gonorrhea,

ii) the high incidence of foetal loss due to syphillus, ricketsae, toxoplasmosis, goitre and malaria,

iii) injury and surgical proceedures involving the genital tract.

From the small amount of available evidence, it appears there are very high levels of both gonorrhea and syphillis in sub-Saharan Africa (Osoba (1981)). Belsey (1979) speculates that some delivery and birth rituals in sub-Saharan Africa, such as the practice among the Hausa of Nigeria of pouring near boiling water into the genital tract following delivery, may increase the risk of infertility, and that female circumcision, which is widely practised in sub-Saharan Africa, performed under septic conditions may also increase the risk of infertility.

There is evidence that sterility has been less prevalent among more recent cohorts (e.g. Sala-Diakanda *et al.* (1981, p287) and Lesthaeghe (1986, p225)).

1.3.6 <u>Other Factors</u>

It is to be expected that in underdeveloped and generally less nourished populations, such as those of sub-Saharan Africa, ages at menarche will be higher than those found in Europe (e.g. Gray (1979, pp220-223)). There is a lack of data on age at menopause in sub-Saharan African populations, although Gray (1979, pp227-229), cites a study in which South African Bantu women were found to have significantly lower ages at menopause than white women. Menopause marks the end of a continuum of declining physiological fertility rather than an abrupt termination of reproductive potential. However, in sub-Saharan Africa (as elsewhere) the impact of declining physiological fertility is virtually impossible to assess (Gray (1979), pp229-232).

The impact of variation in the frequency of intercourse on fertility patterns in tropical Africa is hard to assess due to a lack of reliable data. In some parts of Africa, particularly the "labour exporting" countries in southern Africa (Lesthaeghe (1986)), prolonged spousal separation may have the effect of reducing fertility by reducing frequency of sexual intercourse.

Assessment of the relationship between foetal loss and fertility is complex. High fertility is frequently associated with low socioeconomic status which in turn may be associated with a high risk of foetal loss (Gray (1981, p94)). Moreover, data on spontaneous foetal loss tend to be unreliable (Gray (1979, p232)). As well as chromosomal abnormalities, venereal syphilis, malaria and child-birth or other genital tract trauma are associated with an increased risk of spontaneous abortion (Gray (1979, p235)). Venereal syphilis and malaria are endemic in parts of sub-Saharan Africa and female circumcision and some unskilled birth rituals in sub-Saharan Africa both may be associated with an increased risk of foetal loss (Belsey (1979)). Foetal loss rates as high as 33% have been reported in sub-Saharan African populations (Gray (1979)).

Assessment of the impact of variations in the duration of viability of the ova and sperm in sub-Saharan Africa is almost impossible due to a lack of data.

1.4 Summary

It is shown that throughout sub-Saharan Africa fertility levels are high in comparison to those found in western Europe. The principal reasons for this are: that in most of this region little use is made of modern methods of contraception, and that in most of this region women spend relatively little time outside a sexual union. The widespread practise of observing a long period of postpartum sexual abstinence, and the lengthy durations of postpartum amenorrhea restrain fertility in sub-Saharan Africa from being yet higher.

2 MULTILEVEL MODELS

2.0 Introduction

In this chapter I introduce a recently developed method of statistical analysis, multilevel modelling. This method will be used in the analyses of fertility in Liberia and Ghana which will appear in Chapters 5 and 6.

2.1 Hierarchical Structures and Survey Analysis

In this section I define a hierarchical structure and discuss the relevance of this concept to the analysis of survey data.

Formally a hierarchical structure is a system in which "units" at one "level" are grouped within "units" at higher "levels". The term "unit" refers to a set of attributes. So a single human being at a point in time, an organisation at a point in time or a single human being at a set of points in time are all examples of units. The term "level" has been defined as "one of the poles of an inclusion-relationship that orders a pair of social units" (van den Eeden and Huttner (1982)). Put more simply this definition says that some types of units are contained within some other types of units and in this situation a "level" describes a type of unit. Levels are weakly ordered and "lower-level" units are said to be included within a "higher-level" unit. So, if a population of individual human beings is partitioned into a set of groups we can refer to the "individual-level" as the lower level and the "group-level" as the higher level. Similarly, the individual observed at a point in time could be treated as the lower level and the individual observed at a series of points in time could be treated as a corresponding higher level. Some examples of hierarchical structures are:

i) When pupils (level 1 units) are educated in classes (level 2 units) and these classes are within schools (level 3 units).

ii) When women (level 1 units) live in neighbourhoods/communities (level 2 units) which in turn lie within counties (level 3 units), regions (level 4 units) and countries (level 5 units).

iii) When the individual observed at a point in time is the level 1 unit, the individual observed over a set of points in time is the level 2 unit, groups of individuals observed over a set of points in time are the level 3 unit and so on.

These examples show that data from both cross-sectional and longitudinal studies can have a hierarchical structure.

Anthropological work such as that of Morris and Marsh (1988) argues that human beings in all types of societies feel the need to band together in groups or "tribes". If this is true then survey data collected for all sorts of studies of human behaviour will contain hierarchical structures. In fact for reasons of economy samples will often be selected on the basis of natural groupings (i.e. cluster sampling) (e.g. Kish and Frankel (1974)). That sample designs often imply that such clusters/groupings are to be regarded as random samples from wider populations provides further reason for the implications of hierarchical structures to be examined. Morris and Marsh (1988) claim that a characteristic of "tribes"/groups is that members of the same "tribe"/group feel they have more in common with each other than with other groups. A consequence of the nature of such groupings is that survey data collected from units within the same group will often be more homogenous than for units in different groups (e.g. Kish and Frankel (1974), Holt, Smith and Winter (1980), Aitken and Longford (1986), Skinner, Holt and Smith, (1989, ch 10)). This could occur because individuals in the same group aspire to norms for that group, because each individual can exert influence on other members of his/her group to behave in the way he/she does, because members of the same group face common experiences or because individuals have selected (or have been selected) to join a group in which the other members are broadly similar to themselves. Similarly, it could be argued that measurements made on the same individual at a set of different points in time will often be more homogenous than a set of measurements in which a different individual was measured at each point in time. Analyses of survey data often seek to understand or "explain" variation in one or more types of measurements that have been collected. When this is the case, the homogeneity of units within the same group will need to be accounted for.

In summary, for both cross-sectional and longitudinal types of survey, a hierarchical stucture will often be implicit in the data. Where the data have a hierarchical structure, observations are likely to show within-group correlations. Such within-group correlations form an aspect of population structure which needs to be to be taken into account properly when models of such data are constructed.

2.2 Some Methods of Statistical Analysis Which Do Not Consider the Hierarchical Structure of Data Properly

2.2.0 Introduction

The previous section argues that not only will data often have an inherently hierarchical structure but also that this structure will be related to variation in the values of some variables. This section discusses some possible approaches to the analysis of hierarchically structured data.

To illustrate my arguments, I consider the case where the data have a two-level hierarchy (the simplest hierarchical structure) and Y_{ij} , the value of the variable Y measured on individual j in group i, is the dependent variable.

2.2.1 Regression/Analysis of Covariance

A conventional approach is to fit a simple regression model to explain variation in Y_{ij} in terms of some other variable X_{ij}. That is:

$$Y_{ij} = \alpha + \beta X_{ij} + \varepsilon_{ij} \qquad (2.2.1)$$

where α (a constant) represents the intercept (i.e. the expected value for Y_{ij} if X_{ij} were to take the value 0), β (again a constant) represents the slope (i.e. the expected change in Y_{ij} for a change of 1 unit in X_{ij}), and the ε_{ij}'s represent the residuals (i.e. the variation in Y_{ij} not "explained" by X_{ij}). The ε_{ij}'s are assumed to come from a normal distribution with mean zero and some (constant) variance σ^2. Furthermore the ε_{ij}'s are assumed to be independent. That is:

$$\text{Cov} (\varepsilon_{ij}, \varepsilon_{ik}) = 0 \text{ and } \text{Cov} (\varepsilon_{ij} , \varepsilon_{kl}) = 0$$

In this model the quantity ($\alpha + \beta X_{ij}$) (i.e. $E(Y_{ij} | X_{ij})$) is called the fixed part and the quantity ε_{ij} is called the random part.

This simple regression model can be extended to include more than one explanatory variable . For example:

$$Y_{ij} = \beta_0 + \beta_1 X_{1ij} + \beta_2 X_{2ij} + \ldots + \beta_k X_{kij} + \varepsilon'_{ij} \qquad (2.2.2)$$

where $\beta_1 , \ldots , \beta_k$ are constants , $X_{1ij}, \ldots, X_{kij}$ are independent variables and ε'_{ij} is the residual for the ij_{th} observation (again the ε'_{ij} 's are assumed to have zero mean, some constant variance and are independent and normally distributed).

A problem with the individual-level regression model (2.2.2) is that it does not suggest how the group structure affects the dependent variable. The model specifies that observations are independent. However, for reasons given in Section 2.1, observations from the same group will often be more homogenous than observations from different groups. In other words, observations from within the same group are correlated. It can be seen from Models 2.2.1 and 2.2.2 that regression models cannot describe correlations in the ε_{ij}'s and so correlations within groups can only be represented to the extent which group-level variables in the model capture this. Hence, individual-level regression models can give misrepresentations of the variance structure. In Section 2.3.2.1.2 I show that misrepresentation of the variance structure can lead to misstated precision in estimates of coefficients of the fixed part. Furthermore, it could be argued that, because of their failure to represent correlations within groups, regression-type models are unable to offer pointers as to whether group-level variables can be added to existing models to give better fitting models.

A more technical consideration concerns the estimation of the statistical significance of the coefficients of a model of the form of (2.2.2). The significance of a coefficient will be misstated if the correlation of observations within clusters is ignored. Usually, the standard error of a coefficient will be underestimated if the positive intra-cluster correlation of residuals is ignored (exceptions to this rule will be the comparatively slight overestimation of the standard errors of individual-level variables for which there is negligible variation in the cluster means e.g. "centered" variables (Holt and Scott (1981))).

In summmary, regression models can often be inadequate representations of the structure of hierarchically structured data.

The so-called "means-on-means" regression could be employed to study relationships between group-level factors. This method explains variation in the mean value of Y_{ij} in group i (i.e. $\bar{Y}_i$) in terms of other variables for this group. These other variables may have been measured at the group-level or they may be the mean values within the group of variables measured at the individual level. For example:

$$\bar{Y}_i = b_0 + b_1\bar{X}_{1i} + \ldots + b_k\bar{X}_{ki} + c_1 Z_{1i} + \ldots + c_p Z_{pi} + \alpha_i \quad (2.2.3)$$

where $\bar{X}_{ki}$'s are the mean values of variables which have been measured at the individual level, Z_i's are variables which have been measured at the group level and α_i's (the residuals) are assumed to be independent and come from a normal distribution with zero mean and some constant variance.

A problem with using this group-level regression approach lies in relating the model to variations in individual-level behaviour. Individuals within the same group will usually differ in some characteristics and Model 2.2.3 does not represent this. Coefficients describing group behaviour from variables aggregated to the within-group mean can differ from the the regression coefficients describing individual behaviour from the (corresponding) disaggregated individual-level observations (e.g. Aitken and Longford (1986)). Consequently inference from a group-level model to individual behaviour (and vice versa) can be erroneous. Incorrect inference from the group-level to the individual-level is called the "ecological fallacy" (e.g. Langbein and Lichtman (1978), Boyd and Iverson (1979)). Moreover, if there is variation in the values of the dependent variable or of the independent variables within groups and observations measured within groups form a random sample of such observations then the variation in the α_i's will in part at least be due to sampling error (e.g. Aitken and Longford (1986)). Furthermore, the fit of a model such as (2.2.3) will be understated by the R^2 statistic. Hence, means-on-means type regressions can give inadequate representations of hierarchically structured data.

Analysis of Covariance extends individual-level regression by allowing the use of group memberships as explanatory variables.

This could extend a model such as (2.2.2) to:

$$Y_{ij} = \alpha_1 + \ldots + \alpha_I + \beta_0 + \beta_1 X_{1ij} + \ldots + \beta_k X_{Kij} + \varepsilon_{ij} \quad (2.2.4)$$

where α_i is a dummy (0,1) variable showing the effect of membership of group i on Y_{ij}.

Furthermore, heterogeneity in the effects of the X_{kij}'s on Y_{ij} in different groups could be incorporated into Model 2.2.4 through the use of interaction terms between α_i's and X_{ij}'s. That is Model 2.2.4 can be extended to:

$$Y_{ij} = \sum_i \alpha_i' + \sum_k \beta_k' X_{kij} + \sum_i \sum_k \gamma_{ik} \alpha_i X_{kij} + \varepsilon_{ij} \quad (2.2.5)$$

where $\alpha_i X_{kij}$ is the interaction between the variable showing membership of group i, α_i, and X_{kij} and the γ_{ik}'s are coefficients relating Y_{ij} to the interaction terms.

Model 2.2.5 could be rewritten as:

$$Y_{ij} = \sum_i \alpha_i' + \sum_i \sum_k \beta_{ki} X_{kij} + \varepsilon_{ij} \quad (2.2.5')$$

where each $\beta_{ki} = \beta_k' + \gamma_{ik}$ when $\alpha_i = 1$. That is β_{ki} is the coefficient relating Y_{ij} to X_{kij} for group i. Hence, (2.2.5') is equivalent to modelling variation in Y_{ij} by a set of regression models with one regression model for each group.

The use of dummy variables for group memberships will mean that the ε_{ij}'s for groups on which observations were made will be uncorrelated. The use of within-group regressions for making inferences to group-level behaviour has been shown to be fallacious (e.g. Langbein and Lichtman (1978)). Hence the analysis of covariance approach is not suitable for making inference to the effects of groups which have not been included in the sample as neither the fixed nor the random parts of such models can properly be used to infer within-group correlations for these non-sampled groups. Furthermore, a limitation of this approach is that many degrees of freedom can be used up by fitting fixed effects for each group. It is questionable whether what may be a large number of regression lines will provide a concise and easily digestible summary of the information. Hence the use of variables decribing group memberships is unsatisfactory as a solution to the problems of the use of regression models to analyse hierarchically structured data.

In summary, individual-level regression models fail to represent hierarchically structured data properly by failing to represent the (unexplained) variation between groups. Group-level regression models fail to represent hierarchically structured data properly by failing to represent the effects of within-group heterogeneity. Furthermore, the use of variables describing group memberships within individual-level regression models can be cumbersome and fails to represent properly that the groups are a random sample from a wider population.

2.2.2 Generalized Linear Models

The regression/ANOCOVA models in Section 2.2.1 may be thought of as special cases of a broader class of models, generalized linear models. The generalized linear model is of the form:

$$Y_{ij} = f\,(\,\beta_0 + \beta_1 X_{1ij} + \ldots + \beta_K X_{Kij}\,) + \varepsilon_{ij} \quad (2.2.6)$$

where $\mu = \beta_0 + \beta_1 X_{1ij} + \ldots + \beta_K X_{Kij}$ is known as the linear predictor and $\eta = f^{-1}(\mu)$ is known as the link function. Examples of such link functions are:

a) $\eta = \mu$ for normally distibuted data.

b) $\eta = \ln(\mu)$ for Poisson data.

c) $\eta = \ln[\mu(1 - \mu)^{-1}]$ for binary or binomial data.

d) $\eta = \mu^{-1}$ for gamma distributed data.

(e.g. McCullagh and Nelder (1983), Dobson (1983), Aitken *et al.* (1989)).

Many of the criticisms of the use of a generalized linear model of the form of Model 2.2.6 for data with a hierarchical structure parallel the criticisms of Models 2.2.2 to 2.2.5. Firstly, Model 2.2.6, as it stands, does not represent the within-group correlation shown by the data and cannot be used to represent heterogeneity in the effects of the explanatory variables across groups. Model 2.2.6 could be extended to include variables indicating group membership. That is:

$$Y_{ij} = f(\,\beta_0 + \beta_1 X_{1ij} + \ldots + \beta_K X_{Kij} + \alpha_1 + \ldots \alpha_I\,) + \varepsilon_{ij} \quad (2.2.7)$$

Furthermore, Model 2.2.7 could be extended to incorporate heterogeneity in the effects of the explanatory variables in different groups by including interaction terms between the X_{kij}s and the group membership variables. That is:

$$Y_{ij} = f\left(\sum_{i=1}^{I} \alpha_i + \sum_{k=1}^{K} \beta_k X_{kij} + \sum_{i=1}^{I} \sum_{k=1}^{K} \gamma_{ik} \alpha_i X_{kij} \right) + \varepsilon_{ij} \quad (2.2.8)$$

However, neither of these models can offer inference to the within-group correlations of non-sampled groups. Moreover, if the number of groups in a sample is large it is cumbersome to fit a fixed effect for each group let alone interaction terms involving these. Consequently the variation between groups and heterogeneity in the effects of the explanatory variables between groups are best modelled using a random effect rather than fixed effects (see Anderson and Aitken (1985) for a discussion of this for interviewer effects).

A further consideration is that, as has already been noted for OLS regression models, for generalized linear models the standard errors of coefficients will be misstated (usually understated) if the correlation of observations within clusters is ignored. However, whereas coefficients of OLS models are unbiased estimates of the true parameters, coefficients of single level non-linear models are biased estimates of the true parameters (Neuhaus *et al.* (1991) for logistic models). The significance of coefficients tends to be misstated if within-cluster correlation of observations is ignored. Furthermore, goodness-of-fit statistics will also be misstated if the correlation of observations within clusters is ignored (e.g. Holt and Ewings (1989) for logistic models).

In conclusion, the analysis of hierarchically structured data clearly requires random variation at both the group-level and at the individual-level to be modelled. Methods of analysis which represent variation in individual-level behaviour (across some population) from both the nature of individuals and the nature of groups to which they belong are known as "contextual analyses" (Boyd and Iverson (1979), Mason *et al.* (1983)).

2.2.3 Slopes-as-Outcomes

Boyd and Iverson (1979) developed an early approach to contextual analysis in which the estimated values of coefficients of within-group regression equations are treated as the outcome variables of regression equations at the group-level. This, involves a within-group model and a between-group model. The within-group model, consisting of a set of within-group regression models, could be written in the form:

$$Y_{ij} = \beta_{0i} + \beta_{1i}X_{1ij} + \ . \ . \ . + \beta_{Ki}X_{Kij} + \varepsilon_{ij} \quad (2.2.9)$$

where X_{1ij} , . . ., X_{Kij} ,are variables measured at the individual-level, the β_{ki}'s relate Y_{ij} to the X_{kij}'s for group i, and the ε_{ij}'s (error terms) are normally distributed with mean zero and some variance.

The between-group model, which explains variation in the estimated values of the within-group coefficients, could be written in the form:

$$\beta_{ki} = \Theta_{k0} + \Theta_{k1}Z_{1i} + \ . \ . \ . + \Theta_{kP}Z_{Pi} + \alpha_{ki} \qquad (2.2.10)$$

for k =1, . . . ,K.

where the Z_{pi}'s are variables measured at the group level, the Θ_{kp}'s are coefficients relating β_{ki} to the Z_{pi}'s and the α_{ki}'s (error terms) are normally distributed with zero mean and some variance.

Equations 2.2.9 and 2.2.10 specify the basic model of contextual analysis. By substituting from (2.2.10) into (2.2.9) we can obtain a single equation:

$$Y_{ij} = \Theta_{00} + \sum_{p=1}^{P} \Theta_{0p}Z_{pi} + \sum_{k=1}^{K} \Theta_{k0}X_{kij} + \sum_{k=1}^{K} \sum_{p=1}^{P} \Theta_{kp}Z_{pi}X_{ij}$$
$$+ \sum_{k=1}^{K} X_{kij}\alpha_{ki} + \alpha_{0i} + \varepsilon_{ij} \qquad (2.2.11)$$

The problem with Boyd and Iverson's approach to contextual analysis lies in the estimation proceedure they adopted. This involves, firstly, estimating within-group coefficients by OLS regressions and then estimating between-group coefficients by OLS regression on the coefficients obtained from these within-group regressions. The β_{ki}'s obtained for the within group Model 2.2.9 are only estimates of the true underlying relationships (e.g. Raudenbush and Bryk (1986)). Boyd and Iverson's method does not take into account the imprecision inherent in these estimates and so underestimates standard errors for coefficient estimates in the single equation (2.2.10). This imprecision in the within-group coefficient estimates may be compounded because the values of independent variables for individuals in the same group are often more homogenous than in general. A consequence of not allowing for the imprecision of within-group coefficients is that outliers in the estimates of within-group parameters can exert undue influence on the between-group model. It should also be noted that some of the observed variation in coefficents in the within-group model is due to the effect of sampling and so is not potentially explainable by group-level variables. Consequently, the success of the between-group model in explaining differences in the processes operating in different groups will appear to be understated (by for example R^2). Moreover, if the sampling design differs between different groups then the reliability of the coefficient estimates for different within-group regressions will differ. As OLS estimates are based on the assumption of equal variances across cases of the dependent variable, coefficient estimates in the between-group model will be distorted. Finally, the Boyd and Iverson approach fails to incorporate a stategy for allowing for the effects of multicollinearity between within-group independent variables on the values and precisions of coefficient estimates (Boyd and Iverson only considered cases with a single within-group independent variable) (see Raudenbush and Bryk (1986) for a discussion of Boyd and Iverson's method).

This critique of the Boyd and Iverson approach shows that there was a need for the development of a more sophisticated approach to contextual analysis which took proper account of the reliabilities of coefficients from the within-group model. In the next section I set out a more appropriate method for the analysis of hierarchically structured data.

2.3 The Multilevel Model

2.3.0 Introduction

In this section I formally introduce multilevel models together with an appropriate estimation proceedure for such models. Basically, a multilevel model has random variation at more than one level. That is, the value of the coefficient for at least one level 1 variable (including the constant term) varies between different groups, and the set of these values is treated as a random sample from the set of coefficients of a wider population of level 2 units.

The most commonly used form of multilevel model is the linear multilevel model. I introduce such models in Section 2.3.2. A multilevel model can have two levels or more than two levels. In Section 2.3.2.1 I introduce linear multilevel models using the simplest case of such models, namely the two-level model, and in Section 2.3.2.2 I discuss the extension of this theory to models with three or more levels. The linear multilevel model may be thought of as a special case of the more general class of multilevel models which also encompasses nonlinear multilevel models. In Section 2.3.3 I introduce the more general class of nonlinear multilevel models. In all sections I assume that there is a single dependent variable (for a discussion of multilevel models with a multivariate outcome see Goldstein (1987, ch.5)).

2.3.1 The_Linear_Multilevel_Model

2.3.1.1 The_Linear_Two-level_Model

2.3.1.1.1 The_Specification_of_a_Linear_Two-level_Model

The framework for the the two-level linear model is similar to that of the slopes-as-outcomes model presented in Section 2.2.3. However, in Section 2.3.1.2. I show that the estimation procedures for these two types of model differ and that only the multilevel model offers coefficient estimates which are consistent with the estimated variance-covariance structure.

Formally, a linear two-level model is specified by:

1) A set of explanatory variables . This can include variables measured level 1, variables measured at level 2, and a constant term.

2) A fixed/random status for the coefficient of each explanatory variable. That is, the coefficient of each explanatory variable may be either:

a) fixed: this means that the coefficient takes the same value across all units ($\beta_{ij} = \beta$ (a constant)).

b) random at level 2: that is, the coefficient has the same value for observations in the same level 2 unit but can take different values for observations in different level 2 units ($\beta_{ij} = \beta + \alpha_i$).

c) random at level 1: that is the coefficient can take different values for different observations ($\beta_{ij} = \beta + \varepsilon_{ij}$).

d) random at both level 1 and level 2: that is, the coefficient can take different values for different observations but the values of coefficients from the same level 2 unit are correlated. ($\beta_{ij} = \beta + \alpha_i + \varepsilon_{ij}$).

A minimal condition for a model to be a multilevel model is that either at least one coefficient is random at level 1 and at least one coefficient is random at level 2 or at least one coefficient is random at both level 1 and level 2.

3) A covariance structure between coefficients. That is, coefficients random at the same level can have a non-zero

covariance or zero covariance. Coefficients random at different levels are assumed to have zero covariance. Given the variance stuctures of the coefficients and the covariances between these, a matrix of the variances of residuals (the V matrix) can be formed.

4) A distribution for the error terms (i.e. each error term is assumed to follow a normal distribution).

A linear two-level model is often described using two components, namely the within-group model (i.e. the within level 2 unit model) and the between-group model (i.e. the between level 2 unit model) (e.g. Mason *et al.* (1983), Raudenbush and Bryk (1986)).

The within-group model for the linear two-level model can be written:

$$Y_{ij} = \beta_{0ij} + \beta_{1ij}X_{1ij} + \beta_{2ij}X_{2ij} + . . . + \beta_{Kij}X_{kij} \quad (2.3.1.1.1)$$

for $j=1, . . ., n_i$ individuals in group i: $i=1, . . . I$.

where Y_{ij} is the dependent variable measured on individual j in group i, $X_{1ij}, . . ., X_{Kij}$ are independent variables measured on individual j in group i and $\beta_{0ij}, . . . , \beta_{Kij}$ are coefficients relating Y_{ij} to the independent variables measured at the individual level. If β_{0ij} is random at level 1 (i.e. $\beta_{0ij} = \beta_0 + \varepsilon_{0ij}$, $var(\varepsilon_{0ij}) \neq 0$) and is assumed to follow a normal distribution, and all the other β_{kij}'s are constant (i.e. $\beta_{kij} = \beta_k + \varepsilon_{kij}$, $var(\varepsilon_{kij}) = 0$, $k=1, . . ., K$) then (2.3.1.1) is the multiple regression model (2.2.2) . If at least one of the β_{kij}'s is random at level 1 (i.e. $\beta_{kij} = \beta_k + \varepsilon_{kij}$, $var(\varepsilon_{kij}) \neq 0$ for some $k = 0, . . ., K$) and at least one of the β_{kij}'s is random at level 2 ($\beta_{kij} = \beta_{ki} = \beta_k + \alpha_{ki}$, $var(\alpha_{ki}) \neq 0$ for some $k = 0, . . . , K$) or at least one of the β_{kij}'s is random at both level 1 and level 2 ($\beta_{kij} = \beta_{ki} + \varepsilon_{kij} = \beta_k + \alpha_{ki} + \varepsilon_{kij}$, $var(\alpha_{ki}) \neq 0$ and $var(\varepsilon_{kij}) \neq 0$) then (2.3.1.1) is a multilevel model. To describe the multilevel case, in addition to (1.3.1.1) we can write a between-group model:

$$\beta_{ki} = \Theta_{0k} + \Theta_{1k}Z_{1i} + . . . + \Theta_{pk}Z_{Pi} + \alpha_{ki} \quad (2.3.1.1.2)$$

for at each β_{ki} $k=0, . . . K$.($\beta_{kij} = \beta_{ki} + \varepsilon_{kij}$) where $Z_{1i}, . . ., Z_{Pi}$ are independent variables measured at the group level, α_{ki} is the error term, and Θ_{pk} are coefficients relating β_{kij} to the independent variables measured at level 2. It should be noted that for the β_{kij}'s which are not random at level 2, $\Theta_{kp} = 0$ for $p= 1, . . ., P$ and $var(\alpha_{ki}) = 0$.

The within-group and between-group models can be combined to produce a single equation. By substituting from (2.3.2.1.2) into (2.3.2.1.1) the model can be reexpressed as:

$$Y_{ij} = \Theta_{00} + \sum_{p=1}^{P} \Theta_{p0}Z_{pi} + \sum_{k=1}^{K} \Theta_{0k}X_{kij} + \sum_{p=1}^{P} \sum_{k=1}^{K} \Theta_{pk}X_{kij}Z_{pi} + \alpha_{0i} + \sum_{k=1}^{K} X_{kij}\alpha_{ki} + \sum_{k=1}^{K} X_{kij}\varepsilon_{kij} + \varepsilon_{0ij} \quad (2.3.1.1.3)$$

Here, ($\Theta_{00} + \sum_{p=1}^{P} \Theta_{p0}Z_{pi} + \sum_{k=1}^{K} \Theta_{0k}X_{kij} + \sum_{p=1}^{P}\sum_{k=1}^{K} \Theta_{pk}X_{kij}Z_{pi}$)

is known as the fixed part,

and $(\alpha_{ki} + \sum_{k=1}^{K} X_{kij}\alpha_{ki} + \sum_{k=1}^{K} X_{kij}\varepsilon_{kij} + \varepsilon_{0ij})$

is known as the random part.

The major distinction between the two-level linear model and the single level regression/ANOCOVA model is the more complex variance-covariance structure between the Y_{ij}'s in the multilevel case. In the single-level model observations are assumed to be independent whereas in the multilevel case this is not true in general.

To illustrate this I give the variance-covariance structure of Model 2.3.1.1.3:

If $\varepsilon_{kij} \sim I(0, \sigma_{1k}^{2})$ $k=0,\ldots K$

with $\mathrm{cov}(\varepsilon_{kij}, \varepsilon_{k'ij}) = \sigma_{kk'}$ $k,k'=0,\ldots,K$ $k \neq k'$ in general $\sigma_{kk'} \neq 0$

and $\alpha_{ki} \sim I(0, \sigma_{2k}^{2})$ $k=0,\ldots K$

with $\mathrm{cov}(\alpha_{ki}, \alpha_{k'i}) = \sigma_{2kk'}$, $k,k'=0,\ldots,K$ $k \neq k'$

again $\sigma_{2kk'} \neq 0$ in general.

and we assume that the α_{ki}'s and the ε_{kij}'s are uncorrelated, then:

$$\mathrm{var}(Y_{ij} | X_{1ij}, \ldots, X_{Kij}, Z_{1i}, \ldots, Z_{Pi}) = \sigma_{10}^{2} + \sum_{k=1}^{K} \sigma_{1k}^{2} X_{kij}^{2} + 2\sum_{k=1}^{K} \sigma_{10k} X_{kij} + 2\sum_{k=1}^{K} \sum_{k'=1}^{K} \sigma_{1kk'} X_{kij} X_{k'ij} + \sigma_{20}^{2} + \sum_{k=1}^{K} \sigma_{2k}^{2} X_{kij}^{2}$$

$$+ 2 \sum_{k=1}^{K} \sigma_{20k} X_{kij} + 2 \sum_{\substack{k=1 \\ k \neq k'}}^{K} \sum_{k'=1}^{K} \sigma_{2kk'} X_{kij} X_{k'ij} \qquad (2.3.1.1.4)$$

and

$$\mathrm{cov}(Y_{ij}, Y_{ij'} | j \neq j', X_{1ij}, \ldots, X_{Kij}, X_{1ij'}, \ldots, X_{Kij'}, Z_{1i}, \ldots, Z_{Pi}) = \sigma_{20}^{2} + \sum_{k=1}^{K} \sigma_{2k}^{2} X_{kij} X_{kij'} + \sum_{k=1}^{K} \sigma_{20k} (X_{kij} + X_{kij'})$$
$$+ \sum_{\substack{k=1 \\ k \neq k'}}^{K} \sum_{k'=1}^{K} \sigma_{2kk'} (X_{kij} X_{k'ij} + X_{kij'} X_{k'ij}) \qquad (2.3.2.1.5)$$

and

$$\mathrm{cov}(Y_{ij}, Y_{i'j'} | i \neq i', j \neq j', X_{1ij}, \ldots, X_{Kij}, Z_{1i}, \ldots, Z_{Pi}, X_{1i'j'}, \ldots, X_{Ki'j'}, Z_{1i'}, \ldots, Z_{Pi'}) = 0 \qquad (2.3.1.1.6)$$

So the linear multilevel model differs from the linear single level model in the respect that observations from the same level 2 unit are assumed to have a non-zero covariance (in general). Observations from different groups are assumed to have zero covariances. This assumption will often not be born out in reality and level 2 units will frequently interact to some extent (e.g in the Davies *et al* (1988) analysis of wages in the engineering industry in Rochdale using individual and firm characteristics the level 2 units (i.e. firms) compete and cooperate with each other).

As stated earlier the form of Model (2.3.1.1.3) stems from the choice of fixed/random status for the coefficient of each level 1 independent variable. The implications of the choice of the fixed/random status are:

a) A fixed coefficient implies that the "effect" of the independent variable is the same for all units. In this case any apparent differences in the effect of the independent variable between level 2 units shown by the within-group OLS regression equations are attributed to:

i) sampling

or

ii) misspecification of the within-group model. For example, if a linear relationship between the independent variable and the dependent variable is specified in the within-group model when the underlying relationship is non-linear.

Furthermore, a fixed coefficient implies that the "effect" of the independent variable is the same on all level 1 units within the same group (given the values of other level 1 independent variables). That is, there is no heterogeneity in this "effect" which has not been accounted for.

b) If the coefficient of a level 1 variable is random at level 2 then the "effect" of the independent variable is different in different level 2 units. This could occur if the process through which the independent variable "effects" the dependent variable differs between different level 2 units (in the population of such level 2 units) and that at least some of the variation in the coefficients of the OLS regressions for different level 2 units will be attributable to characteristics of these level 2 units. Alternatively, Mason (1989, p7) has suggested that when the meaning of a level 1 variable differs in the context of different level 2 units, and so the process through which the measured independent variable "effects" the measured dependent variable differs between level 2 units, the coefficient of the independent variable should be treated as random at level 2. A consequence of a variable having a coefficient random at level 2 is that the "unexplained" variance at level 2 will be assumed to vary systematically with the value of the variable (see 2.3.1.1.4).

c) If the coefficient of a variable is random at level 1 then the process through which the independent variable "effects" the dependent variable is different for different level 1 units (in the population of these level 1 units) and that there is heterogeneity in this "effect" which will not have been accounted for by other level 1 terms in the model (e.g. by interaction terms with other level 1 variables or by quadratic, cubic etc. terms for the variable). A consequence of a variable having a coefficient which is random at level 1 is that the "unexplained" variance at level 1 is assumed to vary systematically with the value of the variable (see 2.3.1.1.4).

d) If the coefficient of a level 1 variable is random at both level 1 and level 2 then the process through which the variable "effects" the dependent variable is different in different level 2 units (throughout the population of these level 2 units) and for different level 1 units in the same level 2 unit (throughout the population of these level 1 units in the same level 2 unit for the population of level 2 units) and there is both some heterogeneity in this effect which can be accounted for by characteristics of the level 2 units and some heterogeneity in this effect which can be accounted for by level 1 terms not already included in the model. A consequence of a variable having a coefficient which is random at both level 1 and level 2 is that the "unexplained" variances at both level 1 and level 2 are assumed to vary systematically with the value of this variable (see 2.3.1.1.4).

Furthermore, the form of Model 2.3.1.1.3 depends on the covariances between coefficients which are random at the same level. If variables are orthogonal then the coefficients will be determined independently and the term for the covariance between these can be treated as zero. In particular, if a variable at level 1 is "centered" (i.e. it has the form $X_{kij} - \bar{X}_{ki}$ where $\bar{X}_{ki}$ denotes the mean value of X_{kij} for level 2 unit i) then there is a zero (level 2) covariance between the coefficient of this term and the intercept β_{0ij} (e.g. Raudenbush (1989)). In general, however, there will not be a zero covariance between coefficients random at the same level. These covariances show confounding influences in the values of random coefficients for variables with a given scale of measurement. For convenience in the interpretation of the model these covariances are sometimes constrained to be zero. Longford (1989) argues that covariance terms should not be constrained to zero on the grounds that the scale of measurement is one of the factors that determines the values of these parameters.

The structure of Model 2.3.1.1.1 is fairly complex. Some commonly used special cases of this are:

1) The Hierarchical Linear Model (HLM) (Raudenbush and Bryk (1986)). This has the constant term random at level 1 and level 2 and all other coefficients either random at level 2 or fixed. That is, the Hierarchical Linear Model does not allow coefficients other than the constant to be random at level 1. This creates a simpler level 1 structure, but does not indicate the extent to which unexplained level 1 variance is a product of unexplained heterogeneity in level 1 effects. The single equation form for a HLM is as follows:

$$Y_{ij} = \Theta_{00} + \sum_{p=1}^{P} \Theta_{p0} Z_{pi} + \sum_{k=1}^{K} \Theta_{0k} X_{kij} + \sum_{k=1}^{K} \sum_{p=1}^{P} \Theta_{pk} Z_{pi} X_{kij} + \alpha_{0i} + \sum_{k=1}^{K} X_{kij} \alpha_{ki} + \varepsilon_{kij} \qquad (2.3.2.1.7)$$

2) The additive variance component model (e.g. Mason *et al.* (1983)). This assumes β_{0ij} is random at level 1 and level 2 and all other coefficients are fixed. This gives a two-level model in which the fixed part contains no cross-level interactions.

Furthermore, the random part of the model is considerably simplified and does not allow for unexplained heterogeneity in the effects of the level 1 independent variables. The single equation version of the additive model is as follows:

$$Y_{ij} = \Theta_{00} + \sum_{p=1}^{P} \Theta_{p0} Z_{pi} + \sum_{k=1}^{K} \Theta_{0k} X_{kij} + \alpha_{0i} + \varepsilon_{0ij} \qquad (2.3.1.1.8)$$

3) The Random Effects Analysis Of Variance. This fits only a constant term which is random at level 1 and level 2 (i.e all other independent variables are assumed to have zero coefficients). This gives a simple decomposition of the variance between the levels. The Random Effects ANOVA model is formulated as follows:

$$Y_{ij} = \Theta_{00} + \alpha_{0i} + \varepsilon_{0ij} \qquad (2.3.1.1.9)$$

This model differs from the fixed effects ANOVA in the respect that the α_i's are used for inference to a larger population of effects. The proportion of the total variance which occurs between level 2 units is known as the "intra-group correlation" or the "intra-cluster correlation":

$$\text{Intra-group correlation} = \frac{Var(\alpha_{0i})}{Var(\alpha_{0i}) + Var(\varepsilon_{0ij})}$$

This gives an indication of the importance of level 2 unit factors as determinants of behaviour.

In the following section I present an appropriate estimation procedure for linear two-level models.

2.3.1.1.2 Parameter Estimation For The Linear Two-level Model

This section presents the Iterative Generalised Least Squares procedure (Goldstein (1986), (1987)) for estimating the parameters of a two-level model of the form given by (2.3.1.3). This is not the only procedure to have been used to estimate the parameters of multilevel models. Other estimation procedures adopted include the use of the EM algorithm developed by Dempster, Laird and Rubin (1977) (e.g. Mason *et al.* (1983) and Raudenbush and Bryk (1986)) and the Fisher scoring algorithm (Longford (1987), (1989)).

The general estimator of coefficients for a linear model is the Generalised Least Squares (GLS) estimator. That is, given a general linear model expressed in matrix form :

$$Y = X\beta + \omega$$

where Y is the $(n \times 1)$ vector of responses, X is an $(n \times q)$ design matrix (n.b. in the case of Model 1.3.1.3 $q = (P + 1) \times (K + 1)$), β is a $(q \times 1)$ vector of fixed coeficients to be estimated (e.g. $\beta = (\Theta_{00} , \Theta_{10} , \ldots, \Theta_{P0} , \Theta_{01} , \ldots, \Theta_{PK})$) and ω is the $(n \times 1)$ vector of residuals with $E(\omega) = 0$. By convention, the first entry in each row of X is 1 so the k_{th} record has the form:

$$Y_k = \beta_0 + \sum_i \beta_i X_{ik} + \omega_k \quad i = 1, . . . , p-1.$$

Also,

$$Cov(Y|X\beta) = Cov(\omega) = E(\omega\omega^T) = V$$

The Generalised Least Squares estimator of β for this model is:

$$\hat{\beta} = (X^T V^{-1} X) X^T V^{-1} Y$$

and the covariance matrix of $\hat{\beta}$ is:

$$(X^T V^{-1} X)$$

When $V = \sigma^2 I$,Ordinary Least Squares estimates are obtained.

In the two-level case the variance-covariance matrix has a block-diagonal form and can be written:

$$V = \underset{i}{\oplus} \{ V_{1,i} + (X_{2ki}) \Omega_2 (X_{2ki})^T \}$$

where $V_{1,i} = \overset{n_i}{\underset{j=1}{\oplus}} \{ (X_{1kij}) \Omega_1 (X_{1kij})^T \}$

and n_i is the number of units in the i_{th} level 2 unit, (X_{1kij}) denotes the matrix of explanatory variables which are random at level 1, Ω_1 is the covariance matrix of the corresponding level 1 error terms, (X_{2ki}) is the design matrix of explanatory variables which are random at level 2 for the i^{th} level 2 unit and Ω_2 is the covariance matrix of the corresponding level 2 error terms.

However, the elements of the variance-covariance matrix for the two-level model are in general unknown. Goldstein (1986), (1987) set out an Iterative Generalised Least Squares (IGLS) procedure to produce consistent estimators of V and $\hat{\beta}$. To begin with this uses the OLS estimate of V in the Generalised Least Squares estimator of β to produce an initial estimate $\hat{\beta}$ of β (in fact any feasible estimate of V could have been used for this). From this estimate the residuals have values:

$$\hat{\omega}_{ij} = (Y_{ij} - X_{ij}\hat{\beta})$$

Each $\hat{\omega}_{ij}^2$ is an estimator of $Var(Y_{ij}|X_{0ij}, \ldots, X_{Kij}\ Z_{0i}, \ldots, Z_{Pi})$, and each $\hat{\omega}_{ij}\hat{\omega}_{ij'}$ ($j \neq j'$) is an estimator of $Cov(Y_{ij}, Y_{ij'}|X_{0ij}, \ldots, X_{Kij}, X_{0ij'}, \ldots, X_{Kij'}, Z_{0i}, \ldots, Z_{Pi})$. These estimators can be used to provide estimators of the parameters of V (i.e. the elements of Ω_1 and Ω_2). These come from the generalised least squares estimators:

$$\hat{\beta}^* = (X^{*T} (V^*)^{-1} X^*)^{-1} X^{*T} (V^*)^{-1} Y^*$$

where Y^* is the vector of upper triangle elements of $(Y - X\hat{\beta})(Y - X\hat{\beta})^T$ (i.e. $(\omega_{11}^2, \omega_{11}\omega_{12}, \omega_{12}^2, \omega_{11}\omega_{13}, \ldots \omega_{In_I}^2)$, V^* is the covariance matrix of Y^* (see Browne (1974) and (1984) for the form of this), and X^* is the design matrix linking Y^* to V in the regression of Y^* on X^*.

The estimates of Ω_1 and Ω_2 (which give an estimate of V) in turn can be used to provide an improved estimate of β, $\hat{\beta}_2$. This $\hat{\beta}_2$ in turn can provide improved estimates of Ω_1 and Ω_2. This process continues until the estimates of β and V are consistent (i.e. convergence is achieved). Goldstein (1986) shows that these consistent estimates are equivalent to the maximum likelihood estimates under assumptions of normality.

The variance-covariance matrix of the fixed parameters is:

$$Var(\hat{\beta}) = (X^T \hat{V}^{-1} X)^{-1}$$

and the variance-covariance matrix of the random parameters is:

$$Var(\hat{\beta}^*) = (X^{*T} \hat{V}^{*-1} X^*)^{-1}$$

It is worth noting that it is possible for the above procedure to produce negative estimated variances. Such negative estimates are clearly inadmissible. The problem of negative variance estimates can be avoided by, at each iteration, using an estimate of β^* which minimises the value of $(Y^*-X^*\beta^*)(Y^*-X^*\beta^*)^T$ subject to the constraint that all variance parameters in the estimate are non-negative (Pfeffermann and LaVange (1989, p245)).

The above estimation procedure is applicable for situations where all observations are weighted equally. In some situations this may not be appropriate. In particular, if units are selected for inclusion with unequal probabilities then to obtain unbiased and consistent estimates of population parameters observations need to be weighted inversely proportional to their selection probabilities. In such cases the fixed parameters can be estimated using a probability weighted generalized least squares estimator $\hat{\beta}_{pw}$:

$$\hat{\beta}_{pw} = (X^T W V_{pw}^{-1} W X)^{-1} X^T W V_{pw}^{-1} W Y$$

where $W = \text{diag}\{ w_{ij} \}^{0.5}$ where w_{ij} is the inclusion probability of the ij^{th} unit. The random parameters can be estimated from its analogue for the random part $\hat{\beta}^*_{pw}$ (i.e. the parameters of V_{pw}). Estimation of parameters can be carried out by a similar iterative procedure to that set out above. It is to be noted, however, that if ML3 (Prosser *et al.* (1991) is used to estimate parameters the estimates of $Var(\hat{\beta}_{pw})$ provided will be incorrect (c.f. e.g. Dumouchel and Duncan (1983), Nathan and Smith (1989, p155)).

From the above estimation procedure we can be see that Boyd and Iverson's approach (discussed in Section (2.2.2)) produces estimates of the parameters and of the variance-covariance structure of error terms which are inconsistent under the application of Generalised Least Squares.

Comparing the Iterative Generalized Least Squares with OLS estimates for a model of the form (2.3.1.3) we can see that although fixed parameters estimated by OLS are unbiased ($E(\hat{\beta}) = E((X^TX)^{-1}X^TY) = E((X^TX)^{-1}X^T(X\beta + \varepsilon_{ij}) = \beta$, as $E(\varepsilon_{ij})=0$), the precision of these estimates is misstated ($Cov(\hat{\beta}) = (X^TX)^{-1}X^TVX(X^TX)^{-1}$ which, unlike the $cov(\hat{\beta})$ estimated by OLS, involves V the correct variance-covariance matrix) unless V is diagonal. Holt and Scott (1981) show misestimation of the standard errors of the fixed coefficients in OLS simple regression depends on a) the numbers of level 1 units within level 2 units b) the intra-group correlation of residuals and c) the intra-group correlation of the explanatory variable, that the misestimation (i.e underestimation) of the standard error of the intercept is more pronounced than the misestimation of the standard error of the explanatory variable and that misestimation of the standard error of the explanatory variable increases with the intra-group correlation of that variable.

Finally, it is to be noted that OLS does not offer a decomposition of the unexplained variance into its components.

2.3.1.1.3 Hypothesis Testing

In general, the true underlying values of the parameters of a two-level model such as (2.3.1.3) are unknown. Consequently, it will often be useful to carry out tests about the values of these parameters.

In the case of fixed parameters of Model 2.3.1.3 the null and alternative hypotheses will be of the form:

H_0: $R\beta = r$

and

H_1: $R\beta \neq r$

where R, is a known $g \times q$ design matrix (n.b. for Model 2.3.1.3 $q = (P + 1) \times (K + 1)$), and r is a known $g \times 1$ matrix).

(Thus to test

H_0: $\Theta_{pk} = 0$

against

$H_1: \Theta_{pk} \neq 0$,

R is set to be the $1 \times q$ matrix with a one in the position corresponding to the position of Θ_{pk} in β and zeros elsewhere, and r is a vector of zeros).

These hypotheses can be tested by forming the Wald statistic (e.g. Buse (1982), Goldstein (1987), Pfeffermann and LaVange (1989)):

$$W_M = (R\hat{\beta} - r)^T (R (X^T \hat{V}^{-1} X)^{-1} R^T)^{-1} (R\hat{\beta} - r)$$

If H_0 is true (and $\hat{V}$ is close to V) this statistic will asymptotically have a $\chi^2(g)$ distribution. Consequently, H_0 can be tested by comparing the value of the W_M statistic with values from $\chi^2(g)$ tables.

A 95% confidence interval for any particular element of β, say Θ_{pk} , can be obtained by setting W equal to the value defining the 5% tail region of the χ^2 distribution with 1 degree of freedom and solving the appropriate quadratic form to find the single non-zero element of the $1 \times q$ matrix, R, say d_{pk} (i.e. the element corresponding to the position of Θ_{pk} in β). The 95% confidence interval for Θ_{pk} will then be ($\Theta_{pk} - d_{pk}$, $\Theta_{pk} + d_{pk}$).

If the estimates of fixed parameters of a model have been obtained using a probability weighted estimator, hypotheses of this form need to be tested by forming the design-based Wald statistic W_D (see Pfeffermann and Lavange (1989)):

$$W_D = (R\hat{\beta}_{pw} - r)^T (R \{ \hat{Var} (\hat{\beta}_{pw}) \} R^T)^{-1} (R\hat{\beta}_{pw} - r)$$

As noted earlier (see Section 2.3.2.2) if the method of regressing WY on WX is used to estimate $\hat{\beta}_{pw}$ using existing multilevel software such as ML3 the estimates of Var($\hat{\beta}_{pw}$) provided by the software will be incorrect. This implies that chi-squared test statistics provided by this software will also be incorrect.

The issue of how to approach hypothesis testing for the random parameters of a multilevel model is less clear cut. According to Longford (1989) " the choice of free parameters in the variance matrices . . . presents a new challenge to the data analyst for which there is limited or no experience to fall back on ". This difficulty stems from the fact that the random parameters of a multilevel model can include not only the variances of random coefficients but also covariances between these random coefficients. Hence the question arises of whether constraining a (random) coefficient to be zero should entail also constraining covariance terms involving this coefficient (which are also parameters of the random part) to be zero. It could be argued that unless this is done such parameters become meaningless. Thus there is a dilemma concerning how hypotheses regarding random coefficients should be formulated. It should be noted that if all explanatory variables are orthogonal this issue will not arise.

However, once the null and alternative hypotheses regarding random parameters of a multilevel model such as (2.3.1.3) have been formulated:

Suppose:

$H_0 : R^*\beta^* = r^*$

and

$H_1 : R^*\beta^* \neq r^*$

where R^* is a known $g^* \times q^*$ design matrix (n.b. in the case of (1.3.1.3) $q^* = (K + 1)\times(K + 2)$ and r^* is a known $g^* \times 1$ matrix).

A Wald statistic for the null hypothesis is of the form:

$$W_M^* = (R^*\hat{\beta}^* - r^*)^T (R (X^{*T}(V^*)^{-1}X^*)^{-1} R^T)^{-1} (R^*\hat{\beta}^* - r^*)$$

The distributional properties of W_M^* when (as will often be the case) H_0 lies on the boundary of the parameter space has been the subject of some debate (e.g. Anderson and Aitken (1985, p208)). Self and Liang (1987) show that the limiting distributions of likelihood ratio statistics when H_0 lies on the boundary of the parameter space are mixtures of chi-squared distributions. In particular, Self and Liang show that the limiting distribution used to test the existence of a single variance component should be a 50:50 mixture of χ_0^2 and χ_1^2. However, when H_0 is not on the boundary of the parameter space then, if H_0 is true, W_M^* will asymptotically follow a $\chi^2(g^*)$ distribution and, consequently, H_0

can be tested by comparing W_M^* to $\chi^2(g^*)$ tables. In many cases the value of W_M^* will be sufficiently large that it will be clear whether a H_0 formulated with different constraints (or lack of them) on covariances should be rejected or not (assuming an assumption regarding the distribution of W_M^* has been made). However in other cases the formulation of hypotheses will be crucial to the decision of whether or not a random term is dropped. It is worth restating that if all explanatory variables are orthogonal (and hence covariance terms are zero), the issue of how hypotheses should be formulated does not arise.

2.3.1.1.4 Analysis_of_Residuals

For a two-level model of the form (2.3.1.3), for each actual observation (Y_{ij} , Z_{1i} ,. . ., Z_{Pi} , X_{1ij} ,. . ., X_{Kij}) the value of the fixed part is known as the fitted value or the predicted value for that observation ($\hat{Y}_{ij}$) and the value of the random part is known as the composite residual for that observation ($\tilde{Y}_{ij} = Y_{ij} - \hat{Y}_{ij}$).

As can be seen from (2.3.1.3.), each composite residual consists of a number of component parts. Thus estimates are required for these components of the composite residuals (i.e. for each $\tilde{Y}_{ij}$ we require an estimate of each α_{ki} (where $Var(\alpha_{ki}) \neq 0$) and each ε_{kij} (where $Var(\varepsilon_{kij}) \neq 0$) for k= 0, . . ., K). Estimates of these components for the units at each level (conditional on the values of the composite residuals and the values of the parameters of the random part) can be obtained from the expected values of products of the (transposes of) vectors of coefficients of ordinary regression of the vectors of terms random at that level on $\tilde{Y}_{ij}$ with the $\tilde{Y}_{ij}$ in the various units (i.e. the expected values of, say, $\alpha = \{ \alpha_0, . . ., \alpha_K \}$ in the various level 2 units and of, say, $\varepsilon = \{ \varepsilon_0 , . . ., \varepsilon_K \}$ in the various level 1 units)(see Goldstein (1987, p49) and Goldstein and McDonald (1988)) where:

$$\alpha = N_2^T V^{-1} \tilde{Y}_{ij}$$

where $N_2^T = (X_{2kij}) \Omega_2$

where X_{2kij} is the matrix of explanatory variables which are random at level 2 and Ω_2 is the covariance matrix of the corresponding level 2 error terms.

and

$$\varepsilon = N_1^T V^{-1} \tilde{Y}_{ij}$$

where $N_1^T = (X_{1kij}) \Omega_1$

where X_{1kij} is the matrix of explanatory variables which are random at level 1 and Ω_1 is the covariance matrix of the corresponding level 1 error terms.

In the special case of additive variance models of the form given by (2.3.1.5) the composite residuals have only two components (α_i and ε_{ij}) and so these are estimated as follows:

$$\hat{\alpha}_i = n_i \, \sigma_{20}^{\;2} \, (n_i \, \sigma_{20}^{\;2} + \sigma_{10}^{\;2})^{-1} \, \tilde{Y}_i$$

where $\tilde{Y}_i = n_i^{-1} (\sum_{j=1}^{n_i} \tilde{Y}_{ij})$

and

$$\hat{e}_{ij} = \sigma_{10}^{\;2} \, (\sigma_{10}^{\;2} + \sigma_{20}^{\;2})^{-1} \, \tilde{Y}_{ij}$$

The estimates of the components of residuals are Bayesian-styled "conditional" or "posterior" estimates given the assumption that prior estimates of these components are zero. Estimates of components measured at level 2 are often referred to as "shrunken" estimates because their variances are less than the variances of the corresponding coefficients estimated for within-level 2 unit regressions (e.g. Aitken and Longford (1986), Goldstein (1987)). The variances of the "shrunken" estimates give unbiased estimates of the true between-level 2 unit variances of coefficients. This contrasts with the variances of coefficients estimated from within level 2 regressions which reflect sampling variances in addition to underlying between-level 2 unit variances.

"Shrunken" estimates of within level 2 unit coefficients (i.e. the β_{ki}'s) can be obtained by adding the estimate of a coefficient in the fixed part of the model to estimates of the corresponding level 2 component of the random part for the various level 2 units (i.e. $\hat{\beta}_{ki} = \hat{\beta}_k + \hat{\alpha}_{ki}$). Put another way a "posterior" estimate of a within level 2 unit coefficient is obtained based on a prior estimate of this coefficient which is the expected value of all such coefficients.

The "shrunken" estimates of level 2 unit "effects" (i.e. the Bayesian-styled "conditional" or "posterior" estimates) need to be distinguished as representations of the "effects" of the level 2 units from the estimates of level 2 unit "effects" in OLS models such as Model 2.2.5. The estimates in Model 2.2.5 are the maximum likelihood estimates of the individual level 2 unit "effects" and hence the "shrunken" estimates represent biased estimates of these effects. However, in general "shrunken" estimates should have smaller mean squared error than the "unshrunken" maximum likelihood estimates of these effects (e.g. Lindley and Smith (1972)). Furthermore, due to their having been "shrunk", the Bayesian-styled estimates can be used collectively as random effects to make inference to the distribution of a wider population of level 2 unit effects whereas the estimates of the effects of level 2 units in Model 2.2.5 can only be used individually as fixed effects to make inference to the level 2 unit on which they are made. The "shrunken" estimates should also be distinguished as representations of level 2 unit effects from the use of the means of the (level 1) residuals within level 2 units estimated for OLS models such as (2.2.2) as level 2 "effects". The method of using mean residuals does not take into account their differing reliabilities in different sized level 2 units and hence these mean residuals cannot collectively be used for inference to a wider population of effects. Furthermore, this method cannot be used to reflect the possibility of different "slopes" in the different level 2 units (e.g. Aitken and Longford (1986) and Fitz-Gibbon (1989)). It should be noted that if "effects" of level 2 units correlate with a variable(s) in the fixed part of a model then not only the (fixed) "effect(s)" of that variable(s) but also the level 2 unit "effects" as represented by the "shrunken" level 2 residuals will be biased (or for that matter mean residuals within level 2 units estimated by OLS) (Raudenbush and Bryk (1989, p213)). For this reason it is perhaps better to refer to the interpretation of "shrunken" level 2 residuals as *residual* level 2 unit effects rather than as level 2 unit effects.

The distributions of the estimates of components can be used to identify outliers either at level 1 or at level 2 and to check the assumptions of normality. It is to be noted that the process of "shrinkage" removes the possibility of level 2 outliers being attributable to the lower reliabilities of smaller samples (c.f. the α_i's in Model 2.2.5). Plots of these estimates of components against variables with fixed coefficients could be made to check whether some of these coefficients should be made random and plots of these estimates of components against relevant further explanatory variables could be used to check if these variables could usefully be added to the model. It should also be noted that estimates of level 2 residuals could be used to indicate whether fixed effects for individual level 2 units are potentially useful explanatory variables. The distributions of level 1 residuals within level 2 units could also be used to indicate potential (level 2) explanatory variables (e.g. Plewis (1989)). Furthermore, the "shrunken" estimates of level 2 "effects" could be used to provide rank orderings for these units (e.g. Aitken and Longford (1986)).

2.3.1.2. Linear Models With Three or More Levels

A hierarchical structure may have more than two levels. For example individuals (level 1 units) live in settlements or villages (level 2 units), groups of settlements form counties (level 3 units) groups of counties form regions (level 4 units) and so on.

A three-level model has random variation at three levels. That is at least one set of coefficients from a two-level model is either random at level 3, random at level 1 and level 3, random at level 2 and level 3 or random at all three levels. Hence if the within level 2 unit model is:

$$Y_{1ij} = \beta_{01ij} + \sum_{k=1}^{K} \beta_{k1ij} X_{k1ij} \qquad (2.3.1.2.1)$$

where Y_{lij} is the dependent variable measured on individual j in level 2 unit i and level 3 unit l, the X_{klij}'s are independent variables measured on individual j in level 2 unit i and level 3 unit l and the β_{klij}'s are coefficients relating Y_{lij} to the independent variables and at least one β_{klij} is random at level 1 (i.e. $\beta_{klij} = \beta_{kli} + \varepsilon_{klij}$, $var(\varepsilon_{klij}) \neq 0$)

Then for at least one β_{klij} there is a between level 2 unit model of the form:

$$\beta_{kli} = \Theta_{0kl} + \sum_{p=1}^{P} \Theta_{pkli} Z_{pli} \qquad (2.3.1.2.2)$$

where Z_{pli} are independent variables measured on level 2 unit i and level 3 unit l and the Θ_{pkli} are coefficients relating the β_{kli}'s to the level 2 independent variables and at least one Θ_{pkli} is random at level 2 (i.e. $\Theta_{pkli} = \Theta_{pkl} + \alpha_{pkl}$, and $var(\alpha_{pll}) \neq 0$).

In a three-level model at least one coefficient is random at level 3. That is for at least one of the Θ_{pkli}'s there is a between level 3 unit model of the form:

$$\Theta_{pkl} = \Omega_{0pkl} + \sum_{t=1}^{T} \Omega_{tpkl} W_{tl} + \varphi_{pkl} \qquad (2.3.1.2.3)$$

for some p, k, p=1,. . .,P ,k=1,. . .,K.

where the W_{tl} are independent variables measured at level 3, and Ω_{tpkl} are coefficients relating the Θ_{pkl}'s to the level 3 independent variables and φ_{pkl} are the level 3 residuals. As before equations (2.3.1.2.1), (2.3.1.2.2) and (2.3.1.2.3) can be combined to obtain a single equation version of the model.

From the above it should be clear that the model could be extended to have h levels where h is any integer greater or equal to two. That is, an h-level model has the form:

$$Y_{i_h i_{h-1} \cdot\cdot\cdot i_1} = \sum_{k=1}^{h} \beta_{i_h i_{h-1} \cdot\cdot\cdot i_k} X_{i_h i_{h-1} \cdot\cdot\cdot i_k} \qquad (2.3.1.2.4)$$

where $Y_{i_h i_{h-1} \ldots i_1}$ denotes the dependent variable measured on level 1 unit i_1 in level 2 unit i_2 . . . and level h unit i_h , each $X_{i_h i_{h-1} \ldots i_k}$ denotes a ($n_k \times 1$) vector of independent variables measured at the k_{th} level of the model (this vector includes interaction terms between independent variables measured at the k_{th} level and variables measured at the k_{th} , $k + 1_{th}$, . . ., h_{th} levels) and each $\beta_{i_h i_{h-1} \ldots i_k}$ denotes a ($1 \times n_k$) vector of coefficients (each element of each $\beta_{i_h i_{h-1} \ldots i_k}$ may be random at level k, random at level k + 1 , . . ., random at level h or random at any combination of these levels). Again, it should be clear that the V matrix for the h-level model will have a block-diagonal structure. This can be written (e.g. Goldstein, Prosser and Rasbash (1989)) as:

$$V_{h-k} = \underset{h-k}{\oplus} \{ V_{h-k-1} + X_{i_h i_{h-1} \ldots i_{h-k}} \Omega_{h-k} X_{i_h i_{h-1} \ldots i_{h-k}} \}$$
(2.3.1.2.5)

for k = 0,. . .,h-1

where Ω_{h-k} is the covariance matrix for the coefficients which are random at level h-k (i.e. the elements of $X_{i_h i_{h-1} \ldots i_{h-k}}$).

From the above it should be clear that estimation of and hypothesis testing for linear multilevel models with three or more levels can be carried out using the estimation equations and test statistics presented in Sections 2.2.1.1.2 and 2.2.1.1.3 respectively. Residual analyses should include analysis of the components of residuals at each of the levels of a model.

2.3.2 The General (Nonlinear) Multilevel Model

The general multilevel model is the sum of both a linear component and a nonlinear component both of which may contain fixed and random variables (Goldstein (1991)).

$$Y = f(X_1\beta + Z_u u) + X_2\gamma + Z_e e \qquad (2.3.3.1)$$

where f is a nonlinear function, e, u are vectors of random variables with zero means and corresponding design matrices Z_e and Z_u , β and γ are vectors of fixed coefficients with design matrices X_1 and X_2.

In most applications, e will be a vector of coefficients random at level 1 and u will be a vector of coefficients random at higher levels. Furthermore, in most applications the set of variables in X_2 will be empty (see Goldstein (1991) for an example when this is not the case). If f is the identity function, X_2 is empty

(or equivalently γ is constrained to be zero), e is a vector of variables random at level 1 and u is a vector of variables random at higher levels, then the Model 2.3.3.1 is of the form of Model 2.3.2.2.4.

If X_2 is empty, e contains only the constant level 1 random term and u contains is a vector of variables random at higher levels each of which is assumed to follow a normal distribution, that is (in the two-level case):

$$Y_{ij} = f\left(\sum_{k=1}^{k} X_{kij}\beta_k + X_{kij}\alpha_{ki} \right) + \varepsilon_{ij} \qquad (2.3.3.2)$$

where $\alpha_{ki} \sim N\ (\ 0,\ \sigma_k^{\ 2}\ )$,

then we can define a class of multilevel models, which is an extension of the class of "generalized linear models" (GLIM models) (as described by e.g. McCullagh and Nelder (1983), Dobson (1983), Aitken *et al.* (1989)) to incorporate non-independent errors, where f (the inverse of the link function) can any of the following forms:

a) $f(x) = x$ for normally distributed data (i.e. (2.3.3.2) is the Hierarchical Linear Model (2.3.2.1.7)).

b) $f(x) = 1 - (1 + e^{x})^{-1}$ for binary or binomial data.

c) $f(x) = e^{x}$ for Poisson data.

d) $f(x) = x^{-1}$ for gamma distributed data.

(see Longford (1988a), (1988b)).

In the case of binary or binomial data the level 1 variance is not identified and should be constrained to 1. For Poisson data the level 1 variance term is usually also constrained to 1, although, if desired, extra-Poisson (level 1) variation may be incorporated into the model (e.g. to allow for overdispersion or underdispersion).

Goldstein (1991) discusses a method for the estimation of the general multilevel model (2.3.3.1) which uses the linear first-order terms of the Taylor expansion for f and the Iterative Generalized Least Squares algorithm. Longford (1988a) uses the Fisher scoring algorithm to provide approximate quasilikelihood estimation of models (with two or more levels) of the form of (2.3.3.2). Wong and Mason (1985) show how the EM algorithm can be employed for the estimation of a Hierarchical Logistic Regression model.

3 THE METHODOLOGY OF ENCOMPASSING AND ITS IMPLICATIONS FOR DEMOGRAPHIC RESEARCH

3.0 Introduction

In this chapter I introduce a new methodology developed for use in econometrics, principally by David Hendry (e.g. Hendry (1987)). Other leading figures behind the development of this methodology are Grayham Mizon and Jean-Francois Richard. Henceforth, I shall refer to this methodology as "Hendry's Methodology" or "Encompassing". Hendry sets out criteria which a model should satisfy to be congruent with the available information. Encompassing is one of these criteria. It is, however, the criteria which most markedly distinguishes this methodological approach. The implications of this methodology in the context of statistically oriented demographic research are discussed. A personal perspective on the utility of this approach is presented which is based on my experience of modelling fertility data from Ghana and Liberia.

One of the original motivations for investigating encompassing was that this new methodological perspective may throw light on questions concerning model selection where the parameters of models include both fixed and random effects (e.g. in the case of multilevel models). A search of the literature revealed that encompassing has thus far only been formalised for models with fixed effects (Hendry and Richard (1989, p414). Hence, in Section 3.5.2, I discuss the extension of encompassing to the comparison of multilevel models.

3.1 Models and Model Evaluation

"A model of any set of phenomena is a formal representation thereof in which certain features are abstracted while others are ignored with the intent of providing a simpler description of the salient aspects of the chosen phenomena"(Hendry and Richard (1982, p4).

Central to Hendry's approach to evaluating models is the concept of the data generating process (DGP). This DGP is in effect the (true) joint probability of the sample data (Gilbert (1986)). Constructing a statistical model invariably involves:

a) (deliberately or inadvertently) removing unwanted variables by marginalizing the DGP with respect to these variables,

b) conditioning the endogenous (dependent) variable(s) on the exogenous (independent) variables,

c) asserting a suitable distribution for the conditioned, marginalized DGP

d) replacing the unknown parameters by their estimated values.

In Hendry's approach a model is evaluated in terms of whether it can tentatively be regarded as a "useful approximation" to the data generating process.

The following criteria are proposed as a basis for assessing whether a model is a "useful approximation" to the data generating process (Hendry (1988), Hendry and Richard (1982)):

i) data coherency. That is a model is more useful if differences between fitted values generated by the model and actual values are random and correctly specified (i.e. assumptions regarding , for example, the autocorrelation, heteroscedasticity, intra-cluster correlation of errors are valid).

ii) Data admissibility and measurement accuracy. A model is data admissible if it predicts all data constraints with probability unity. By this criteria, for example, a logit model is preferable to a normal regression model if the dependent variable is bounded by 0 and 1. Measurement inaccuracy (including non-coverage) can seriously limit the usefulness of models.

iii) Theory consistency and identifiability. Theory plays a key role in interpreting parameters of a model and hence it is useful for an empirical model to reproduce the theory model.

iv) Parameter constancy. It is useful if the parameters of a model remain constant over time.

v) Valid conditioning. The inference which can be conducted using a model depends on the "exogeneity" status of its "independent" variables (see Engle et al. (1983) for a discussion of exogeneity status). The usefulness of a model is enhanced if it can be used for policy prescription and/or forecasting.

vi) Parsimony. That is, the "simpler" a model is the better.

vii) The encompassing principle. This principle stipulates that a "useful" model should be able to predict the behaviour of relevant characteristics of other models. In effect, this principle involves valuing a model in terms of its ability to mimic a property of the DGP with respect to rival models (e.g. Mizon (1984), Hendry and Richard (1989)). If one model (say, A) can be used to predict the value of a statistic (say, p) for a rival model (say, B) we say "model A encompasses model B with respect to p".

The DGP is in general not known. For any phenomena a large number of models could typically be viewed as candidates to represent this process. Criteria i)-v) can be used to eliminate inappropriate or nonsensical candidates for this process. Criteria vi) can be used to eliminate unnecessarily complicated candidates. The most distinctive feature of Hendry's methodology is criteria vii). In the following section I formally describe the encompassing principle (criteria vii)) and show that adherence to this criteria for evaluating models should enable research to progress in the direction of presenting the best model with the information currently available. As the DGP ,in general, is unknown, the issue of whether the best model with the information currently available is in fact the DGP cannot be assessed.

3.2 The Encompassing Principle

Two models, say models M_1 and M_2, can be represented by density functions say $f(Y \mid X_1, \alpha)$ and $g(Y \mid X_2, \delta)$ respectively where Y is a (set of jointly) dependent variable(s), X_1 and X_2 are sets of independent variables and α and δ are finite-dimensional, and identifiable parameter vectors within their respective models. For example, M_1 and M_2 could be the regression models:

$$M_1: Y = X_1\beta_1 + u_1 \quad u_1 \sim N (0, \sigma^2 I_n)$$

$$M_2: Y = X_2\beta_2 + u_2 \quad u_2 \sim N (0, \tau^2 I_n).$$

where n is the number of observations.

Comparison of two such models, M_1 and M_2, defined on a common distributional framework (see Mizon (1984) for a discussion of the need for this) by the encompassing principle can involve any statistic, (p) say, relevant to the analysis of M_2 and hence a function of Y and X_2. However, consideration of the parameter vector of M_2 (i.e. δ) can be particularly useful.

If (a model of) the DGP were known then this could be used to predict the value of p for any rival model. In other words, the DGP encompasses any rival model with respect to all statistics relevant to the analysis of the model. Consequently, if a candidate model for this process is not able to encompass a rival model with respect to some relevant statistic, then it cannot be (a model of) the DGP.

Formally, if p_α is the value of p under the assumption that M_1 is the DGP then:

M_1 encompasses M_2 with respect to p iff $\Phi = (p - p_\alpha) = 0$.

In practice the value of Φ will not be known. However, if p can be consistently estimated (say by $\hat{p}$) and α (the parameter vector of M_1) can be consistently estimated (say by $\hat{\alpha}$) then $E_\alpha(\hat{p} - E(p)_{\alpha=\hat{\alpha}}) = \hat{\Phi}$ estimates Φ. Furthermore, if n is the number of observations, then the limiting distribution of (sqrt(n) $\times \hat{\Phi}$) on M_1 is $N(0, V_\alpha(\Phi))$. Testing the hypothesis:

H_0: M_1 encompasses M_2 with respect to p

involves testing whether $\hat{\Phi}$ is significantly different from zero and can be carried out by forming the Wald Encompassing Statistic (WET) with respect to p:

$$\eta_W(p) = n\, \hat{\Phi}^T\, \hat{V_\alpha}(\Phi)^{-1}\, \hat{\Phi} \quad \underset{M_1}{\overset{d}{\rightarrow}} \chi^2(l)$$

where $l = \text{rank}\ \hat{V_\alpha}(\Phi)$.

In some cases the calculation of a WET can be tedious, complicated or even intractable. In such cases a procedure based on Monte Carlo simulation for values of $\hat{\Phi}$ and $V_\alpha\hat{}(\Phi)$ or $V_\alpha\hat{}(\Phi)$ only can be gainfully adopted (Lu and Mizon (1990)).

As mentioned earlier, it is particularly useful to see whether one model, say M_1, can encompass a rival model, say M_2, with respect to the (complete) parameter vector of M_2. This is known as complete parametric encompassing (CPE). The importance of complete parametric encompassing is that if M_1 provides complete parametric encompassing of M_2, this is sufficient (but not necessary) to show M_1 encompasses M_2 with respect to *any* statistic relevant to the analysis of M_2 (for the proof of this see Mizon and Richard (1986)).

The encompassing principle is defined at a high degree of generality where contending models may differ by their functional forms (e.g. linear vs log-linear, see Hendry and Richard (1989), pp403-406) and their choices of conditioning variables. Of particular note is that encompassing can be used both when the parameters of the models are nested and when they are non-nested. These scenarios are discussed separately in the following two sections. The two scenarios are linked in that if two models M_1 and M_2 are non-nested then M_1 encompasses M_2 if and only if M_1 encompasses the minimum completing model M_c. In other words for a model to encompass a non-nested model is equivalent to it encompassing the model within which both models are nested.

3.2.1. Parsimonious Encompassing

It can be seen from the above that encompassing tests can be used in the comparison of both nested models (i.e. where the parameters of one model form a subset of those of its rival model) and non-nested models. If M_1 is nested within M_2 then M_2 will automatically (completely parametrically) encompass M_1. However, if M_1 can also (completely parametrically) encompass M_2 then parsimony (criteria vi)) stipulates that M_1 is the more useful.

3.2.2. Encompassing and Non-nested Models

When two (suitably interpretable) models, say M_1 and M_2, are non-nested, the four possible outcomes to the comparison of these models (assuming one particular basis of comparison is used and a chosen significance level is strictly adhered to) are as follows:

1) Each model is able to encompass the other. In this case neither model has convincingly been shown to be false and so the set of candidates has not been reduced. This will arise if the models are observationally equivalent (i.e. reparameterisations of each other) or if data are too weak (i.e. too sparse or poorly measured) to allow discrimination between the models.

2) M_1 is able to encompass M_2 but M_2 is not able to encompass M_1. In this case there is evidence that M_2 is not a good candidate to represent the DGP but no evidence that M_1 is not a good candidate. Hence M_2 can be viewed as in need of improvement or possibly rejected outright.

3) M_2 is able to encompass M_1 but M_1 is not able to encompass M_2.

In this case M_1 is to be viewed as inadequate.

4) Neither model is able to encompass the other. In this case neither model can be viewed as a good candidate to represent the DGP. It could remain to find a model which forms a good candidacy to represent this process. The joint model M_c will automatically encompass both M_1 and M_2. If M_c is congruent with the available information then this (at least temporarily) can be regarded as a good candidate. Otherwise, interpretable models combining features of M_1 and M_2 should be investigated as possible good candidates.

Prior to the formalisation of encompassing, a number of tests had been formulated for non-nested models including the Cox generalized likelihood test, the Davidson and Mackinnon J-test, the Pesaran N^2 test and the JA-test of Fisher and Mcleer (see Mackinnon (1983) for a review of tests of non-nested models). Mizon (1984) showed how the formulation of WET statistics can be viewed as a test-generating procedure, and Mizon and Richard (1986) showed that each of the tests listed above is equivalent to a WET for M_1 encompasses M_2 with respect to $\hat{\tau}^2$. Moreover, tests of complete parametric encompassing should have high power against alternative bases of comparison. Thus the class of Wald Encompassing Test statistics has been able to unify empirical criteria used in the comparison of nested models and (various) empirical criteria used in the comparison of non-nested models.

3.3 Implications of the Encompassing Methodology

3.3.1 Emphasis of Model Comparison over Model Selection

Model comparison is the evaluation of alternative explanations of empirical phenomena. Put more simply, model comparison is an overview of what alternative models can (and cannot) do well (e.g. according to criteria i) to vii) listed above). This is to be distinguished from model selection in that model comparison need not involve choosing a single preferred model on the basis of a single chosen criteria (e.g. Amemiya (1980) for a review of criteria proposed for purposes of model selection), although in practise the two are sometimes related. The outcome of model selection (i.e. the single preferred model) may often reflect such things as the accuracy of measures used for variables, the functional forms selected, whether dummy variables have been used to represent special events and so on. The danger associated with model selection is that it may lead researchers to ignore that evidence is not sufficiently informative to allow clear discrimination between the selected model and a rival model and so leads to undue attention being placed on reformulating inessential details of models such as measures, functional forms etc. and to insufficient attention being placed on such issues as whether models are essentially equivalent (mutually encompassing) or whether models are essentially separate (mutually non-encompassing) and in need of unification (by a model which can encompass both).

In linear regression for model M_1 to encompass a rival model M_2

with M_2 not encompassing M_1 implies that R^2 for M_1 is more than that for M_2. The converse, however, does not automatically follow.

3.3.2 Preference for a General to Simple Approach over Simple to General

According to the encompassing methodology the researcher should aim towards developing a Tentatively Adequate Conditional Data Characterisation (TACD). A model is a TACD if (see Hendry and Richard (1982, p21):

i) it encompasses all rivals,

ii) it is data coherent,

iii) it is data admissible,

iv) its parameters of interest are constant,

v) its current conditioning variables are weakly exogenous for the parameters of interest.

Precisely how a researcher develops a TACD depends among other things on his/her knowledge, imagination and luck and so cannot be prescribed. The point made here is that for a model to be a TACD is a more stringent criteria than for it merely to confirm (via "significant" coefficients) the theories from which it was developed in the sense that a model which is a TACD should be able to account for findings made by other comparable models as well. That a model within which all existing models are nested automatically encompasses these models provides good reason for a general to simple approach to be preferred over a simple to general one.

A further important consideration is that encompassing is non-transitive (Hendry (1989)). Thus a simple to general approach involving just adding variables is an invalid strategy for arriving at a TACD.

3.4 Evaluating the Encompassing Methodology

In this section I evaluate the Hendry methodology against a "straw man" alternative which involves researchers fitting models to some available data but in which encompassing tests are not carried out (c.f. Gilbert (1986)). This alternative has to some extent been invented as detailed methodological prescriptions for empirically based research in the social sciences are not readily available, but in my view constitutes a reasonable representation of existing social science research practise.

To illustrate my arguments I will caricature how a new demographic "theory" would be evaluated under "traditional" (i.e. pre (non)-encompassing) and encompassing methodologies.

In the following discussion it is assumed that theories (e.g. of the determination of fertility) are empirically evaluable in the sense of being falsifiable (as described by e.g. Popper (1963, ch. 1)). It is also assumed that theories can be evaluated empirically by constructing statistical models to test consistency between theory and some observed data. Suppose the new theory[1] (whose proprietor is called Mason) is:

H_{Mason}: Women's Status explains differences in current fertility between countries.

Suppose the single existing theory[1] (whose proprietor is called

Caldwell) is:

$H_{Caldwell}$: The presence or absence of near universal female education at primary level explains differences in current fertility between countries.

Then a caricature of the "traditional" paradigm is that Mason confirms her theory by testing whether or not the coefficient of the variable chosen to represent women's status is significant.

In the encompassing methodology Mason (or some other researcher) should, in addition to checking other criteria for congruence with the available information, employ an encompassing test to compare her model of fertility differentials against Caldwell's. The four possible outcomes of this are:

1) Each of the models developed by Caldwell and Mason encompasses the other. Thus Mason's "finding" is equivalent to Caldwell's (albeit that the wording of and formulation of the theories may appear different - such things can amount to camouflage).

2) Mason's model encompasses Caldwell's but not vice versa. In this case Mason's theory is superior as, within the framework of her model, Mason can account for Caldwell's findings and provide explanations of differentials which Caldwell's model cannot account for. This situation (or, formally, that a latter model is a TACD) should be the goal of a latter researcher.

3) Caldwell's model encompasses Mason's but not vice versa. Here Mason's theory is deficient as its findings can already be accounted for by existing theory but Mason's theory cannot account for some existing "known" results (i.e. Mason's theory is degenerate).

4) Neither model encompasses the other. Thus the two theories are to a significant extent separate. In this situation the formulation of a more comprehensive theory of differentials in current fertility in such a way that both Caldwell's and Mason's findings are encompassed by the new theory is required.

Thus encompassing allows an overview of theoretical contributions to be developed. Moreover, encompassing encourages the development of a (more) comprehensive theory rather than of piecemeal or essentially duplicative theoretical contributions. It should also be clear that choosing one or other theory by a selection criteria (e.g. adjusted R^2) is irrelevant in the context of theory development (assessing the "overlap" of theories via encompassing is far more important).

A second feature of the "traditional" approach is that neither corroboration nor rejection of a hypothesis of whether a particular variable affects the dependent variable (in Mason's case that women's status affects current fertility or, strictly speaking, whether or not the hypothesis of no effect can be rejected) is definitive. For example, it may be that in one model the null hypothesis of no effect (e.g. of women's status) is rejected whilst in another model the same hypothesis is not rejected or (worse!) that one model apparently corroborates a positive effect whilst another corroborates a negative effect. This aspect of statistical modelling has undoubtedly contributed to the perceptions that "one can prove anything with statistics" and that "for any economist ready to argue one theory one can find an economist who will argue conversely". Whilst encompassing does not actually infer that corroboration or rejection is definitive indeed Hendry believes that virtually all statistical models are misspecified (e.g. Hendry and Richard (1989, p399)), if different models support conflicting hypotheses then encompassing tests (which entail testing whether models are, tentatively, to be regarded as "true") can be used to decide whether the "proof" provided by any or both of the frameworks/models used as a test of the hypothesis can be rejected in the light of another model.

In practise the distinction between the "traditional" methodological approach and the encompassing approach may be less clear cut than in the situation outlined above. This would be the case if latter theorists implicitly recognised the need to account for earlier theories in the framework of their models. Nonetheless, the encompassing principle is valuable as an explicit representation of this research principle, and encompassing tests allow latter researchers to evaluate whether or not they have incorporated the salient features of earlier research into their models.

3.5 Examples of the Application of Encompassing

In Section 3.5.1, I present both the theory and a trivial example of how encompassing claims can be tested in order to compare OLS regression models. In Section 3.5.2 I discuss criteria for the comparison of multilevel models, this discussion includes the proposal of a statistic which could be used to compare models with non-nested sets of regressors and illustation of this test using a simple example.

3.5.1. Comparisons of OLS Regression Models

Consider the case of the two regression models:

M_1: $Y = X_1\beta + u_1 \quad u_1 \sim N(0, \sigma^2 I_n)$

M_2: $Y = X_2\gamma + u_2 \quad u_2 \sim N(0, \tau^2 I_n)$.

where n is the number of observations.

A basis of comparison would be the vector of fixed parameters of M_2, $p = \hat{\gamma}$. This is consistently estimated by:

$$\hat{\gamma} = (X_2^T X_2)^{-1} X_2^T Y$$

Under the assumption that M_1 is the D.G.P. p takes the form:

$$\gamma_\alpha = (X_2^T X_2)^{-1} X_2^T X_1\beta$$

so

$$\gamma_{\hat{\alpha}} = \hat{\alpha} = (X_2^T X_2)^{-1} X_2^T X_1 \hat{\beta} = (X_2^T X_2)^{-1} X_2^T X_1 (X_1^T X_1)^{-1} X_1^T Y$$

hence

$$\hat{\Phi} = (X_2^T X_2)^{-1} X_2^T (I - X_1 (X_1^T X_1)^{-1} X_1^T) Y = (X_2^T X_2)^{-1} X_2^T M_{X_1} Y$$

where $M_{X_1} = I - X_1 (X_1^T X_1)^{-1} X_1^T$.

Furthermore,

$$\hat{V}(\Phi) = n\,\hat{\sigma}^2 (X_2^T X_2)^{-1} X_2^T M_{X_1} X_2 (X_2^T X_2)^{-1}$$

(using $\hat{V}(\Phi) = V_\alpha(\hat{\gamma}) - D\,V(\hat{\alpha})\,D^T$:where $D = \text{plim}_\alpha(d\gamma_\alpha/d\alpha^T)$ - e.g. Mizon (1984)),

and the hypothesis:

H_0: M_1 encompasses M_2 with respect to $\hat{\gamma}$

can be tested by the WET

$$\eta_W(\hat{\gamma}) = Y^T M_{X_1} X_2 (X_2^T M_{X_1} X_2)^{-1} X_2^T M_{X_1} Y\, \hat{\sigma}^{-2} \xrightarrow[M_1]{d} \chi^2(1).$$

Moreover, the WET is related to the F-test statistic, say F_c(1, n - l - k), associated with the hypothesis that $\gamma^{*} = 0$ in the so-called joint model:

$$M_c: \quad Y = X_1\beta^{*} + \bar{X}_2\gamma^{*} + u_c \qquad u_c \sim N(\, 0,\, \omega^2 I_n \,)$$

where $\bar{X}_2$ denotes the vector of those parameters in X_2 which are not in X_1,

by the identity:

$$F_c = (\, n - k - 1 \,)\, \eta_w (\, \delta \,)\, (\, nl - l\eta_W(\, \delta \,)\,)^{-1}$$

(e.g. Mizon (1984), Hendry and Richard (1989)).

From this we can see that M_1 encompasses M_2 if and only if M_1 (parsimoniously) encompasses the joint model M_c.

Another possible basis for comparison is $\hat{\tau}^2$. Mizon (1984) shows that:

$$\eta_w(\hat{\tau}^2) = [(n-1)(\hat{\tau}^2-\hat{\sigma}^2)-\hat{\beta}^T X_1 M_{X_1} X_1\hat{\beta}]^2(4\hat{\sigma}^2\hat{\beta}^T M_{X_2} M_{X_1} M_{X_2} X_1\hat{\beta})^{-1} \xrightarrow[M_1]{d} \chi^2(1)$$

This test is asyptotically equivalent to a vast range of one degree of freedom test statistics for comparing M_1 versus M_2 when M_1 and M_2 are non-nested (Mizon and Richard (1986)).

A third basis of comparison is the complete parameter vector $\hat{\delta} = (\, \hat{\gamma},\, \hat{\tau}^2 \,)$. Mizon and Richard (1986) show that the CPE test has the form:

$$\eta_w(\, \hat{\delta} \,) = Y^T M_{X_1}\bar{X}_2(\bar{X}_2^T M_{X_1}\bar{X}_2)^{-1}\bar{X}_2 M_{X_1} Y\sigma^{-2} \xrightarrow[M_1]{d} \chi^2(1)$$

This test is asymptotically equivalent to the WET $\eta_w(\, \hat{\gamma} \,)$ (Mizon and Richard (1986)).

Illustration

In this section I present a simple example to illustrate the use of encompassing tests in the case of OLS regression. The models to be compared are of children ever born to 49 year old women surveyed in the GDHS:

M_1: CEB = β_0 + β_1PRIMARY + β_2SECONDARY+ u_0 $\quad u_0 \sim N(0,\sigma^2)$

M_2: CEB = γ_0 + γ_1CHRISTIAN + γ_2MUSLIM + u_1 $\quad u_1 \sim N(0,\tau^2)$

Results of various tests are provided by PC-GIVE (see Hendry (1986)) in the following form:

Table 3.5.1: Output From PC-GIVE for Encompassing Tests

Model 1 v Model 2	Form	Test	Form	Model 2 v Model 1
-4.889	N(0,1)	Cox	N(0,1)	-9.640
4.707	N(0,1)	Ericsson IV	N(0,1)	9.201
1.001	$Chi^2(2)$	Sargan	$Chi^2(2)$	1.693
0.491	F(2,50)	Joint Model	F(2,50)	0.841
[0.6150]		Probability		[0.4372]

Here, for the F-test,the hypothesis $M_1 \varepsilon M_2$ is not rejected at the 5% level and, for the F-test, the hypothesis $M_2 \varepsilon M_1$ is not rejected at the 5% level. Thus, M_1 and M_2 are observationally equivalent.

3.5.2. Comparison of Multilevel Models

The application of encompassing to the choice of regressors problem has received considerable attention. However, in practice, survey data will often exhibit a positive intra-cluster correlation and/or coefficients in a model may vary across clusters (see Section 2.1). I would argue that the question of whether the residuals to a model exhibit a positive intra-cluster correlation and of whether coefficients to a model vary across clusters could be evaluated by the criteria of data coherency. That is, a satisfactory model is one for which the residuals exhibit no intra-cluster correlation and for which coefficients to not vary across clusters. Thus the presence of intra-cluster correlation in residuals should be taken as evidence of omitted regressors (either regressors measured at level 2 or regressors measured at level 1 which exhibit a positive intra-cluster correlation) and likewise the presence of a coefficient which varies across clusters should be taken as evidence of omitted interaction effects involving that particular regressor (c.f. Gilbert's (1986, p292) comment regarding serial correlation). In practise, however, finding a (suitably interpretable) set of regressors which can eliminate intra-cluster correlation and variation of coefficients at the cluster level may not be tenable given data availability. If this is so then a "tentatively adequate" model may be one which:

i) is data admissible,

ii) has conditioning variables which are all at least weakly exogenous,

iii) encompasses all rival models,

iv) adequately characterises variation in coefficients across clusters.

To date encompassing has been formalised for comparing models with fixed effects only. This section contains suggestions for as to how encompassing claims can be evaluated when both models to be compared are multilevel models (which contain random effects).

Before proceeding I will briefly mention the possibility of removing the "problem" of intra-cluster correlation by fitting a fixed effect for each cluster. The issue of whether fixed effects or random effects should be used (e.g. for intercepts varying across groups) have been discussed extensively elsewhere (e.g. Hsiao (1986, ch. 3), Anderson and Aitken (1985)). As stated in Chapter 2, my view is that a random effect is preferable to such a set of dummy variables (i.e. fixed effects) on the grounds that the random effect offers inference to a wider population, provided such a population exists.

Suppose we have two linear multilevel models:

M_1: $Y = X_1\beta + X_1^{\#}U_{1i} + u_{1ij}$

M_2: $Y = X_2\gamma + X_2^{\#}U_{2i} + u_{2ij}$

where $X_1^{\#}$, $X_2^{\#}$ denote the subvectors of X_1 and X_2 respectively containing those variables whose coefficients are random at level 2.

M_1 and M_2 are implicitly nested within the joint model:

M_c: $Y = X_1\beta^* + \bar{X}_2\gamma^* + X_1^{\#}U_{1i}^* + \bar{X}_2^{\#}U_{2i}^*$

where $\bar{X}_2$ is the set of variables in X_2 but not in X_1 and $\bar{X}_2^{\#}$ is the set of variables in $X_2^{\#}$ but not in $X_1^{\#}$.

It is to be expected that $M_1 \varepsilon M_2$ iff $M_1 \varepsilon M_c$. However, the controversy surrounding concerning testing parameters on the boundary of the parameter space (see Section 2.3.2.1.3) would also be manifest in the development of an encompassing test for models with nonnested random parameters. Hence,I aim at the more conservative goal of developing encompassing tests for the special case of models whose random parameter vectors are identical.

A basis of comparison is the vector of fixed parameters of M_2, p = $\hat{\gamma}$. This is consistently estimated by the GLS estimator:

$\hat{\gamma} = (X_2^T\hat{V}_2^{-1}X_2)^{-1}X_2^T\hat{V}_2^{-1}Y$

The estimates of γ and V_2 can be obtained by, for example, Iterative Generalized Least Squares (Goldstein (1986), (1987), Pfeffermann and LaVange (1989)).

Under the assumption that M_1 is the DGP, this takes the form:

$$\gamma_\alpha = (X_2^T V_2^{*-1} X_2)^{-1} X_2^T V_2^{*-1} X_1 \beta$$

where $(Y - \gamma_\alpha X_2) \sim N(0, V_2^*)$.

and this is estimated by:

$$\gamma_{\alpha = \hat{\alpha}} = (X_2^T \hat{V}_2^{*-1} X_2)^{-1} X_2^T \hat{V}_2^{*-1} X_1 \hat{\beta}$$

$$= (X_2^T \hat{V}_2^{*-1} X_2)^{-1} X_2^T \hat{V}_2^{*-1} X_1 (X_1^T \hat{V}_1^{-1} X_1)^{-1} X_1^T V_1^{-1} Y$$

($\gamma_{\alpha = \hat{\alpha}}$ and $\hat{V}_2^*$ can be estimated by IGLS)

Thus the following estimate of Φ can be obtained:

$$\hat{\Phi} = ((X_2^T \hat{V}_2^{-1} X_2)^{-1} X_2 \hat{V}_2^{-1} - (X_2^T \hat{V}_2^{*-1} X_2)^{-1} X_2^T \hat{V}_2^{*-1} X_1 (X_1^T \hat{V}_1^{-1} X_1)^{-1} X_1^T \hat{V}_1^{-1}) Y$$

Using $V(\Phi) = V_\alpha(\hat{\gamma}) - V_\alpha(\gamma_{\alpha = \hat{\alpha}}) = V_\alpha(\hat{\gamma}) - D\, V(\hat{\alpha})\, D'$

$$V_\alpha(\hat{\gamma}) = (X_2^T V_2^{*-1} X_2)^{-1}$$

$$D = (X_2^T V^*{}_2^{-1} X_2)^{-1} X_2^T V_2^{*-1} X_1$$

$$V(\hat{\alpha}) = (X_1^T V_1^{-1} X_1)^{-1}$$

So $$\hat{V}(\Phi) = (X_2^T \hat{V}_2^{-1} X_2)^{-1} - (X_2^T \hat{V}^*{}_2^{-1} X_2)^{-1} X_2^T \hat{V}_2^{*-1} X_1 (X_1^T \hat{V}_1^{-1} X_1)^{-1} X_1^T \hat{V}_2^{*-1} X_2 (X_2^T \hat{V}_2^{*-1} X_2)^{-1}$$

Hence a WET can be calculated (using e.g. MINITAB, GAUSS). It is straightforward to check that in the special case of V_1 and V_2 being diagonal (i.e. M_1 and M_2 are regression models) this WET is that for the vector of fixed parameters in the case of OLS regression. It should be noted that in the special case of multilevel models with nested fixed parameters, the encompassing test by virtue of requiring iteration requires more computing time than the "conventional" chi-squared test (see Section 2.3.2.1.3).

Illustration

In this section, I present a simple example to illustrate the encompassing test proposed above. This example only differs from that used in Section 3.5.1 in the respect that the two models contain a term for residual variance at the cluster level. That is the models are:

M_1: $CEB = \beta_0 + \beta_1 PRIMARY + \beta_2 SECONDARY + u_{1i} + u_{1ij}$

M_2 $CEB = \gamma_0 + \gamma_1 CHRISTIAN + \gamma_2 MUSLIM + u_{2i} + u_{2ij}$

where $u_{ki} \sim N(0, \sigma_{ki}^2)$ and $u_{kij} \sim N(0, \sigma_{kij}^2)$ $k = 1,2$.

The results produced by the test described above and those for the test of each model as a reduction of the joint model obtained using the FTES command in ML3 are presented in the Table 3.5.2:

Table 3.5.2: Test Statistics For Encompassing Tests of the Multilevel Models (M_1 and M_2)

Model 1 v Model 2	Form	Test	Form	Model 2 v Model 1
0.08	$Chi^2(2)$	Parr	$Chi^2(2)$	2.50
0.04	$Chi^2(2)$	ML3	$Chi^2(2)$	2.08

Hence under both the above tests $M_1 \varepsilon M_2$ is not rejected at the 5% level and under both tests $M_2 \varepsilon M_1$ is not rejected at the 5% level. Thus M_1 and M_2 are observationally equivalent.

3.6 Model Selection For Multilevel Models: A Postscript

As mentioned in the introduction to this chapter, one of the original motivations for investigating literature on encompassing was that light may be thrown on the issue of model selection for multilevel models. In this section I briefly set out my position regarding this question.

Firstly, what is important is to evaluate whether a model encompasses its rivals. This ensures that research is progressive. To this end model selection in the sense of selecting a single best model by a selection criteria is irrelevant and hence developing criteria for selection is of no importance.

Secondly, random parameters are generally less useful (interpretable) than fixed parameters and researchers should concentrate primarily on improving the fixed part of their model. Random coefficients can be used as a guide as to which sorts of omitted fixed effects could improve the model.

Thirdly, a general to simple stategy for model evaluation is preferable to simple to general.

Consequently, my position is that one should aim at developing a "tentatively adequate" multilevel model (ideally a tentatively adequate" single level model). In theory the route employed should be a general to simple route involving, firstly, fitting all the fixed and random effects that one believes plausible then removing nonsignificant random effects and then removing nonsignificant fixed effects. In practise the amount of computing time and/or space required to fit very general multilevel models (at least at present) may prove prohibitive. The main reason for this situation occurring is likely to be the large number of covariance terms that will feature in the random part of such a model. For this reason Longford (1988) advocates eliminating nonsignificant fixed effects first and then testing for significant random effects as a practical (selection) strategy.

How one judiciously chooses a restricted set of random coefficients whose parameters will give a relatively good approximation to the parameters of the full set of random coefficients when computation of the full set of random coefficents is impractical is not something I can prescribe, and theory information, in general, offers little help for making decisions. In some cases, I would suggest computing the full model on a subset of the data and noting the "most significant" parameters as a possible approach (n.b. this option is not feasible for VARCL (Longford (1988)) due to restrictions on the number of parameters which can be computed in this package).

3.7 Application_of_Encompassing_in_This_Research

In Section 3.3.2 I argued that researchers should aim at developing a TACD for the data available to them. Thus a model developed should encompass all rival models. In the case of this research, extensive trawls of literature on fertility in both Ghana and Liberia failed to uncover a model which strictly is comparable to my own and hence would need to be shown to be encompassed.

It should be also noted that the extension of encompassing to (fixed effects) nonlinear models is still to be developed (Hendry (1989, p437)), let alone its extension to nonlinear random effects models. Since, the models fitted elsewhere in this thesis are nonlinear random effects models, there are technical problems which would need to be overcome before encompassing claims could be tested even if this were necessary.

[1]This is a fiction used as part of an illustration of the encompassing principle. Any similarity with any of the work of any researcher should be ignored.

4. A CASE FOR A MULTILEVEL APPROACH TO ANALYSING FERTILITY

4.0 Introduction

In Chapter 1 a framework for the analysis of fertility was summarised as follows:

Social, cultural and environmental factors.	——>	Intermediate fertility variables	——>	Fertility

Whilst exhaustive sets of intermediate fertility variables have been formulated (e.g. Davis and Blake (1956), Bongaarts (1981)), a comprehensive theory of the determination of fertility based on indirect variables has yet to be successfully constructed. In the construction of such a theory there are numerous variables which potentially have a role to play. In particular, it is to be noted that such variables (including measures of fertility themselves) could in theory at least be measured at the level of the individual woman (the micro level) and/or at various levels of aggregate behaviour (macro levels) (e.g. Hermalin (1983)). Examples of such macro levels include the household, the community, the region and the nation.

This chapter argues that both theoretical models and empirical models of fertility determination should relate to both macro-level and micro-level behaviours; that existing major theories on fertility determination, most notably that of Caldwell (1982), already implicitly recognize both macro-level and micro-level factors, and consequently, that statistical analyses should be able to relate fertility patterns to both macro-level and micro-level characteristics.

4.1 Macro-level Influences Individual-level Fertility

Much research on fertility involves the analysis of fertility determination at the individual level. The need to maintain a macro-level/areal-level perspective on the outcome of such analyses lies in the the very nature of demography, in which the concept of population as an aggregate of individuals is central (e.g. Hermalin (1975)). However, the need to maintain a macro-level perspective on fertility determination at the individual level arises from the way in which (in the words of Ryder (1983)):

"the institutional setting . . . always and everywhere conditions individual decisions and behaviour" (p15).

A purely micro-level investigation of fertility would ignore processes of conditioning. A consequence of macro-level factors influencing the determination of fertility at the individual level is that inference from purely individual-level analyses back to the macro/population-level can be fallacious.

A macro-level dimension which affects fertility behaviour at the individual level is implicit in Caldwell's theory on fertility, specifically, the social climate in which decisions relating to fertility are made (see Caldwell (1976 and 1982), and Caldwell and Caldwell (1985) for a discussion specifically of the role of institutional pressures on fertility). According to the Caldwells (1985, p124):

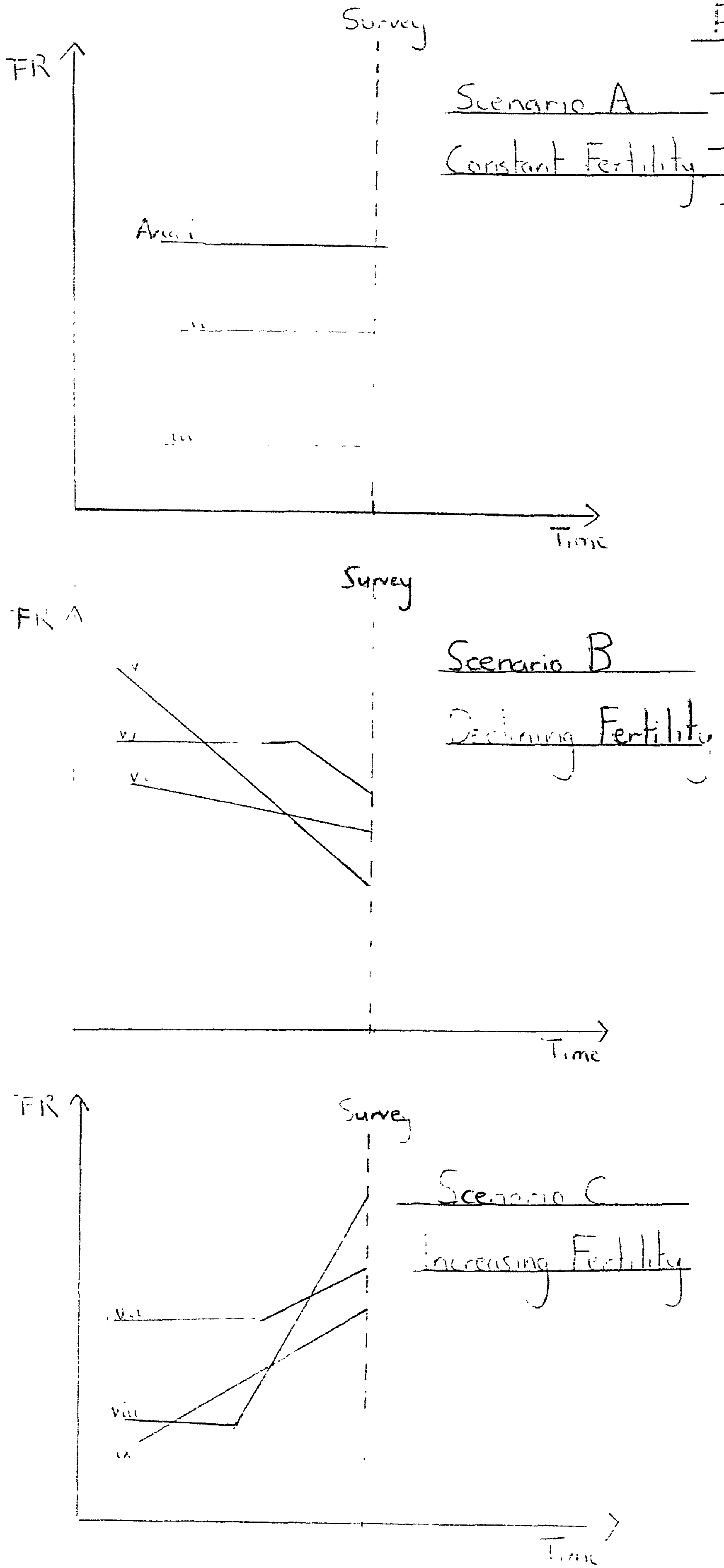
"institutional pressures exist at three levels: the individual, the family, and the community".

Examples of plausible macro-level effects on fertility involving the conditioning of individuals by those around them are "spillover" effects from individual education (Cochrane (1979, p30)). Cochrane argues that the education of one person can improve the (contraceptive) information available to his/her friends, that the education of one person can have an impact on the economic opportunities of others, and that educated people are able to change the attitudes (and hence behaviours) of those around them. This suggests that individual fertility might be related to levels of education which pervade in the community. A macro-level "spillover" effect of education (which serves as a medium for "western" values) on fertility is also implicit in Caldwell's theory of fertility (see Caldwell (1982, ch. 10)). Caldwell argues that mass education is a factor which precipitates the onset of fertility decline. Moreover, it is implicit in his theory is that education has spillover effects by which mass education induces changes in the normative climate, whereas "when only a fraction of the population has been to school there remain strong forces to maintain family morality as the basic morality" (Caldwell (1982, p329)). It should be noted that this theory is concerned with the onset of fertility decline rather than explanation of fertility differentials.

The relationship between fertility decline and fertility differentials for different macro-level units observed at a point in time is one which needs to be clearly explained. The explanation presented here is illustrated by Figure 3.1. The fertility level at a point in time in any given macro-level unit may reflect: that fertility in that unit has been constant over

Figure 3.1

Hypothetical Relationships Between Current and Past Fertility



time (Scenario A), that a decline in fertility has taken place over recent years (and possibly over a longer period) (Scenario B) or that an increase in fertility has taken place over recent years (and possibly over a longer period) (Scenario C). A sample of macro-level units will contain units from some or all of these three types. Thus different macro-level units can reasonably be viewed as being at different stages of a fertility transition, although, in general, lower fertility is more likely to indicate that a decline in fertility has taken place. A given fertility level, therefore, is not always synonymous with the presence or absence of a fertility decline (e.g. a TFR of around 6.5 in a country could be the level of fertility which has prevailed over recent years (e.g. in Nigeria) or a lower level of fertility than has prevailed in recent years (e.g. in Kenya)). Hence, I would argue, factors which can generally explain fertility decline in those macro-level units in which it has taken place can often contribute to the explanation of fertility differentials between macro-level units. However there are, for example, fertility differentials between macro-level units where it can reasonably be assumed that fertility decline is not underway in any of these macro-level units (Scenario A) (e.g caused by different customary durations of abstinence and/or levels of sterility in different areas of sub-Saharan Africa). This illustrates that not all the factors which can explain fertility differentials between macro-level units can be viewed as contributing to an explanation of fertility decline in such macro-level units generally. The estimates of parameters of a model based on cross-sectional data will often differ from the estimates of the same parameters in a model based on time-series data (e.g. Browning (1985)) and so testing a hypothesis regarding a particular variable's contribution to the explanation of fertility differentials should not be viewed as synonymous with the test of that variable's relevance to the explanation of fertility decline. However, as Mason (1989) somewhat pithily observes, in the absence of true time series data (for most developing countries there is a lack of such data) and of constructive alternative suggestions, the utility of analysing the significance of variables which could infer dynamic changes to (spatially defined) macro-level units over time as explanations of fertility differentials and using these to make inference to change over time is perhaps most pertinently assessed against the alternative of doing nothing.

A corollary to the above argument is that Caldwell's theory suggests a (macro-level) relationship between the incidence of mass education and fertility when some macro-level units can reasonably be viewed as being at a stage prior to the onset of fertility decline and in other macro-level units it can reasonably be assumed that fertility decline is underway. Although the significance of a variable representing the incidence of mass education as an explanation of fertility differentials between such macro-level units should not be viewed as synonymous with the significance of this variable as an explanation of fertility decline, in the absence of practical alternative methods of empirically examining theories of fertility decline it seems reasonable to view it as a guide to the pertinence of a theory of fertility decline.

Casterline (1985b) has also argued that a relationship between community levels of parental education and fertility is plausible and that empirical examination of such a relationship is best examined by a multilevel approach.

Smith (1989) reviews "key" theories of fertility in which macro-level "institutional" aspects are implicit, namely those of Caldwell (1982), Cain *et al.* (1979), and Mason (1984, 1986), and concludes that:

"there is substantial support for the proposition that the key elements impinging on fertility inhere at the systematic, institutional, aggregate level." (p171)

However, this conclusion could be criticized on the ground that the theories to which Smith refers lack empirical verification.

Macro-level variables may be related to intermediate fertility variables either directly or indirectly through their effects on individual-level variables which are directly related to intermediate fertility variables (e.g. Entwisle *et al.* (1989)). An example of a direct macro-level effect is high infant and child mortality (within a society) instilling in prospective parents a need for large numbers of children to insure against the future loss of some children (Hirschman and Guest (1990)). The effect of a macro-level variable may vary according to the characteristics of the individual (cross-level interaction). Likewise, the effect of individual characteristics on individual fertility may vary between macro-level units and macro-level variables may or may not be available to "explain" this variation. An example of an individual-level effect on fertility which differs between macro-level units is the relationship between a woman's education and her fertility. Cochrane (1979) shows that this relationship may be "inverse" in some contexts and "curvilinear" in others.

A number of researchers have sought to understand the roles of specific macro-levels in fertility determination.

4.1.1 <u>The Household</u>

Ryder (1983) stresses the role of the household in the determination of fertility. He argues that family structure (both its age structure and its occupational structure) has important consequences for wealth flows from child to parent and vice-versa and consequently for the economic cost and benefits of children which feature so prominently in Caldwell's theory of fertility. According to Ryder, changes in family structure should be seen in the context of societal-level changes (modernization).

4.1.2 <u>The Community</u>

Using sampling errors from WFS first country reports, Chayovan (1982) established that a substantial amount of variation in reproductive behaviour occurs between rather than within the sampled communities. Casterline (1985a and 1987) and Bilsborrow and Guilkey (1987) have both attempted to analyse ways in which the community setting can influence fertility-related behaviours. Casterline (1985a) argues that the effects of community and institutional settings on fertility can be classified in the following categories:

i) Effects on the economic costs and benefits of children (i.e.

the community or institutional setting determines the economic opportunity structures which in turn provide incentives for high or low fertility).

ii) Effects on internalized values concerning the family, marriage and fertility (i.e. "normative pressures applied through socialization processes and more deliberate means" (Casterline (1985a, p68)).

iii) Social and administrative pressures bearing on the reproductive behaviour of individuals and couples (e.g. the provision of family planning services).

Casterline (1985a) reviews studies aiming to link agricultural development, industrial development, village modernization/prosperity, educational opportunities, health services and sanitation, community isolation and social pressures with fertility levels. However, he found that few of the studies produced strong empirical evidence of community effects. The exceptions largely came from among studies which linked community electrification or community levels of school attendance to fertility. Bilsborrow and Guilkey (1987) review studies which aim to link the community or institutional setting to fertility or fertility-related behaviour through its effects on the availability and cost of contraceptive services, the availability of health facilities, the availability of educational facilities, the existence of transportation, electrification and other economic infrastructure, and/or economic conditions. However, whilst admitting that existing evidence of effects of community-level factors on fertility and fertility-related behaviour is "weak" (p115) they argue that this is a reflection of inadequate conceptualizations of the process whereby community factors influence fertility and of the use of inadequate data. Casterline (1987) produces an extensive set of recommendations on how community-level data can be improved. A criticism which could be levelled against much of the existing empirical examinations of community effects is that the issue of whether effects exist has been represented solely by the extent to which this can be measured by the (fixed) effects of variables measured at the community level. The issue of whether there is residual unexplained variation between communities has not been addressed. This issue is important as the extent of unexplained variation at the community level indicates the extent to which further community level variables can potentially explain variation in fertility-related behaviour.

4.1.3 The Nation

National-level characteristics as factors relating to individual-level fertility patterns have been examined by Mason, Wong and Entwisle (1983), Entwisle and Mason (1985) and Wong and Mason (1991). The justifications provided for the use of national-level characteristics are firstly, "transitionality" (i.e. intersocietal variations are related to how far a society has progressed through the demographic transition); and, secondly, that fertility reduction policies such as family planning programs are implemented at the national level. It is worth noting that the first of these arguments could be applied to any geographically defined macro-level. The relationship between fertility transition and fertility differentials has been discussed earlier.

A sizeable body of research on fertility has been conducted solely at the aggregate level. One reason for this is that change (usually decline) in fertility over time can only reasonably be examined by reference to the change within aggregate-level units, and is usually examined by reference to spatially defined aggregate units (e.g. nations). Much of the following discussion of the need for analyses of fertility behaviour to retain an ability to relate aggregate level relationships back to the individuals of which the aggregates are comprised (micro-level analysis) is drawn from Smith (1989).

4.2 Relating_Macro-level_Analyses_of_Fertility_Back_to_the Individual-level

The case for the need to maintain a micro-level perspective on fertility arises from the ultimate determination of fertility by individuals and couples. In the words of Ryder (1983, p20):

"there is something at least incomplete if not wrong with a model which denies free will"

The existence of choice for individuals and couples is reflected by heterogeneity in fertility levels within all societies.

As mentioned in Chapter 2, inference from studies of aggregate-level behaviour to individual-level behaviour can be fallacious (the so-called "ecological fallacy") and so relationships at the individual level need to be tested as well as testing relationships at the aggregate level (e.g. Hermalin (1986, p98)). More important, than that the conceptualization of fertility theory acknowledges that individual women and couples can and do influence their own fertility, is the clear need to examine differentials in fertility between subgroups within societies. Smith (1989) cites the example of the need to distinguish whether or not a society with an intermediate overall level of fertility consists of a low fertility élite and a high fertility underclass. Similarly, there is a need to recognize that in some African countries the fact that there is little change in fertility at the national level can disguise the fact that fertility in urban areas is declining and fertilty in rural areas is increasing.

A second argument for maintaining a micro-level perspective on fertility is the "elevated importance of the interests of the individual relative to those of the group" (Smith (1989, p175)) in more modern societies. An example of a reason for the declining importance of a particular group structure, the family, (taken from Caldwell (1982, p329)), is that education, "attacks the traditional family's economic structure by weakening the authority of the old over the young (and male over female)". Thus, an important aspect of inter macro-level comparisons is the extent of variation between individuals within macro-level units.

A further reason for relating macro-level analyses of fertility (which as mentioned earlier are often undertaken because change over time can only be sensibly measured at the macro level) to the micro level is the micro-economic/micro-analytic features of current approaches to the indirect determination of fertility (e.g. although Caldwell (1976 and 1982) is concerned largely with fertility decline over time, most of the reasons he gives for the changes he predicts arise from his investigation of the

(micro-level) economic rationality of high versus low fertility). A related reason for maintaining a micro-level perspective on fertility is that the composition of the macro-level units themselves can be a reflection of migration into these units, decisions about which are at least partly made on the basis of individual-level characteristics. For example, fertility levels in shanty areas of large cities reflect in part that the educated élite prefer not to move to these areas. Consequently, explanation of fertility differentials between macro-level units needs to bear in mind micro-level factors which relate to migration/selection into communities.

Another issue, raised by Smith, is the need to be able to investigate and test hypotheses formulated at different levels. In particular, macro-level theories may need to be compared to micro-level alternatives (e.g. the implications of a "curvilinear" micro-level relationship between individual education and fertility (Cochrane (1979)) could throw light on macro-level investigations of the relationship between aggregate-level education and aggregate-level fertility). That micro-level data can be used for constructing macro-level variables (e.g. group means) provides further reason for maintaining a micro-level perspective in analyses of fertility which are conceived primarily at the macro/areal level.

When survey data are used it is also worth noting that some variation between societal level measures will reflect sampling variation. Thus within societal variation may need to be considered when macro-level relationships are considered.

4.3 Conclusions/Implications for Statistical Analyses

In conclusion, investigation of fertility should maintain both macro-level perspectives and a micro-level perspective. Moreover, a theory of fertility determination will be more convincing if it can satisfactorily be empirically demonstrated. As argued in Chapter 2, the method of statistical analysis most suited for relating both macro-level behaviour and micro-level behaviour to (a behaviour such as) fertility is multilevel modelling. This allows both macro-level variables, micro-level variables and interaction terms involving these to be related to (individual-level) fertility. Random coefficients for these variables can be incorporated into such models to model unexplained heterogeneities in the effects of explanatory variables. The multilevel approach allows apparently contradictory conclusions reached from analyses at different levels to be reconciled, and estimation procedures adopted for multilevel models provide unbiased estimates of coefficients and components of the variance-covariance structure in combination with better estimates of the standard errors of fixed coefficients than single-level models. Moreover, I would take issue with Smith's statement that the use of multilevel modelling is "of little value" until protocols for comparative community study are established (Smith (1989, pp180-181)). The importance of estimating the extent of unexplained variation between communities as an indicator of the potential utility for community-level variables of improved estimation of the standard errors of coefficients of fixed effects in multilevel as opposed to single-level models alone implies that multilevel models constitute an important development for the empirical examination of theories of fertility determination.

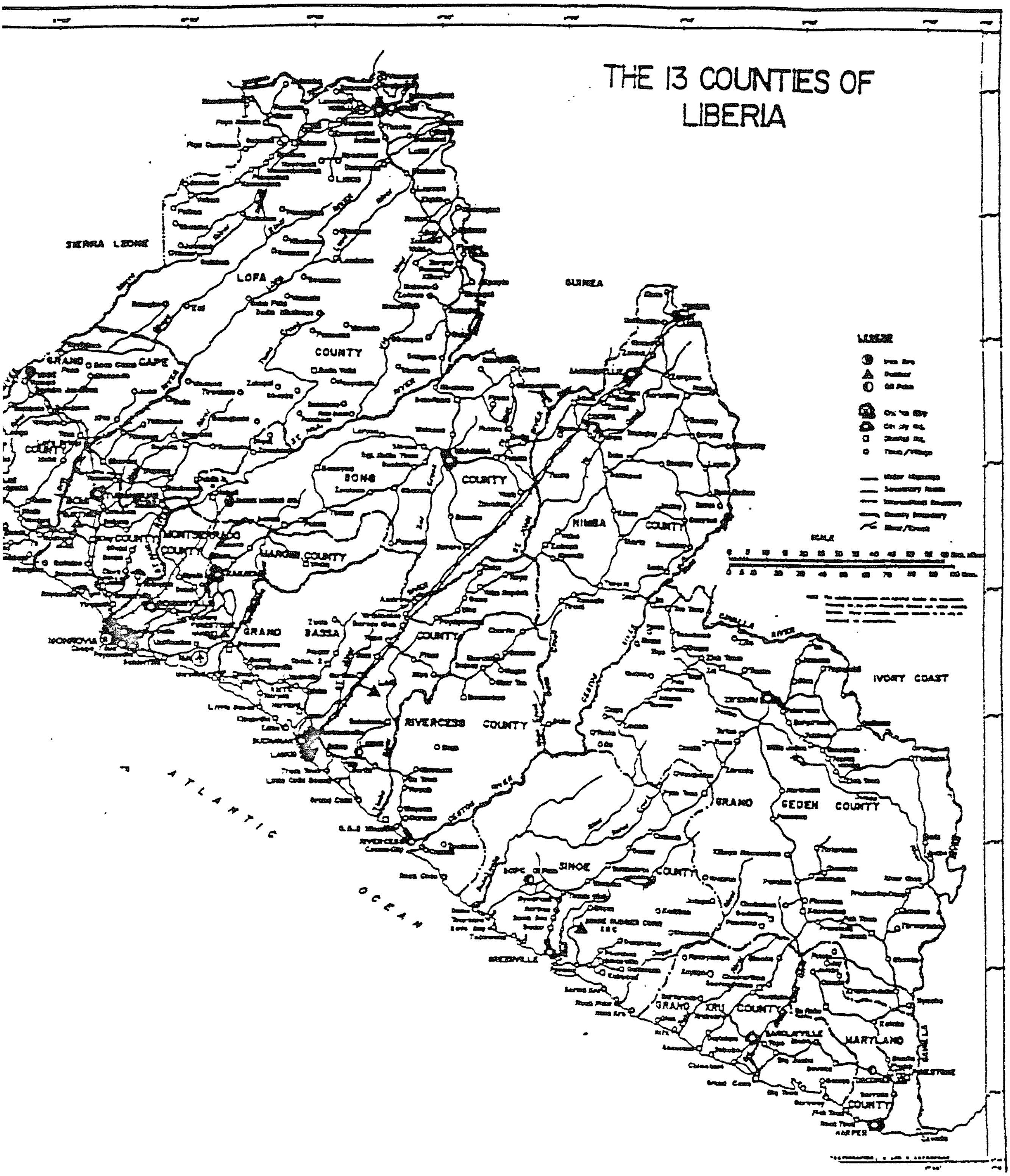
Analyses of the wealth of data collected as part of the Demographic and Health Surveys (DHS) potentially can be used to shed light on the indirect determination of fertility. Macro-levels which could be incorporated into such analyses include the household, the cluster (a proxy for community), the region and the nation. To model the effects of all the possible combinations of levels of measurement that could feature in a theory of fertility determination (or even just all the possible combinations of the above stated levels of measurement) would be an immense task and so a restricted form of analysis is necessary. The numbers of women of reproductive age found living in the same household tend to be small and hence distinguishing between the household and individual levels often could prove of limited value. Furthermore, household data collected by these surveys is not extensive enough to allow investigation of the household-level "inter-generational" effects postulated by Ryder. National-level analyses of the type adopted by Mason *et al.* (1983), Entwisle and Mason (1985) and Wong and Mason (1991) ignore the heterogeneities of fertility within nations (i.e. between regions and/or communities) and the use of nations as a level in a potential theory of fertility has been criticized by Smith (1989) on the grounds that these units are too large to facilitate in depth comparative analysis. In my view this criticism could also be levelled at the use of regions in analyses of fertility. As a result of these considerations, in this thesis I restrict analyses of data to having two-level hierarchies in which the clusters used in the DHS surveys (used as a proxy for communities) form the macro-level and individual women form the micro-level.

5 LIBERIA

5.1 Introduction

Liberia is a republic situated on the west coast of Africa. It is bordered to the west by Sierra Leone, to the east by Ivory Coast and to the north by Guinea (see Map 5.1.1). Liberia is small by African standards with a land area of 99,068 square kilometers (approximately 38,250 square miles). Based on the 1984 census the population is 2.1 million (source: Republic of Liberia Ministry of Planning and Economic Affairs (1987)). The population is growing rapidly with an average annual rate of increase between 1974 and 1984 of 3.4 percent (Republic of Liberia Ministry of Planning and Economic Affairs (1987)). The crude birth rate is estimated to be 45 per thousand and the crude death rate is estimated to be 13 per thousand (source: Population Reference Bureau (1990)). The only large urban area is the capital, Monrovia (see Photos 5.1 and 5.2), with a population (based on the 1984 census) of 421,000 (Republic of Liberia Ministry of Planning and Economic Affairs (1987)). The population of Monrovia has increased dramatically in recent years (the 1984 census figure was more than double the population recorded in the 1974 census). This reflects widespread internal rural-urban migration (e.g. Zachariah and Conde (1981, p62) and Grear (1987)).

Liberia has a hot, humid, tropical climate. The rainy season lasts from April to October and the dry season, when the Harmatton wind blows from the north-east, lasts the rest of the year. Most of Liberia is covered by tropical rain forests (see Photo 5.3), lap 5.1.1 Liberia



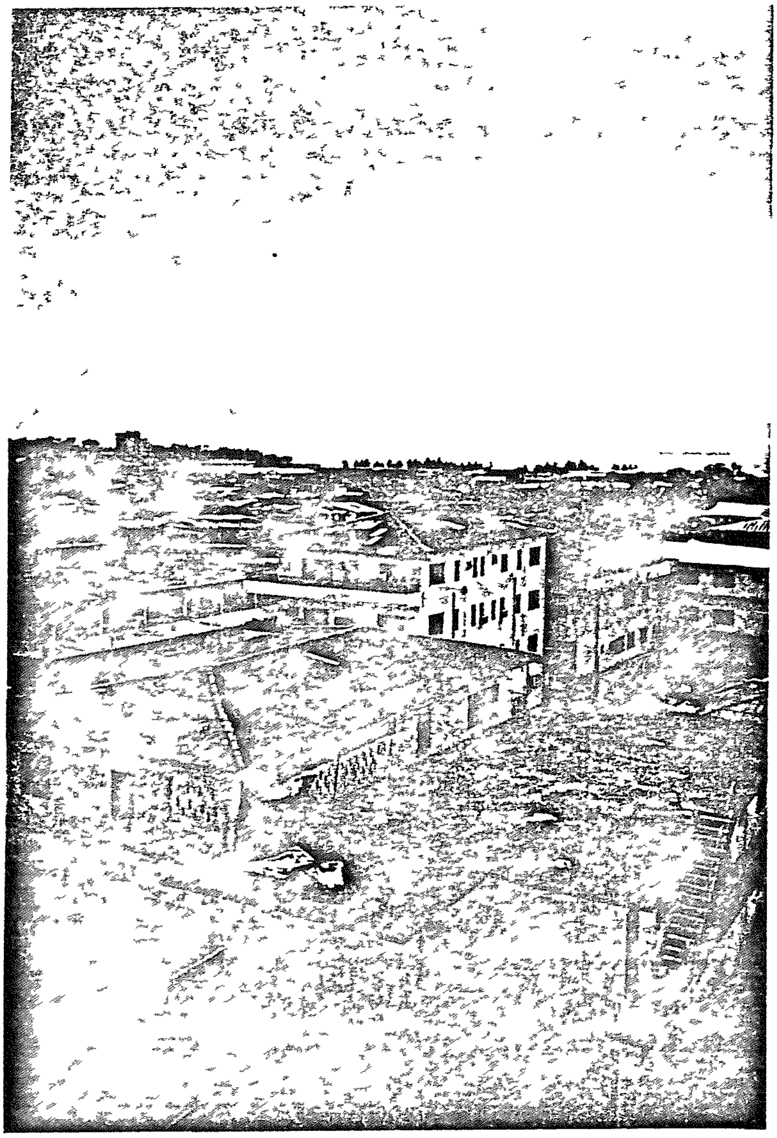


Photo 5.1

Monrovia. The View from the Carlton Hotel

Photo 5.2

Monrovia: A View Across H St Paul River

Photo 5.3: Rainforest Near Robertsport, Cape Mount County

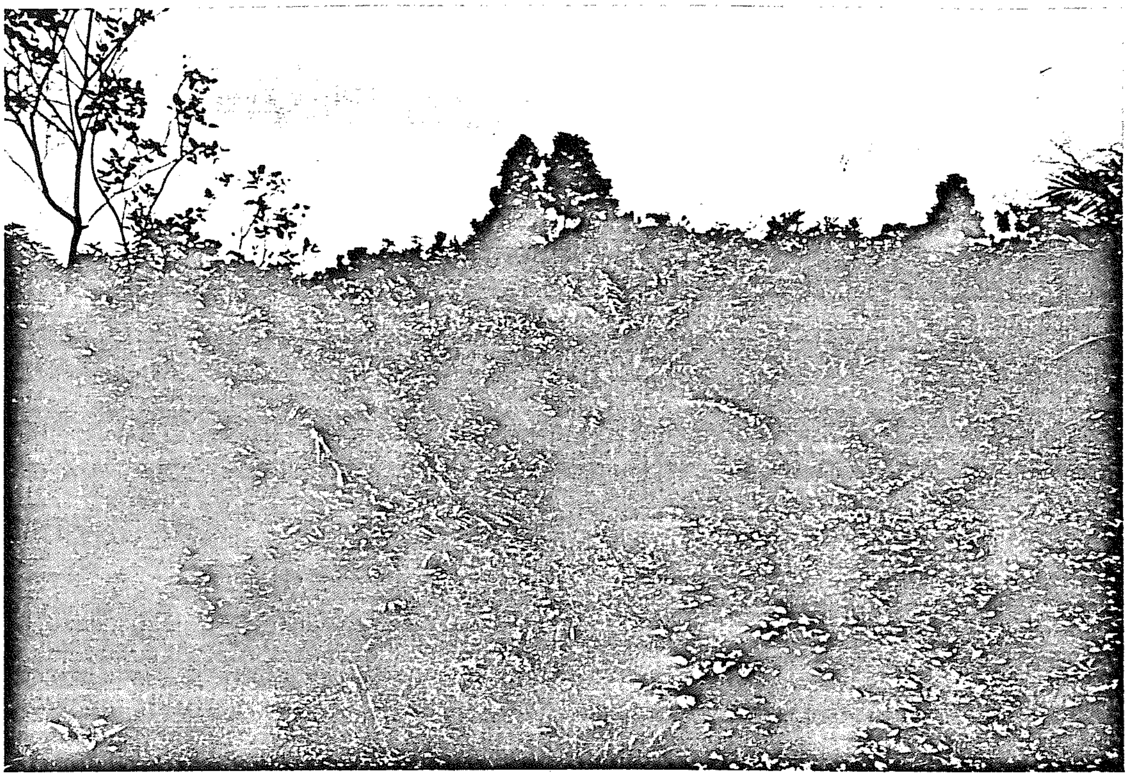
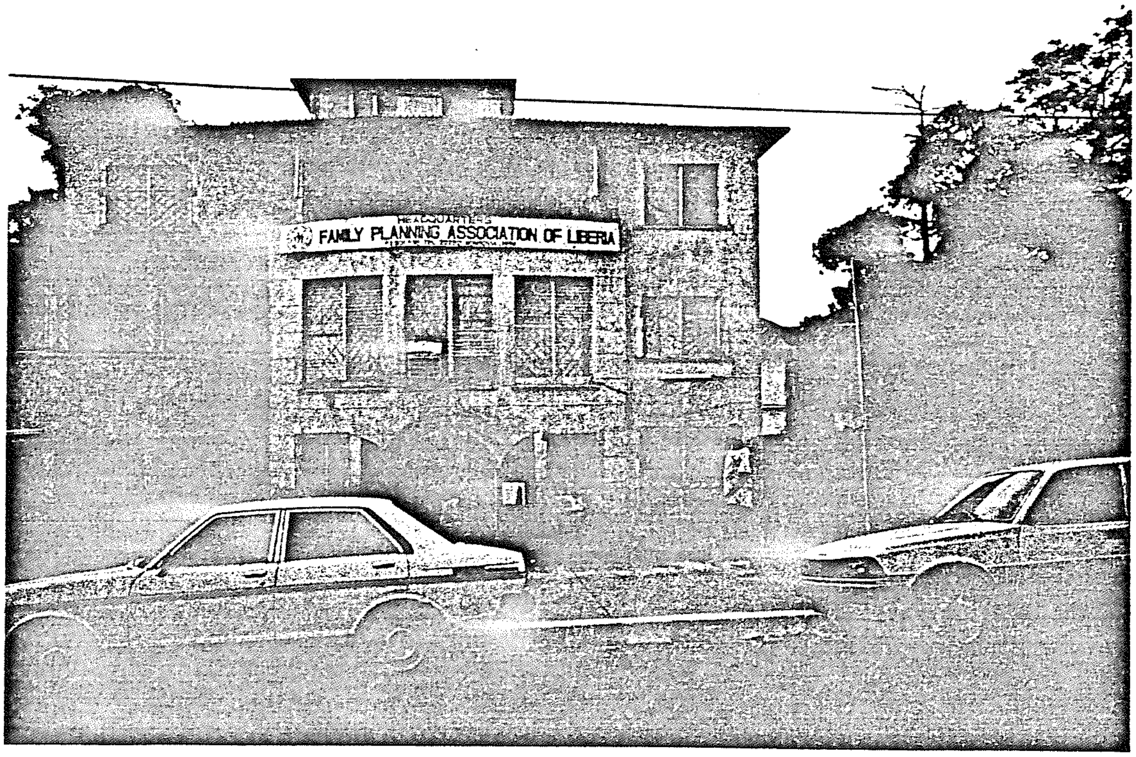


Photo 5.4: FPAL Headquarters, Broad St., Monrovia.



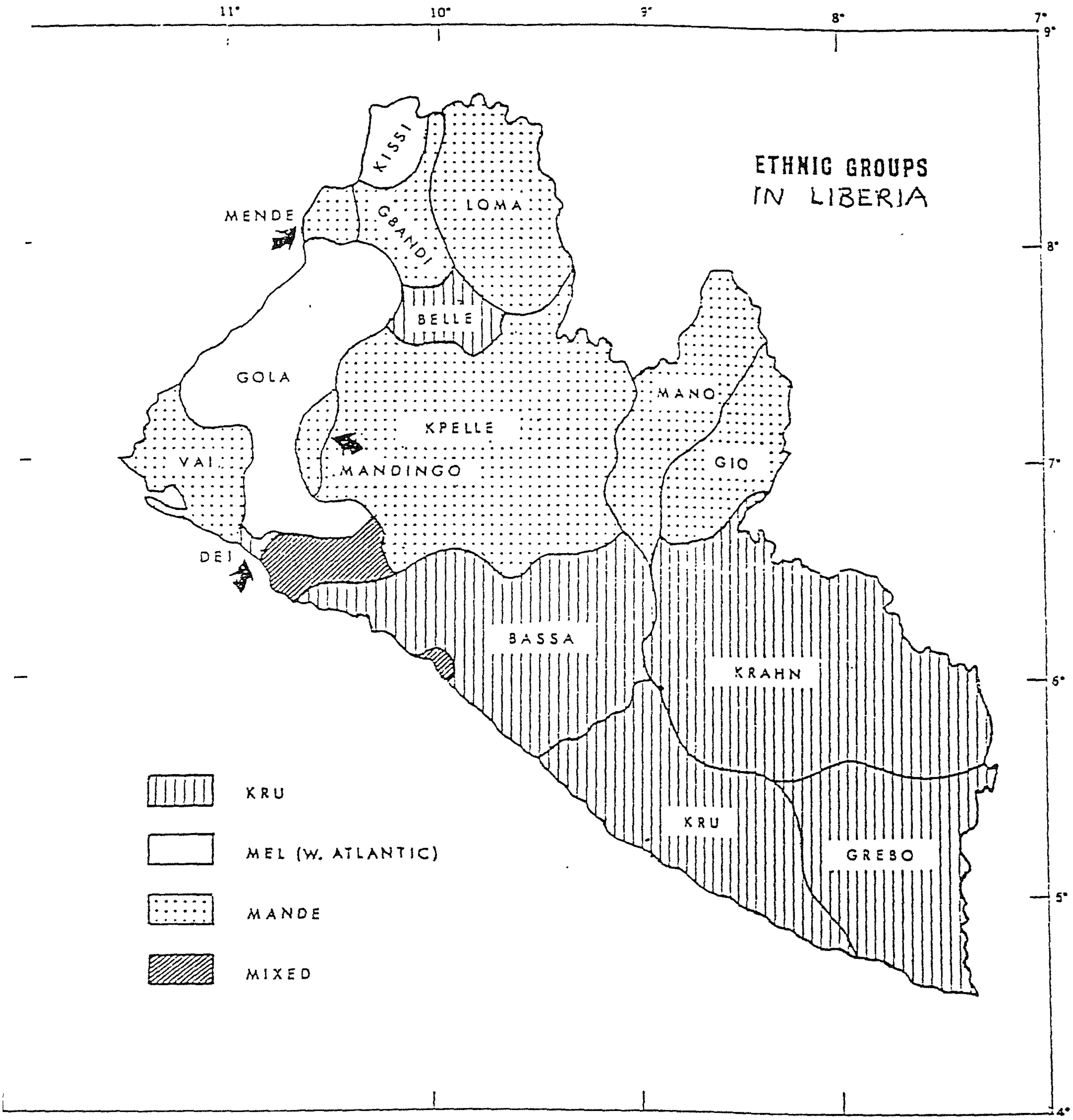
except for savanna woodlands in the north and northwest and the mangrove marshes and lagoons on the coastal belt.

Following the abolition of slavery in the USA, Liberia was settled by some ex-slaves. In 1847 Liberia declared independence and was recognized by Britain, thus forming the first Negro republic. Politically, Liberia has maintained strong links with the USA and used the US dollar as its currency. Until a coup d'état brought Samuel Doe to power in 1980, the governments of Liberia were always formed from the Americo-Liberian section of the population even though the descendants of the ex-slaves form less than 3% of the total population. In 1990 a bloody civil war erupted and Doe was killed. At the time of writing there is an uneasy peace with an interim government supported by peace-keeping troops from ECOWAS controlling Monrovia and two rival rebel armies controlling most of the rest of the country (Momoh (1992)).

Christianity is the predominant religion in Liberia, although followers of Islam and of traditional African beliefs are also numerous. The population is ethnically diverse with sixteen recognized tribal groups as well as the Americo-Liberian/Congo people (descendents of freed slaves) and migrant groups (Map 5.1.2 shows the locations of these tribes). The largest of the tribes are the Kpelle and the Bassa. Linguistically, the indigenous tribes fall into three main groups; the Kwa or Kru group (which consists of the Bassa, Belle, Dey, Grebo, Krahn and Kru/Sapo tribes), the West Atlantic or Mel group (which consists of the Gola and Kissi tribes) and the Mande group (which consists of the Gbandi, Gio, Kpelle, Lorma, Mano, Mende, Mandingo and Vai tribes)(e.g. Schulze (1973)).

Map 5.12: Ethnic Groups in Liberia

Source: Von Gnielinski (1972)



The education system has been modelled on that of the U.S.A., but a large proportion of the population are uneducated with only 34 out of every 100 school age children in Liberia ever having attended school (Gongar (1989)). Illiteracy is widespread: the 1984 census reported that only 31.4% of the population aged 10 and above and only 21.4% of the female population aged 10 and above were literate (Republic of Liberia Ministry of Planning and Economic Affairs (1987)). Health facilities are inadequate (official sources report that 46% of the population remains without ready access to modern health services (Belleh (1989)). Electricity is supplied to only a few areas, and even in these areas power cuts are frequent.

Economically, the most important activity is the iron ore industry. This industry alone accounted for 62.5% of the value of exports in 1983 (source: Republic of Liberia Ministry of Planning and Economic Affairs (1984)). Other important exports are rubber, logs and timber, coffee, cocoa, and diamonds. The majority of the population, however, is engaged in traditional agriculture with rice and cassava grown as the main crops. In recent years the Liberian economy has suffered a severe recession (between 1980 and 1983 the average fall in GDP was 4.4% per year (Republic of Liberia Ministry of Planning and Economic Affairs (1984))). This reflects a fall in the world demand for Liberia's exports and the effects of an unprecedented capital flight after the 1980 coup. A GDP per capita of $450 and an estimated infant mortality rate of 87 per 1000 births (source: Population Reference Bureau (1990)) indicate that Liberia remains an underdeveloped country.

5.2 A Review of Research on Fertility in Liberia

5.2.1 Introduction

Fertility levels in Liberia are high and similar to those found in other West African countries (see Table 1.2.1). The total fertility rate (TFR) is 6.4 and the crude birth rate is 45 per 1000 (source: Population Reference Bureau (1990)). These levels reflect patterns of fertility close to those of a "natural fertility" population in which children are greatly valued (Mehrotra (1981), Handwerker (1986, p90)). Anecdotal evidence gathered during my fieldwork suggests that in Liberia children have traditionally been regarded as a source of income in the sense that they work and help to support parents. Furthermore, some respondents claimed that having large numbers of children traditionally gave high esteem. This has also been found by Handwerker according to whom there is considerable stigma attached to infertility with infertile women being pitied (by their friends), ridiculed (by other women) or divorced or ostracized (by their husbands) (Handwerker (1986, p104)).

Research on fertility in Liberia has not been extensive. In this section I review some analyses of fertility data collected in Liberia prior to the 1986 Demographic and Health Survey (LDHS). Some observations of my own made during a brief visit to Liberia are also included in this section. It is to be noted that the data used in most of the research reviewed here were of poor quality. Mehrotra (1981) and Kollehon (1984, 1986 and 1989) both carried out separate analyses of fertility data from the 1974 census. It is likely that these data were not of a particularly high quality and that underreporting of births was considerable. Hence the TFR of 4.53 reported by Mehrotra is a gross underestimate. Gisilanbe (1990) analysed fertility data from the 1984 census. Again it is likely that data on current fertility are of poor quality. The TFR calculated by Gisilanbe for this census (3.6) seems unrealistic. Dzegede (1981) looked at data from the 1962 census. Once again, data from this census are likely to be of poor quality (Denog-Beh (1987)). Chieh-Johnson (1987) analysed data from a survey carried out in 1985 among the Gola, Gio, Bassa, and Kpelle tribes in rural Liberia. Handwerker (1981 and 1986) analysed small samples of data from Monrovia and rural Liberia respectively, collected in 1977-78. Woods *et al* (1985) and Nichols *et al* (1987) reported results from a survey of adolescents in Monrovia carried out in 1984.

5.2.2 Fertility Differentials

5.2.2.1 Urban-Rural Residence

Research carried out prior to the 1986 LDHS suggests that in Liberia, as in other sub-Saharan African countries (see Section 1.2.2.1) , urban fertility levels are lower than those of rural areas, but that compared with other African countries the difference between fertility levels in urban and rural areas is comparatively slight. For example, Mehrotra (1981, p137) concludes:

"The place of residence of a woman in either rural or urban centers seems to have little impact on fertility in Liberia."

The 1970 Population Growth Survey found the TFR (based on women aged 15-44) for rural areas (6.1) to be slightly higher than that for urban areas (5.9) (Republic of Liberia (1971)). Gisilanbe (1990) found that for data from the 1984 census the standardized number of children ever born in rural areas was 0.2 higher than in urban areas. Dzegede (1981) showed that the child-woman ratio (i.e. the ratio of the number of children aged under 5 years to the number of women aged 15-44) is lower for urban areas than for rural areas. Kollehon (1986) showed that the mean number of children ever born was higher in rural areas (3.0) than in urban areas (2.6), although after age was controlled for the difference was substantially reduced. Kollehon also found that the extent to which fertility was higher in rural areas than urban areas was more pronounced in the more developed coastal area of Liberia than in the less developed hinterland.

5.2.2.2 Female Education

Research carried out prior to the 1986 LDHS suggests that, as is generally the case in other sub-Saharan African countries (see Section 1.2.2.2), Liberian women with secondary level education have lower fertility than less educated women. The evidence on whether women with primary level education have lower fertility than women with no education is inconclusive. Standardized numbers of children ever born calculated by Gisilanbe (1990) for data from the 1984 census show an "inverse" relationship with woman's highest level of education. That is, the standardized number of children ever born is successively lower with no schooling (3.5), primary (3.4), secondary (3.0), vocational

(2.7) and college (2.1) levels of education. However, among women aged 30-44 a "curvilinear" relationship is found with women with primary level education having a higher number of children ever born than women with no schooling. This latter finding is consistent with a finding for the 1974 census that women in the 25-34 and 35-49 age groups, who had primary level education only tended to have higher fertility levels than women in the same age group who were illiterate or had been educated at High School or beyond, a pattern which was found when subsamples for rural women only and urban women only were analysed (Kollehon (1986)). The 1970 Population Growth Survey found lower fertility levels among literate women than among illiterate women (Republic of Liberia (1971)), with this differential being more pronounced in urban areas.

5.2.2.3 Ethnicity/ Religion

A study of differences in fertility between some of the major tribes of Liberia (Chieh-Johnson (1987)) found fertility levels of ever married women from the Gola tribe to be higher than those of such women from the Bassa, Kpelle and Gio tribes, but no significant differences between fertility levels of ever married women in the latter three tribes. In all four tribes illiterate women had a higher mean number of children ever born than literate women. In the Gola and Kpelle tribes Moslem women had higher mean numbers of children ever born than their Christian counterparts. Kollehon (1989) finds lower numbers of children ever born among Americo-Liberian women than among women from the Bassa, Vai, Grebo, Kru and Kpelle ethnic groups but that with the possible exception of the Bassa these differentials could be accounted for by differing distributions of age, marital status, education and work status. However, there appears to be little difference in fertility levels between religious groups. Gisilanbe (1990) found only very slight differences in the standardized numbers of children ever born between Muslim (3.4), Christian (3.4) and none/other (3.3) religious categories.

5.2.2.4 Other Factors

Fertility levels have been found to be lower among wage working women than among both non-wage-working women and "other" women (excluding students)(Kollehon (1984)). It has also been found that fertility levels were considerably lower than average among students and lower than average among a retired/other work status category than among other work status categories (Kollehon (1986)).

In his analysis of fertility in Monrovia, Handwerker (1981) theorises that fertility levels reflect values stemming from differing income-earning possibilities. He measures these income-earning possibilities by the highest level of education of a woman's most recent husband/lover (because education determines the access to income earning possibilities). The women who, because of the college-level education of their "husband", Handwerker assumes to have high, reliable incomes and a "husband" with a professional/managerial position, tended to have low fertility and fertility desires. Women whose husbands had secondary level education, who (according to Handwerker) had husbands employed in white collar and skilled manual occupations with reliable incomes tended to have the highest fertility and fertility desires. Women with uneducated husbands had low fertility and fertility desires which Handwerker attributed to economic uncertainty and high unemployment in this niche.

5.2.3 The Proximate Determinants of Fertility

5.2.3.1 Marriage

Marriage in Liberia can take Christian, Islamic or traditional African forms. Payment of bridewealth is common as a part of the marriage process. As in other sub-Saharan African countries (see Sections 1.3.1.1 and 1.3.1.2), in Liberia marriage is almost universal and females tend to marry at young ages. Mehrotra (1981) found a singulate mean age at first marriage for females (SMAM) of 19.1. Handwerker (1986) found a very low mean age at first marriage (17.0) for a small sample of women in rural Liberia, surveyed in 1977-78. This reflected almost universal marriage at young ages (96% of the ever married women had married below age 22). Among ethnic groups, Mehrotra found the SMAM for females to be highest for the "no tribal affiliation" (Americo-Liberian/Congo) category and for the Kru tribe. Chieh-Johnson (1987) found younger ages at first marriage among Gola women than among women in the Kpelle, Bassa and Gio tribes. The Gola was the only one of the four tribes studied where the majority of the women had Moslem husbands. Wives are often considerably younger than their husbands. Mehrotra found that within ethnic categories SMAMs for males were generally about 6-7 years above those for females. Handwerker (1986) found a mean age at first marriage for ever married men of 26 years for a small sample of men in rural Liberia.

Although in Liberia only one wife is legally recognized, the practise of polygyny (i.e. a man having more than one traditionally recognized wife) is widespread (Mehrotra (1981), Handwerker (1986) for rural areas). According to Mehrotra, in Liberia a husband with more than one wife lives with his chief wife and keeps his other wives in a separate structure. Anecdotal evidence gathered during my fieldwork suggests that in polygynous marriage jealousy between wives can be a problem and one male respondent said that a polygynously married man should try not to show favouritism between his wives. Mehrotra found the practise of polygyny to be most widespread among the Mano and Lorma tribes and among the other tribes category and lowest among the "no tribal affiliation" category. Chieh-Johnson (1987) found that polygyny was practised in all four tribes she surveyed, although the majority of the women were monogamously married. Anecdotal evidence gathered during a visit to Liberia suggests that multipartnering exists considerably beyond recognized wives. A song popular during my visit, "Who's Own Lala", tells of a woman "cheating" on her husband and many respondents claimed such behaviour was commonplace.

Due to the recent civil war, it is likely that widowhood is currently far more common than existing research suggests. Among ethnic groups Mehrotra found widowhood to be most common among the Lorma tribe (high mortality among the Krahn, Gio, Mano and Mandingo in the civil war could mean the picture is very different now), and divorce/separation to be most common among the Kru and least common among the "no tribal affiliation" category. However, Mehrotra suggests that the impacts of widowhood and divorce/separation on fertility are small in Liberia (although this may be different now). Mehrotra (p71) suggests that the low levels of divorce/separation among the "Congos" could be attributed to a higher proportion of civil (and hence more binding) marriages in this group. Mehrotra also found the rate of divorce/separation to be inversely related to the extent of polygyny. Chieh-Johnson (1987) found low reported rates of widowhood and divorce are in all four tribes (although she suggests that under-reporting could explain this). Handwerker (1986) found that roughly one (married) woman in six had married more than once.

Although most births occur to "married" women in Liberia, there is evidence that pre-marital sex is widespread (Woods *et al.* (1985, p10) Nichols *et al.* (1987, p173)) and that there are high levels of pre-marital pregnancies.

5.2.3.2 Contraception

Modern methods of contraception available in Liberia include the pill, IUDs, injectables, condoms, foaming tablets, diaphragms and sterilization. These methods can be obtained at subsidised prices and are available in most, although by no means all, areas of the country. In addition to modern methods, abstinence, withdrawal and folk methods such as the rope (the wearing of a string with a small sack of herbs round the waist by the youngest child until it can walk), the clay pot (a clay pot with herbs is placed under the bed with the mouth of the pot down to the floor), the use of pebbles in the cervix and the burying of the placenta as part of an act of homage to spirits are also practised (Sherman (1981)).

Family planning was initiated in Liberia in 1959 when the Family Planning Association of Liberia (FPAL), a non-profit, non-govermmental and non-political organization which provides family planning information and services, was established (Photo 5.4 shows the headquarters of FPAL on Broad St., Monrovia). However, FPAL did not begin its delivery of family planning information until 1965 and did not add full service delivery until 1966 (Pragma Corporation (1988, p157)). FPAL has subsequently been joined by the Ministry of Health and Social Welfare (see Photo 5.5) and the Christian Health Association of Liberia in providing family planning services while the Catholic Church has become involved in promoting natural family planning. Contraceptives can also be obtained through medicine stores although these are generally more expensive (Photo 5.6 shows a medicine store in Buchanan). The promotion of family planning in Liberia has taken place against a background of socio-cultural inhibitions (Sherman (1984)). For example a senior hospital worker in Robertsport, Cape Mount county said that many prospective clients feared that using contraception would prevent them ever having another child (Photo 5.7 shows the hospital). Consequently, FPAL has aimed at gaining gradual acceptance for family planning. Acceptance of a need for child-spacing is seen as the first step in this process. Publicity promoting family planning portrays spacing children too closely as leading to infant deaths and poor health for both children and mother (see Photos 5.8-5.10). Until the establishment of the National Population Commission in 1988, Liberia did not have a well-defined

Photo 5.5: Ministry of Health and Social Welfare, Monrovia

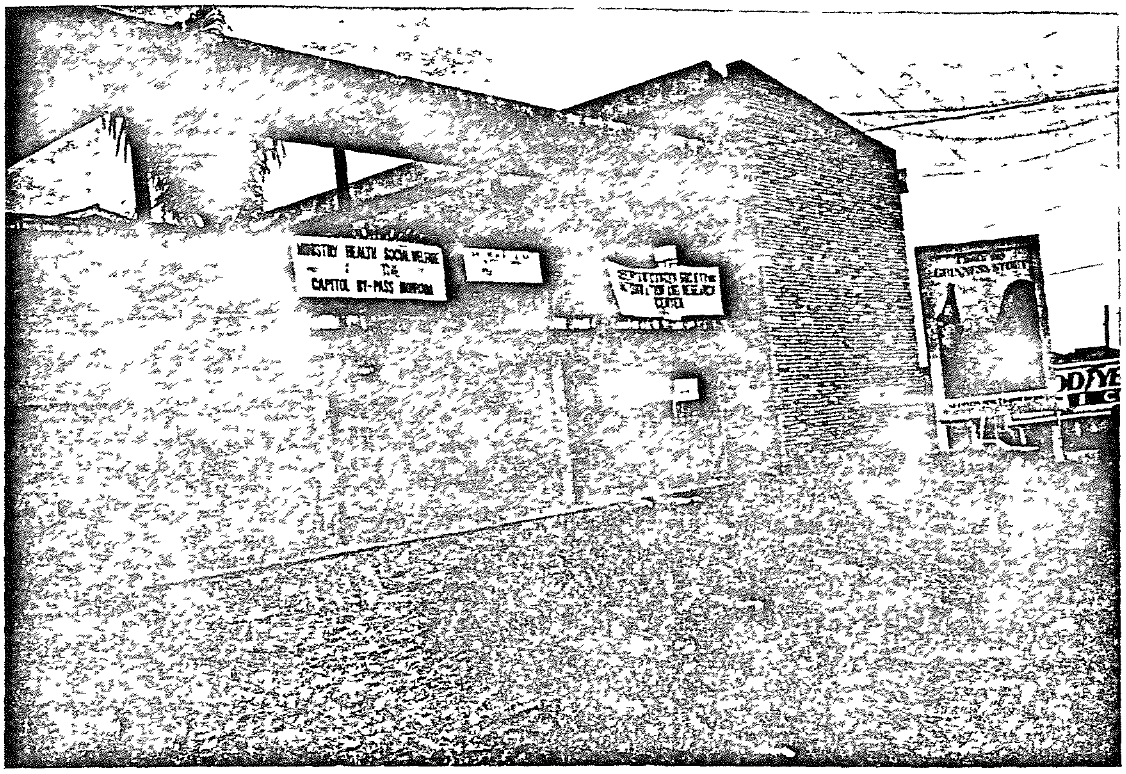


Photo 5.6: Medicine Store, Buchanan

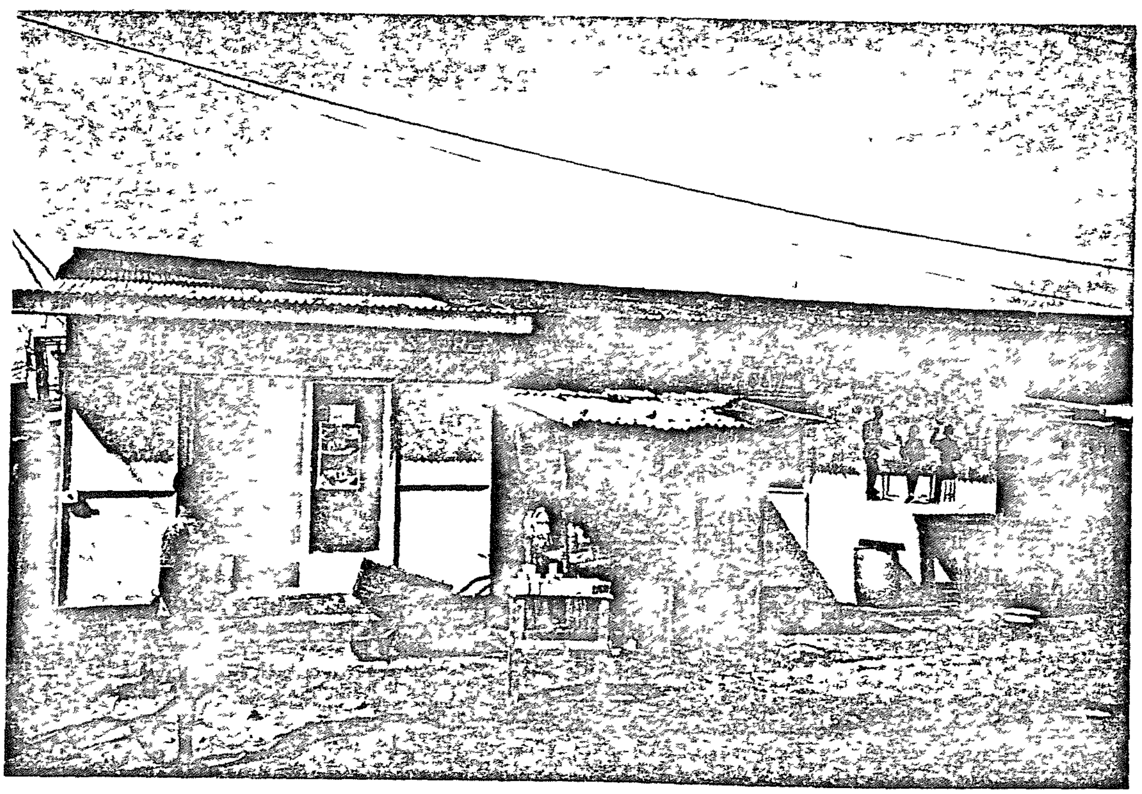
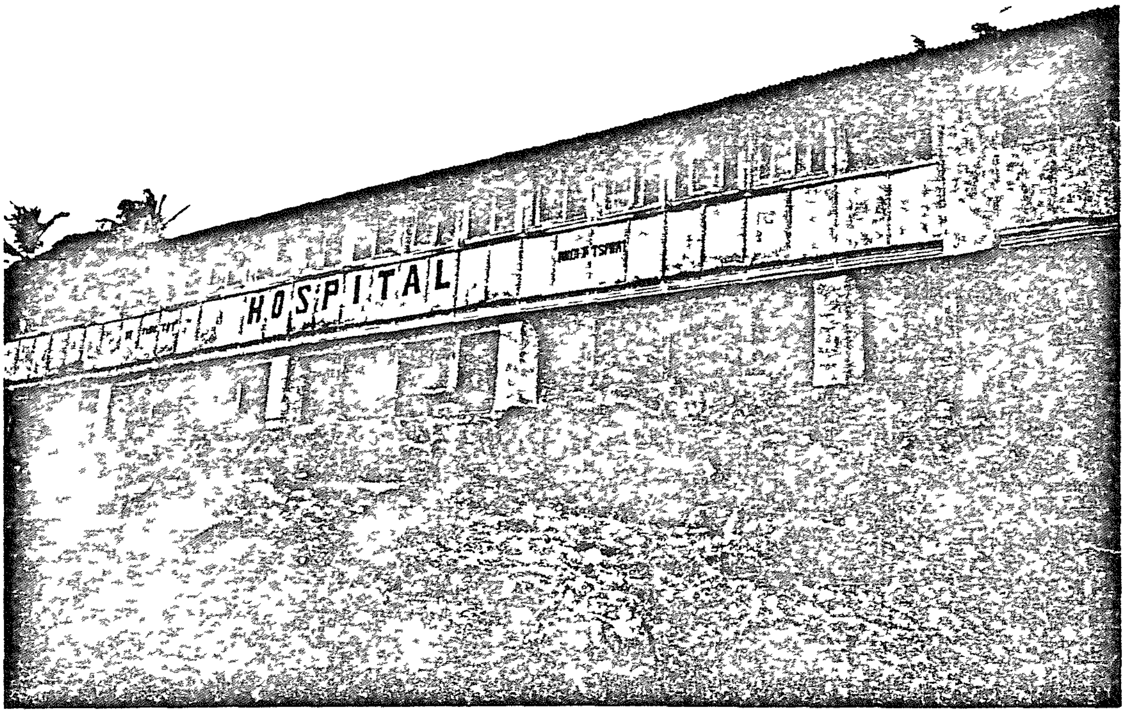


Photo 57

St. Timothy's Hospital, Robertsport.



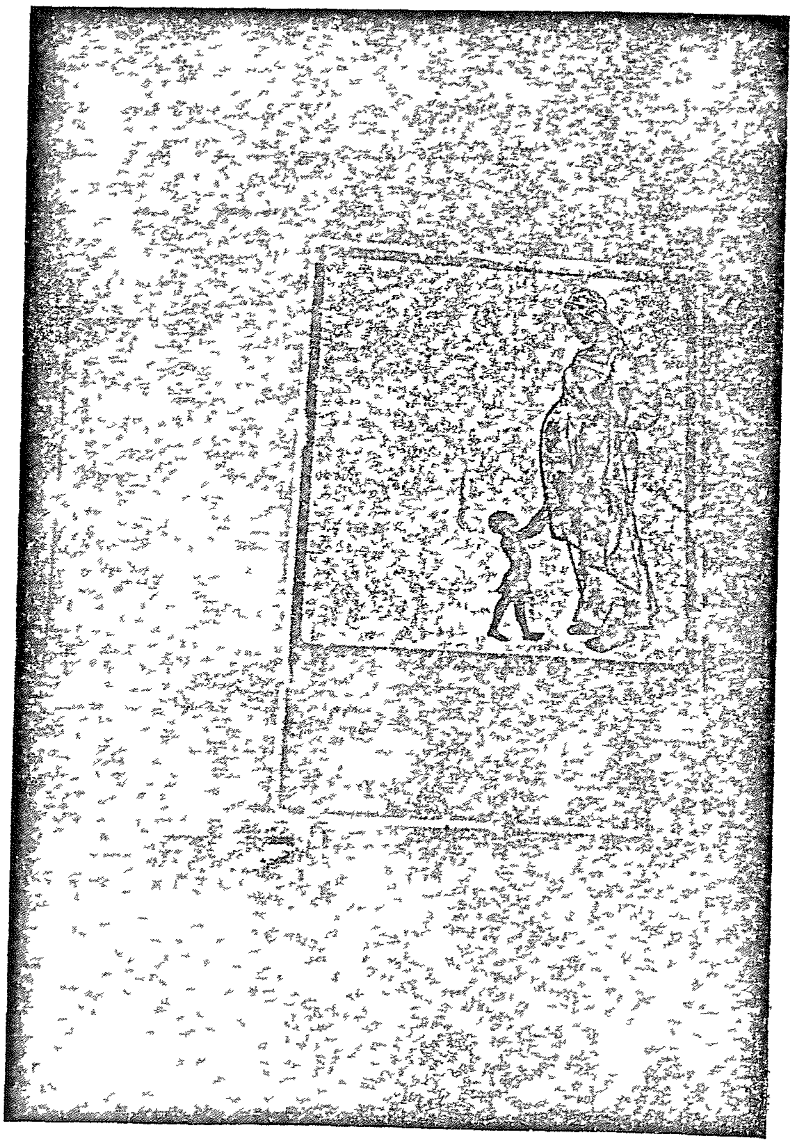


Photo 58: FPAL Publicit

The Need for

Birth Spacing.

(Aimed at the Illiterate)

Photo 5.9: FPAL Publicity

What Happens if the Children in a Family are Spaced Close Together

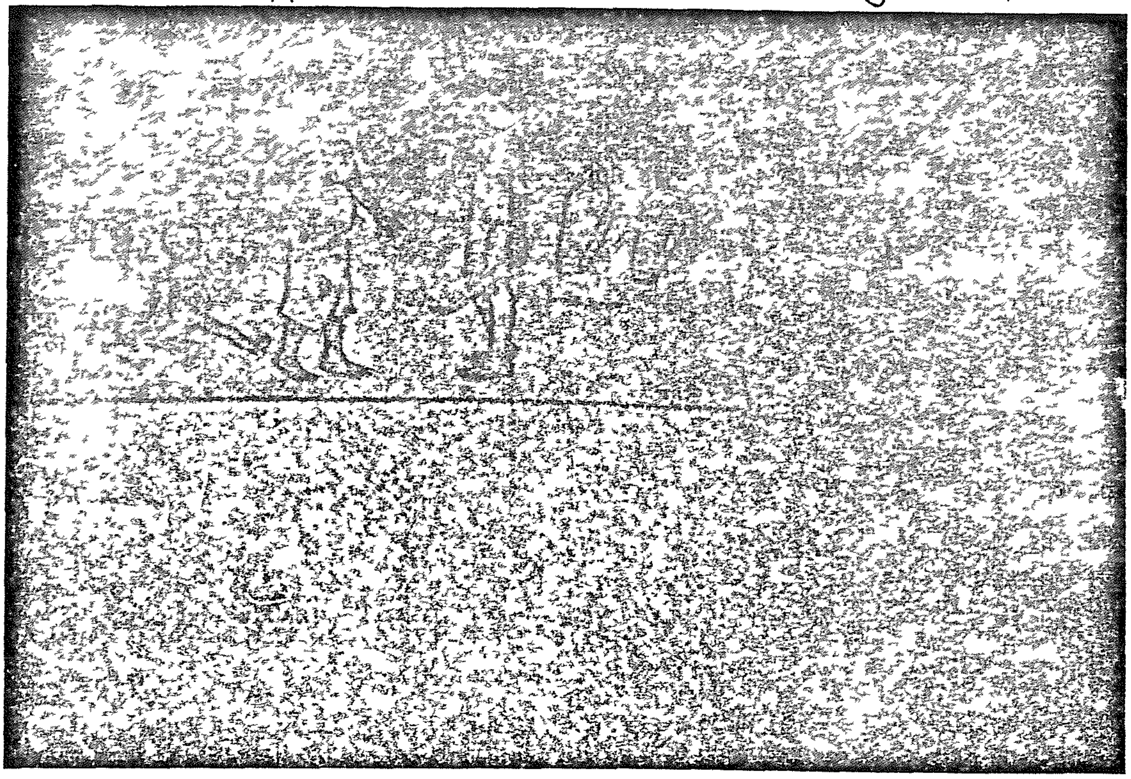
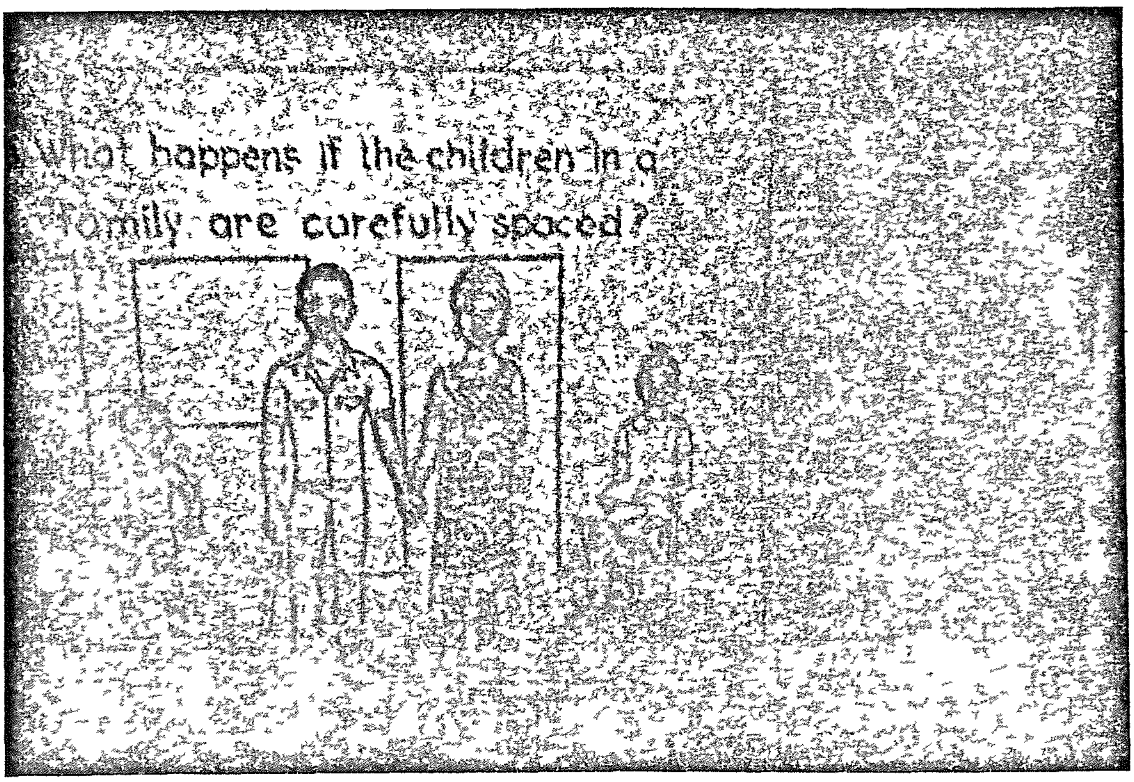


Photo 5.10 FPAL Publicity

What Happens if the Children in a Family are Carefully Spaced



and comprehensive population policy. However, current government policy is to promote a family of four. Publicity used by FPAL portrays smaller families as healthier, better fed, better clothed, better educated and happier (see Photos 5.11 and 5.12). Teenagers are now being targeted by FPAL with the aim of preventing unwanted pregnancies (which can disrupt education) or abortions (see Photos 5.13 and 5.14). FPAL's contraceptives are available at half price to students.

Family planning workers in Liberia reported that interest in family planning is a relatively recent phenomenon. A study of records of numbers of clients for family planning at the FPAL clinic in Fantitown near Robertsport, Cape Mount county (Photos 5.15 and 5.16 picture the clinic and the record is shown in Figure 5.2.1) suggests that only a small proportion of women in the area are using family planning (although this area may be atypical due to its large Muslim community). Chieh-Johnson's data show that, as in other African countries (see Section 1.3.2.2.), there are low levels for use of contraception in Liberia (10.9% of all women surveyed said they were currently using a method of contraception and 32.7% said they had ever done so). The pill was the most used modern method of contraception. These low levels of contraceptive use cannot be attributed to a lack of knowledge of contraception as a majority of the women surveyed (67.3%) knew of a method of contraception. In my view, the low levels of contraceptive use in Liberia primarily reflect a lack of demand, as opposed to a lack of supply, for contraception. An FPAL worker in whose house I stayed reported that he had not been able to sell a single condom from a consignment he had

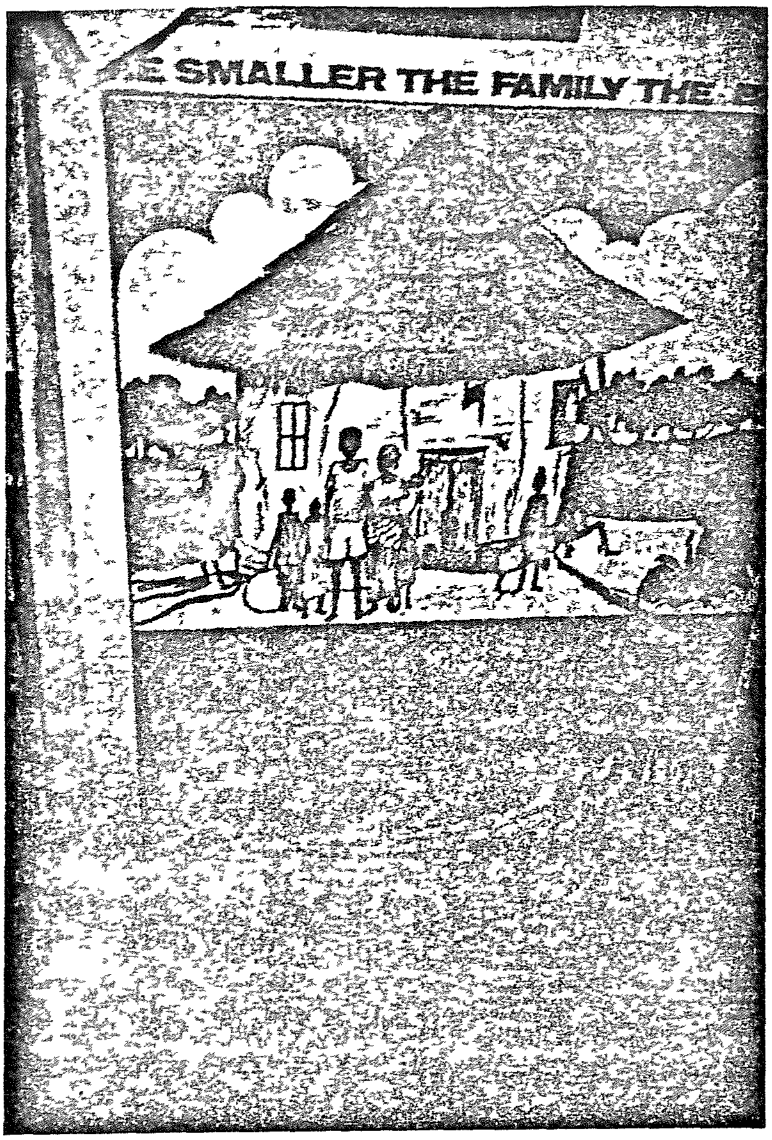


Photo 5.11 · FPAL Publicity -
The Smaller the Family the Better

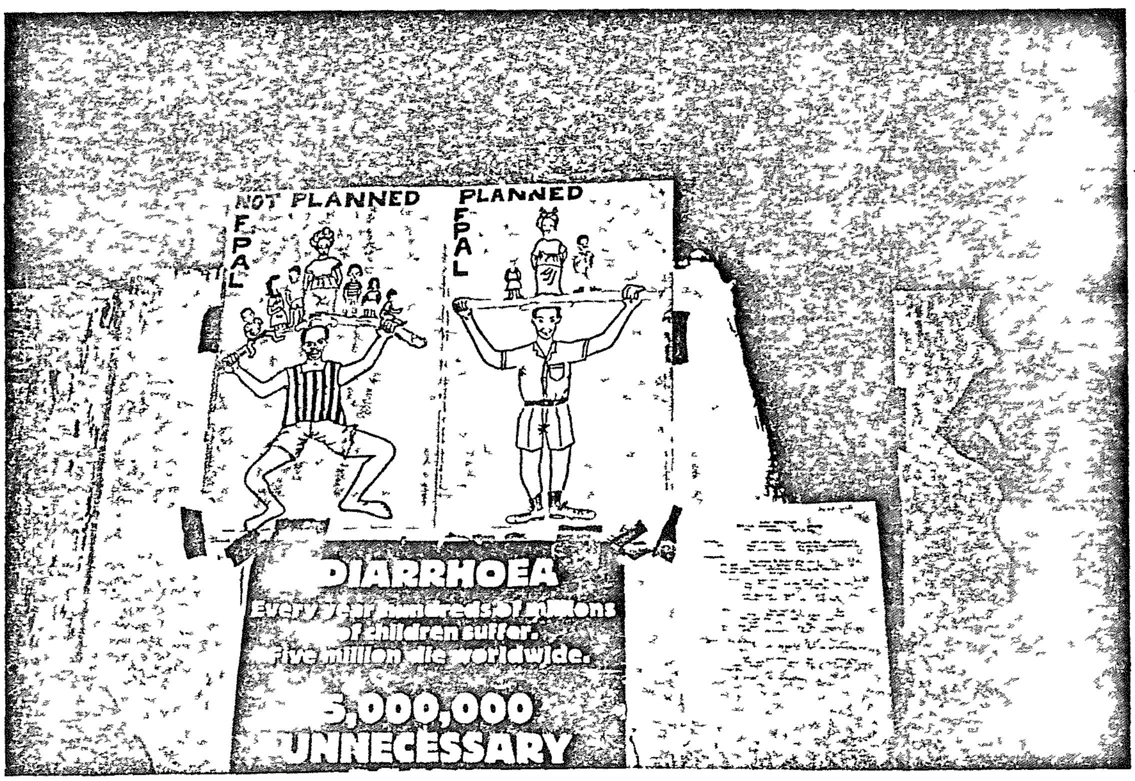


Photo 5.12
FPAL Publici
Not Plannec
Versus Planne

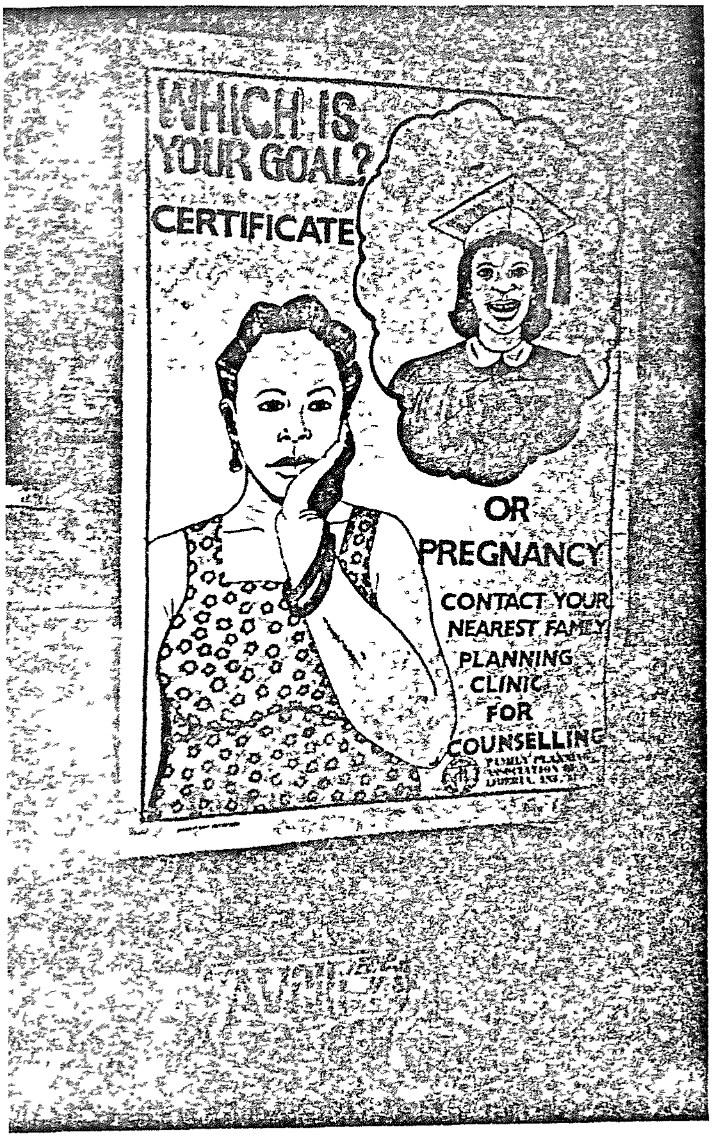


Photo 5.13
FPAL Publicity
Which is Your Goal?
Certificate or Pregnancy.

Photo 5.14 FPAL Publicity.
Don't Disturb My Education

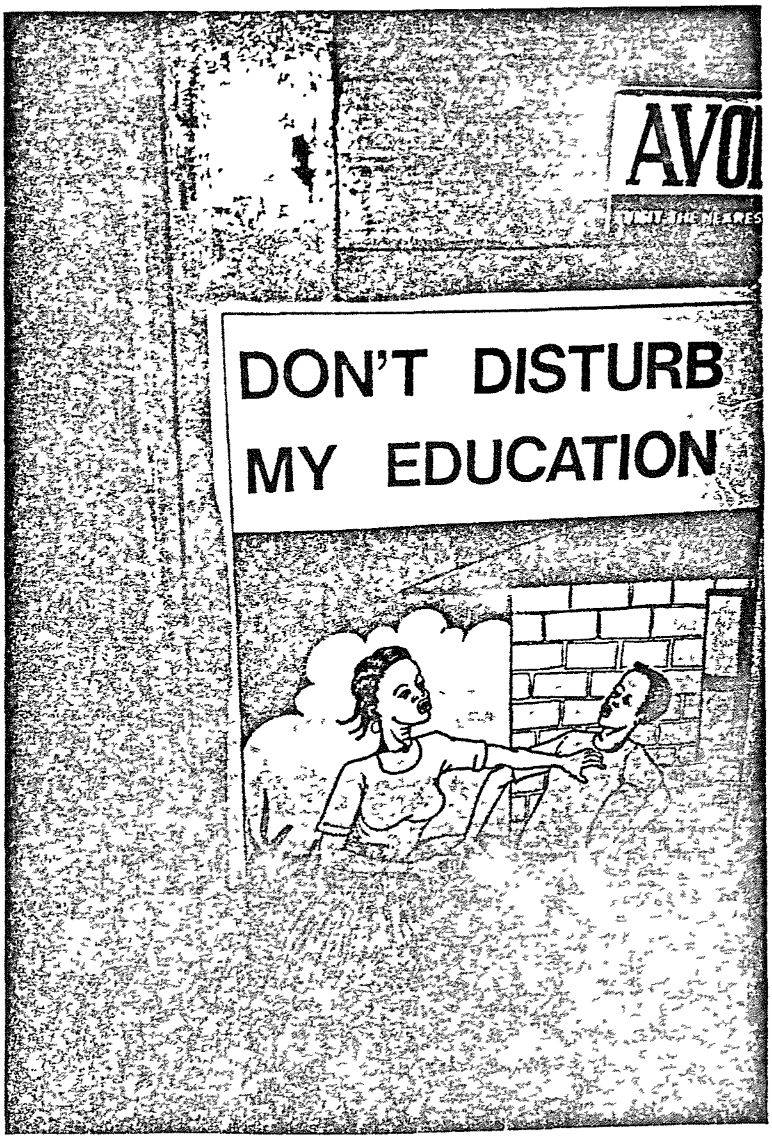


Photo 5.15

FPAL Clinic, Fantitown, Cape Mount County

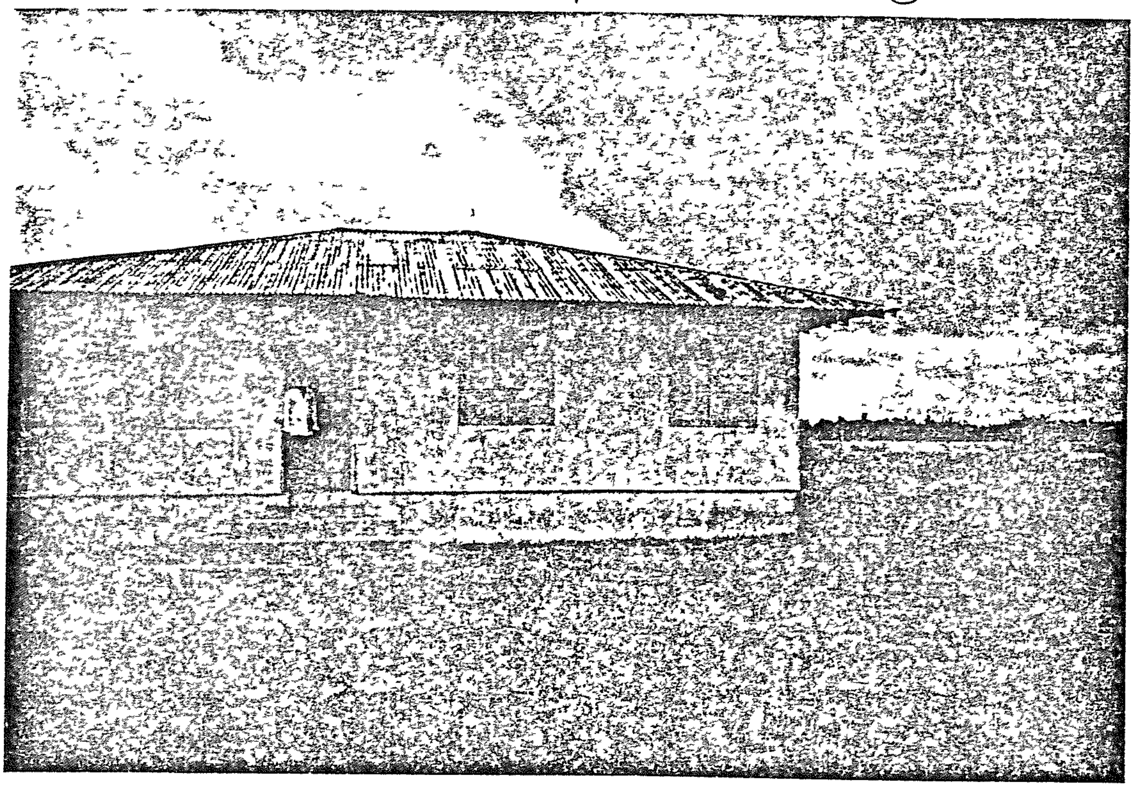


Photo 5.16

FPAL Clinic, Fantitown, Cape Mount County

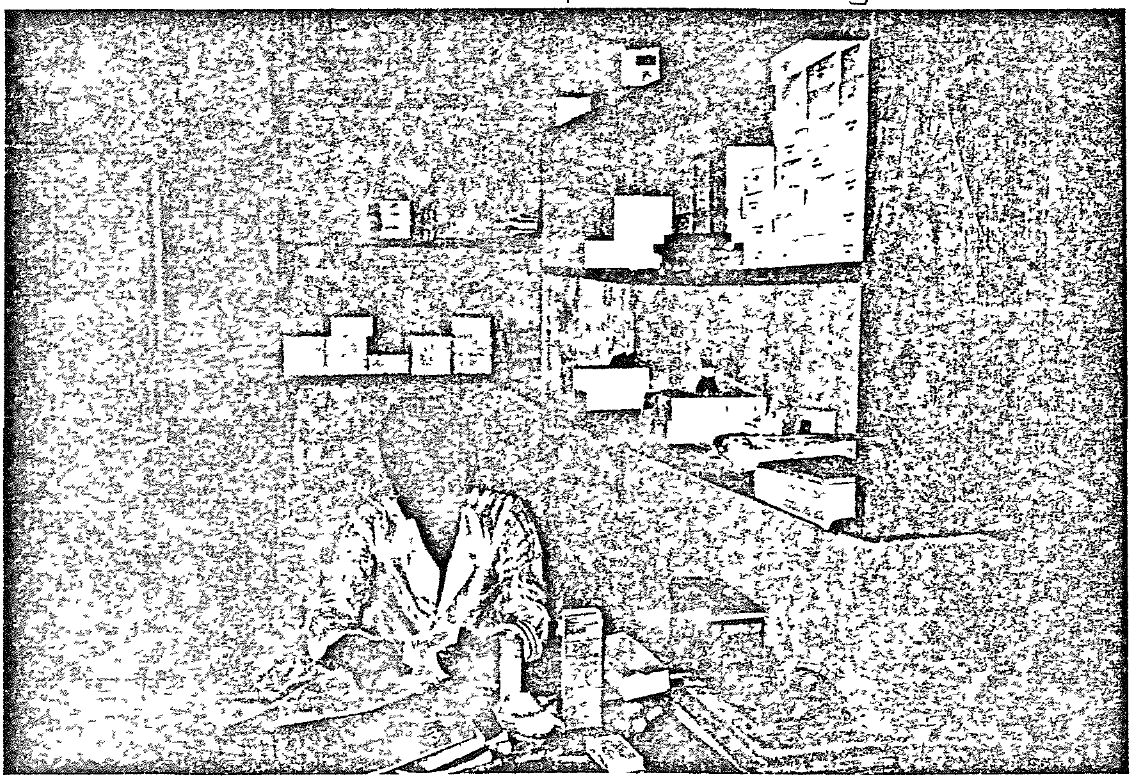


Figure 5.2.1

FAMILY PLANNING ASSOCIATION OF LIBERIA, INC.
ACTIVITIES' SHEET & CASH INTAKE RECORD FORM
Must be Used Daily, Weekly, Monthly, Quarterly, Semi & Annually

Date: Jan 1985

NAME OF CLINIC: Fantitown
REPORTING OFFICER: [illegible]

CONTRACEPTIVES:

TALLY	NOS.
ORAL:	
New Acceptors	15
Cont'd Acceptors	15
Revisits for Supplies	2
Other Visits	5
a. Side Effects	—
b. Treatments	—
c. Check-Up	2
d. Discontinued	1
Total Visits	30
Total Supplies Issued	30 cycles
INJECTABLE:	
New Acceptors	0
Cont'd Acceptors	0
Revisits for Supplies	0
Other Visits	0
a. Side Effects	0
b. Treatments	0
c. Check-Up	0
d. Discontinued	0
Total Visits	0
Total Supplies Issued	0
IUD:	
New Acceptors	1
Cont'd Acceptors	0
Revisits for Supplies	0
Other Visits	0
a. Side Effects	0
b. Treatments	1
c. Check-Up	1
d. Discontinued	0
Total Visits	2
Total Supplies Issued	1

TALLY	NOS.
FOAM TABLES:	
New Acceptors	0
Cont'd Acceptors	0
Revisits for Supplies	0
Other Visits	0
Total Visits	0
DIAPHRAGM:	
New Acceptors	0
Cont'd Acceptors	0
Revisits for Supplies	0
Other Visits	0
Total Visits	0
JELLY:	
New Acceptors	
Cont'd Acceptors	0
Revisits for Supplies	0
Other Visits	0
Total Visits	0
FOAM CREAMS: (DELFEN & KOROMEX)	
New Acceptors	0
Cont'd Acceptors	0
Revisits for Supplies	0
Other Visits	0
Total Visits	0
CONDOMS:	
New Acceptors	
Cont'd Acceptors	0
Revisits for Supplies	0
Other Visits	0
Total Visits	0
PROSPECTIVE:	
New	1
Old	1
	2

OTHER SERVICES:

	NOS.
INF/SUB-FERTILITY:	
New	2
Old	1
TOTAL	3
a. Examined	2
b. Treated	1
c. Rec. Pills	1
Cycles	6
d. Referred	0
e. Reported Preg.	0
GYNECOLOGY:	
New	5
Old	0
TOTAL	5
a. Examined	5
b. Treated	5
c. Rec. Pills	0
Cycles	0
Referred	
Reported Preg.	
PRE-NATAL:	
New	15
Old	10
TOTAL	25
a. Examined	25
b. Treated	0
c. Rec. Pills	0
Cycles	0
d. Referred	0
e. Reported Preg.	0
NUTRITION:	
New	
Old	
TOTAL	

CASH INTAKE:

METHODS:	QUAN.	FEES	PAID	BAL.
PILLS	5	$1.00	$4.00	$1.00
INJECTABLE	0	0	0	0
IUD	1	4.00	—	$4.00
FOAM TABS.	0	0	0	0
DIAPHRAGM	0	0	0	0
JELLY	0	0	0	0
FOAM CREAMS	0	0	0	0
CONDOMS	0	0	0	0
TOTAL CASH	5	5.00	$4.00	$5.00

CLINIC FEES:

Injectables				
Amp. Caps.				
Flagyl				
Terramycin				
Sulfa				
Choloroq.				
Iron				
Vitamin				
Vag. Sups.				
Others				
Vit. Syrup				
Choloroq. Syrup				
Antibiotic				
Cough				
Anti-Diabetic				

REGISTRATION:

Contraceptive				
Nutrition				
Inf/Sub.				
Gyn.				
[illegible]				
[illegible]				

received eight years earlier and that a sizable quantity of vaginal foams had also gone to waste as a result of low demand (although again I must stress that this area is predominantly Muslim and so may be atypical).

The explanation of low levels of contraceptive use is probably the strong disapproval of these techniques in Liberia (Handwerker (1981, p266) and (1986, p103)). According to Handwerker these techniques were mainly used when women engaged in pre or extra marital affairs. Contraceptive use was far more common among women from the "élite" (i.e. women whose husbands had college-level education) than in other sections of society (Handwerker (1981)). Chieh-Johnson (1987) found that the most common reasons for non-use of contraception were a desire to have as many children as possible (30.4%), where the woman was breastfeeding (22.4%) and a belief in leaving things "up to God" (19.2%).

Contraceptive use has been reported to be more widespread among students than among adolescents who were no longer attending school (Woods *et al* (1985, p10) and Nichols *et al.* (1987, p173)). This indicates that childbearing may be foregone by those wishing to continue in education.

5.2.3.3 Abortion

Abortion is illegal in Liberia except in cases of genetic defect, mental disorder or rape (Woods *et al* (1985, p2)). Official figures report the number of abortions in 1988 as 1178 (Republic of Liberia Bureau of Vital and Health Statistics (1989)). However, this figure probably considerably underestimates the level of abortion in Liberia because of the omissions of abortions carried out by some independently-run organizations and of "backstreet" abortions. Use of abortion is strongly disapproved of in Liberia (e.g. Handwerker (1981, p266) and (1986, p103)) and usually only practised if an unmarried woman does not want to or cannot marry the child's husband, if she does not want to bear children for her husband, if the husband disowns the pregnancy or if the woman's life is threatened by the pregnancy. Handwerker (1981, p281) reports that in Monrovia women from the "elite" (i.e. their husbands had had college-level education) are more likely to have had an abortion than women from other sections of society. Getaweh (1978, p39) reports that for Vai people in Liberia:

"if a woman aborts it is believed the unborn child will bear witness against her on the day of judgement".

Woods *et al* (1985, p14) found that abortion is widely used by students who become pregnant, but that its practice was less common among non-students.

5.2.3.4 Postpartum Non-Susceptibility

5.2.3.4.1 Breastfeeding

As in other sub-Saharan African countries (see Section 1.3.4.1), the practise of breastfeeding appears to be nearly universal in Liberia. Evidence of this is provided by Chieh-Johnson (1987), who found that only a minority of the women had not breastfed their last child and by David (1987) who found that only 3.5% of the infants surveyed had been bottlefed since birth (i.e. had never been breastfed). David found the use of breastmilk substitutes to be more common among more educated mothers and among working mothers.

Durations of breastfeeding tend to be lengthy in Liberia. Handwerker (1986, p105) reports that customary periods for lactation in rural Liberia varied from 4 years following the birth of a boy and 3 years following the birth of a girl to a general rule that children should be breastfed until they can walk. Chieh-Johnson (1987) found that mean durations of breastfeeding were shorter among younger women which indicates that the effects of lactational amenorrhea on fertility may be declining over time.

5.2.3.4.2 Postnatal Sexual Abstinence

As in other West African countries (see Section 1.3.4.3), in Liberia the observance of lengthy periods of postnatal sexual abstinence appears to be common. Significant mean durations for the last completed period of postnatal abstinence were reported for all the four tribal groups in Chieh-Johnson's study with the longest mean duration being for the Gio women (10.1 months). The Kpelle had a mean duration of abstinence of 10.0 months, the Gola 8.6 months and the Bassa 7.8 months. Chieh-Johnson reported that durations of abstinence tended to be shorter among the younger women surveyed. This suggests that the practise of postnatal abstinence could be declining over time. The virtue of abstaining from sexual intercourse following a birth appears to be widely upheld in Liberia. David (1987) reported that a considerable majority (71%) of the urban women surveyed felt that it was wrong for a nursing mother to have intercourse, the justifications for this being the "dire consequences" for the health of the baby if sex took place during lactation. Handwerker (1986, p105) reported specific durations of abstinence varying between 3 months and 5 years and observed that the duration of abstinence was closely related to the duration of lactation practised, the justification for this being fear that the resumption of sexual relations during lactation would lead to the death of the youngest child.

5.2.3.5 Sterility

There is evidence that, as in other sub-Saharan African countries (see Table 1.3.5.1), levels of sterility are high in Liberia. Mehrotra (1981, p161) reports that the 1974 census of Liberia found nearly 10% of women who were at the end of their reproductive life span to be childless. Handwerker (1981, p281) found that in Monrovia infertility was more common among women whose husband had had secondary level education as his highest level of education than among women from other categories of access to money. He attributed this to higher levels of gonorrheal infection in this niche. Handwerker (1986, p97) also found that gonorrhea was widespread in rural Liberia. Official data on the prevalence of infertility almost certainly underestimate the extent of the problem (259 cases were reported in 1988 (Republic of Liberia Bureau of Vital and Health Statistics (1989))). Nichols *et al.* (1987, p174) report a high prevalence of sexually transmitted diseases among adolescents in Monrovia. Official data on the prevalence of gonorrhea and syphillis are almost certainly highly inaccurate (22 cases of gonorrhea and 22 cases of syphillis were reported for 1988 (Republic of Liberia Bureau of Vital and Health Statistics (1989))).

5.2.4. Fertility and the Proximate Determinants

Chieh-Johnson (1987) fitted multiple regression models to explain numbers of children ever born for samples of women from the Bassa, Kpelle, Gola and Gio tribes and the women from all these four tribes combined. In the case of the entire sample she found significant positive relationships for age at first marriage, duration of marriage, duration of breastfeeding (this is surprising as longer durations of lactation should lengthen durations of amenorrhea and so reduce fertility), and number of infants/children dead. The models fitted could be criticized on the grounds that variables controlling for the effects of age were not used. An explanation of (for example) the finding that the number of infant deaths had the most significant positive relationship with number of children ever born could be because older women tend to have high numbers both of children ever born and infant deaths. Nonetheless, the contrasting regression coefficients of the four separate within-tribe regressions (Chieh-Johnson (1987, p59)) illustrate how fertility patterns vary with social context. Furthermore, as the tribal samples were drawn in ethnically homogenous areas, area-specific phenomena could also explain these contrasting results.

Handwerker (1986, p101) also fitted a multiple regression model to his data. Handwerker's model showed significant positive relationships between the number of pregnancies a woman had experienced and age, neonatal mortality, infant mortality, child mortality and the average length of lactation (this last finding is perhaps surprising), as well as significant negative relationships for a history of gonorrhea, polygynous marriage, age at first sex and average length of postpartum abstinence.

5.3 The Liberia Demographic and Health Survey

The Liberia Demographic and Health Survey (LDHS) was conducted between February and July 1986. This national sample survey included an extensive selection of fertility and family planning related questions. Compared with the data used for earlier research (see Section 5.2) the LDHS data on fertility address a broader range of questions and are almost certainly more accurate than the census data and are more nationally representative than the samples analysed by Chieh-Johnson (1987), Handwerker (1981 and 1986) and Woods *et al.* (1985) and Nichols *et al.* (1987).

5.3.1 Characteristics of the Women Surveyed

A two-stage sampling procedure was used for the LDHS. 5239 women aged between 15 and 49 were surveyed. These women came from 156 censal enumeration areas/clusters. Compared to the 1984 census population, two areas, namely Sinoe and Grand Gedeh counties were oversampled. This meant that to obtain national estimates the observations needed to be weighted appropriately (details of the weights are provided in Appendix 5A).

The current ages of the women show considerable heaping on to ages which are a multiple of five. This suggests inaccuracy in the reported values of current age (for a discussion of this problem vis-a-vis the Liberian census see Denog-Beh (1987)). The extent of the inaccuracy is shown by Whipple's index (based on women aged 23-47) (e.g. Newell (1988, pp23-24)) which measures 163. This indicates that reported ages are at best a rough indication of true ages. I present data by age in 5 year age groups with the lower bounds of groups being ages which are a multiple of five. The distribution of the women by these 5 year age groups (after weighting factors have been applied) is broadly similar to that of the 1984 census. This is shown in Table 5.3.1.1:

Table 5.3.1.1: LDHS Weighted Distribution by Age

Age	Frequency	% LDHS n=5238	% 1984 census
15-19	1139	21.7	23.8
20-24	1027	19.6	20.8
25-29	1084	20.7	17.5
30-34	655	12.5	12.6
35-39	626	11.9	11.2
40-44	327	6.2	7.7
45-49	380	7.2	6.4
	5238	100.0	100.0

The distributions of the women surveyed by county of residence before and after weighting are presented in Table 5.3.1.2. The locations of these counties can be seen in Map 5.1.1.

Table 5.3.1.2: LDHS Distribution by County Before and After Weighting

County	Frequency Before Weighting	Frequency After Weighting	Percent (%) Before Weighting n=5238	Percent (%) After Weighting n=5238
Bomi	129	178	2.5	3.4
Bong	457	629	8.7	12.0
Grand Bassa	324	446	6.2	8.5
Cape Mount	114	157	2.2	3.0
Grand Gedeh	920	293	17.6	5.6
Grand Kru	46	63	0.9	1.2
Lofa	348	479	6.6	9.1
Margibi	280	385	5.3	7.4
Maryland	84	116	1.6	2.2
Montserrado	1086	1495	20.7	28.5
Nimba	548	754	10.5	14.4
Rivercess	68	94	1.3	1.8
Sinoe	834	150	15.9	2.9
	5238	5238	100.0	100.0

The most populous county, Montserrado, contains the capital city, Monrovia. This county enjoys a considerably greater degree of socio-economic development than the rest of Liberia. Table 5.3.1.2 also illustrates the extent of oversampling in Sinoe and Grand Gedeh counties.

Liberia has sixteen recognized indigenous tribes, and these tribes can be grouped into three main linguistic groups (see Section 5.1). The (weighted) distributions of the women by tribe and ethno-linguistic groups are shown in Tables 5.3.1.3 and 5.3.1.4:

Table 5.3.1.3: LDHS Weighted Distribution by Tribe

Tribe	Frequency	Percent (%) n=5233
Bassa	664	12.7
Belle	18	0.3
Dey	32	0.6
Gbandi	149	2.8
Gio	401	7.7
Gola	244	4.6
Grebo	380	7.3
Kissi	187	3.6
Kpelle	854	16.3
Krahn	219	4.2
Kru/Sapo	555	10.6
Lorma	312	6.0
Mandingo	317	6.1
Mano	413	7.9
Mende	47	0.9
Vai	197	3.8
None	25	0.5
Other	219	4.2
	5233	100.0

Table 5.3.1.4: LDHS Weighted Distribution by Ethnic Group

Ethnic Group	Frequency	Percent (%) n=5233
Kwa (Kru)	1868	35.7
Mande	2690	51.3
West Atlantic (Mel)	431	8.2
Other	244	4.7
	5233	100.0

The locations of the tribes and ethno-linguistic groups can be seen from Map 5.1.2. The largest tribe, the Kpelle, is most heavily concentrated in Bong county. The second largest tribe, the Bassa, forms the majority of the sample in Grand Bassa and Rivercess. The Kru/Sapo group forms the majority of the sample in

Sinoe (one of the oversampled counties) and Grand Kru. The other oversampled county, Grand Gedeh, is populated mainly by the Krahn and Grebo tribes. The "other" category contains minor Liberian tribes, tribes from other African countries and migrants from Lebanon, India, Pakistan, the U.S.A. and Europe. The Americo-Liberians and Congos will be in the "other" and "none" categories.

Christianity is the predominant religion in Liberia. Nearly half the women sampled (48% after weighting) belonged to a Protestant church and 6% (after weighting) were Catholic. One seventh of the (weighted) sample (14.4%) were Muslims. Roughly one fifth (21.3% after weighting) of the women specifed another religion. This category would contain African based religions such as the Private Church/Aladura and the Faith Healing Temple as well as followers of other world religions such as Buddhists, Hindus, Bahais and the Unification church. Table 4.3.1.5 shows the (weighted) distribution of the women by religion:

Table 5.3.1.5: LDHS Weighted Distribution by Religion

Religion	Frequency	Percent (%) n=5231
Protestant	2517	48.0
Catholic	321	6.1
Muslim	753	14.4
Traditional/Other	1118	21.3
None	522	10.0
	5231	100.0

The women from the Bassa, Grebo, Kpelle, Krahn, and Kru/Sapo tribes are predominantly Protestant. The women from the Vai and Mandingo tribes are mainly Muslim. The largest religious category for the women from each of the other tribes is Protestant except for the Mano tribe in which the largest religious category is no religion.

Protestants formed more than half those sampled in Bong, Grand Gedeh, Grand Kru, Maryland, Montserrado and Sinoe counties. In Cape Mount county Muslims formed the majority of the sample. In Bomi the sample was mainly either Protestant or Muslim. In Bassa, Margibi, and Rivercess the sample consisted mainly of women from the Protestant or traditional/other catagories. In Nimba and Lofa the sample was mainly either Protestant or of no religion.

Information on whether clusters were in urban areas or rural areas is not included in the data. However, whilst in Liberia I was able to obtain information from the enumerators file on the locations of clusters (full details of this information appear in Appendix 5C). From this information I constucted categories for urban-rural residence. The (weighted) distribution of the sample between these categories is presented in Table 5.3.1.6:

Table 5.3.1.6: LDHS Weighted Distribution by Type of Place of Residence

Type of Place of Residence (*)	Frequency	Percent (%) n=5238
Rural	3115	59.4
Monrovia (a)	1283	24.5
Another City (b)	841	16.1
Urban (c)	2124	40.5
	5238	100.0

(*) These categories were created using information on the locations of clusters and are somewhat arbitrary. They are unlikely to correspond with corresponding categories for the variable "where lived as young girl" (q102 of questionairre)

(a) Greater Monrovia (cluster numbers 321-346).

(b) Bong Mines (cluster number 356), Buchanan (Grand Bassa) (382-383), Charleville (370) Gbanga (365), Greenville (120), Harbel (Firestone) (353), Harper (408), Kakata (374), Marshall (371), Nyien (357), Robertsport (305), Sasstown (406), Tapitta (398), Tubmanberg (Bomi Hills) (319), Voinjama (310), Yekepa (388), Zoe (395), Zorzor (307), or Zwedru (210-211).

(c) (a) and (b) combined.

Roughly two-fifths of the women lived in urban areas during childhood. Of these over one third had been brought up in Monrovia. Only 10% of the sample reported having been brought up in a village (this could partly reflect the fact that some very remote areas were not sampled). The Weighted proportions for type of place of childhood residence are presented in Table 5.3.1.7:

Table 5.3.1.7: LDHS Weighted Distribution by Type of Place of Childhood Residence

Where Lived as Young Girl	Frequency	Percent (%) n=5238
Village	554	10.6
Town	2523	48.4
Monrovia	805	15.5
Another City	1326	25.5
	5238	100.0

The sample reflects the widespread illiteracy in Liberia. Two thirds of the women were completely illiterate and half of the remaining women were only partially literate. Weighted figures showing the extent of literacy among the women are presented in Table 5.3.1.8:

Table 5.3.1.8: LDHS Weighted Distribution by Literacy

Literacy	Frequency	Percent (%) n=5238
Literate	947	18.1
Partly Literate	835	15.9
Illiterate	3455	66.0
	5238	100.0

The women surveyed were asked if they had ever attended school and if so to give the highest level of schooling they had. The weighted results show that the majority of the women were uneducated (62.6%). Roughly one-fifth (18.4%) of the weighted sample had primary education (i.e. between one and six years education) as their highest educational level and a further 16.4% (weighted) had secondary education (i.e between 7 and 12 years schooling) as their highest educational level. Only 2.1% of the women had been educated beyond secondary school. Weighted figures for the highest educational level are presented in Table 5.3.1.9:

Table 5.3.1.9: LDHS Weighted Distribution by Woman's Highest Level of Education

Highest Level	Frequency	Percent (%) n=5238
No schooling	3281	62.6
Primary	964	18.4
Secondary	883	16.9
Vocational	34	0.7
Higher	75	1.4
	5238	100.0

5.3.2 The Proximate Determinants of Fertility

5.3.2.1 Marriage

The LDHS data show that marriage is almost universal in Liberia. Only 0.5% (weighted) of the women aged between 45 and 49 had never married or lived with a man. Marriage (including consensual unions) tends to occur when the women are young (36% of the women aged between 15 and 19 had married or lived with a man) (c.f. Section 5.2.3.1). The (weighted) percentages of women who have ever married or lived with a man by age group are presented in Table 5.3.2.1.1:

Table 5.3.2.1.1: LDHS Weighted Percent Ever Married by Age

Age	Number	% Ever Married
15-19	1139	36.0
20-24	1027	75.3
25-29	1084	92.0
30-34	655	94.0
35-39	626	98.8
40-44	327	98.3
45-49	380	99.5

However, more women describe themselves as living with a man than as being married (38.3% of the weighted sample as opposed to 29.2%). The (weighted) distribution of the sample by current marital status is presented in Table 5.3.2.1.2:

Table 5.3.2.1.2: LDHS Weighted Distribution by Current Marital Status

Current Marital Status	Frequency	Percent (%) n=5238
Single	1123	21.4
Married	1531	29.2
Living Together	2007	38.3
Widowed	83	1.6
Divorced	164	3.1
Not Living Together	329	6.3
	5238	100.0

In Montserrado county the proportions ever married by age indicate higher than average ages at first marriage. There is evidence of low ages of marriage in Bomi, Rivercess and Nimba counties. In Maryland county almost no teenage women are married and no women aged over 25 are unmarried. The highest proportions of married teenage women are found in Rivercess, Cape Mount and Nimba counties and the lowest proportions are found in Maryland and Monserrado. The counties with the highest proportions of single women are Maryland and Kru Coast. However, the samples in these counties are small and contain disproportionately large numbers of women aged 15-19.

There is evidence of comparatively late ages at first marriage among the Lorma and Kru/Sapo tribes whilst the Mandingo, Gio and Mano women tend to marry at very young ages. Unmarried women of older ages are most commonly found in the other/none ethnic group, however, in this heterogenous category a high proportion of teenage girls have married. Of the ethno-linguistic categories, the Mande women tend to marry earliest and women from the "Other" category tend to marry latest.

The proportions of single women by age group suggest that Catholic women have the latest ages for marriage with Protestant women also having comparatively high ages at marriage. Muslim women tend to be married at young ages as do women with no religion and women from the traditional/other category.

Women in rural areas tend to marry at earlier ages than women in urban areas. The lowest proportions of married teenage women are found in "cities" other than Monrovia, but the proportions of women aged over 20 who are single tend to be higher in Monrovia than in the other "cities".

The LDHS data suggest that there are considerable variations in women's ages of first marriage by highest level of education. Ages at first marriage tend to be very low for uneducated women. A comparatively high proportion of teenage women whose highest level of education was primary are single. However, non-marriage among women over 20 in this group is comparatively rare. It is rare for a teenage woman with at least secondary education to be married and comparatively large proportions of these women in older age groups have remained single indicating comparatively late ages at first marriage among this group.

The (weighted) distribution of the women by marital status and background characteristics is shown in Table 5.3.2.1.3:

Table 5.3.2.1.3: LDHS Weighted Current Marital Status by Background Characteristics

Characteristic	Percent (%) Single	Married	Living Together	Widow	Divorced	Not Living Together	n
Age							
15-19	64.0	9.7	22.1	0.4	1.4	2.5	1170
20-24	24.7	20.2	45.2	0.1	2.5	7.2	980
25-29	8.0	34.3	45.0	0.6	3.2	9.0	1015
30-34	6.0	38.3	43.6	1.7	3.5	6.8	657
35-39	1.2	42.4	43.1	2.4	4.5	6.4	640
40-44	1.7	40.3	39.7	6.6	4.4	7.3	372
45-49	0.5	51.0	30.8	6.2	5.7	5.7	404
Region							
Bomi	17.1	11.6	62.8	0.0	0.8	7.8	178
Bong	16.2	27.4	43.5	2.4	2.8	7.7	629
Grand Bassa	16.0	65.1	7.4	0.3	8.0	3.1	446
Cape Mount	14.0	10.5	70.2	0.0	0.0	5.3	157
Grand Gedeh	16.7	12.5	63.5	1.2	1.5	4.6	293
Kru Coast	32.6	0.0	63.0	0.0	2.2	2.2	63
Lofa	23.0	31.6	17.4	0.9	1.4	5.7	479
Margibi	21.1	58.2	7.9	1.8	2.9	8.2	385
Maryland	46.4	6.0	35.7	4.8	2.4	4.8	116
Montserrado	29.7	20.8	36.4	1.4	2.6	9.1	1495
Nimba	12.4	31.2	46.0	3.3	5.1	2.0	754
Rivercess	11.8	67.6	11.8	0.0	5.9	2.9	94
Sinoe	22.7	1.9	66.4	1.0	0.1	7.8	150
Ethnic Grp							
Kwa	26.4	24.8	36.3	1.5	3.3	7.6	1868
Mande	17.4	32.1	40.4	1.7	3.0	5.4	2690
West Atlantic	22.0	27.8	41.2	1.9	1.9	5.1	431
Other	27.0	34.8	25.4	0.6	4.5	7.2	244
Tribe							
Bassa	22.9	44.6	18.8	1.5	6.0	6.2	664
Belle	30.2	15.1	39.5	0.0	0.0	15.1	18
Dey	21.7	21.7	47.8	0.0	0.0	8.7	32
Gbandi	16.6	32.4	38.0	0.0	4.6	8.3	149
Gio	12.4	30.2	47.1	2.4	4.1	3.8	401
Gola	26.6	22.6	39.0	1.7	3.4	6.8	244
Grebo	31.0	10.8	47.1	2.3	2.4	6.4	380
Kissi	16.2	34.5	44.2	2.2	0.0	2.9	187
Kpelle	17.7	35.4	35.1	2.0	2.4	7.4	854
Krahn	21.3	15.2	52.8	1.1	2.2	7.4	219
Kru/Sapo	29.6	15.1	42.7	1.3	1.5	9.8	555
Lorma	34.2	20.3	38.1	0.4	2.2	4.8	312
Mandingo	11.0	48.9	36.5	0.9	0.9	1.8	317
Mano	13.3	28.0	46.0	3.7	5.7	3.3	413
Mende	23.4	26.4	44.3	0.0	0.0	5.9	47
Vai	18.1	14.8	25.4	0.6	4.5	7.7	197
Other/None	27.0	34.8	25.4	0.6	4.5	7.7	244

Religion							
Protestant	27.7	21.1	38.5	2.0	3.1	7.5	2517
Catholic	31.8	24.8	31.2	2.3	1.8	8.1	321
Muslim	10.3	40.2	43.6	0.5	1.3	4.1	753
Trad/Other	13.7	42.2	30.3	1.6	5.2	7.2	651
None	15.9	34.5	41.2	1.3	3.5	3.7	989
Place of Res.							
Urban	30.5	22.8	34.6	1.3	3.1	7.8	2124
Rural	15.5	33.4	40.7	1.8	3.2	5.3	3115
Childhood Res.							
Village	13.8	35.4	40.1	2.1	3.1	5.5	554
Town	15.4	31.5	43.1	1.6	2.9	5.4	2523
Monrovia	37.3	18.8	31.5	0.7	3.4	8.3	805
Oth. City	26.3	28.7	32.6	1.8	3.5	7.1	1326
Literacy							
Literate	44.0	15.8	28.2	1.6	2.2	8.2	947
Semi lit.	43.1	14.8	31.1	0.9	3.2	7.3	835
Illiterate	10.0	36.5	42.8	1.8	3.4	5.5	3455
Education							
None	9.3	37.1	43.1	1.7	3.4	5.5	3281
Primary	40.9	16.5	31.1	1.3	2.9	7.2	964
Secondary	44.0	12.5	31.4	1.4	2.5	8.1	883
Higher	34.0	40.7	14.0	1.3	2.5	7.5	109

Polygyny is widespread in Liberia and 38% (weighted) of women who were married or living together reported that their man had another "wife". A higher (weighted) proportion of women are in polygynous as opposed to monogamous "marriages" in Grand Gedeh, Lofa, Kru Coast and Rivercess counties. Among the Mandingo, Gbandi and Mende tribes a majority of women are polygynously married. Furthermore, among Muslims polygynous unions are in the majority. Polygyny is rare among women with at least secondary level education, among women from the other/none ethnic group and in Montserrado and Margibi counties.

5.3.2.1 Contraception

The LDHS data show low levels of contraceptive use in Liberia. Only 8% (weighted) of the women surveyed said they are currently using a method of contraception a figure which includes the 7% (weighted) who said they are currently using a so-called "efficient" or modern method of contraception (i.e. pill, IUD, injections, diaghragm, condom, or sterilization of either partner). Just over one fifth (21.7% weighted) of the women had ever used a method of contraception. These levels of contraceptive use are slightly lower than those reported in a smaller, less representative, earlier survey by Chieh-Johnson (see Section 5.2.3.2). Of these "ever users" a relatively high proportion (86% weighted) have used an efficient method of contraception. These low levels of contraceptive use occurred despite 71.7% knowing of a method of contraception and 70.3% knowing of a modern method of contraception. The proportions knowing of or using contraception are presented in Table

5.3.2.2.1:

Table 5.3.2.2.1: LDHS Weighted Levels of Contraceptive Knowledge and Contraceptive Use

Contraceptive Knowledge/Use	Frequency	Percent (%) of All Women Surveyed n=5238
Knows any method	3758	71.7
Knows any "efficient" method	3685	70.3
Ever used any method	1137	21.7
Ever used any modern method	973	18.6
Currently using	439	8.4

The age group in which (weighted) levels of use of contraception are highest is 20-24, whilst in the 15-19 age group levels of contraceptive use are lowest.

Levels of contraceptive use are highest in Montserrado, Maryland and Margibi counties and are generally lowest in Grand Bassa and Rivercess, although it is in Cape Mount county where levels of "ever use" of contraception are lowest.

The highest levels of contraceptive use are found among women in the Other/None, Grebo, Belle, Mende and Kru/Sapo categories. The lowest levels of contraceptive use are found among the Mandingo and Dey women. Of the ethno-linguistic categories, the Mande and West Atlantic groups tend to have low levels of contraceptive use and the Kwa and "Other" categories tend to have relatively high levels of contraceptive prevalence.

Catholic women have comparatively very high levels of contraceptive prevalence and Protestant women also have above average levels. Muslim women , women with no religion and women with traditional/other beliefs have low levels of contraceptive prevalence.

As in other sub-Saharan African countries (see Section 1.3.2.3), women who live in urban areas have considerably higher levels of contraceptive use than women who were brought up in rural areas. The levels of contraceptive use in Monrovia are similar to those in other "cities". Levels of contraceptive use for women brought up in cities are similarly considerably higher than those of women brought up in towns or the countryside.

Contraceptive use is rare among uneducated women and among women with primary level schooling only, but becomes considerably more common among more highly educated women. Likewise, contraceptive use is considerably more common among literate women than among illiterate women.

The (weighted) percentages of women who have ever used any method of contraception, have ever used a modern method of contraception, who are currently using any method of contraception and who are currently using a modern method of contraception by background characteristics are presented in Table 5.3.2.2.2:

Table 5.3.2.2.2: LDHS Weighted Contraceptive Use by Background Characteristics

Characteristic	(wtd) % Ever Used Any	Modern	(wtd) % Currently Use Any	Modern
Age				
15-19	13.2	10.7	5.3	4.0
20-24	27.9	23.8	11.6	9.9
25-29	24.2	21.3	8.7	7.4
30-34	25.3	23.7	9.3	7.6
35-39	21.4	19.3	6.7	5.9
40-44	17.9	16.1	10.1	7.6
45-49	14.7	12.4	7.9	6.6
Region				
Bomi	17.1	16.3	5.4	5.4
Bong	18.4	14.9	4.8	4.2
Grand Bassa	13.3	8.3	2.5	1.9
Cape Mount	10.5	10.5	4.4	4.4
Grand Gedeh	15.6	12.6	3.9	3.8
Kru Coast	13.0	10.9	4.4	4.4
Lofa	19.0	16.4	6.3	5.5
Margibi	25.7	23.2	11.1	9.6
Maryland	34.5	33.3	13.1	10.7
Montserrado	32.0	28.1	14.8	11.6
Nimba	14.6	12.4	5.7	5.1
Rivercess	16.2	7.4	2.9	2.9
Sinoe	18.9	17.3	8.0	6.8
Ethnic Group				
Kwa	27.7	24.0	10.3	9.1
Mande	17.4	14.7	6.6	5.4
West Atlantic	17.9	15.1	5.4	4.2
Other	30.3	25.8	18.9	13.1
Tribe				
Bassa	20.6	16.4	6.5	5.6
Belle	30.2	30.2	15.1	15.1
Dey	17.4	13.0	4.4	4.4
Gbandi	21.2	15.7	3.7	3.7
Gio	17.2	14.8	5.8	5.1
Gola	20.3	16.4	5.1	4.0
Grebo	33.9	30.8	15.6	13.7
Kissi	14.8	13.3	5.9	4.4
Kpelle	16.8	13.4	5.7	4.8
Krahn	23.0	20.0	5.9	5.9
Kru/Sapo	34.2	30.5	13.3	11.5
Lorma	27.4	24.3	11.5	8.8
Mandingo	7.4	6.1	2.2	1.3
Mano	14.7	13.3	6.3	5.7
Mende	26.4	23.4	14.7	8.8
Vai	20.9	18.1	11.9	9.8
Other/None	30.3	25.8	18.9	13.1

Religion				
Protestant	28.0	24.2	11.0	8.9
Catholic	43.7	40.7	24.2	21.9
Muslim	10.3	9.2	3.7	2.7
Trad/Other	16.8	13.2	4.0	3.3
None	10.4	7.7	3.2	3.0
Place of Residence				
Urban	34.7	31.1	15.4	12.8
Rural	12.8	10.0	3.6	3.0
Childhood Residence				
Village	11.7	9.9	4.0	3.8
Town	14.6	11.9	4.3	3.3
Monrovia	38.6	25.3	17.8	14.3
Oth. City	29.3	11.3	12.3	10.6
Literacy				
Literate	59.7	53.0	28.5	23.1
Semi lit.	26.7	23.0	8.4	7.4
Illiterate	10.1	8.1	2.9	2.5
Education				
None	9.9	7.9	3.0	2.6
Primary	21.3	17.6	5.8	5.5
Secondary	60.1	53.5	27.4	21.8
Higher	69.8	64.6	40.4	32.9

Among specific methods of contraception currently used, by far the most popular method is the pill (55% weighted of all current users). This is shown in Table 5.3.2.2.3:

Table 5.3.2.2.3: LDHS Weighted Contraceptive Use by Method Type

Method	Frequency	Percent (%) of Current Users n=439
Pill	244	55.6
IUD	37	8.4
Injections	15	3.4
Condom, Raincoat	10	2.3
Female sterilization	52	11.8
Male sterilization	0	0.0
Periodic abstinence	46	10.5
Withdrawal	10	2.3
Other	17	3.9
	439	100.0

The "other" category includes non-scientifically proven methods such as the rope and acts of homage to gods or idols (see Section 5.2.3.2)

5.3.2.3 Postpartum Non-Susceptibility

Median durations for breastfeeding, postpartum amenorrhea and postpartum sexual abstinence appear to be similar to those for other West African countries. These durations were calculated using "current status" data for breastfeeding, amenorrhea and abstinence by the time since a birth. The (weighted) proportions breastfeeding, amenorrheic or abstaining by the time from a birth until the interview are presented in Table 5.3.2.3.1 and are illustrated by Figure 5.3.2:

Figure 5.3.2

Postpartum Non-Susceptibility (Liberia)

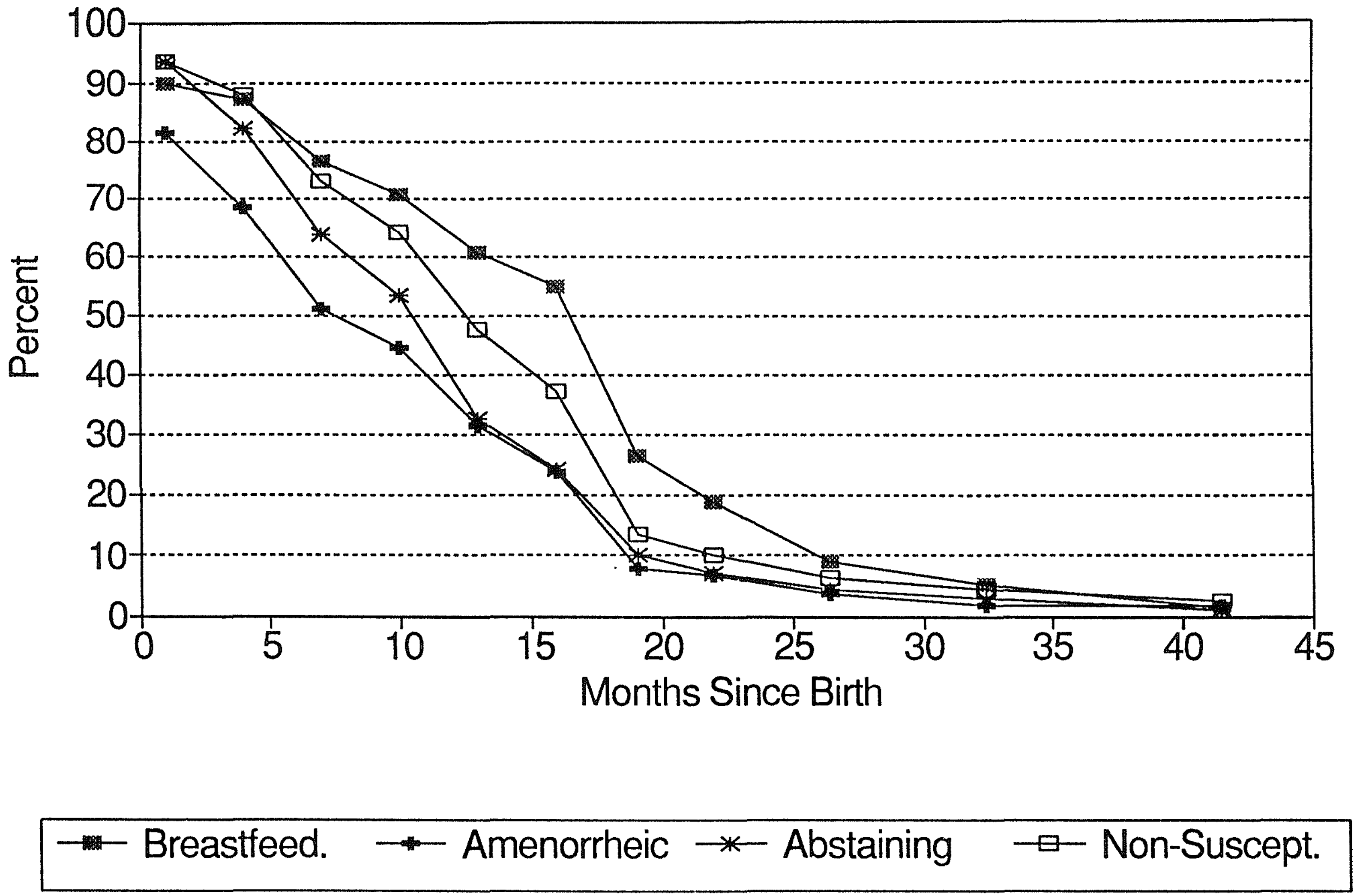


Table_5.3.2.3.1:_LDHS_Weighted_Percent_Breastfeeding,_Amenorrheic Abstaining_and_Non-Susceptible_by_Months_Since_Birth

Months Since Birth	% Breastfeed	% Amenorrheic	% Abstain	% Non-Susceptible	No. of Cases
0-2	89.6	81.2	93.5	93.5	308
3-5	87.3	68.4	82.1	87.6	307
6-8	76.2	51.0	63.9	72.8	357
9-11	70.8	44.6	53.7	64.4	298
12-14	60.5	31.7	32.8	47.6	271
15-17	54.8	24.0	24.4	37.1	221
18-20	26.7	8.0	10.2	13.9	187
21-23	19.0	6.5	7.0	10.0	200
24-29	9.2	3.7	4.7	6.3	489
30-35	5.1	1.8	3.1	4.6	390
36-47	1.3	1.8	1.1	2.3	875

The median duration of breastfeeding of the sample is 17 months, that of amenorrhea is 10 months and that of abstinence is 11 months. The median duration of postpartum non-susceptibility is 13 months. The proportions abstaining are larger than the proportions amenorrheic for all durations since birth below 36 months. This suggests that abstinence is the predominant limiting factor for durations of postpartum non-susceptibility.

Durations of breastfeeding tend to be relatively short in Montserrado county and are relatively long in Lofa, Kru Coast, Cape Mount and Grand Gedeh counties. The Kru/Sapo have the shortest durations of breastfeeding whilst the Gbandi have the longest. Generally, durations of breastfeeding tend to be shorter among the Kwa speaking tribes than among the other ethnic categories. Among the religious categories, Christians practise the shortest durations of breastfeeding whilst women with no religion practise the longest durations of breastfeeding. Women who live in urban areas have noticeably shorter durations of breastfeeding than women who live in rural areas. Women who were brought up in Monrovia practise considerably shorter than average durations of breastfeeding. Durations of breastfeeding decline considerably with increasing levels of female education

Durations of amenorrhea tend to be relatively short in Montserrado county (median around 7 months) and in the counties along the coast to the south of Monrovia (i.e. Grand Bassa, Rivercess, Sinoe and Maryland) and relatively long in the interior of Liberia (i.e. Lofa, Bong, Nimba and Grand Gedeh counties). Among tribes, the Bassa, the Grebo, Other/None and Kru/Sapo tend to have relatively short durations of amenorrhea, whilst the Gola have the longest durations of amenorrhea. Generally, the Kwa speaking tribes tend to have shorter durations of amenorrhea than the Mande and West Atlantic ethno-linguistic groups. Among religious groups Christians tend to have the shortest durations of amenorrhea and traditional/other and women with no religion tend to have the longest durations. Women who live in urban areas tend to have shorter durations of amenorrhea than women who live in rural areas. Women who were brought up in Monrovia have considerably shorter than average durations of amenorrhea. Women with secondary level or above education have considerably shorter than average durations of amenorrhea.

Durations of abstinence vary considerably between the counties of Liberia with the shortest durations of abstinence being in Grand Bassa, Maryland and Montserrado counties and the longest being found in Lofa (median around 23 months). Among tribes, the Kru/Sapo, Grebo and Bassa have the shortest durations of abstinence, whilst the Gbandi practise the longest durations. Among ethno-linguistic groups, the Kwa tend to have the shorter durations of abstinence than the Mande and the West Atlantic. Of the religious groups Protestants have the shortest durations of abstinence and women with no religion have the longest durations. Women who live in urban areas tend to have slightly shorter durations of abstinence than women who live in rural areas. The durations of abstinence among women with secondary level or above education (median around 6 months) are noticeably short (for mean durations of breasteeding, amenorrhea and abstinence see Chieh-Johnson *et al.* (1988, p26).

In Lofa county (median around 23 months) durations of postpartum non-susceptibility are considerably different from the overall pattern. The Gbandi tribe (median around 23 months) and the Gola (16 months) have the longest durations of non-susceptibility whilst the Kru/Sapo (median around 10 months) have the shortest durations. Generally, the Kwa-speaking women tend to have shorter durations of non-susceptibility than the Mande or West Atlantic ethno-linguistic groups. Among the religious categories, durations of non-susceptibility are only noticeably longer than average among women with no religion (median around 15 months). Women who live in urban areas have shorter durations of non-susceptibility (median around 10 months) than women who live in rural areas (13 months). Women who were brought up in Monrovia have considerably shorter than average durations of non-susceptibility (median around 8 months). Durations of non-susceptibility are considerably shorter than average among women with secondary level or above education (median around 9 months), but do not differ much between uneducated women and women with primary level only education (the median duration in both the latter two groups being around 13 months).

In almost all the above sub-categories of the LDHS sample the median duration of abstinence exceeds that of amenorrhea (the median duration of amenorrhea slightly exceeds that of abstinence only in Grand Gedeh, Kru Coast and Nimba counties). This indicates that it is largely abstinence which limits the duration of post-natal non-susceptibility.

Interestingly, women who have ever used a method of contraception tend to have shorter periods of breastfeeding, amenorrhea, and abstinence and post-natal non-susceptibility than women who have not used contraception (based on weighted median durations calculated by the current status method for the sample). This is shown in Table 5.3.2.3.2:

Table 5.3.2.3.2: LDHS Weighted Median Durations of Breastfeeding, Amenorrhea, Abstinence and Postpartum Non-Susceptibility by Contraceptive Use

	Median Duration (months)			
Contraceptive Use	Breastfeed	Amenorrhea	Abstinence	Non-Susceptible
Ever Used	11	6	7	7
Never Used	18	11	11	13

5.3.2.4 Sterility

There is little evidence of primary sterility among the women surveyed. Only 3.4% of ever married women aged 40-44 and 2.7% of ever married women aged 45-49 were childless (both figures are weighted).

All but two of the 26 (21 after weighting) supposedly sterile women have received no formal education. Most of these women were brought up in towns. Another notable characteristic of these childless, older, married women is that they are disproportionately drawn from the Kru/Sapo ethnic category.

5.3.3 Fertility Differentials

The sample shows that there are high levels of fertility in Liberia. The (weighted) TFR (based on weighted births less than five years before the survey to women aged 15-49) is 6.4. The (weighted) mean number of children ever born over all the women surveyed is 3.1. For those women at the end of their reproductive years (i.e. those women aged 45-49) the mean number of children ever born is 6.8. For the LDHS data the ratio of the mean number of children ever born to women at the end of childbearing (i.e. women aged 45-49) to the TFR (i.e. the P/F ratio) is 1.06. This could be interpreted either as suggesting that a slight decrease in fertility has taken place or as evidence of underreporting/undercounting of births during the five years preceding the survey (see van de Walle and Foster (1990) for a discussion).

5.3.3.1. Fertility and the Proximate Determinants

Married women have a higher TFR than women in other categories of marital status. The TFR for women in consensual unions is only slightly lower than that for married women. Levels of current fertility for divorced women are considerably below those for married women. The data show surprisingly high levels of fertility among never married women (TFR=3.5). This presumably reflects that, in Liberia, being childless is abhorrent even to women who do not want to be married, as well as the high levels of teenage pregnancy. Current fertility levels among women who are no longer living with a man are only slightly below those of women who are still cohabiting outside marriage. Widows have a higher (weighted) mean number of children ever born than any other category for marital status. Married women have a higher mean number of children than women in consensual unions and a higher mean number of children ever born than divorced women. Women in a consensual union have a higher mean number of children ever born than women who were no longer in such a relationship. Single women have the lowest mean number of children ever born. After standardizing these figures for age, widows still have the highest number of children ever born. There is no apparent difference in the cumulative fertility levels of married women and women in consensual unions. Divorced women have lower levels of cumulative fertility than married women. However, there is almost no difference between the standardized mean numbers of children of women in consensual unions and women who have ceased to be in such unions. Single women have the lowest fertility levels, however, it is worth noting that these fertility levels are far from negligible. Fertility levels by current marital status are shown in Table 5.3.3.1.1:

Table 5.3.3.1.1: LDHS Weighted Fertility Levels by Current Marital Status

Marital Status (+)	M.B.L.5Y. (a)	T.F.R. (b)	M.C.E.B. (c)	S.M.C.E.B. (d)
Single	0.46	3.5	0.7	2.0
Married	1.13	7.2	4.2	3.2
Living Together	1.16	7.1	3.4	3.2
Widowed	0.65	6.1	5.5	3.8
Divorced	0.73	4.5	3.3	2.7
Not Living Tog.	1.11	6.9	3.5	3.3

(+) The weighted numbers of cases are as in Table 5.3.2.1.2.
(a) Mean number of Births in the Last Five Years (i.e. 0-4 years before survey).
(b) Total Fertility Rate.
(c) Mean number of Children Ever Born.
(d) Standardized Mean number of Children Ever Born.

The TFRs show that current fertility is slightly higher among women in monogamous unions than among women in polygynous unions. Women in polygynous unions have a higher mean number of children than women in monogamous unions. However, standardization for age shows that the higher mean number of children ever born for women in polygynous unions is entirely due to the older ages of these women. After standardization, the numbers of children ever born was slightly higher for monogamous women. This is shown in Table 5.3.3.1.2:

Table 5.3.3.1.2: LDHS Weighted Fertility Levels by Polygyny

Any Other Wives	M.B.L.5Y. (a)	T.F.R. (b)	M.C.E.B. (c)	S.M.C.E.B. (d)
Yes	1.16	7.0	3.9	3.2
No	1.14	7.2	3.7	3.3

(a) Mean number of Births in the Last Five Years (i.e. 0-4 years before survey).

(b) Total Fertility Rate.

(c) Mean number of Children Ever Born.

(d) Standardized Mean number of Children Ever Born.

TFRs show that levels of current fertility among women who have not used contraception are slightly higher than among women who have ever used contraception and considerably higher than among current users of contraception (see Table 5.3.3.1.3).

Women who are currently using contraception or have ever used contraception have higher mean numbers of children ever born than women who have not used contraception. This finding is in line with similar findings by the Caldwells (1986) for Ibadan, Nigeria and Bhatia (1986) for rural Ghana. The Caldwells explained their finding by the shorter durations of breastfeeding, amenorrhea and abstinence practised by contraceptors (as reported earlier this was also the case for the women in the Liberia DHS). Bhatia explains his finding by stating that in developing countries contraception is usually sought by women already burdened by a large number of children. It is interesting that standardization for age leaves the mean numbers of children ever born virtually unchanged. Fertility levels by use of contraception are as presented in Table 5.3.3.1.3:

Table_5.3.3.1.3:_LDHS_Weighted_Fertility_Levels by_Contraceptive_Use

Contraceptive Use	M.B.L.5Y. (a)	T.F.R. (b)	M.C.E.B. (c)	S.M.C.E.B. (d)
Never Used	0.96	6.5	3.0	3.0
Ever Used Any	1.05	6.3	3.5	3.5
Ever Used Modern	1.03	6.2	3.6	3.5
Current User	0.87	5.3	3.4	3.4

(a) Mean number of Births in the Last Five Years (i.e. 0-4 years before survey).

(b) Total Fertility Rate.

(c) Mean number of Children Ever Born.

(d) Standardized Mean number of Children Ever Born.

5.3.3.2 Fertility_Differentials_by_Background_Characteristics

The sample shows that there are high levels of fertility in Liberia. The (weighted) TFR (based on weighted births less than five years before the survey to women aged 15-49) is 6.4. The (weighted) mean numbers of births less than five years before the survey show that peak reproductive ages are between 20 and 29. Current fertility is low among 15-19 year olds presumably because many of these women are single (see Sections 5.3.2.1 and 5.3.3.1). However, the levels of fertility in this group are far from negligible, indicating that Liberia has a problem with teenage pregnancy. Current fertility among 45-49 year olds is also low, presumably because many of these women have become subfecund (see Section 1.3.6) or have voluntarily decided to cease childbearing (see Section 1.3.4.3.2). The (weighted) mean number of children ever born over all the women surveyed is 3.1. For those women at the end of their reproductive years

(i.e. those women aged 45-49) the mean number of children ever born is 6.8. As would be expected the mean number of children increases with each successive five-year age group. These increases are smaller between the 35-39 age group and the 40-44 age group and between the 40-44 age group and the 45-49 age group than between other (younger) age groups. This would reflect declining fecundity and some of these women becoming infecund or voluntarily deciding to cease childbearing. The (weighted) mean numbers of births less than five years before the survey and (weighted) mean numbers of children ever born for each five year age group (and comparable figures for the 1984 census) are presented in Table 5.3.3.2.1:

Table_5.3.3.2.1:_LDHS_Weighted_Fertility_Levels_by_Age

Age	Mean No. Births Last 5 Years(*)	Mean No. Children Ever Born 1986 LDHS	1984 Census
15-19	0.5	0.5	0.9
20-24	1.3	1.8	2.3
25-29	1.4	3.2	3.5
30-34	1.2	4.2	4.7
35-39	1.0	5.3	5.5
40-44	0.7	5.9	6.0
45-49	0.4	6.8	6.2

(*) i.e. weighted mean number of babies born less than 60 months before the survey. The age of a baby was calculated from data on the month and year of birth and the month and year of interview. For some births in 1981 the month of birth was missing. These births were NOT counted as births within the 5 year period.

The true underlying level of fertility may have been even higher than was shown by the data due to under-reporting. However, the significant increases in the numbers of children reported for the

LDHS sample between the 35-39 age group and the 40-44 age group and between the 40-44 age group and the 45-49 age group indicate that under-reporting is unlikely to have been a major factor. This contrasts with the slight increase in fertility levels between the 40-44 age group and the 45-49 age group for the census data which indicates that under-reporting of births may be significant among women aged 45-49.

Levels of current fertility differ considerably between the regions of Liberia. Cape Mount, Bomi, Grand Gedeh and Sinoe have the highest TFRs whilst Lofa and Montserrado have TFRs which are significantly below the national average. Furthermore, there are considerable differences in the levels of cumulative fertility between the counties of Liberia. Standardized mean numbers of children ever born differ considerably between the counties of Liberia. The highest standardized mean numbers of children ever born are in Grand Kru and Bomi and the lowest standardized mean numbers of children ever born are in Lofa and Nimba.

The TFRs differ considerably between tribes and to some extent these differences reflect differences in fertility between the regions in which these tribes are concentrated. The Vai, Krahn and Kpelle tribes have the highest TFRs whilst the Mende, Lorma and Other/None ethnic categories have the lowest TFRs. There is considerable variation in the levels of cumulative fertility between tribes. Standardized mean numbers of children ever born are highest for the Vai and the Grebo and lowest for the Other/None group and the Mandingo.

When tribes are grouped into ethno-linguistic categories, the Kwa (Kru) speaking women tend to have the highest levels of fertility and women in the "Other" category tend to have the lowest levels of fertility.

Christians have lower (weighted) levels of current and past fertility than women from other religious categories. Differences in levels of current fertility between Muslim women, women with "other" religions and women with no religion are slight. Differences in standardized numbers of children ever born between religious groups are slight. This finding is similar to that of Gisilanbe (1990) (see Section 5.2.2).

As in other African countries (see Section 1.2.2.1), women in urban areas have lower levels of current fertility levels than women in rural areas. Women in the large urban area of Greater Monrovia have lower levels of current and past fertility than other smaller urban areas. However, the contrast between fertility in urban areas and rural areas is perhaps not as great as elsewhere in sub-Saharan Africa (c.f. Section 1.2.2.1). Women in rural areas also tend to have higher numbers of children ever born than women in urban areas and women in Greater Monrovia tend to have fewer children ever born than women in other urban areas. However, these differences in numbers of children ever born are largely due to the older ages of women in rural areas and younger ages of women in Monrovia. After standardization for age differences in numbers of children ever born by type of place of residence are slight (this is consistent with findings by Kollehon (1986) - see Section 5.2.2.1).

Women who were brought up in Monrovia have the lowest levels of current fertility. It is interesting to note that women who were brought up in cities other than Monrovia have the highest levels of current fertility. Women who were brought up in Monrovia also had a considerably lower (weighted) mean number of children ever born than women brought up in other areas. However, this was partly because of the younger average age of these women The standardized mean number of children ever born for women brought up in Monrovia is only slightly below average. Partially literate women have a higher TFR and standardized mean number of children than both illiterate and literate women. Similarly the LDHS data show a "curvilinear" relationship between a woman's level of education and her fertility for both current and cumulative levels of fertility with women whose highest level of education was primary school having the highest fertility levels and women who have had higher or vocational education having the lowest fertility levels. This contrasts with the "inverse" relationship observed for data from the 1984 census (Gisilanbe (1990)- see Section 5.2.2).

Mean numbers of births 0-4 years before the survey, TFRs, mean numbers of children ever born and standardized mean numbers of children ever born by backgound characteristics are presented in Table 5.3.3.2.2:

Table 5.3.3.2.2: LDHS Weighted Fertility Levels by Background Characteristics

Characteristic (+)	M.B.L.5Y. (a)	T.F.R. (b)	M.C.E.B. (c)	S.M.C.E.B. (d)
County				
Bomi	1.13	7.6	3.9	3.7
Bong	1.10	6.9	3.3	3.3
Grand Bassa	1.02	6.8	3.5	3.3
Cape Mount	1.19	7.6	4.1	3.5
Grand Gedeh	1.08	7.5	4.0	3.6
Grand Kru	1.11	7.2	3.3	3.8
Lofa	0.85	5.6	2.6	2.7
Margibi	1.06	6.9	3.1	3.2
Maryland	0.77	5.9	2.5	3.3
Montserrado	0.89	5.7	2.8	3.0
Nimba	0.92	6.0	3.0	2.8
Rivercess	1.15	6.9	3.4	3.2
Sinoe	1.04	7.4	3.6	3.6
Tribe				
Bassa	0.98	6.4	3.2	3.2
Belle	1.28	N.A.(*)	3.2	N.A.(*)
Dey	1.26	6.8	3.7	3.3
Gbandi	0.96	6.5(**)	2.7	2.9 (**)
Gio	0.93	6.0	3.1	2.9
Gola	0.84	5.9	3.3	3.3
Grebo	0.97	6.7	3.3	3.6
Kissi	1.08	6.7	3.2	3.1
Kpelle	1.05	6.9	3.4	3.2
Krahn	1.05	7.1	3.4	3.5
Kru/Sapo	0.97	6.5	3.5	3.4
Lorma	0.75	5.5	2.5	2.8
Mandingo	1.01	6.3	2.5	2.6
Mano	0.95	6.3	2.9	2.9
Mende	0.71	3.2	2.5	2.8
Vai	1.18	7.8	3.6	3.6
Other/None	0.86	5.6	2.2	2.4

Characteristic (+)	M.B.L.5Y. (a)	T.F.R. (b)	M.C.E.B. (c)	S.M.C.E.B. (d)
<u>Ethnic Group</u>				
Kwa	0.99	6.6	3.3	3.4
Mande	0.98	6.4	3.0	3.0
West Atlantic	0.95	6.2	3.3	3.2
Other	0.86	5.6	2.2	2.4
<u>Religion</u>				
Protestant	0.92	6.1	3.1	3.2
Catholic	0.92	5.9	2.8	3.0
Muslim	1.07	6.7	3.1	3.1
Traditional/Other	1.06	6.9	3.3	3.2
None	1.02	6.8	3.1	3.0
<u>Type of Place of Residence</u>(#)				
Rural	1.01	6.7	3.3	3.1
Monrovia	0.91	5.8	2.7	3.0
Another City	0.93	6.1	2.9	3.2
Urban	0.92	6.0	2.8	3.1
<u>Type of Place of Childhood Reidence</u>				
Village	0.97	6.3	3.3	3.0
Town	0.99	6.6	3.4	3.1
Monrovia	0.89	5.5	2.4	3.0
Another City	1.00	6.6	3.0	3.3
<u>Literacy</u>				
Literate	0.80	4.8	2.1	2.8
Partly Literate	0.92	7.0	2.1	3.5
Illiterate	1.04	6.7	3.6	3.1
<u>Highest Level of Education</u>				
No education	1.04	6.6	3.7	3.1
Primary	0.92	7.1	2.1	3.6
Secondary	0.87	5.1	2.2	3.1
Higher/Vocational	0.58	2.9	2.2	1.9

(+) The weighted numbers of cases are as in Tables 5.3.1.2 to 5.3.1.9.

(a) Mean number of Births in the Last Five Years (i.e. 0-4 years before survey).

(b) Total Fertility Rate.

(c) Mean number of Children Ever Born.

(d) Standardized Mean number of Children Ever Born.

(*) The number of women from the Belle tribe was too small for a total fertility rate or a standardized mean number of children ever born to be calculated.

(**) The total fertility rate and the standardized mean number of children ever born for the Gbandi tribe are based on imputed mean numbers of births in the last 5 years and children ever born of 0.92 and 5.9 respectively for the 40-44 age group (i.e. the means for women aged 40-44 in the sample as a whole) because there were no Gbandi women in this age group.

(#) see Table 5.3.1.5. for details of these categories.

5.4 Differentials in Fertility Between Communities

5.4.0 Introduction

In this section I describe differentials in fertility between communities/neighbourhoods in Liberia using data from the LDHS. The clusters (i.e. census enumeration areas) used as part of the sampling scheme are used as a representation of communities/neighbourhoods. As mentioned in Section 5.3.0, 156 such clusters were included in the sample. Information on the location of these clusters is presented in Appendix 5C.

In Chapter 4 I argued that the community environments in which women live form an integral part of quasi-anthropological explanations of fertility levels in sub-Saharan Africa. However, differentials in fertility levels and in the proximate determinants of fertility by the community in which a woman lives seldom, if ever, appear in descriptions of fertility data. The most likely reason for this would seem to be the difficulties associated with summarising such differentials. In Section 5.4.1 I discuss these difficulties and outline the method used for summarising inter-community differentials in fertility during in the rest of Section 5.4.

5.4.1 Method of Summary of Between-Community Differentials in Fertility

Due to the large number of communities/clusters included in the sample, description of the between-community differentials using the within-community mean values of measures of fertility or of proximate determinants of fertility would be cumbersome (see Section 2.2.1). Using summary statistics, in particular the mean and variance, to describe the distribution of the "true" within-community means is a far more concise method of description. This is the approach used here. As mentioned in Chapter 2, it should be noted that the mean and variance of the set of actual/"raw" estimates of within-community means are not the best estimates of the mean and variance of the population of "true" within-community means because:

a) the reliability of these estimates varies due to the different numbers of women per community,

b) some of the variance between the "raw" estimates of within-community means is attributable to sampling variation.

A method by which the "true" mean and variance of the within-community means can be estimated is random effects analysis of variance (see Section 2.2.3).

A second consideration when summarising the between-community differentials is that, although, in general, levels of measures of fertility or of proximate determinants of fertility in individual communities are unlikely to be of great interest, identifying those communities which have the highest or the lowest levels of fertility, marriage or contraceptive use is undoubtedly of interest. It is to be noted that the ordering by size of the "raw" estimates of within-community means is highly susceptible to the effects of sampling with communities containing few observations being prone to a relatively high or a relatively low estimated mean. However, the ordering of the so-called shrunken/posterior means estimated as part of a random effects analysis of variance should be far less susceptible to the effects of sampling variation. Laird and Louis (1989) discuss this issue at length and propose a method of ranking based on the expectation of the posterior rank. They also show that if the within-cluster variance is constant across clusters the ordering of the posterior means is identical to that produced by their method. Hence, in the following summaries communities with particularly high or particularly low fertility are identified using the ordering of the shrunken means.

In the case of the LDHS data the need to weight the data complicates the analysis of residuals. It is noted that even in the case of single-level models there are no firmly established ground rules for the analysis of residuals when the data have unequal weights. In the following analyses the shrunken means used to indicate the communities with the highest or lowest underlying levels of fertility and to check normality of the distribution of the population of such means are the sum of:

i) the weighted estimated population mean,

ii) shrunken residuals where the shrinkage factor for each community is based on the weighted estimate of the between-community variance, the weighted estimate of the within-community variance and the number of women sampled in that community.

It should be noted that the influence of a community on the parameters of a random effects analysis of variance model depends on the weight for that community.

5.4.2 Differentials In the Proximate Determinants of Fertility Between Communities

5.4.2.1 Marriage

The (weighted) random effects analysis of variance shows significant variance in the proportion of women aged 15-49 years in a community who are currently "married" (women in consensual unions being counted as "married"). The estimated "true" between-community variance is 0.02 (standard deviation = 0.13). This constitutes roughly 7% of the total variance. The between-community variance is clearly significant as the estimated standard deviation is (0.13) and its estimated standard error is only (0.011). The distribution of the shrunken means is roughly normal (see Figure 5.4.1 in Appendix 5G). Hence, over the population of all "true" within-cluster means, roughly 68% of clusters will have a "true" proportion of women aged 15-49 who are married in the range (0.57, 0.82) and roughly 95% of clusters will have a "true" proportion of women aged 15-49 who are married in the range (0.44, 0.95). The parameters of the (weighted) random effects ANOVA are presented in Table 5.4.1:

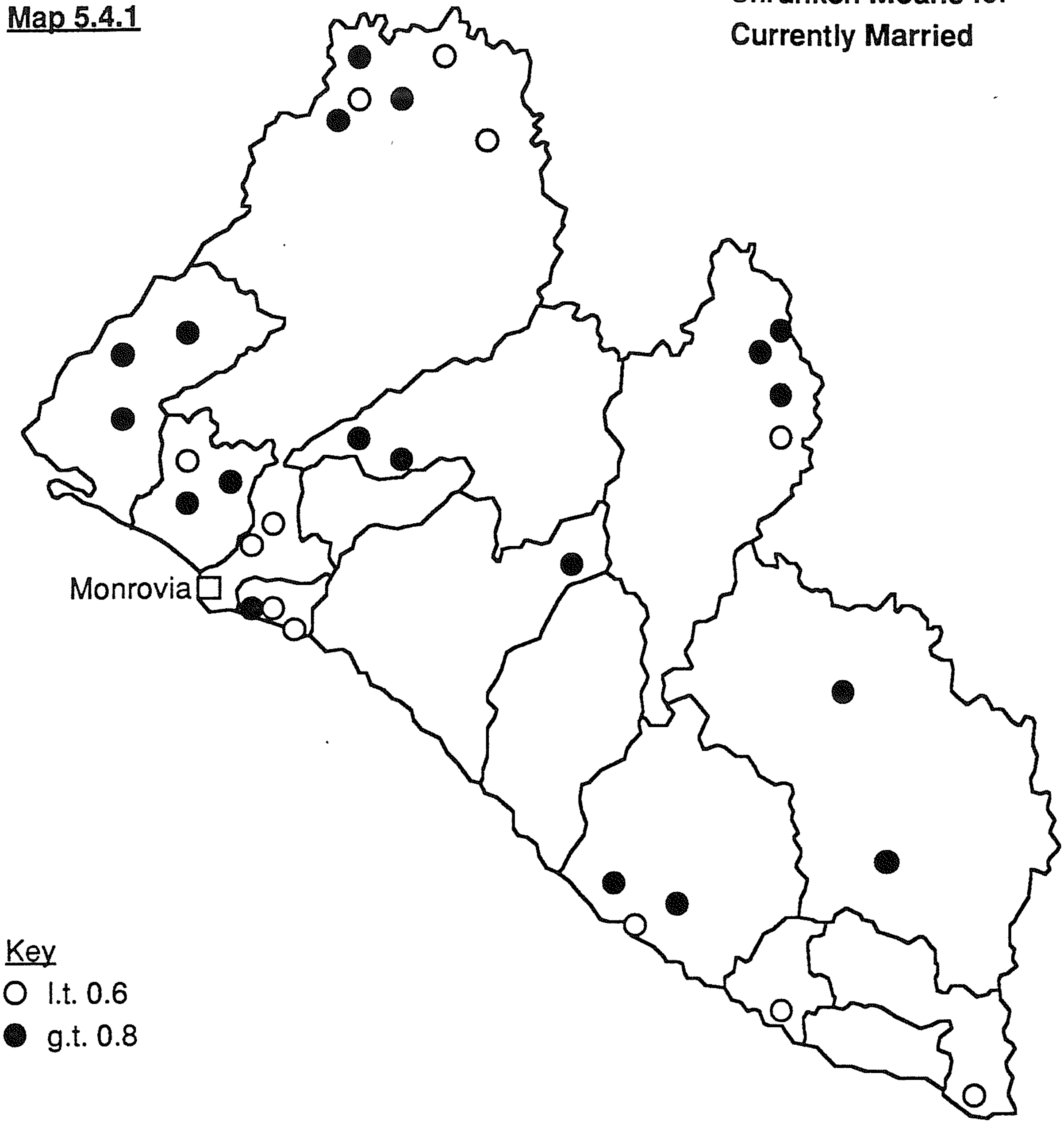
Table 5.4.1: Weighted Random Effects ANOVA for Currently Married

Parameter	Estimate
Fixed	
Constant	0.69
Random	
Between-community variance	0.02
Within-community variance	0.20
Intra-cluster correlation	0.07

Of the communities sampled only Harper (no. 408) is an outlier to the distribution of shrunken means. Map 5.4.1 shows the (approximate) locations of the clusters with a relatively high or a relatively low shrunken mean for "currently married". The communities with relatively high shrunken means tend to be rural and whilst those with relatively low shrunken means tend to be in urban areas, particularly in Greater Monrovia. The relative value of a shrunken mean is determined by the "raw" mean and the number of observations for that community (which determines the "shrinkage factor" - see Section 2.3.1.1.4). It therefore follows that a communities in the DHS sample but not shown on Map 5.4.1 is not particularly noteworthy either because its raw mean is close to the national average or because the sample contains only a few observations from that community and so the raw mean has been subjected to considerable shrinkage. The five communities with the lowest shrunken means and the five communities with the highest shrunken means are presented in Table 5.4.2. The raw and shrunken means for all communities sampled are

Map 5.4.1

Shrunken Means for Currently Married



presented in Appendices 5D and 5E respectively.

Table 5.4.2: Highest/Lowest Shrunken Means Currently Married

Rank	Cluster No.	Township	County	Shrunken Mean
1	408	Harper	Maryland	0.41
2	335	Monrovia	Montserrado	0.46
3	121	Greenville	Sinoe	0.46
4	348	Virginia	Montserrado	0.46
5	310	Voinjama	Lofa	0.50
152	320	Gutheria Pl.	Bomi	0.87
153	219	(rural)	Gr. Gedeh	0.88
154	218	(rural)	Gr. Gedeh	0.88
155	312	(rural)	Lofa	0.90
156	397	Slorlay	Nimba	0.90

5.4.2.2 Contraception

5.4.2.2.1 Current Use of Contraception

The (weighted) random effects ANOVA shows a significant variance across communities in the proportion of women who are currently using a method of contraception. The estimated "true" between-community variance is 0.005 (standard deviation = 0.07) and constitutes roughly 6% of the total variance. The estimated standard deviation is twelve times the size of its standard error. The distribution of the shrunken means has a marked positive skew (see Figure 5.4.2 in Appendix 5G)(n.b. approximation of this distribution by a normal distribution should be invalid as the overall mean (0.08) is less than 0.1 - e.g. Anderson (1988, p132)). The positive skew reflects the sizable number of communities in which none of the women sampled is using a method of contraception. The parameters of the (weighted) random effects ANOVA are presented in Table 5.4.3:

Table 5.4.3: Weighted Random Effects ANOVA for Currently Using Contraception

Parameter	Estimate
Fixed	
Constant	0.08
Random	
Between-community	0.005
Within-community	0.07
Intra-cluster correlation	0.06

Map 5.4.2 shows that in large parts of the rural hinterland contraception is virtually unused. The communities with relatively high contraceptive use are mostly in Greater Monrovia. However, not every community in Greater Monrovia has an above average proportion of women using contraception and in one cluster in Paynesville the raw mean is zero. The raw and shrunken means for each community are presented in Appendices 5D and 5E respectively. The five communities with the lowest shrunken means and the five communities with the highest shrunken means are presented in Table 5.4.4:

Map 5.4.2

Shrunken Means Currently Using Contraception

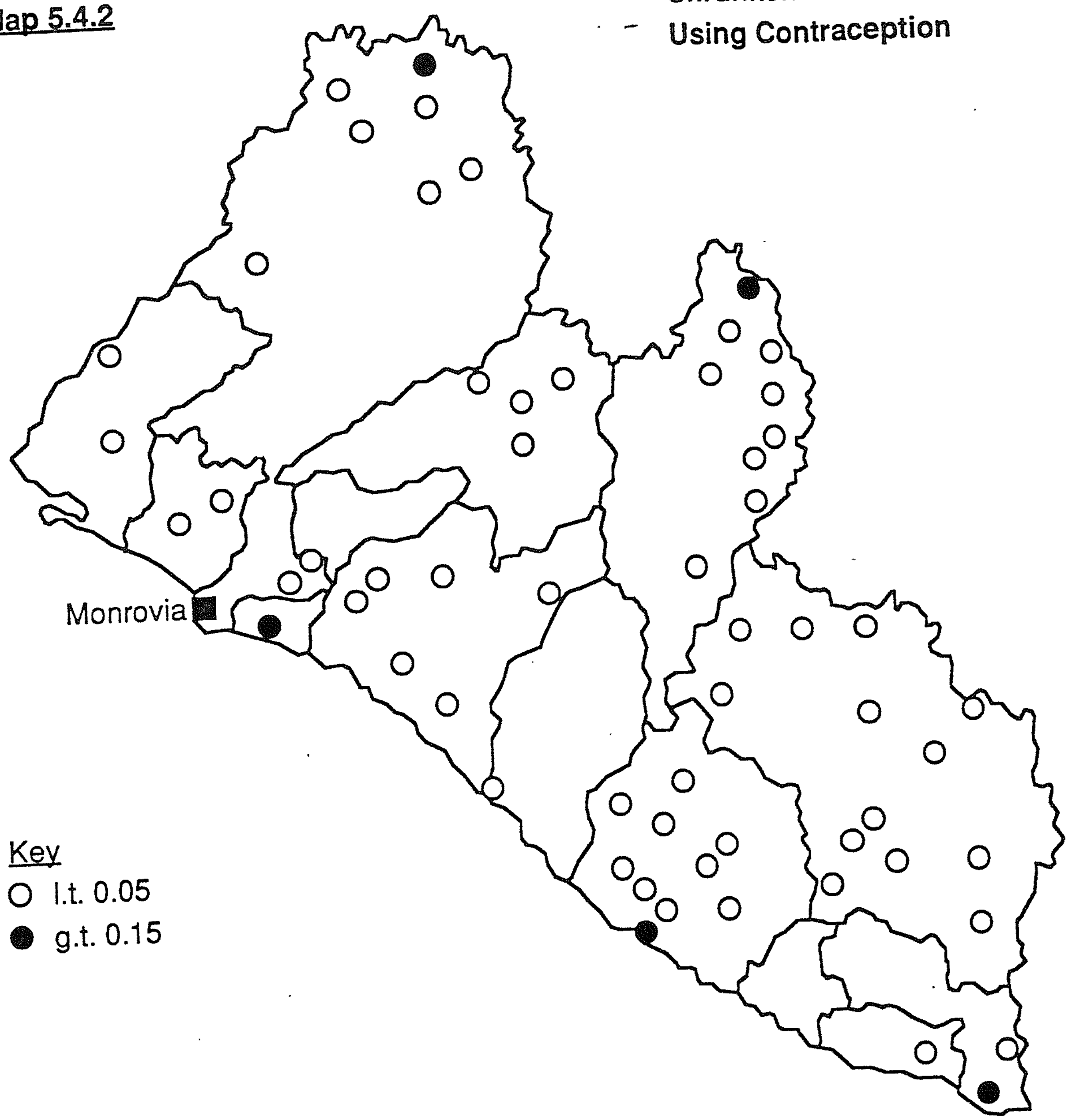


Table 5.4.4: Highest/Lowest Shrunken Means for Currently Using Contraception

Rank	Cluster No.	Township	County	Shrunken Mean
1	363	(rural)	Bong	0.02
2	390	(rural)	Nimba	0.02
3	221	(rural)	Gr. Gedeh	0.02
4	201	(rural)	Gr. Gedeh	0.02
5	211	Zwedru	Gr. Gedeh	0.02
152	321	Monrovia	Montserrado	0.23
153	310	Voinjama	Lofa	0.23
154	333	Monrovia	Montserrado	0.24
155	370	Charleville	Margibi	0.25
156	329	Monrovia	Montserrado	0.26

5.4.2.2.2 Ever Use of Contraception

The (weighted) random effects ANOVA shows significant variance in the proportion of women in a community who have ever used a method of contraception. The estimated "true" between-cluster variance is 0.02 (standard deviation = 0.13). This constitutes roughly 11% of the total variance. The size of the estimated standard deviation (0.13) relative to its estimated standard error (0.01) shows the between-community variance is significant. The distribution of the shrunken means has a positive skew (see Figure 5.4.3 in Appendix 5G). This reflects that in a number of communities none of the women sampled has ever used a method of contraception. The parameters of the (weighted) random effects ANOVA presented in Table 5.4.5:

Table 5.4.5: Weighted Random Effects ANOVA for Ever Used Contraception

Parameter	Estimate
Fixed	
Constant	0.20
Random	
Between-community	0.02
Within-community	0.15
Intra-cluster correlation	0.11

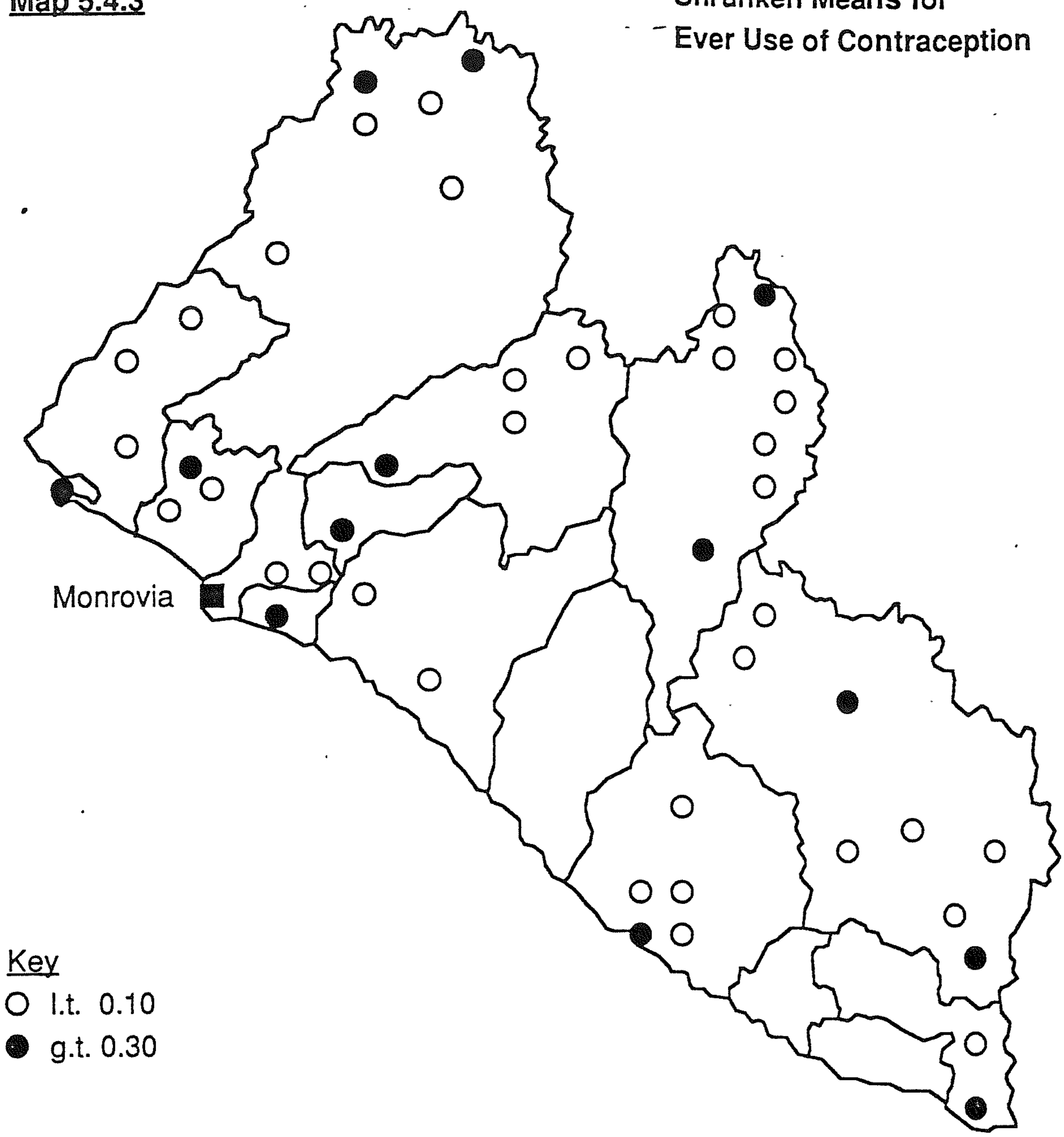
The raw and shrunken means for each community presented in Appendices 5D and 5E respectively. Map 5.4.3 shows that the communities with relatively high shrunken means tend to be rural and those with relatively low shrunken means tend to be urban. Zoegeh district in Nimba county is an area of noticeably low contraceptive use with the raw proportion of women having ever used contraception in three of the four clusters in this district being zero. The five lowest shrunken means and the five highest shrunken means are presented in Table 5.4.6:

Table 5.4.6: Highest/Lowest Shrunken Means Ever Used Contraception

Rank	Cluster No.	Township	County	Shrunken Mean
1	221	(rural)	Gr. Gedeh	0.03
2	393	(rural)	Nimba	0.03
3	392	(rural)	Nimba	0.03
4	394	(rural)	Nimba	0.03
5	313	(rural)	Lofa	0.04
152	311	Voinjama	Lofa	0.42
153	330	Monrovia	Montserrado	0.44
154	310	Voinjama	Lofa	0.47
155	341	Monrovia	Montserrado	0.47
156	370	Charleville	Margibi	0.53

Map 5.4.3

Shrunken Means for Ever Use of Contraception



5.4.3 Differentials in Fertility Between Communities

5.4.3.1 Current Fertility

The (weighted) random effects ANOVA shows a slight but significant between-community variance in current fertility as measured by the number of births to a woman in the last five years. The estimated "true" between-community variance is 0.02 (standard deviation = 0.15). This constitutes only about 2% of the total variance. However, the estimated standard deviation (0.15) is roughly seven times the size of its standard error (0.02), indicating that the between-community variance is significant. The distribution of the shrunken means is roughly normal (see Figure 5.4.4 in Appendix 6G). Hence, over the population of communities, roughly 68% of within-community means will lie in the range (0.84, 1.14) and roughly 95% will lie in the range (0.69, 1.29). The parameters of the (weighted) random effects ANOVA are presented in Table 5.4.7:

Table 5.4.7: Weighted Random Effects ANOVA for Children Born in the Last Five Years

Parameter	Estimate
Fixed	
Constant	0.99
Random	
Between-community	0.02
Within-community	0.92
Intra-cluster correlation	0.02

Arthington (cluster no. 347) is an outlier to the distribution of shrunken means. The raw and shrunken means for each community are presented in Appendices 5D and 5E respectively. The communities with noticeably lower than average fertility tend to be either in or near Monrovia or in the one of the other larger urban areas on the coast or in Lofa county. The communities with higher than average fertility tend to be rural (see Map 5.4.4). The lowest and highest shrunken means are presented in Table 5.4.8. Of the communities with the lowest shrunken means some (e.g. No. 408 Harper) have a low shrunken mean for "currently married" whilst others (e.g. No. 310 Voinjama) have a high shrunken mean for "current use of contraception".

Table 5.4.8: Highest/Lowest Shrunken Mean Children Born in the Last Five Years

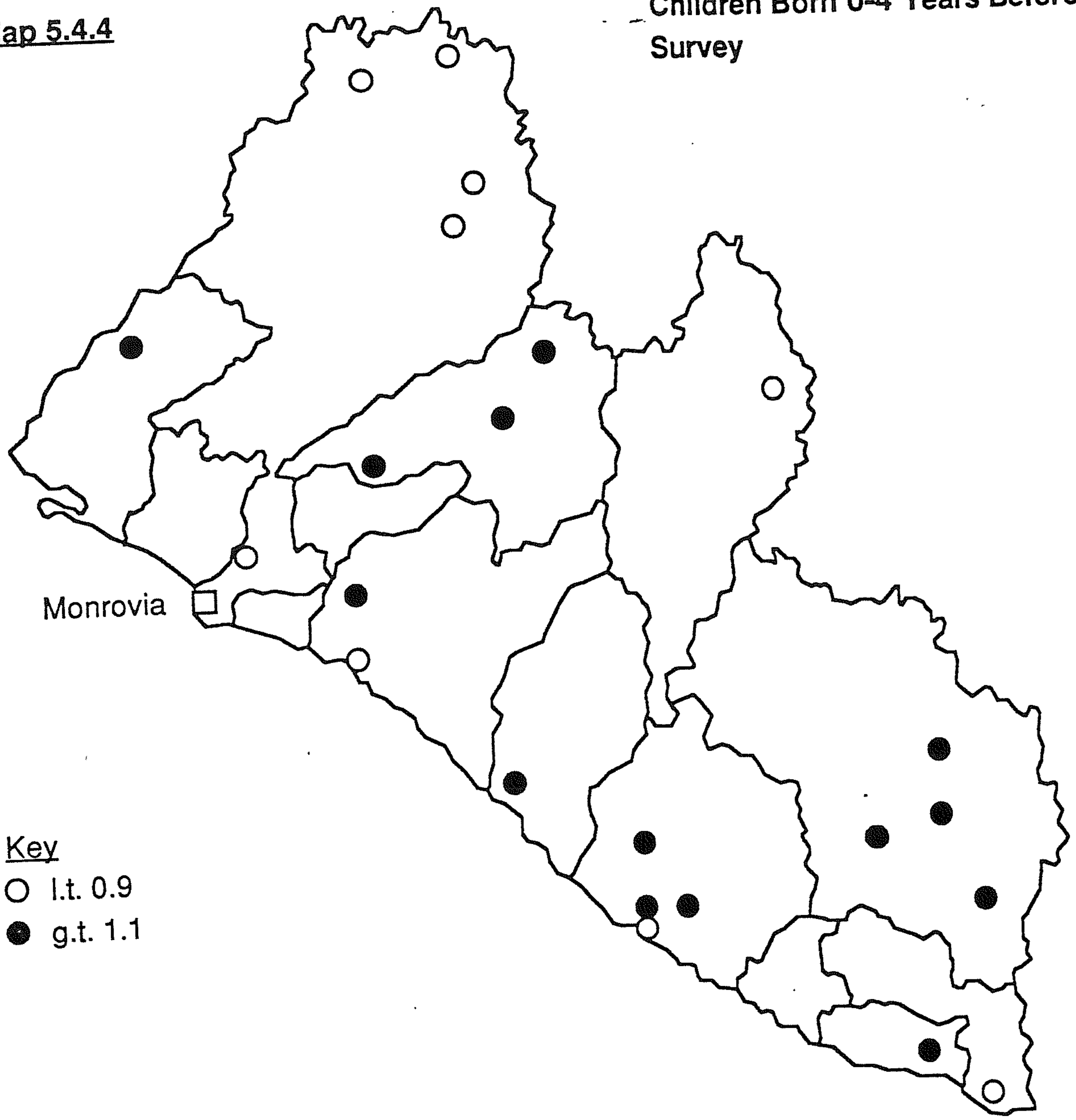
Rank	Cluster No.	Township	County	Shrunken Mean
1	347	Arthington	Montserrado	0.67
2	408	Harper	Maryland	0.78
3	310	Voinjama	Lofa	0.80
4	333	Monrovia	Montserrado	0.81
5	327	Monrovia	Montserrado	0.81
152	364	(rural)	Bong	1.17
153	214	(rural)	Gr. Gedeh	1.17
154	215	(rural)	Gr. Gedeh	1.19
155	357	Nyien	Bong	1.20
156	218	(rural)	Gr. Gedeh	1.27

5.4.3.2 Cumulative Fertility

The (weighted) random effects ANOVA shows significant between-community variance in the number of children ever born to a woman. The estimated between-cluster variance is 0.33 (standard deviation = 0.58). This constitutes roughly 4% of the total variance. The estimated standard deviation (0.58) is

Map 5.4.4

Shrunken Mean Numbers of Children Born 0-4 Years Before Survey



roughly seven times the size of its standard error (0.006). The distribution of the shrunken means is roughly normal (see Figure 5.4.5 in Appendix 6G). Hence, over the population of all communities, in roughly 68% the "true" mean number of children ever born will be in the range (2.63, 3.79) and in roughly 95% the "true" mean number of children ever born will be in the range (2.06, 4.37). The parameters of the (weighted) random effects ANOVA are presented in Table 5.4.9:

Table 5.4.9: Weighted Random Effects ANOVA for Children Ever Born

Parameter	Estimate
Fixed	
Constant	3.21
Random	
Between-community	0.33
Within-community	8.12
Intra-cluster Correlation	0.04

The raw and shrunken means for each cluster are presented in Appendices 5D and 5E. Two communities in Grand Gedeh county (clusters no.223 and 208) are outliers to the distribution of shrunken means. Map 5.4.5 shows that communities where there is a notably higher than average number of children ever born children ever born are mainly in the rural areas of Sinoe and Grand Gedeh. The communities where there is a notably lower than average mean number of children ever born are mostly in Greater Monrovia. The communities with the lowest and highest shrunken means are shown in Table 5.4.10:

Map 5.4.5

Shrunken Mean Numbers of Children Ever Born

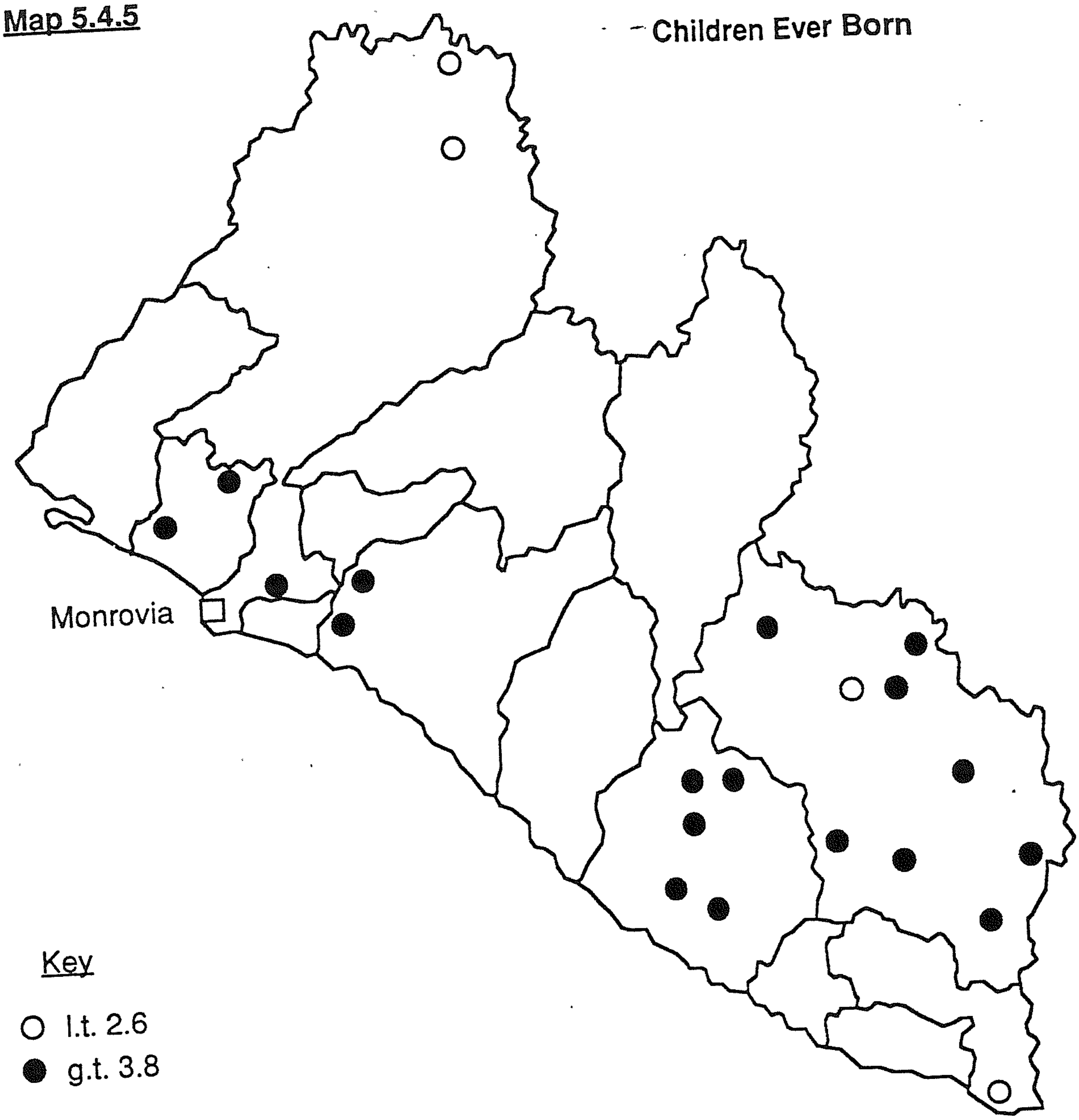


Table 5.4.10: Highest/Lowest Shrunken Mean Children Ever Born

Rank	Cluster No.	Township	County	Shrunken Mean
1	333	Monrovia	Montserrado	2.42
2	408	Harper	Maryland	2.43
3	325	Monrovia	Montserrado	2.44
4	310	Voinjama	Lofa	2.44
5	308	(rural)	Lofa	2.44
152	221	(rural)	Gr. Gedeh	4.39
153	214	(rural)	Gr. Gedeh	4.44
154	104	(rural)	Sinoe	4.50
155	223	(rural)	Gr. Gedeh	4.76
156	208	(rural)	Gr. Gedeh	4.82

5.5 Multilevel Models of Fertility in Liberia

5.5.0 Introduction

Although the fertility differentials described in Sections 5.3 and 5.4 are valuable for descriptive purposes, each of these differentials will reflect the influences of "confounding" factors on women's fertility in addition to those of the variable for which differences in fertility levels have been tabulated. For example, the lower fertility levels of Christian women could be partly or fully attributable to the higher educational levels of these women. Hence, there is a need for a multivariate modelling approach whereby the issue of whether a particular variable effects fertility independently of confounding factors can be assessed. As mentioned in Section 5.4, there are numerous communities (as defined by cluster) in the sample and these communities can be viewed as a random sample from the population of all such communities in Liberia. Hence, the effects of community are more appropriately modelled using a random effect than using fixed effects (see Chapter 2). The method of modelling which enables both the fixed effects (for variables described in Section 5.3) and a random effect for community to be properly estimated is multilevel modelling (see Chapter 4 for a general case for using multilevel models of fertility). Consequently, in this section I present multilevel models of fertility using the LDHS data.

The socioeconomic, cultural and community variables in Sections 5.3 and 5.4 affect fertility indirectly through their effects on the proximate determinants of fertility (see Section 1.1). Hence, the channels through which these effects operate need to be established both by multivariate, multilevel analyses of their effects on (values of variables describing) the proximate determinants and by quantifying the effects of the proximate determinants on fertility. Thus, as well as modelling the effects of chosen socioeconomic, cultural and community variables on fertility, I also model the effects of these variables on some measures of the proximate determinants of fertility[1].

[1]These analyses are performed separately with univariate response variables. Fitting a single model with a multivariate response variable (e.g. Goldstein (1987, ch.5), Liang, Zeger and Qaqish (1991)) would have been preferable. The ML3 software has only very recently been adapted to offer a facility for such analyses (Goldstein (1992)). Investigation of this seems an interesting area for further research.

5.5.1 Preliminary Considerations

5.5.1.1 The Response Variables Chosen

Two individual-level measures of fertility are used as response variables; the number of children born to a woman during the five years preceding a survey and the number of children ever born to a woman. These variables are tangible, easily interpreted, individual-level measures of current and cumulative fertility respectively. Some error in the measurement of the number of children born during the five years preceding the survey may occur as a result of underreporting of births or of misreporting of children's dates of birth. The number of children ever born to a woman is also susceptible to underreporting, particularly that of children born in the distant past to older women. Of the two measures of fertility, the number of births to a woman in the last five years is arguably more interesting by virtue of its being more contemporary (e.g. Hirschman and Guest (1990a, p376) and (1990b, p126)). In the case of an area like sub-Saharan Africa in which a fertility transition is anticipated or is already underway, focusing on current fertility is particularly important. Moreover, current fertility is more readily explained by data from a cross-sectional survey such as the LDHS than is cumulative fertility.

Of the proximate determinants of fertility, marriage and contraceptive use are arguably of greatest interest. Moreover, as it is current, as opposed to cumulative fertility which is of greatest interest, a variable indicating whether or not a woman is currently "married" (with women in consensual unions being counted as married) and a variable indicating whether or not a woman was currently using contraception were considered to be the most pertinent measures of marriage and contraceptive use to analyse. A variable indicating whether or not a woman has ever used contraception has also been analysed. As shown in Section 5.3, in Liberia postpartum amenorrhea and postpartum sexual abstinence are both very important determinants of fertility. Analysis of such differentials should be carried out using multilevel analogues of survival analysis models. Such analyses are outside the scope of this present work.

5.5.1.2 The Explanatory Variables Chosen

The explanatory variables used are measured at two levels; the individual (woman) and the community. This is because the fertility of a woman is determined both by the characteristics she may posess and by characteristics of the community in which she lives (see Chapter 4). For reasons discussed in Section 5.5.0, the effects of communities are more appropriately modelled using a random effect rather than a fixed effect. However, whilst assessment of whether "the community of residence" makes a difference to the fertility of a woman is important, it could be argued that identifying particular characteristics of a community which can (at least partially) account for such differences is yet more informative. Hence, as well as a random effect for community, variables (i.e. fixed effects) measured at the community level have also been included as explanatory variables.

The following explanatory variables have been included in the analyses:

A) Individual Level:

1) Woman's age. Six (0,1) dummy variables are used to indicate whether a woman is aged 15-19, 20-24, 25-29, 30-34, 35-39, 40-44 or 45-49, with women aged 15-19 forming the reference category.

2) Woman's education. Three (0,1) dummy variables are used to indicate whether a woman's highest level of education is none, primary, secondary or higher/vocational, with women with no schooling forming the reference category.

3) Woman's religion. Four (0,1) dummy variables are used to indicate whether a woman is Protestant, Catholic, Muslim, traditional/other or of no religion, with Protestants forming the reference category.

4) Woman's ethnic group. Three (0,1) dummy variables are used to indicate whether a woman's ethno-linguistic group is Kwa, Mande, West Atlantic, or "other", with Kwa forming the reference category. It is to be noted that these ethnic categories are not the ethnic groups/tribes with which Liberians themselves identify. However, because the tribes with which indigenous Liberians identify themselves are fairly numerous (and so a model containing a variable for each of these tribes would be cumbersome), these tribes have been grouped along linguistic lines to form a more manageable representation of ethnicity (see Section 5.1 for details of this).

B) Community level:

5) Urban-rural. This was not available from the data, but was constructed using information from the enumerators' file (see Section 5.3.1).

6) The levels of female education in a community. This is

measured by two variables;

i) the proportion of women in a cluster with primary-level education only.

ii) the proportion of women in a cluster with secondary-level education or above.

Each of these two variables has been estimated from the individual-level data and so will be subject to measurement/sampling error. These variables are interpreted as effects of primary level and secondary and above level education respectively at the community level over and above the effects of individual-level education. Such effects of the contextual level of education can be interpreted as:

a) educational opportunities. That is higher contextual levels of education indicate the proximity of educational facilities for the children. The desire for a better educated family motivates restriction of family size. Family planning workers in Liberia claimed that it was this demand for smaller, better educated families which was leading to an upsurge in the demand for family planning.

b) normative schooling effects (Entwisle *et al.* (1989, p26), Cochrane (1979, pp30-31)). That is, in communities with higher contextual levels of education norms will tend to be "westernized" (c.f. Caldwell (1982, ch. 10)).

c) a proxy for socioeconomic development, the degree of urbanization, and the degree of ethnic, socioeconomic and educational heterogeneity of the population (Lesthaeghe *et al.* (1985, p61)).

d) a proxy for women's status. A secondary dimension behind the contextual level of education is the relative status of women (the economic prosperity/development of a community and possibly the cost of education constitute the primary dimension). The relative status of women is likely to be inversely related to fertility (Mason (1985)).

The reason for including two variables for the contextual level of education stems from the depth/breadth contoversy regarding the effect of the contextual level of education. Caldwell (1982, ch. 10) stresses the importance of the breadth of education (as would be indicated by the proportion of women with primary education or above) as a determinant of the onset of fertility decline, whilst Hirschman and Guest (1990) argue the need to focus on an indicator of the proportion of women with modern household roles (for which they use the proportion of women in a community with secondary education or above). Using the two variables allows the relative utility of the two measures to be compared.

7) A random effect for community.

It is to be noted that in the following analyses "community" is represented by the cluster (i.e. census enumeration area) in which a woman lives. This choice of the representation of communities is discussed at length in Section 5.5.1.3.

It should also be noted that the LDHS did not include collection of community-level data. Moreover, there is a lack of published data (from e.g. census or other surveys) for the units at this level. Hence, the only available ways of obtaining community-level variables were to construct them either from personal "knowledge" (as in the case of urban-rural) or from the individual-level data (as in the case of the two X-bar-type variables: proportion primary only and proportion secondary or above).

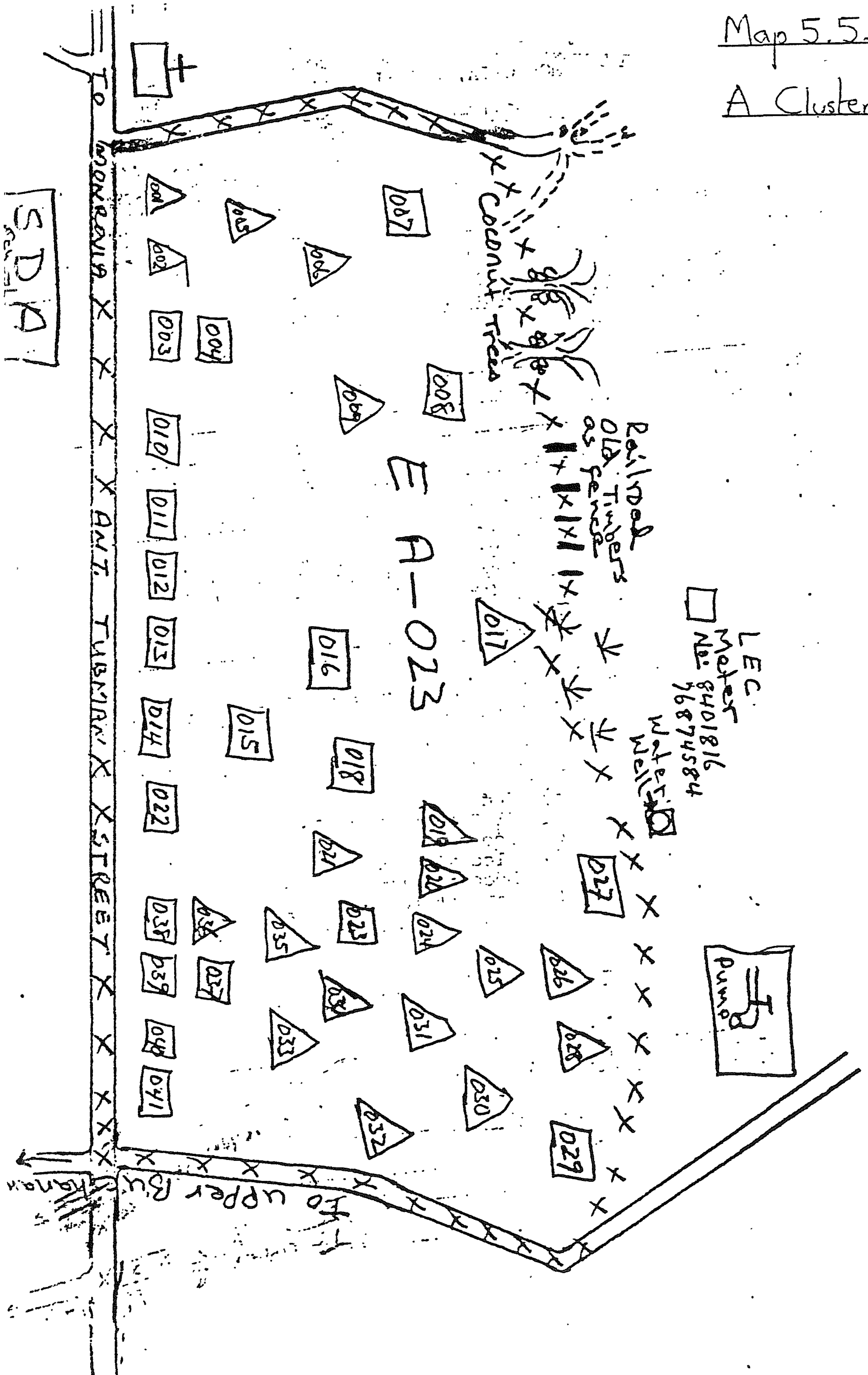
The explanatory variables used here have "indirect" effects on fertility at the individual level in the sense that they influence fertility through their effects on the proximate determinants of fertility (see Section 1.1). In order that the analyses of the chosen measures of proximate determinants of fertility can be linked to the analyses of fertility the same explanatory variables as used in the analysis of fertility were used in these analyses.

5.5.1.3 The Choice of Representation of Communities

The models fitted are two-level models using individual women as the level 1 units and the clusters (i.e. census enumeration areas) in which the women currently live as level 2 units. The LDHS obtained responses from 5239 women (level 1 units) living in 156 clusters (level 2 units) (Appendix 5C gives details of the locations of these clusters).

The level 2 units were chosen to give an approximate representation of "communities". Whilst I have argued in Chapter 3 that community characteristics are relevant to the determination of fertility patterns, this particular choice of representation of communities needs to be qualified with regard to its use in the modelling of numbers of chidren born in the last five years and the number of children ever born.

Firstly, the representation of communities is by arbitrary spatial areas chosen as part of the sampling scheme because of their convenience to administrators rather than because they were deemed to be meaningful sociological entities (Map 5.5.0 shows a cluster in Monrovia). Some clusters are contained within the same larger "community" (e.g. Monrovia) whilst other clusters may contain a number of smaller village "communities". Entwisle (1989) states that a meaningful representation of communities should involve mapping a neighbourhood defined in terms of social interaction onto a spatial grid. She suggests activity spaces and friendship patterns as possible criteria for encapsulating the wider concept of social interaction. In terms of modelling fertility this suggests that it would be desirable for women to be measured as part of the same cluster/community as, say, the family planning clinic they attend, the church they attend, the friends they are influenced by and so on. The boundaries of the clusters in the LDHS are defined by such things as streets, alleys, railroads and city limits in urban areas and by such things as roads, streams, creeks, bushes and imaginary lines in rural areas (Aliaga (1986))(e.g. the boundary of the cluster shown by Map 5.5.0.is formed by roads, coconut trees, a fence and an imaginary line passing through a water well). These boundaries have been chosen to satisfy criteria regarding the numbers of occupied structures in an enumeration area and of geographical contiguity (Republic of Liberia (1977, p6)). The arbitrary choice of such boundaries is likely to render them less than optimal in satisfying the criteria used to define "communities" both because of the sizes of the clusters and because of their shapes. Furthermore, it could be argued that the criteria suggested by Entwisle to define "communities" imply that either a cross-classified structure or a variable hierarchy (Goldstein (1987, ch. 7)) would be more appropriate. The representation of



Map 5.5.C

A Cluster in Monrovia

"communities" affects analyses of the data. In particular, the choice of arbitrary spatial areas as representations of "communities" is likely to understate the links between numbers of births to women and community level characteristics.

Secondly, communities will have changed over time due to migration, mortality and structural changes. Some of the women will have lived previously in other enumeration districts (although the extent of this is hard to ascertain because data on migration histories have not been collected), and even those women who have not migrated between areas will have experienced changes in their patterns of social interaction as a result of deaths, and the in-migration and out-migration of others. Moreover, the infrastructure in different areas will have changed over time. The number of children ever born to a woman reflects the cumulative exposure to determinants of fertility over time and so may reflect the nature of the community(ies) in which she lived in the past. Numbers of children born in the last five years reflect the cumulative exposure to determinants of fertility during the last 5 years and 9 months and also may be viewed as partly reflecting influences on a woman prior to this period (e.g. those which have infuenced whether she is married or has parity-specific reasons for using birth control). However, the models will only relate numbers of children born to a woman to current characteristics of the cluster in which she currently lives. Hence, the availability of current status data alone inhibits the explanation of the response variable (of course, this problem is considerably more important in the case of children ever born than for children born in the last five years).

The analysis of data faces the problem that differences between clusters in numbers of births may reflect non-random selection of women into these clusters as well as effects of communities per se. For example, it seems likely that the composition of samples from shanty towns in Monrovia reflect non-random selection processes whereby wealthy individuals and families have selected not to migrate to such areas. Ethnicity would seem to be another factor which is related to selection of the part of Monrovia into which an individual or a family migrates (e.g. Carter (1969)). This is reflected in the fact that various areas of Monrovia are named after ethnic groups (e.g. Bassa Community, Congotown, Loma Quarter, New Kru Town, Vai Town -see Appendix 5C).

The possibility of selection effects means that compositional differences between communities need to be controlled for before community effects can be identified.

5.5.1.4 <u>The Choice of Link Functions</u>

The number of births to a woman in the five years before the survey and the number of children ever born to a woman are both count-type variables, valued on the non-negative integers only and so the Poisson distribution is a more appropriate distributional form for this variable than, say, the normal or binomial distributions (e.g. McCullagh and Nelder (1983, pp14-16), Little (1978, p25) (this is the criterion of data admissibility in Chapter 3). It is to be noted that the assumption underlying this distribution that each woman in the population faces the same constant expectation over time of bearing a child does not hold in actual populations (Brass (1958), Ogum (1978), Bhattacharya and Nath (1987)). The risk of conceiving for a particular woman varies over time (e.g due to pregnancy, contraceptive use, amenorrhea or sexual abstinence). Moreover, between different sexually active, non-pregnant, non-contracepting, non-amenorrheic women the risk of conceiving may differ (Sheps (1964), Sheps and Menken (1973)). Hence, constraining the within-community variance to equal the mean (as for a Poisson model) may not be appropriate for these response variables.

The response variables indicating whether or not a woman is married, currently using contraception or has ever used contraception are all binary. For these analyses a logistic link has been used (e.g. McCullagh and Nelder (1983, p14), Little (1978, p26)).

5.5.1.5 Interpretation_of_the_Parameters_of_Nonlinear Multilevel_Models

5.5.1.5.1 Multilevel_Logistic_Regression

In the multilevel logistic regressions the $\hat{\beta}$ parameters are interpreted as the estimated change in the log of the odds if the value of a (fixed) explanatory variable changes by one and the values of all other fixed explanatory variables and the value of the random effect are unchanged (i.e. assuming *ceteris parabus*). These $\hat{\beta}$ parameters are also the estimated mean change in the log of the odds over the population of all communities if the value of a (fixed) explanatory variable increases by one and the values of all other fixed explanatory variables are unchanged. The exponentiated parameter estimates (exp($\hat{\beta}$)'s) indicate the estimated ratio of the odds when the value of a fixed explanatory variable changes by one and the values of all other fixed explanatory variables are unchanged for women from the same community (i.e. with the same value for the random effect). The $\exp(\hat{\beta})$'s are also the median of the ratios of the odds over the population of all communities when the value of a fixed explantory variable changes by one and the values of all other fixed explanatory variables are unchanged.

The expected value of the log odds is given the value of the fixed explanatory variables and of the random effect is $\hat{\beta}X + \hat{u}_i$. If the value of the random effect is unknown (as in the case of a non-sampled cluster) the expected value of the log of the odds is $\hat{\beta}X$. The expected value of the odds given the value of the fixed explanatory variables and the value of the random effect is $\exp(\hat{\beta}X + \hat{u}_i)$. The expected value of the odds given the value of the fixed explanatory variables if the value of the random effect is unknown is $\exp(\hat{\beta}X)E(\exp(u_i)) = \exp(\hat{\beta}X + \hat{\sigma}^2)$ where $\hat{\sigma}^2$ is the estimated variance of the random effect for community. The median value of the odds given the value of the fixed explanatory variables over the population of clusters is $\exp(\hat{\beta}X)$. The probability of an event given the value of the fixed explanatory variables and the value of the random effect is $\exp(\hat{\beta}X + \hat{u}_i)/(1 + \exp(\hat{\beta}X + \hat{u}_i))$. Over the population of values of the random effect the median probability of an event is $\exp(\hat{\beta}X)/(1 + \exp(\hat{\beta}X))$.

5.5.1.5.2 <u>Multilevel_Log-linear_Models</u>

In the multilevel loglinear models the $\hat{\beta}$ parameters are interpreted as the estimated change in the log of the expected number of births if the value of a fixed explanatory variable changes by one and the values of all other fixed explanatory variables are unchanged and the value of the random effect is unchanged. These $\hat{\beta}$ parameters are also the mean change in the log of the expected number of births over the population of all communities if the value of a fixed explanatory variable changes by one and the values of all other fixed explanatory variables are unchanged. The exp($\hat{\beta}$)'s indicate the ratio of the expected numbers of births if the value of a fixed explanatory variable changes by one and the values of all other explanatory variables are unchanged for women from the same community (i.e. with the same value for the random effect). These exp($\hat{\beta}$)'s are also the median of the ratio of the expected numbers of births if the value of a fixed explanatory variable changes by one and the values of all other explanatory variables are unchanged over the population of all communities. The expected value of the log of the number of births given the value of the fixed explanatory variables and of the random effect is $\hat{\beta}X + \hat{u}_i$. If the value of the random effect is unknown the expected value of the log of the number of births is $\hat{\beta}X$. The expected value of the number of births given the value of the fixed explanatory variables and the value of the random effect is $\exp(\hat{\beta}X + \hat{u}_i)$. The expected value of the number of births given the value of the fixed explanatory variables if the value of the random effect is unknown is $\exp(\hat{\beta}X)E(\exp(u_i)) = \exp(\hat{\beta}X + \hat{\sigma}^2)$ where $\hat{\sigma}^2$ is the estimated variance of the random effect for community. The median value of the number of births given the value of the fixed explanatory variables over the population of clusters is exp($\hat{\beta}X$).

5.5.1.6 The_Use_of_Differential_Weights

As mentioned earlier (see Section 5.3.1), the LDHS oversampled two counties, namely Sinoe and Grand Gedeh. Thus, to obtain consistent national-level estimates of model parameters units needed to be weighted inversely proportional to their selection probabilities (see Appendix 5A for details of the weights).

5.5.1.7 The_Choice_of_Software

Of the available packages, VARCL (Longford (1988b)) offers the choice of normal, binomial, Poisson and gamma error distributions, and, although ML3 (Prosser *et al.* (1991)) was originally designed to fit models only if the data are assumed to follow a normal distribution, this package can now also be adapted to provide approximate quasi-likelihood estimates of the parameters of logit and loglinear models (Goldstein (1991) outlines the method, Paterson (1991) is an example of an application).

VARCL software package was chosen to estimate models as this is the only one of the packages available for multilevel modelling for which a weighting facility operates correctly (n.b. the suggestion in Goldstein (1987) that a premultiplying the data by the square root of the weights gives incorrect estimates of the random parameters). Generally speaking, VARCL is inferior to ML3 in that it limits the number of explanatory variables in a model, can only be used to test the significance of a contrast between a factor in a categorical variable and the baseline factor and lacks facilities for the analysis of residuals. It is also considerably less user-friendly with regard to data manipulation than ML3.

5.5.2 Results

In this section I present models of fertility, marriage and contraceptive use in Liberia using the LDHS data. For each of the chosen response variables two models are presented, the first includes all the fixed and random effects described in Section 5.5.1.2 and the second is a more parsimonious model which excludes the less significant contrasts of the former model. Although it is the analyses of fertility which are primarily of interest, the analyses of the chosen measures of the proximate determinants preceed those of the chosen measures of fertility in order that the results from the former can be incorporated into the discussions of the latter.

5.5.2.1 The_Proximate_Determinants_of_Fertility

5.5.2.1.1 Marriage

Parameter_Estimates

A binary variable indicating whether or not a woman is "married" is analysed. Listwise deletion is used for missing data and so 5232 women from 156 clusters are included for analysis.

In Table 5.5.1. two sets of parameter estimates are presented; the first is that when data are weighted and the second is that when data are unweighted. The main differences between the two sets of parameters are:

a) in the unweighted analysis Protestant/Catholic contast is much smaller than in the weighted analysis

b) the effect for the proportion of women with secondary level education or above is considerably more significant in the unweighted analysis.

and c) the random effect for community is much smaller and less significant in the unweighted analysis.

The main findings of the weighted analysis are:

1) The probability of a woman being married increases with age until age 40 but is significantly lower (at the 5% level) for women aded 40-49 than for women aged 35-39[2,3].

2) The probability of a woman being married decreases as her level of education increases[2]. The probability of a woman being married is significantly lower if she has primary education only than if she has no education and is significantly lower if she has secondary level or above education than if she has primary level education only[2].

3) The probability of a woman being married differs significantly between religions[2]. Muslim women have the highest probability of being married, followed by women with no religion and Protestant women have the lowest probability of being married[2].

4) Differences in the probabilities of being married between ethnic groups are insignificant[2].

5) Women in urban areas have a significantly lower probability of being married than women in rural areas[2].

6) The levels of education in the community in which a woman lives do not significantly reduce the probability of her being married[2,3].

7) The random effect for community is significant[4]. The change in deviance from omitting this from the weighted analysis is 203.3.

Table 5.5.1: Full Multilevel Logistic Model of Currently Married: Weighted and Unweighted Parameter Estimates

Fixed Parameter	$\hat{\beta}$ wtd	$\hat{\beta}$ unw	S.E. ($\hat{\beta}$) wtd	S.E. ($\hat{\beta}$) unw	exp($\hat{\beta}$) wtd	exp($\hat{\beta}$) unw
Level 1						
15-19	-0.48**	-0.25**	n.e.	n.e.	0.62	0.78
20-24	1.47**	1.48**	0.10	0.10	4.35	4.39
25-29	2.02**	2.00**	0.11	0.11	7.54	7.39
30-34	2.15**	2.21**	0.13	0.13	8.58	9.12
35-39	2.35**	2.38**	0.14	0.14	10.49	10.80
40-44	1.89**	2.00**	0.16	0.16	6.62	7.39
45-49	2.00	2.03	0.16	0.16	7.39	7.61
No Education	0.00**	0.00**	n.a.	n.a	1.00	1.00
Primary	-0.60**	-0.59**	0.10	0.09	0.55	0.55
Secondary	-0.84**	-0.96**	0.11	0.11	0.43	0.38
Higher	-0.91	-0.83	0.23	0.26	0.40	0.44
Protestant	0.00	0.00	n.a.	n.a.	1.00	1.00
Catholic	0.26**	-0.00**	0.14	0.15	1.30	1.00
Muslim	1.17	1.18	0.14	0.15	3.22	3.25
Tradit./Other	0.22**	0.15**	0.12	0.12	1.25	1.16
None	0.49	0.40	0.11	0.11	1.63	1.49
Kwa	0.00	0.00	n.a.	n.a.	1.00	1.00
Mande	0.16	0.04	0.10	0.09	1.17	1.04
West Atlantic	0.12	-0.03	0.16	0.17	1.13	0.97
Other	-0.07	-0.13	0.18	0.19	0.93	0.88
Level 2						
Rural	0.00*	0.00*	n.a.	n.a.	1.00	1.00
Urban	-0.42	-0.35	0.19	0.14	0.66	0.70
Prop. Primary	0.16	0.04*	0.69	0.51	1.17	1.04
Prop. Sec+	-0.53	-0.88	0.51	0.39	0.59	0.41

Random Parameter	$\hat{\sigma}^2$ wtd	$\hat{\sigma}^2$ unw	$\hat{\sigma}$ wtd	$\hat{\sigma}$ unw	S.E. ($\hat{\sigma}$) wtd	S.E. ($\hat{\sigma}$) unw
Level 2						
Constant	0.43++	0.15++	0.66	0.39	0.06	0.05
Level 1						
Constant	1.00	1.00	1.00	1.00	n.a.	n.a.

Model Statistics

	wtd	unw
Deviance	5014.5	5066.2

Key
n.a. not applicable
n.e. not estimated (by VARCL).
* $0.01 \le p < 0.05$
** $p < 0.01$
+ $2.71 \le$ Change in Deviance < 3.84
++ $3.84 \le$ Change in Devaince

Table 5.5.2: Simplified Weighted Multilevel Logistic Model of Currently Married

Fixed Parameter	$\hat{\beta}$	S.E.$(\hat{\beta})$	$\exp(\hat{\beta})$
Level 1			
15-19	-0.38	n.e.	0.68
20-24	1.47**	0.10	4.39
25-34	2.06**	0.10	7.85
35-39	2.34**	0.14	10.38
40-49	1.94**	0.13	6.96
No Education	0.00	n.a.	1.00
Primary	-0.61**	0.09	0.54
Second./High	-0.88**	0.10	0.41
Protestant	0.00	n.a.	1.00
Cath./Trad./Oth	0.24*	0.10	1.27
Muslim	1.21**	0.14	3.35
None	0.51**	0.11	1.67
Level 2			
Rural	0.00	n.a.	1.00
Urban	-0.59**	0.14	0.55

Random Parameter	$\hat{\sigma}^2$	$\hat{\sigma}$	S.E.$(\hat{\sigma})$
Level 2			
Constant	0.43++	0.65	0.06
Level 1			
Constant	1.00	1.00	n.a.

Model Statistics

Deviance 5020.1

Key

n.a. not applicable

n.e. not estimated (by VARCL).

* $0.01 \le p < 0.05$

** $p < 0.01$

+ $2.71 \le$ Change in Deviance < 3.84

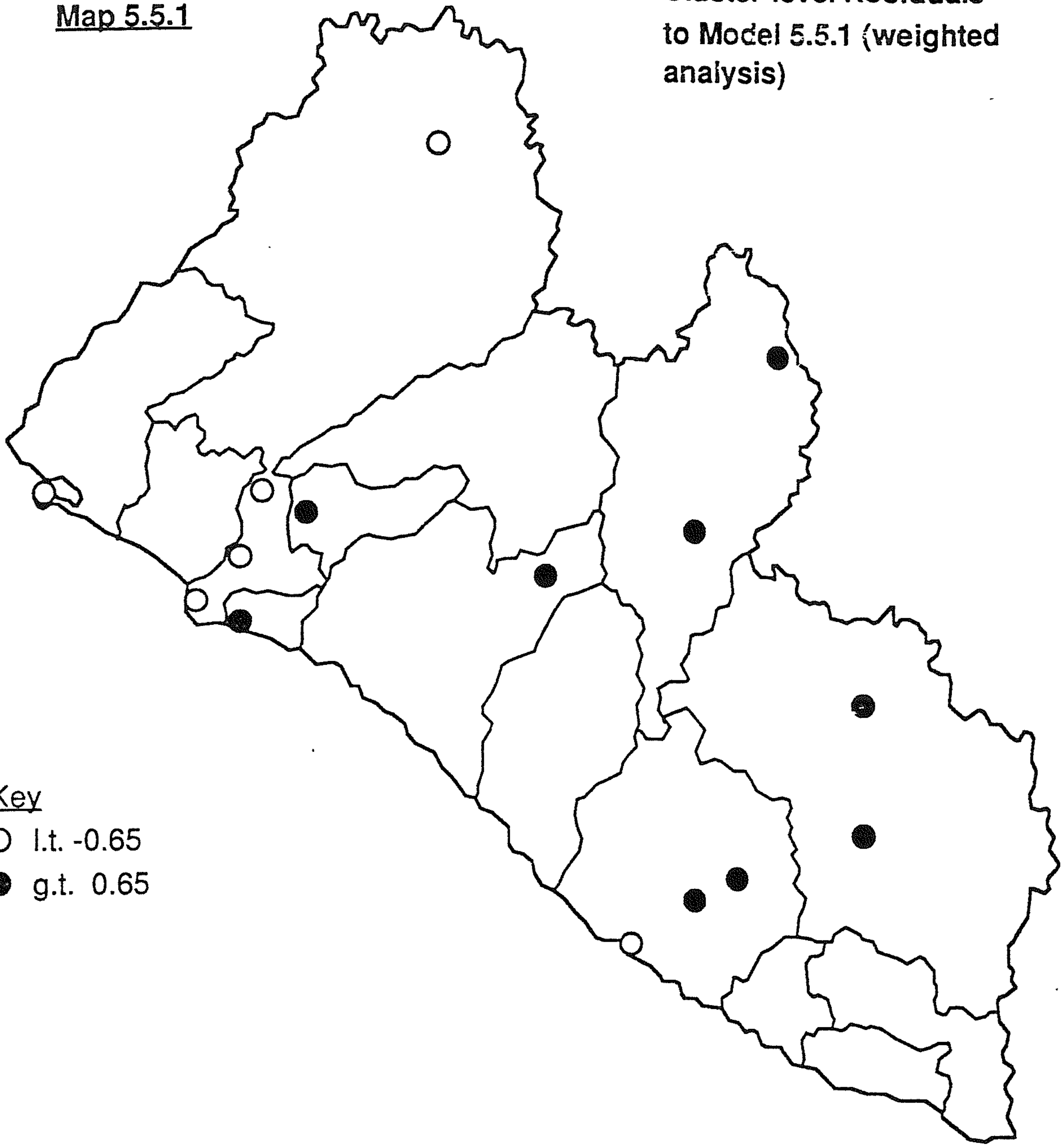
++ $3.84 \le$ Change in Deviance

Community-Level Residuals

Appendix 5F shows the all the estimated residual community effects for the (weighted) model containing all the explanatory variables listed in Section 5.5.1.2 (i.e. the "full weighted" model). The community effects are measured on the logit scale. The histogram in Figure 5.5.1 (see Appendix 5H) shows that the distribution of the community-level residuals follows a normal distribution. Hence, over the population of all communities, roughly 68% of residual community effects will lie in the range (-0.66, 0.66) and roughly 95% will lie in the range (-1.32, 1.32) or, equivalently, for a given value of the fixed explanatory variables, for roughly 68% of communities the odds of a woman being married will be between 0.51 and 1.93 times the value of the fixed part and for roughly 95% of communities the odds of a woman being married will be between 0.27 and 3.74 times the value of the fixed part. There are no outliers to the distribution of the community effects. The (approximate) locations of the larger community-level residuals are shown in Map 5.5.1. This shows that the larger positive residuals, which indicate higher than expected proportions married, tend to be in the south and east of Liberia and the larger negative residuals, which indicate lower than expected proportions married, tend to be in the north and west of Liberia. The five communities with the highest value of the random effect and the five communities with the lowest value of the random effect are shown in Table 5.5.3. The community with the largest positive effect on the probability of a woman being married, Schlieffen (cluster no. 369), is the site of a large army barracks.

Map 5.5.1

Cluster-level Residuals to Model 5.5.1 (weighted analysis)



Key
○ l.t. -0.65
● g.t. 0.65

Table 5.5.3: Highest/Lowest Values of the Random Effect for Community for the "Weighted Full" Model of Currently Married

Rank	Cluster No.	Township	County	Cluster Effect
1	308	(rural)	Lofa	-1.04
2	373	(rural)	Margibi	-0.90
3	354	(rural)	Montserrado	-0.88
4	121	Greenville	Sinoe	-0.85
5	348	Virginia	Montserrado	-0.74
152	397	Slorlay	Nimba	0.83
153	398	Tapitta	Nimba	0.82
154	380	L.A.C.	Gr. Bassa	0.80
155	218	(rural)	Gr. Gedeh	0.93
156	369	Schlieffen	Margibi	1.15

5.5.2.1.2 Contraceptive Use

Current Use of Contraception

Parameter Estimates

A binary variable indicating whether or not a woman is currently using any method of contraception is analysed. Listwise deletion is used for missing data with the result that 5322 women from 156 clusters are included for analysis.

Table 5.5.4 presents two sets of model parameters; one set for a weighted analysis and the other for the unweighted analysis. The main differences between the two sets of parameters are:

a) the baseline is considerably higher for the unweighted analysis,

b) the effects for age are smaller in the unweighted analysis,

c) the effect of urban is smaller in the unweighted analysis,

d) the effect of proportion primary is noticeably smaller in the unweighted analysis, and

e) the random effect for community is considerably smaller in the unweighted analysis.

The differences between the two sets of parameters illustrate the need to use a weighted analysis.

Table 5.5.1.5 presents a simplified model (for a weighted analysis) from which not significant contrasts have been removed.

The main findings are:

1) The probability of a woman having ever used contraception is greatest for women aged 40-49[2]. The probability of a woman using contraception increases until age 34[2], but is significantly less for women aged 35-39 than for women aged 30-34[2].

2) The probability of a woman using contraception increases considerably as her level of education increases[2]. The contrast between women with secondary-level only and higher/vocational is not significant[2].

3) The probability of a woman using contraception varies with religion[2]. Catholic women have the highest probability of using contraception with Muslim women, women with traditional/other beliefs and women with no religion having the lowest probabilities of using contraception[2].

4) Differences in the probability of having used contraception between ethnic groups are not significant[2].

5) Women in urban areas have a higher probability of using contraception than women in rural areas[2].

6) The probability of a woman using contraception increases as the proportion of women in her community with primary level education only increases[2].

7) The random effect for community is highly significant[4]. The change in deviance from omitting this effect (from the weighted analysis) is 78.0.

Table 5.5.4: Full Multilevel Logistic Model of Currently Using Contraception: Weighted and Unweighted Parameter Estimates

Fixed Parameter	$\hat{\beta}$ wtd	$\hat{\beta}$ unw	S.E.($\hat{\beta}$) wtd	S.E.($\hat{\beta}$) unw	exp($\hat{\beta}$) wtd	exp($\hat{\beta}$) unw
Level 1						
15-19	-5.33**	-4.82**	n.e.	n.e.	0.005	0.01
20-24	0.86**	0.67**	0.18	0.18	2.36	1.95
25-29	0.93**	0.69**	0.19	0.19	2.53	1.99
30-34	1.29**	0.85**	0.22	0.22	3.63	2.34
35-39	1.08**	0.71**	0.24	0.24	2.94	2.03
40-44	1.84**	1.53**	0.27	0.26	6.30	4.62
45-49	1.73	1.32	0.27	0.27	5.64	3.74
No Education	0.00**	0.00**	n.a.	n.a.	1.00	1.00
Primary	0.75**	0.61**	0.19	0.19	2.12	1.84
Secondary	2.08**	2.22**	0.17	0.17	8.00	9.21
Higher	2.31	2.27	0.27	0.30	10.07	9.68
Protestant	0.00*	0.00**	n.a.	n.a.	1.00	1.00
Catholic	0.42**	0.55**	0.17	0.17	1.52	1.73
Muslim	-0.79*	-0.78*	0.24	0.27	0.45	0.46
Tradit./Other	-0.61	-0.58	0.24	0.27	0.54	0.56
None	-0.35	-0.39	0.21	0.22	0.70	0.68
Kwa	0.00	0.00	n.a.	n.a.	1.00	1.00
Mande	0.18	0.12	0.15	0.14	1.20	1.13
West Atlantic	-0.27	-0.32	0.27	0.30	0.76	0.73
Other	0.17	0.31	0.22	0.24	1.19	1.36
Level 2						
Rural	0.00**	0.00*	n.a.	n.a.	1.00	1.00
Urban	0.70**	0.41*	0.26	0.20	2.01	1.51
Prop. Primary	2.74	1.91*	0.83	0.80	15.49	6.75
Prop. Sec+	0.97	1.13	0.67	0.54	2.64	3.10

Random Parameter	$\hat{\sigma}^2$ wtd	$\hat{\sigma}^2$ unw	$\hat{\sigma}$ wtd	$\hat{\sigma}$ unw	S.E.($\hat{\sigma}$) wtd	S.E.($\hat{\sigma}$) unw
Level 2						
Constant	0.62**	0.21**	0.79	0.46	0.09	0.09
Level 1						
Constant	1.00	1.00	1.00	1.00	n.e.	n.e.

Model Statistics

	wtd	unw
Deviance	2245.6	2208.7

Key
n.a. not applicable
n.e. not estimated (by VARCL).
* $0.01 \le p < 0.05$
** $p < 0.01$
+ $2.71 \le$ Change in Deviance < 3.84
++ $3.84 \le$ Change in Deviance

Table 5.5.5: Simplified Multilevel Logistic Model of Currently Using Contraception: Weighted Parameter Estimates

Fixed Parameter	$\hat{\beta}$	S.E.($\hat{\beta}$)	exp($\hat{\beta}$)
Level 1			
15-19	-5.33	n.e.	0.005
20-29	0.89**	0.17	2.44
30-34	1.34**	0.21	3.82
35-39	1.11**	0.24	3.03
40-49	1.80**	0.22	6.05
No Education	0.00	n.a.	1.00
Primary	0.76**	0.19	2.14
Secondary/Higher	2.14**	0.16	8.50
Protestant	0.00	n.a.	1.00
Catholic	0.43*	0.17	1.54
Mus/Trad/Oth/None	-0.56**	0.15	0.57
Level 2			
Rural	0.00	n.a.	1.00
Urban	0.88**	0.20	2.41
Prop. Primary	2.73**	1.02	15.33

Random Parameter	$\hat{\sigma}^2$	$\hat{\sigma}$	S.E.($\hat{\sigma}$)
Level 2			
Constant	0.62**	0.79	0.09
Level 1			
Constant	1.00	1.00	n.e.

Model Statistics

Deviance 2257.1

Key
n.a. not applicable
n.e. not estimated (by VARCL).
* $0.01 \leq p < 0.05$
** $p < 0.01$
\+ $2.71 \leq$ Change in Deviance < 3.84
++ $3.84 \leq$ Change in Deviance

Community-Level Residuals

The estimated residuals for all the clusters included in the sample for "weighted full" model are presented in Appendix 5F. The histogram in Figure 5.5.2 (see Appendix 5H) shows that the distribution of the community-level residuals has a positive skew, although assuming that the distribution of these residuals is normal would not seen too unreasonable. The implication of normality is that, over the population of all communities roughly 68% of residual community effects will lie in the range (-0.79, 0.79) and roughly 95% will lie in the range (-1.58, 1.58) or, equivalently for a given value of the fixed explanatory variables, for roughly 68% of communities the odds of a woman currently using contraception will be between 0.45 and 2.20 times the value of the fixed part and for roughly 95% of communities the odds of a woman currently using contraception will be between 0.21 and 4.85 times the value of the fixed part. There are no outliers to the distribution of the community effects. There is no clear geographical pattern to the distribution of the larger community effects (see Map 5.5.2), although it is noticeable the three clusters with the largest positive effects on the probability of a woman using contraception are all in or near to Greenville. The communities with the highest and lowest values of the random effect are shown in Table 5.5.6:

Map 5.5.2

Cluster-level Residuals to Model 5.5.4 (weighted analysis)

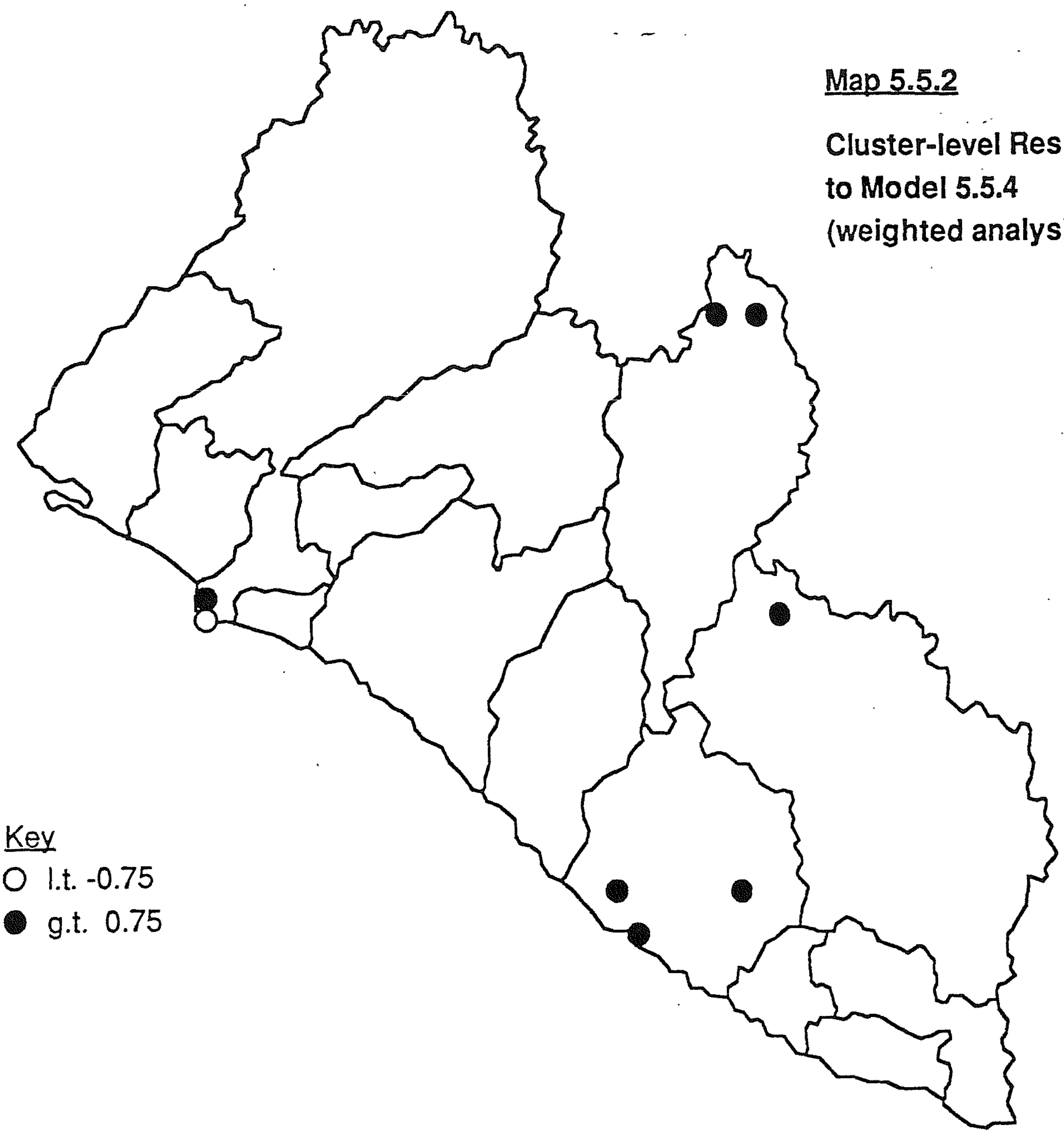


Table 5.5.6: Highest/Lowest Values of the Random Effect for Community for the "Weighted Full" Model of Currently Using Contraception

Rank	Cluster No.	Township	County	Residual
1	323	Monrovia	Montserrado	-1.11
2	326	Monrovia	Montserrado	-0.79
3	211	Zwedru	Gr. Gedeh	-0.72
4	391	(rural)	Nimba	-0.68
5	322	Monrovia	Montserrado	-0.65
152	387	Camp No. 4	Nimba	1.00
153	101	(rural)	Sinoe	1.10
154	119	Greenville	Sinoe	1.10
155	120	Greenville	Sinoe	1.20
156	124	Greenville	Sinoe	1.52

Ever Use of Contraception

Parameter Estimates

A binary variable indicating whether a woman has ever used any method of contraception is analysed. Listwise deletion is used for missing data and so 5232 women from 156 clusters are included for analysis.

Table 5.5.7 presents two sets of model parameters; one set for a weighted analysis and the other for the unweighted analysis. The main differences between the two sets of parameters are:

a) the baseline is considerably higher for the unweighted analysis,

b) the effects for age are smaller in the unweighted analysis,

c) the effect of proportion primary is noticeably smaller in the unweighted analysis,

d) the random effect for community is considerably smaller in the unweighted analysis,

The differences between the two sets of parameters illustrate the need to use a weighted analysis.

Table 5.5.8 presents a simplified model (for a weighted analysis) from which not significant contrasts have been removed.

The main findings are:

1) The probability of a woman having ever used contraception increases until age 30 and then remains roughly constant[2].

2) the probability of a woman having ever used contraception increases as her level of education increases[2]. The contrast between women with secondary-level only and higher/vocational is not significant[2].

3) the probability of a woman having ever used contraception varies with religion[2]. Christian women have the highest probability of using contraception and Muslim women have the lowest probability of having used contraception[2].

4) women in the West Atlantic and "Other" ethnic groups have lower probabilities of having used contraception than women in the Kwa or Mande ethnic groups[2].

5) women in urban areas have a higher probability of having used contraception than women in rural areas[2].

6) the probability of a woman having ever used contraception increases as the proportion of women in her community with primary level education only increases[2].

7) the random effect for community is highly significant[4]. The change in deviance from omitting this effect (from the weighted analysis) is 214.7.

Table 5.5.7: Full Multilevel Logistic Model of Ever Used Contraception: Weighted and Unweighted Parameter Estimates

Fixed Parameter	$\hat{\beta}$ wtd	$\hat{\beta}$ unw	S.E.($\hat{\beta}$) wtd	S.E.($\hat{\beta}$) unw	exp($\hat{\beta}$) wtd	exp($\hat{\beta}$) unw
Level 1						
15-19	-4.16**	-3.71**	n.e.	n.e.	0.02	0.02
20-24	1.22**	0.99**	0.13	0.13	3.39	2.69
25-29	1.52**	1.27**	0.14	0.13	4.57	3.56
30-34	1.88**	1.52**	0.16	0.15	6.55	4.57
35-39	1.85**	1.52**	0.17	0.16	6.36	4.57
40-44	1.70**	1.26**	0.20	0.20	5.47	3.53
45-49	1.58	1.18	0.20	0.20	4.85	3.25
No Education	0.00**	0.00**	n.a.	n.a.	1.00	1.00
Primary	1.15**	0.98**	0.12	0.11	3.16	2.66
Secondary	2.51**	2.50**	0.12	0.12	12.30	12.18
Higher	2.68	2.60	0.27	0.29	14.59	13.46
Protestant	0.00	0.00	n.a.	n.a.	1.00	1.00
Catholic	0.12**	0.16**	0.15	0.16	1.13	1.17
Muslim	-0.84	-0.87	0.17	0.18	0.43	0.42
Tradit./Other	-0.23**	-0.21**	0.14	0.14	0.79	0.81
None	-0.33	-0.36	0.13	0.13	0.72	0.70
Kwa	0.00	0.00	n.a.	n.a.	1.00	1.00
Mande	-0.06	-0.05	0.11	0.11	0.94	0.95
West Atlantic	-0.31*	-0.20*	0.19	0.20	0.73	0.82
Other	-0.49	-0.41	0.21	0.21	0.61	0.66
Level 2						
Rural	0.00**	0.00**	n.a.	n.a.	1.00	1.00
Urban	0.55**	0.47**	0.22	0.16	1.73	1.60
Prop. Primary	2.70	2.20	0.82	0.58	14.88	9.03
Prop. Sec+	0.48	0.58	0.59	0.44	1.62	1.79

Random Parameter	$\hat{\sigma}^2$ wtd	$\hat{\sigma}^2$ unw	$\hat{\sigma}$ wtd	$\hat{\sigma}$ unw	S.E.($\hat{\sigma}$) wtd	S.E.($\hat{\sigma}$) unw
Level 2						
Constant	0.60**	0.20**	0.77	0.44	0.07	0.06
Level 1						
Constant	1.00	1.00	1.00	1.00	n.e.	n.e.

Model Statistics	wtd	unw
Deviance	3885.7	4080.8

Key
n.a. not applicable
n.e. not estimated (by VARCL).
* $0.01 \le p < 0.05$
** $p < 0.01$
+ $2.71 \le$ Change in Deviance < 3.84
++ $3.84 \le$ Change in Deviance

Table 5.5.8: Simplified Multilevel Logistic Model of Ever Used Contraception: Weighted Parameter Estimates

Fixed Parameter	$\hat{\beta}$	S.E. $(\hat{\beta})$	$\exp(\hat{\beta})$
Level 1			
15-19	-4.18	n.e.	0.02
20-24	1.22**	0.13	3.39
25-29	1.53**	0.14	4.62
30-49	1.82**	0.13	6.17
No Education	0.00	n.a.	1.00
Primary	1.17**	0.12	3.22
Secondary/Higher	2.56**	0.12	12.94
Christian	0.00	n.a.	1.00
Muslim	-0.89*	0.16	0.41
Trad./Oth./None	-0.31**	0.10	0.73
Kwa/Mande	0.00	n.a.	1.00
W.A./Other	-0.34*	0.14	0.71
Level 2			
Rural	0.00	n.a.	1.00
Urban	0.69**	0.17	1.99
Prop. Primary	2.79**	0.80	16.28

Random Parameter	$\hat{\sigma}^2$	$\hat{\sigma}$	S.E. $(\hat{\sigma})$
Level 2			
Constant	0.58**	0.76	0.07
Level 1			
Constant	1.00	1.00	n.e.

Model Statistics

Deviance 3897.9

Community-Level Residuals

Appendix 5F presents the estimated residuals for the clusters included in the sample for the "full weighted" model. The histogram in Figure 5.5.3 (see Appendix 5H) shows that the distribution of the community-level residuals follows a normal distribution. Hence, over the population of all communities, roughly 68% of residual community effects will lie in the range (-0.77, 0.77) and roughly 95% will lie in the range (-1.54, 1.54) or, equivalently, for a given value of the fixed explanatory variables, for roughly 68% of communities the odds of a woman having ever used contraception will be between 0.46 and 2.16 times the value of the fixed part and for roughly 95% of communities the odds of a woman having ever used contraception will be between 0.21 and 4.66 times the value of the fixed part. Clusters number 323 and 311 are outliers to the distribution of the community effects. Map 5.5.3 shows that commmunities with relatively large positive effects are disproportionately located in the rural areas on Bong county and communities with relatively large negative effects are disproportionately located in the Grebo-dominated parts of Grand Gedeh county. The five highest and five lowest values of the random effect are shown in Table 5.5.9:

Map 5.5.3

Cluster-level Residuals
to Model 5.5.7
(weighted analysis)

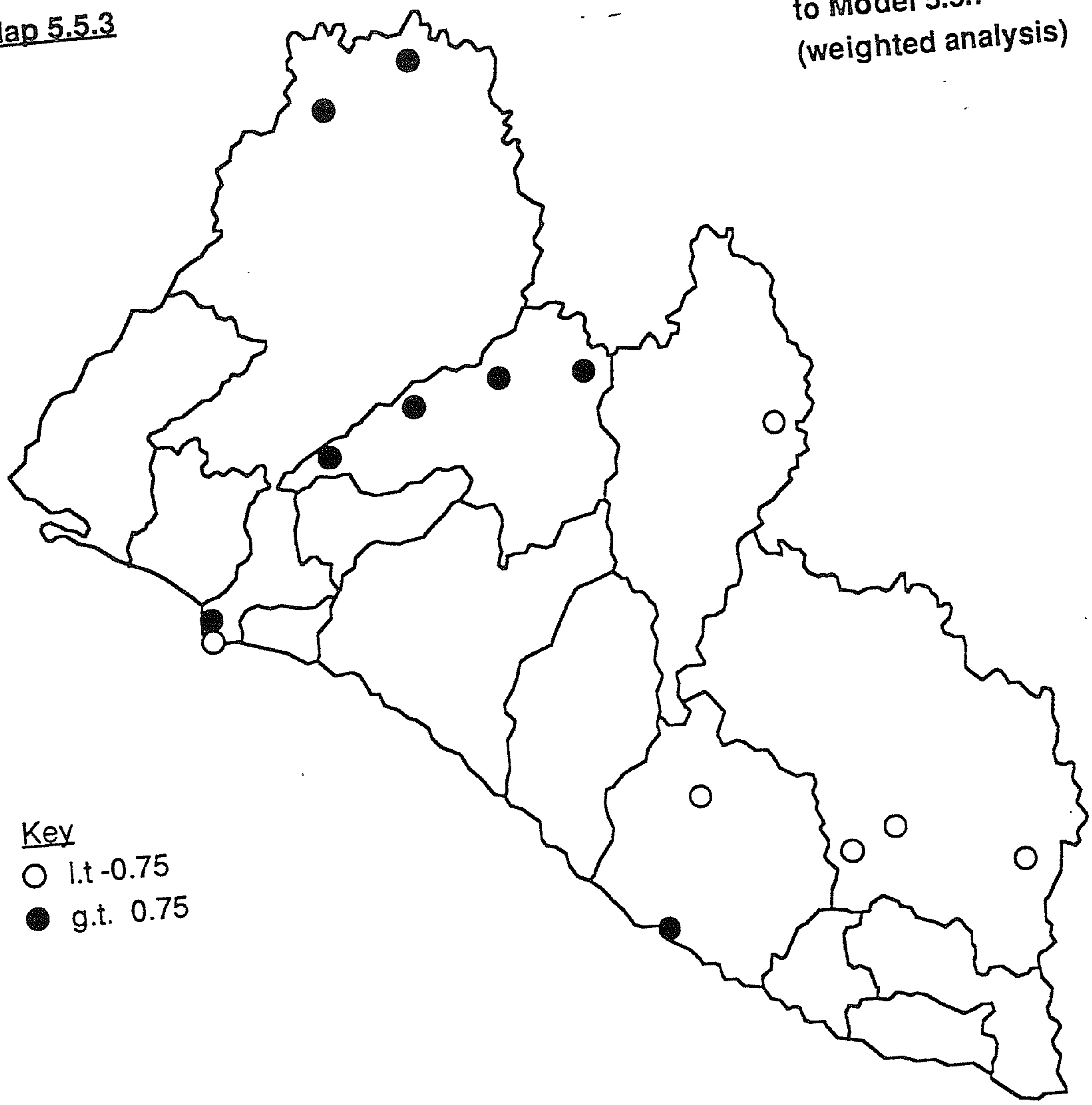


Table 5.5.9: Highest/Lowest Values of the Random Effect for Community for the "Weighted Full" Model of Ever Use of Contraception

Rank	Cluster No.	Township	County	Cluster Effect
1	323	Monrovia	Montserrado	-1.51
2	322	Monrovia	Montserrado	-0.95
3	221	(rural)	Gr. Gedeh	-0.93
4	219	(rural)	Gr. Gedeh	-0.93
5	105	(rural)	Sinoe	-0.87
152	310	Voinjama	Lofa	0.84
153	367	(rural)	Bong	0.86
154	355	(rural)	Bong	1.01
155	338	Monrovia	Montserrado	1.07
156	311	Voinjama	Lofa	1.66

5.5.2.2 Fertility

Current Fertility

Parameter Estimates

The number of children born to a woman during the five years before interview is analysed. Listwise deletion is used for missing data and consequently 5233 level 1 units from 156 level 2 units are included for analysis.

Two analyses are performed: one weighted and the other unweighted. For both analyses extra-Poisson variation was tested for. In each case as the unconstrained estimate of the level 1 variance is significantly different from 1, the assumption that the level 1 variance is Poisson is rejected. In the unweighted analysis the estimated level 1 variance is more than would be expected if a Poisson assumption were made (i.e. there is overdispersion), whilst in the weighted analysis the estimated level 1 variance is less than would be expected if a Poisson assumption were made (i.e. there is underdispersion). Underdispersion indicates the observed numbers of women with numbers of births close to the expected value (i.e. the number of women with 1 birth) is greater than would be expected under a Poisson assumption and the observed numbers of women with numbers of births considerably above the predicted number (i.e. 3 or more births) is less than would be expected under a Poisson assumption. A plausible explanation for underdispersion would be the effects of birth spacing practises. The likely reason for the overdispersion in the weighted analysis is that relevant explanatory variables were omitted from the model.

Table 5.5.10 presents two sets of model parameters, one set for a weighted analysis and the other for the unweighted analysis. In both sets of parameters extra-Poisson variation is estimated. The main differences between the weighted and unweighted parameter estimates are:

a) the intercept value is higher for the unweighted analysis,

b) the negative coefficient for 45-49 years is significantly different from 0 in the unweighted analysis but not in the weighted analysis, and

c) the random effect for community is significant in the weighted analysis but is estimated as 0 for the weighted analysis.

Table 5.5.11 presents the parameter estimates for both a weighted and an unweighted analysis if a Poisson assumption is made for the level 1 variance and Table 5.5.12 presents a "final" model. This model was estimated using the weighted data and allows for extra-Poisson variation, but non-significant parameters have been removed.

The main findings (from the weighted analysis which allows for extra-Poisson variation) are:

1) the most significant fertility differentials are those between age groups ($\chi^2_6 = 829.7$, $p < 0.001$). The plot of the effects for fertility against age has an n-shape with peak fertility levels being for the 25-29 age group[2]. Women aged 45-49 and women aged 15-19 have the lowest fertility[2]. The high proportion of unmarried women (see Table 5.5.1) would explain the low fertility in the 15-19 age group. Relatively high contraceptive use (see Table 5.5.4) would contribute to the relatively low fertility of women aged 45-49.

2) There are highly significant differentials by a woman's highest level of education ($\chi^2_3 = 33.8$, $p < 0.01$). Women with higher or vocational level education are predicted to have roughly half the number of children during the five years that women with no education have had[2]. Women with secondary level education only are also predicted to have significantly lower current fertility than uneducated women[2]. Women with primary level education are predicted to have slightly higher current fertility than uneducated women[2], although the difference is not significant at the 5% level. The relatively high level of contraceptive use (see Table 5.5.4) and relatively low proportion married (see Table 5.5.1) would contribute to the lower fertility of women with secondary or above education.

3) Of the religious categories, Muslim women and women with no religion are predicted to have the highest fertility and

Protestant women are predicted to have the lowest fertility[2]. The effects of religion as measured by the five categories are collectively of modest significance ($\chi^2_4 = 9.1$, $p = 0.06$). Simplifying the representation of religion to Christian/Non-Christian produces a contrast which is significant (at the 5% level). The lower fertility of Christian women would at least in part be due to the lower proportion married (see Table 5.5.1) and the higher proportion using contraception (see Table 5.5.4) in this group.

4) Women from the Kwa/Kru ethnic category are predicted to have higher current fertility than women from the other three ethnic categories, with women from the "other" category being predicted to have the lowest fertility. The significance of ethnicity as measured by these four categories on current fertility is slight ($\chi^2_3 = 4.7$, $p = 0.20$). Simplifying the representation of ethnicity to Kwa/Non-Kwa produces a significant contrast.

5) The urban-rural contrast is not significant at the 5% level. It is possible that the lack of significance for the urban-rural status of an area variable is partially due to measurement error, although I doubt if such error is on a large scale.

6) Neither of the two measures of the level of education in a community is significant at the 5% level. One reason for the non-significance of the proportion of women with primary level education and the proportion of women with secondary-level education variables is that these were estimated from samples of women and so contain measurement error.

7) The random effect for community is significant[3,4]. The change in deviance when this is constrained to zero is 35.0.

Table 5.5.10: Full Multilevel Log-Linear Model (Without Poisson Constraint) of Children Bornin the Last Five Years: Weighted and Unweighted Parameter Estimates

Fixed Parameter	$\hat{\beta}$ wtd	$\hat{\beta}$ unw	S.E.($\hat{\beta}$) wtd	S.E.($\hat{\beta}$) unw	exp($\hat{\beta}$) wtd	exp($\hat{\beta}$) unw
Level 1						
15-19	-0.80**	-0.66**	n.e.	0.06	0.45	0.52
20-24	1.07**	1.00**	0.06	0.05	2.92	2.72
25-29	1.17**	1.08**	0.06	0.05	3.22	2.94
30-34	1.00**	0.94**	0.06	0.05	2.72	2.56
35-39	0.82**	0.76**	0.06	0.05	2.27	2.14
40-44	0.44	0.40*	0.09	0.07	1.55	1.49
45-49	-0.06	-0.18	0.10	0.08	0.94	0.84
No Education	0.00	0.00	n.a.	n.a.	1.00	1.00
Primary	0.07**	0.05**	0.04	0.04	1.07	1.05
Secondary	-0.13**	-0.13**	0.05	0.05	0.88	0.88
Higher	-0.62	-0.63	0.14	0.14	0.54	0.53
Protestant	0.00	0.00	n.a.	n.a.	1.00	1.00
Catholic	0.05*	0.02*	0.07	0.06	1.05	1.02
Muslim	0.10	0.10	0.05	0.05	1.11	1.11
Traditional/Oth.	0.07*	0.02	0.05	0.04	1.07	1.02
None	0.10	0.07	0.04	0.04	1.11	1.07
Kwa	0.00*	0.00**	n.a.	n.a.	1.00	1.00
Mande	-0.08	-0.13*	0.04	0.03	0.92	0.88
West Atlantic	-0.08	-0.14*	0.07	0.06	0.92	0.87
Other	-0.12	-0.17	0.08	0.07	0.89	0.84
Level 2						
Rural	0.00	0.00	n.a.	n.a.	1.00	1.00
Urban	-0.01	-0.06	0.06	0.04	0.99	0.94
Prop. Primary	0.21	0.22	0.22	0.15	1.23	1.26
Prop. Sec/High.	-0.18	-0.20	0.17	0.12	0.84	0.82

Random Parameter	$\hat{\sigma}^2$ wtd	$\hat{\sigma}^2$ unw	$\hat{\sigma}$ wtd	$\hat{\sigma}$ unw	S.E.($\hat{\sigma}$) wtd	S.E.($\hat{\sigma}$) unw
Level 2						
Constant	0.03++	0.002	0.16	0.04	0.02	0.003
Level 1						
Constant	1.11	0.85	1.05	0.92	n.e.	n.e.

Model Statistics

	wtd	unw
Deviance	9488.6	9515.0

Key
n.a. not applicable
n.e. not estimated (by VARCL).
* $0.01 \leq p < 0.05$
** $p < 0.01$
+ 2.71 ≤ Change in Deviance < 3.84
++ 3.84 ≤ Change in Deviance

Table 5.5.11:Full Multilevel Log-Linear Model (With Poisson Constraint) of Children Born in the Last Five Years: Weighted and Unweighted Parameter Estimates

Fixed Parameter	$\hat{\beta}$ wtd	$\hat{\beta}$ unw	S.E.($\hat{\beta}$) wtd	S.E.($\hat{\beta}$) unw	exp($\hat{\beta}$) wtd	exp($\hat{\beta}$) unw
Level 1						
15-19	-0.80**	-0.66**	n.e.	n.e.	0.45	0.52
20-24	1.07**	1.00**	0.05	0.05	2.92	2.72
25-29	1.17**	1.08**	0.05	0.05	3.22	2.94
30-34	1.00**	0.94**	0.06	0.05	2.72	2.56
35-39	0.82**	0.76**	0.06	0.06	2.27	2.14
40-44	0.44	0.40*	0.08	0.07	1.55	1.49
45-49	-0.06	-0.18	0.09	0.09	0.94	0.84
No Education	0.00	0.00	n.a.	n.a.	1.00	1.00
Primary	0.07**	0.05**	0.04	0.04	1.07	1.05
Secondary	-0.13**	-0.13**	0.05	0.05	0.88	0.88
Higher	-0.62	-0.63	0.13	0.15	0.54	0.53
Protestant	0.00	0.00	n.a.	n.a.	1.00	1.00
Catholic	0.05*	0.02*	0.05	0.07	1.05	1.02
Muslim	0.10	0.10	0.05	0.05	1.11	1.11
Traditional/Oth.	0.07*	0.02	0.05	0.05	1.07	1.02
None	0.10	0.06	0.04	0.04	1.11	1.06
Kwa	0.00*	0.00**	n.a.	n.a.	1.00	1.00
Mande	-0.08	-0.13*	0.04	0.03	0.92	0.88
West Atlantic	-0.08	-0.14*	0.06	0.06	0.92	0.87
Other	-0.12	-0.18	0.08	0.08	0.89	0.84
Level 2						
Rural	0.00	0.00	n.a.	n.a.	1.00	1.00
Urban	-0.02	-0.06	0.06	0.04	0.98	0.94
Prop. Primary	0.21	0.23	0.22	0.15	1.23	1.26
Prop. Sec/High.	-0.18	-0.20	0.17	0.13	0.84	0.82

Random Parameter	$\hat{\sigma}^2$ wtd	$\hat{\sigma}^2$ unw	$\hat{\sigma}$ wtd	$\hat{\sigma}$ unw	S.E.($\hat{\sigma}$) wtd	S.E.($\hat{\sigma}$) unw
Level 2						
Constant	0.03++	0.00	0.17	0.00	0.02	0.05
Level 1						
Constant	1.00	1.00	1.00	1.00	n.e.	n.e.

Model Statistics

	wtd	unw
Deviance	9475.3	9515.6

Key
n.a. not applicable
n.e. not estimated (by VARCL).
* $0.01 \le p < 0.05$
** $p < 0.01$
\+ 2.71 ≤ Change in Deviance < 3.84
++ 3.84 ≤ Change in Deviance

Table 5.5.12: Simplified Multilevel Log-Linear Model (Without Poisson Constraint) of Children Born in the Last Five Years: Weighted Parameter Estimates

Fixed Parameter	$\hat{\beta}$	S.E.($\hat{\beta}$)	exp($\hat{\beta}$)
Level 1			
15-19	-0.76	n.e.	0.47
20-24	1.06**	0.06	2.88
25-29	1.15**	0.05	3.15
30-34	0.98**	0.06	2.65
35-39	0.79**	0.06	2.21
40-44	0.41**	0.08	1.51
45-49	-0.08	0.10	0.92
No Educ./Primary	0.00	n.a.	1.00
Secondary	-0.18**	0.05	0.84
Higher	-0.68**	0.14	0.51
Christian	0.00	n.a.	1.00
Non-Christian	0.08**	0.03	1.09
Kwa	0.00	n.a.	1.00
Mande/W.A./Oth.	-0.08*	0.04	0.92

Random Parameter	$\hat{\sigma}^2$	$\hat{\sigma}$	S.E.($\hat{\sigma}$)
Level 2			
Constant	0.03++	0.16	0.02
Level 1			
Constant	1.11	1.05	n.e.

Model Statistics

Deviance	9496.1

Community-Level Residuals

The community-level residuals for the weighted analysis which allows for extra-Poisson level 1 variance are presented in Appendix 5F. These residuals are measured on the log scale. The histogram in Figure 5.5.4 (see Appendix 5G) shows that the residuals follow a normal distribution, although the actual distribution is somewhat light-tailed. The implication of normality is that over the population of all communities roughly 68% of residual community effects will lie in the range (-0.16, 0.16) and roughly 95% will lie in the range (-0.32, 0.32) or, equivalently, for a given value of the fixed explanatory variables, for roughly 68% of communities the mean number of children born to a woman will be between 0.85 and 1.17 times the value of the fixed part and for roughly 95% of communities the mean number of children born to a woman in the last five years will be between 0.73 and 1.38 times the value of the fixed part. Cluster no. 347 (Arthington) is an outlier to the distribution of community-level residuals. Map 5.5.4 shows the (approximate) locations of the communities with relatively large values for the random effect. There is no clear geographical pattern to these communities. The five highest and the five lowest values of the random effect are shown in Table 5.5.13:

Map 5.5.4

Cluster-level Residuals
to Model 5.5.10
(weighted analysis)

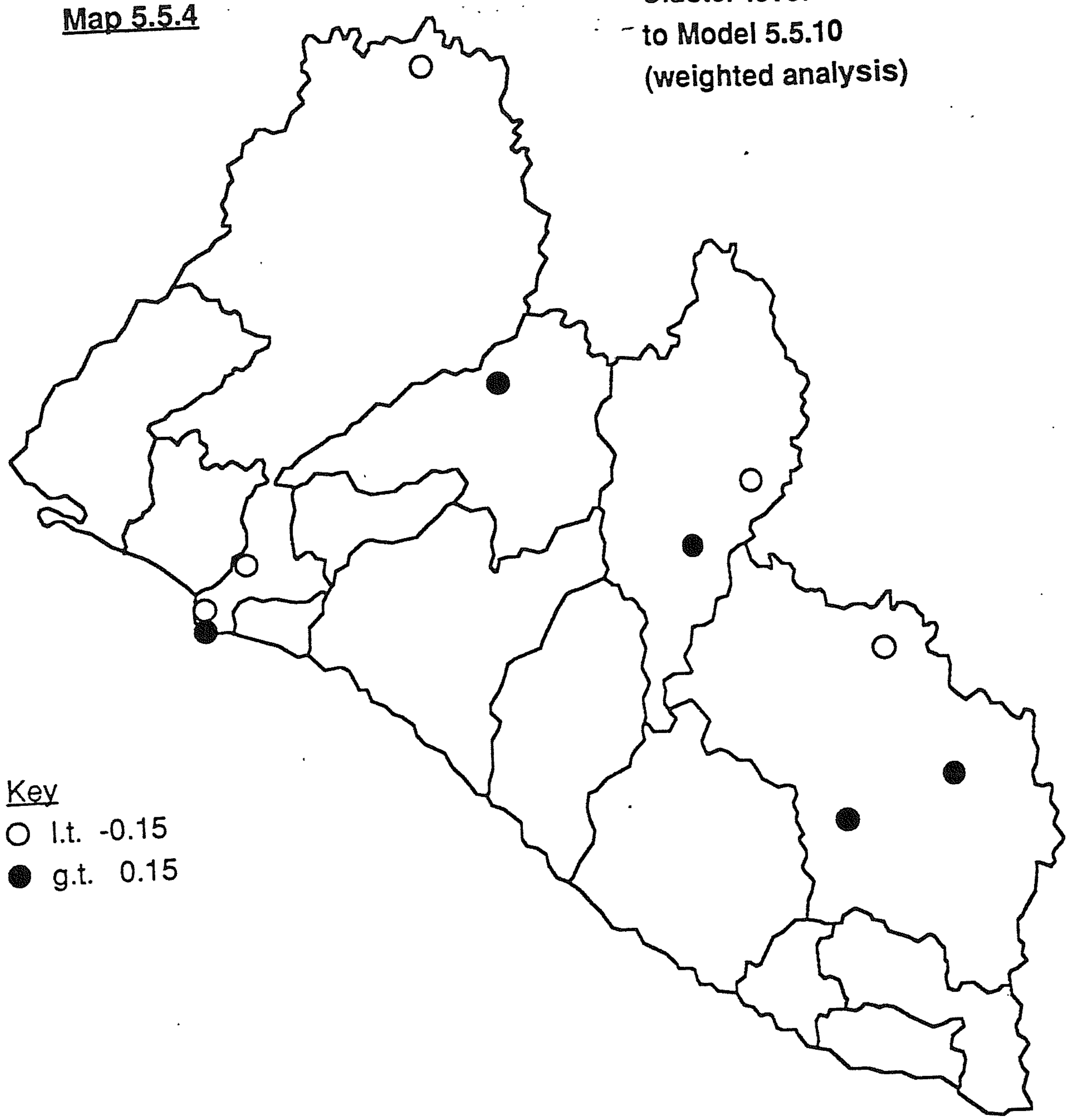


Table 5.5.13: Highest/Lowest Values of the Random Effect for Community for "Weighted Full" Model without a Poisson Constraint of Children Born 0-4 Years Before Survey

Rank	Cluster No.	Township	County	Cluster Effect
1	347	Arthington	Montserrado	-0.35
2	206	(rural)	Gr. Gedeh	-0.23
3	333	Monrovia	Montserrado	-0.17
4	310	Voinjama	Lofa	-0.17
5	392	(rural)	Nimba	-0.16
152	398	Tapitta	Nimba	0.16
153	215	(rural)	Gr. Gedeh	0.16
154	363	(rural)	Bong	0.17
155	218	(rural)	Gr. Gedeh	0.23
156	214	(rural)	Gr. Gedeh	0.24

Children Ever Born

Parameter Estimates

The number of children ever born to a woman is analysed. Listwise deletion is used for missing data and, consequently, 5233 level 1 units from 156 level 2 units are included for analysis.

Two analyses are presented; one weighted and the other unweighted. For each analysis extra-Poisson variation is tested for and it is found that the unconstrained estimate of the level 1 variance is significantly different from 1 and so the assumption that the level 1 variance is Poisson is rejected. Moreover, in both the weighted analysis and the unweighted analysis the level 1 variance is more than would be expected if a Poisson assumption were made (i.e. there is overdispersion). In other words the (weighted) observed numbers of women with numbers of children ever born close to the expected value tend to be less than would be expected under a Poisson assumption and the observed numbers of women with numbers of children ever born considerably above or considerably below the predicted number tend to be more than would be expected under a Poisson assumption. In particular, the (weighted) observed number of women with no children tend to be greater than predicted under a Poisson assumption. The omission of important explanatory variables from the model is a factor which would produce overdispersion.

Table 5.5.14 presents two sets of model parameters, one set for a weighted analysis and the other for the unweighted analysis. In each set of model parameters extra-Poisson variation is estimated. The main differences between the weighted and unweighted parameter estimates are:

a) the intercept is lower in the weighted analysis,

b) the effect of the proportion of women with primary level education only is (just) significant (at the 5% level) in the unweighted analysis but is not significant in the weighted analysis. This reflects both the more negative coefficient and the smaller standard error for this effect in the unweighted analysis,

c) the term for extra-Poisson variation is considerably larger for the weighted analysis.

Thus ignoring the need to use weights in the analysis would produce conclusions which would be somewhat inconsistent with the overall national pattern.

Table 5.5.15 presents the parameter estimates for both a weighted and an unweighted analysis if a Poisson assumption is made for the level 1 variance.

Table 5.5.16 presents a "final" model. This model was estimated using the weighted data and allows for extra-Poisson variation, but non-significant parameters have been removed.

The main findings are:

1) The number of children ever born to a woman increases with age[2]. Moreover, the increases between successive age groups are significant at the 5% level.

2) Women with primary level education only have a higher number of children ever born than women with no education, women with secondary level education only and women with higher/vocational education[2]. Women with higher/vocational education have significantly lower numbers of children ever born than women with secondary level education only[2].

3) Differentials in numbers of children ever born between categories for religion are not significant[2].

4) Of the ethnic categories, the Kwa have the highest fertility and the "Other" have the lowest[2]. The difference in fertility between the Mande and West Atlantic groups is not significant[2].

5) The urban-rural contrast is not significant[2].

6) The effect for the proportion of women in a community with secondary-level or above education is not significant[2]. The effect for the proportion of women in a community with primary-level education only is also not significant[23].

7) The random effect for community is significant at the 5% level[4]. The change in deviance when this effect is constrained to be zero (in the weighted extra-Poisson analysis) is 62.0.

Table 5.5.14: Full Multilevel Log-Linear Model (Without Poisson Constraint of ChildrenEver Born:

Weighted and Unweighted Parameter Estimates

Fixed Parameter	$\hat{\beta}$ wtd	$\hat{\beta}$ unw	S.E. $(\hat{\beta})$ wtd	S.E. $(\hat{\beta})$ unw	exp $(\hat{\beta})$ wtd	exp $(\hat{\beta})$ unw
Level 1						
15-19	-0.79**	-0.65**	n.e.	n.e.	0.45	0.52
20-24	1.39**	1.31**	0.07	0.05	4.01	3.71
25-29	1.98**	1.89**	0.06	0.05	7.24	6.62
30-34	2.26**	2.20**	0.06	0.05	9.58	9.03
35-39	2.50**	2.40**	0.07	0.05	12.18	11.02
40-44	2.59**	2.51**	0.07	0.05	13.33	12.30
45-49	2.74	2.61	0.07	0.05	15.64	13.60
No Education	0.00**	0.00**	n.a.	n.a.	1.00	1.00
Primary	0.12	0.07	0.04	0.03	1.13	1.07
Secondary	-0.04**	-0.03**	0.04	0.03	0.96	0.97
Higher	-0.40	-0.38	0.10	0.08	0.67	0.68
Protestant	0.00	0.00	n.a.	n.a.	1.00	1.00
Catholic	0.01	0.01	0.05	0.04	1.01	1.01
Muslim	0.03	0.02	0.04	0.03	1.03	1.02
Tradit./Oth.	0.01	-0.02	0.04	0.03	1.01	0.98
None	-0.00	-0.02	0.03	0.02	1.00	0.98
Kwa	0.00**	0.00**	n.a.	n.a.	1.00	1.00
Mande	-0.09	-0.13*	0.03	0.02	0.91	0.88
West Atlantic	-0.05**	-0.08**	0.05	0.04	0.95	0.92
Other	-0.27	-0.30	0.07	0.05	0.76	0.74
Level 2						
Rural	0.00	0.00	n.a.	n.a.	1.00	1.00
Urban	0.01	-0.02*	0.05	0.03	1.01	0.98
Prop. Primary	0.12	0.21	0.17	0.11	1.13	1.23
Prop. Sec/High	-0.05	-0.10	0.13	0.09	0.95	0.90

Random Parameter	$\hat{\sigma}^2$ wtd	$\hat{\sigma}^2$ unw	$\hat{\sigma}$ wtd	$\hat{\sigma}$ unw	S.E. $(\hat{\sigma})$ wtd	S.E. $(\hat{\sigma})$ unw
Level 2						
Constant	0.02++	0.01	0.13	0.08	0.01	0.01
Level 1						
Constant	1.84	1.15	1.36	1.07	n.e.	n.e.

Model Statistics

	wtd	unw
Deviance	12341.4	14921.4

Key

n.a. not applicable

n.e. not estimated (by VARCL).

* $0.01 \leq p < 0.05$

** $p < 0.01$

\+ $2.71 \leq$ Change in Deviance < 3.84

++ $3.84 \leq$ Change in Deviance

Table 5.5.15: Full Multilevel Log-Linear Model (With Poisson Constraint) of ChildrenEver Born:
Weighted and Unweighted Parameter Estimates

Fixed

Parameter	$\hat{\beta}$ wtd	$\hat{\beta}$ unw	S.E.($\hat{\beta}$) wtd	S.E.($\hat{\beta}$) unw	exp($\hat{\beta}$) wtd	exp($\hat{\beta}$) unw
Level 1						
15-19	-0.79**	-0.65**	n.e.	n.e.	0.45	0.52
20-24	1.39**	1.31**	0.05	0.05	4.01	3.71
25-29	1.98**	1.89**	0.05	0.05	7.24	6.62
30-34	2.26**	2.20**	0.05	0.05	9.58	9.03
35-39	2.50**	2.40**	0.05	0.05	12.18	11.02
40-44	2.59**	2.51**	0.05	0.05	13.33	12.30
45-49	2.75	2.61	0.05	0.05	15.64	13.60
No Education	0.00**	0.00**	n.a	n.a.	1.00	1.00
Primary	0.12	0.07	0.03	0.02	1.13	1.07
Secondary	-0.04**	-0.03**	0.03	0.03	0.96	0.97
Higher	-0.40	-0.38	0.07	0.08	0.67	0.68
Protestant	0.00	0.00	n.a.	n.a.	1.00	1.00
Catholic	0.01	0.01	0.04	0.04	1.01	1.04
Muslim	0.02	0.02	0.03	0.03	1.02	1.03
Tradit./Oth.	0.02	-0.02	0.03	0.03	1.02	0.98
None	0.01	-0.02	0.02	0.02	1.01	0.98
Kwa	0.00**	0.00**	n.a.	n.a.	1.00	1.00
Mande	-0.08	-0.13*	0.02	0.02	0.92	0.88
West Atlantic	-0.05**	-0.08**	0.04	0.04	0.95	0.92
Other	-0.26	-0.30	0.05	0.05	0.77	0.74
Level 2						
Rural	0.00	0.00	n.a.	n.a.	1.00	1.00
Urban	0.00	-0.02*	0.05	0.03	1.00	0.98
Prop. Primary	0.13	0.21	0.16	0.11	1.14	1.23
Prop. Sec/High.	-0.05	-0.10	0.12	0.09	0.95	0.90

Random

Parameter	$\hat{\sigma}^2$ wtd	$\hat{\sigma}^2$ unw	$\hat{\sigma}$ wtd	$\hat{\sigma}$ unw	S.E.($\hat{\sigma}$) wtd	S.E.($\hat{\sigma}$) unw
Level 2						
Constant	0.02++	0.01++	0.15	0.09	0.01	0.01
Level 1						
Constant	1.00	1.00	1.00	1.00	n.a.	n.a.

Model Statistics

	wtd	unw
Deviance	12513.6	14936.4

Key
n.a. not applicable
n.e. not estimated (by VARCL).
* $0.01 \le p < 0.05$
** $p < 0.01$
\+ $2.71 \le$ Change in Deviance < 3.84
++ $3.84 \le$ Change in Deviance

Table 5.5.16: Simplified Multilevel Log-Linear Model (Without Poisson Constraint) of ChildrenEver Born: Weighted Parameter Estimates

Fixed Parameter	$\hat{\beta}$	S.E. $(\hat{\beta})$	exp $(\hat{\beta})$
Level 1			
15-19	-0.77	n.e.	0.46
20-24	1.39**	0.07	4.01
25-29	1.98**	0.06	7.24
30-34	2.26**	0.07	9.58
35-39	2.50**	0.07	12.18
40-44	2.59**	0.07	13.33
45-49	2.75**	0.07	15.64
No Education	0.00	n.a.	1.00
Primary	0.12**	0.03	1.13
Secondary	-0.04	0.04	0.96
Higher	-0.41**	0.09	0.66
Kwa	0.00	n.a.	1.00
Mande/W. Atlantic	-0.08**	0.03	0.92
Other	-0.25**	0.06	0.78

Random Parameter	$\hat{\sigma}^2$	$\hat{\sigma}$	S.E. $(\hat{\sigma})$
Level 2			
Constant	0.02++	0.14	0.02
Level 1			
Constant	1.84	1.36	n.e.

Model Statistics

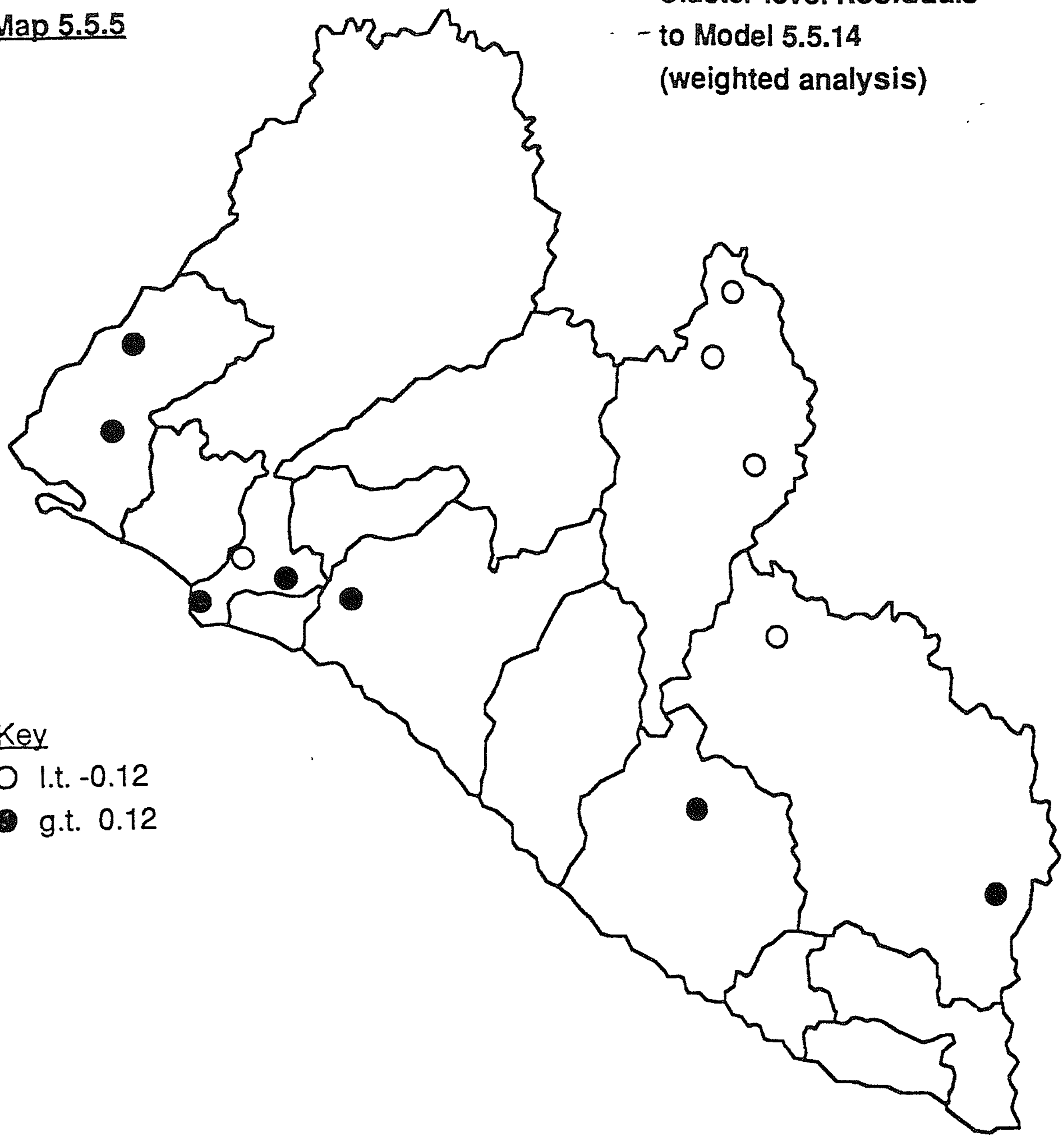
Deviance 12336.3

Community-Level Residuals

The community-level residuals for the weighted analysis which allows for extra-Poisson level 1 variance are presented in Appendix 5F. The histogram in Figure 5.5.5 is roughly a normal distribution, although there are fewer clusters more than one standard deviation above the mean than one would expect under normality. The implication of normality is that over the population of communities roughly 68% of residual community effects will lie in the range (-0.13, 0.13) and roughly 95% will lie in the range (-0.26, 0.26) or, equivalently, for a given value of the fixed explanatory variables, for roughly 68% of communities the mean number of children ever born to a woman will be between 0.88 and 1.14 times the value of the fixed part and for roughly 95% of communities the mean number of children ever born will be between 0.77 and 1.30 times the value of the fixed part. Map 5.5.5 shows that a number of the rural communities in Nimba county have relatively large negative residuals. The five highest values of the random effect and the five lowest values of the random effect are shown in Table 5.5.17:

Map 5.5.5

Cluster-level Residuals to Model 5.5.14 (weighted analysis)



Key
○ l.t. -0.12
● g.t. 0.12

Table_5.5.17:_Highest/Lowest_Values_of_the_Random_Effect for_Community_for_"Full_Weighted"_Model_(No_Poisson_Constraint) of_Children_Ever_Born

Rank	Cluster No.	Township	County	Residual
1	390	(rural)	Nimba	-0.22
2	387	Camp No. 4	Nimba	-0.17
3	393	(rural)	Nimba	-0.16
4	347	Arthington	Montserrado	-0.16
5	204	(rural)	Gr. Gedeh	-0.13
152	341	Monrovia	Montserrado	0.15
153	104	(rural)	Sinoe	0.17
154	349	Crozerville	Montserrado	0.17
155	223	(rural)	Gr. Gedeh	0.19
156	375	(rural)	Gr. Bassa	0.20

5.6 Discussion

The following variables are analysed: "currently married", "currently using contraception", "ever used contraception", "children born 0-4 years before survey" and children ever born". In Section 5.4, it was found that there is significant variation between communities for each of these variables. Moreover, significant community-level effects on each of these variables were found even after controlling for age, education, religion and ethnicity.

In the case of fixed effects, linking the findings from the various analyses is straightforward. For example, women with secondary or above education have a relatively high level of contraceptive use (see Table 6.5.4) and a relatively low level of current fertility (see Table 6.5.10). In the case of the random effects for community a different strategy is required. It would be cumbersome to compare each of the 156 values of the random effect from, say, the analysis of current use of contraception to the corresponding values from say, the analysis of the number of children born in the last five years. A concise way in which the community effects could be linked is by a (weighted) estimate of the covariance of the random effects for, say, these two analyses. Indeed it may also be of interest to study how the covariance between the random effects varies across values of the fixed effects. Had the various responses been analysed as a multivariate response, estimates of such covariances could have been provided along with the parameter estimates. However, analysis of multivariate responses is outside the scope of this work. It should be noted that a facility enabling ML3 to be used to analyse multivariate responses has recently been developed (Goldstein (1992) - personal communication).

Appendix 5A

The Liberia DHS survey is a national level survey. However, the information obtained from Sinoe and Grand Gedeh counties was considered to be particularly important because it could help the Southeast Region Primary Health Care Project in the planning of its programmes to motivate and educate people in these two counties in preventative health care measures. Consequently, these two counties were oversampled (for a fuller discussion of this see Chieh-Johnson et al (1988, pp83-85)).

Within each of the 3 subuniverses of Sinoe County, Grand Gedeh County and the rest of Liberia, the sample design is self-weighting. In Sinoe county 834 women were successfully interviewed, in Grand Gedeh county 920 women were successfully interviewed and in the rest of Liberia 3,485 women were successfully interviewed. To obtain national estimates from the data the following weighting factors needed to be applied:

$w = 0.180202$ for data from Sinoe county,

$w = 0.318122$ for data from Grand Gedeh county,

$w = 1.376195$ for data from the rest of Liberia.

Appendix 5B

Estimates of Bongaarts' Intermediate Fertility Variable Indices

In this section I present estimates of the indices suggested by Bongaarts to quantify the fertility-inhibiting effects of intermediate fertility variables for the LDHS data (see Section 1.1.2 for details of Bongaarts' model).

The estimates of the three indices suggest that post-natal non-susceptibility has a larger inhibiting impact on fertility than either marriage or contraception. The index for non-suceptibility suggests that non-susceptibility reduces the total fecundity rate by 37% (n.b. the assumed minimum postpartum anovulation of 1.5 months, the assumed waiting time to conception of 7.5 months and the assumed addition to birth intervals as a result of intrauterine mortality of 2 months may not be entirely appropriate for Liberia, but this is unlikely to affect the conclusion that post-natal non-susceptibility considerably lengthens birth intervals). The estimate of the index for contraceptive use suggests that the impact of contraceptive use on fertility is slight (n.b. both the adjustment used in this index to take into account the effects of sterility (1.08) and assumed use-effectiveness levels for the various methods of contraception may not be entirely appropriate for Liberia, but because of the low levels of contraceptive use the index will not be greatly affected by this). The estimate of the index for marriage would seem to indicate that the total fecundity rate is reduced by 28% as a result of women being unmarried. However, this index is based on the assumption that unmarried women do not have children. In the case of Liberia, which has a total fertility rate for never married women of 3.5 (higher than the marital fertility rates for most West European countries) and total fertility rates for formerly married women which are even higher (see Table 5.3.3.1.1), this assumption seems absurd. Furthermore, the age-specific marital fertility rates used to calculate this index may not be correct for Liberia. The index for the fertility inhibiting effects of abortion could not be calculated as no data on abortion was obtained by the LDHS (n.b. abortion is illegal in Liberia -see Section 5.2.3.3). The values of the estimates of Bongaarts' intermediate fertility variable indices are presented in Table 5.B.1:

Table 5.B.1: Estimates of Bongaarts Intermediate Fertility Variable Indices

Index	Estimate	
Proportion Married (C_m)	0.72	(a)
Contraception (C_c)	0.92	(b)
Postpartum Non-Susceptibility (C_i)	0.63	(c)
$C_m \times C_c \times C_i$	0.42	

(a) The age-specific proportions currently married and the assumed age-specific marital fertility rates (which are those estimated by Eaton and Mayer (1954) for the Hutterites c.f. Caldwell and Caldwell (1977) cited in Bongaarts (1981, p250)) used to calculate this index are presented in Table 5.B.2:

Table 5.B.2: Age-Specific Proportions Married and Assumed Marital Fertility Rates Used to Calculate Bongaarts' Index for Marriage

Age	m(a)	g(a)
15-19	0.32	0.30
20-24	0.66	0.55
25-29	0.79	0.50
30-34	0.82	0.45
35-39	0.86	0.41
40-44	0.80	0.22
45-49	0.82	0.06

(b) The index of contraception was calculated using the weighted proportion of all women surveyed who are currently using contraception (u = 0.084) and an estimate of the average use-effectiveness of contraception of 0.84 which is based on the weighted proportions of all methods of contraception used (see Table 5.3.2.2.2) and assumed use-effectiveness for each method are presented in Table 5.B.3:

Table 5.B.3: Use-Effectiveness Assumed for Each Method of Contraception in Calculation of Bongaarts Index

Method	Assumed Use-effectiveness
Sterilization	1.00
IUD	0.95
Injections	0.95
Pill	0.85
Condom	0.80
Diaphagm/Foam/Jelly	0.80
Withdrawal	0.70
Rhythm/Safe Period	0.70
Other	0.70

(c) The index of post-natal non-susceptibility is based on an estimated median duration of non-susceptiblity of 13 months.

Appendix 5C (The Locations of Clusters)

Cluster No.	Sample	County	District	Township/Clan
101	21	Sinoe	Butaw	Tarsui t/ship
102	18	Sinoe	Butaw	Butaw t/ship
103	33	Sinoe	Butaw	Murraysville
104	37	Sinoe	Juarzon	
105	26	Sinoe	Juarzon	
106	34	Sinoe	Juarzon	
107	27	Sinoe	Juarzon	
108	30	Sinoe	Juarzon	Balabokre
109	34	Sinoe	Pynestown	
110	27	Sinoe	Pynestown	
111	26	Sinoe	Pynestown	
112	50	Sinoe	Kpanyan	
113	45	Sinoe	Kpanyan	
114	28	Sinoe	Kpanyan	
115	36	Sinoe	Kpanyan	Worteh t/ship
116	33	Sinoe	Dugbe River	
117	38	Sinoe	Dugbe River	
118	45	Sinoe	Dugbe River	Greenville Cm.
119	40	Sinoe	Dugbe River	Greenville Cm.
120	42	Sinoe	Dugbe River	Greenville Cm.
121	44	Sinoe	Dugbe River	Greenville Cm.
122	27	Sinoe	Dugbe River	Greenville Cm.
123	55	Sinoe	Dugbe River	Greenville Cm.
124	56	Sinoe	Dugbe River	Greenville Cm.
201	42	Grand Gedeh	Gbarzon	
202	30	Grand Gedeh	Gbarzon	
203	30	Grand Gedeh	Gbarzon	
204	32	Grand Gedeh	Gbarzon	
205	37	Grand Gedeh	Tchien	
206	34	Grand Gedeh	Tchien	
207	32	Grand Gedeh	Tchien	
208	40	Grand Gedeh	Tchien	
209	30	Grand Gedeh	Tchien	
210	48	Grand Gedeh	Tchien	Zwedru City
211	42	Grand Gedeh	Tchien	Zwedru City
212	48	Grand Gedeh	Tchien	Zwedru City
213	59	Grand Gedeh	Tchien	Zwedru City
214	25	Grand Gedeh	Konobo	Zial t/ship
215	40	Grand Gedeh	Konobo	Zial t/ship
216	35	Grand Gedeh	Konobo	
217	42	Grand Gedeh	Gbaepo	Kanweaken
218	38	Grand Gedeh	Gbaepo	Kanweaken
219	29	Grand Gedeh	Gbaepo	Kanweaken
220	53	Grand Gedeh	Gbaepo	Kanweaken
221	44	Grand Gedeh	Webbo	
222	33	Grand Gedeh	Webbo	
223	45	Grand Gedeh	Webbo	
224	32	Grand Gedeh	Webbo	
301	21	Cape Mount	Porkpa	
302	8	Cape Mount	Gola Konneh	
303	26	Cape Mount	Gola Konneh	

304	29	Cape Mount	Garurla	
305	30	Cape Mount	Garurla	Robertsport
306	13	Lofa	Gbarma	Sirleaf Camp
307	19	Lofa	Zorzor	Zorzor City
308	41	Lofa	Zorzor	
309	35	Lofa	Zorzor	
310	29	Lofa	Voinjama	Voinjama City
311	31	Lofa	Voinjama	Voinjama City
312	26	Lofa	Voinjama	
313	30	Lofa	Kolahun	
314	55	Lofa	Kolahun	
315	48	Lofa	Kolahun	
316	21	Lofa	Kolahun	Kolba City
317	32	Bomi	Klay	
318	33	Bomi	Klay	
319	32	Bomi	Klay	Tubmanberg City
320	32	Bomi	Klay	Gutheria Plantn.
321	38	Montserrado	Gr. Monrovia	Paynesville
322	33	Montserrado	Gr. Monrovia	Paynesville
323	25	Montserrado	Gr. Monrovia	Congotown
324	21	Montserrado	Gr. Monrovia	Congotown
325	45	Montserrado	Gr. Monrovia	Congotown
326	40	Montserrado	Gr. Monrovia	Sinkor
327	34	Montserrado	Gr. Monrovia	Sinkor
328	55	Montserrado	Gr. Monrovia	Sinkor
329	44	Montserrado	Gr. Monrovia	Snapper Hill
330	36	Montserrado	Gr. Monrovia	Snapper Hill
331	22	Montserrado	Gr. Monrovia	South Beach
332	26	Montserrado	Gr. Monrovia	Bassa Community
333	39	Montserrado	Gr. Monrovia	Bishop Brooks
334	18	Montserrado	Gr. Monrovia	Soniwin
335	26	Montserrado	Gr. Monrovia	Soniwin
336	23	Montserrado	Gr. Monrovia	West Point
337	23	Montserrado	Gr. Monrovia	Vai Town
338	44	Montserrado	Gr. Monrovia	Fanima
339	28	Montserrado	Gr. Monrovia	Logan Town
340	28	Montserrado	Gr. Monrovia	Logan Town
341	29	Montserrado	Gr. Monrovia	Logan Town
342	62	Montserrado	Gr. Monrovia	New Kru Town
343	25	Montserrado	Gr. Monrovia	New Kru Town
344	53	Montserrado	Gr. Monrovia	Gardnersville
345	51	Montserrado	Gr. Monrovia	Gardnersville
346	64	Montserrado	Gr. Monrovia	Gardnersville
347	30	Montserrado	St. Paul River	Arthington
348	45	Montserrado	St. Paul River	Virginia
349	21	Montserrado	Careysburg	Crozerville Town
350	33	Montserrado	Firestone	
351	25	Montserrado	Firestone	
352	26	Montserrado	Firestone	
353	31	Montserrado	Firestone	
354	31	Montserrado	Todee	
355	46	Bong	Fuamah	
356	47	Bong	Fuamah	Bong Mines Co.
357	27	Bong	Fuamah	Nyien City
358	31	Bong	Salalah	
359	36	Bong	Sanoyea	
360	23	Bong	Sanoyea	

361	28	Bong	Gbarnga	
362	54	Bong	Gbarnga	
363	47	Bong	Gbarnga	
364	28	Bong	Gbarnga	
365	23	Bong	Gbarnga	Gbarnga City
366	5	Bong	Zota	
367	17	Bong	Panta/Kpaai	
368	45	Bong	Panta/Kpaai	
369	23	Margibi	Mamba Kaba	Schliefflin Town
370	38	Margibi	Mamba Kaba	Charleville Town
371	31	Margibi	Mamba Kaba	Marshall Mun.
372	32	Margibi	Kaketa	
373	19	Margibi	Kaketa	
374	22	Margibi	Kaketa	Kaketa City
375	30	Grand Bassa	No. 1	
376	25	Grand Bassa	No. 1	
377	35	Grand Bassa	No. 2	
378	41	Grand Bassa	No. 3B	
379	31	Grand Bassa	No. 3	
380	24	Grand Bassa	No. 3	LAC Concession
381	26	Grand Bassa	No. 4	
382	43	Grand Bassa	Comm. Buchanan	Buchanan
383	55	Grand Bassa	Comm. Buchanan	Buchanan
384	14	Grand Bassa	Comm. Buchanan	St. John River
385	32	Rivercess	Morveh	
386	36	Rivercess	Timbo	
387	35	Nimba	Sanniquelli	Camp No. 4
388	34	Nimba	Sanniquelli	Yekepa City
389	30	Nimba	Sanniquelli	
390	45	Nimba	Sanniquelli	
391	42	Nimba	Sanniquelli	
392	38	Nimba	Zoegeh	
393	39	Nimba	Zoegeh	
394	36	Nimba	Zoegeh	
395	20	Nimba	Zoegeh	
396	36	Nimba	Gbehlay Geh	
397	27	Nimba	Gbehlay Geh	Slorlay t/ship
398	23	Nimba	Tapitta	Tapitta City
399	29	Nimba	Tapitta	Tapitta City
400	29	Nimba	Tapitta	
401	32	Nimba	Yauvin Men	
402	53	Nimba	Saclepea	Cocepa Plantation
403	27	Nimba	Saclepea	
404	8	Grand Kru	Upper Kru	Togbaklee t/ship
405	20	Grand Kru	Lower Kru	
406	18	Sasstown	Sasstown	Sasstown City
407	21	Maryland	Pleebo	Twansiebo Town
408	63	Maryland	Harper Comm.	Harper

Source: 1986 Liberia Demographic and Health Survey Enumerators File. Unpublished documents.

Appendix 5D ("Raw" Community Means)

Cluster No.	Proportion Currently Married	Current User	Ever User	Mean No. Children Born Last 5 Years	Ever
101	0.67	0.19	0.29	0.81	3.86
102	0.56	0.00	0.06	1.22	2.78
103	0.70	0.00	0.12	1.30	3.36
104	0.84	0.00	0.11	1.19	5.35
105	0.58	0.00	0.00	0.96	2.04
106	0.68	0.09	0.29	1.00	4.88
107	0.78	0.07	0.15	0.93	4.74
108	0.63	0.03	0.20	1.10	4.10
109	0.82	0.00	0.06	1.09	4.50
110	0.89	0.00	0.00	0.67	3.44
111	0.88	0.00	0.19	1.15	4.54
112	0.82	0.02	0.18	0.94	4.06
113	0.80	0.07	0.13	1.18	3.91
114	0.75	0.11	0.29	0.96	3.18
115	0.81	0.03	0.17	1.33	3.75
116	0.85	0.00	0.03	0.88	3.67
117	0.79	0.00	0.03	0.87	3.71
118	0.49	0.13	0.20	1.16	3.27
119	0.60	0.18	0.25	1.05	3.15
120	0.52	0.24	0.26	0.71	2.36
121	0.39	0.11	0.30	1.07	3.05
122	0.70	0.15	0.41	1.30	3.56
123	0.58	0.15	0.29	1.04	2.67
124	0.61	0.16	0.27	0.96	2.75
201	0.83	0.00	0.07	1.12	3.71
202	0.77	0.10	0.10	1.00	5.33
203	0.80	0.00	0.10	0.80	3.97
204	0.78	0.00	0.06	0.97	3.03
205	0.73	0.00	0.16	1.14	3.62
206	0.71	0.09	0.24	0.79	2.00
207	0.63	0.03	0.16	0.88	3.19
208	0.78	0.07	0.25	0.83	5.80
209	0.70	0.13	0.30	1.23	4.27
210	0.90	0.04	0.13	0.96	2.77
211	0.81	0.00	0.12	0.90	2.67
212	0.58	0.12	0.35	1.10	2.31
213	0.58	0.10	0.19	1.07	2.93
214	0.72	0.04	0.20	1.48	5.64
215	0.80	0.00	0.13	1.40	4.73
216	0.74	0.00	0.11	0.83	3.63
217	0.69	0.02	0.21	1.21	4.90
218	0.95	0.00	0.03	1.58	5.05
219	0.97	0.00	0.03	1.28	4.14
220	0.72	0.04	0.19	1.09	3.75
221	0.84	0.00	0.00	0.93	5.05
222	0.70	0.03	0.06	1.03	4.24
223	0.80	0.07	0.36	1.31	5.60

224	0.84	0.00	0.09	1.16	4.00
301	0.95	0.00	0.00	1.43	4.48
302	1.00	0.00	0.00	1.13	4.00
303	0.85	0.04	0.04	1.08	4.00
304	0.86	0.00	0.03	1.24	4.17
305	0.57	0.13	0.33	1.10	4.03
306	0.92	0.00	0.00	1.08	3.00
307	0.63	0.05	0.32	0.78	3.26
308	0.54	0.00	0.02	0.76	2.02
309	0.60	0.00	0.11	0.66	2.91
310	0.41	0.31	0.55	0.52	1.79
311	0.61	0.13	0.48	0.58	2.45
312	1.00	0.00	0.04	1.27	3.00
313	0.87	0.00	0.00	1.00	3.43
314	0.89	0.02	0.07	1.02	2.62
315	0.65	0.06	0.19	0.98	2.75
316	0.48	0.18	0.48	0.62	2.29
317	0.88	0.00	0.06	1.00	4.41
318	0.70	0.03	0.06	1.15	3.94
319	0.47	0.16	0.47	1.09	2.69
320	0.94	0.03	0.09	1.28	4.53
321	0.50	0.29	0.42	0.76	2.45
322	0.76	0.00	0.03	1.03	3.18
323	0.52	0.08	0.20	0.92	2.04
324	0.57	0.24	0.33	0.71	2.33
325	0.58	0.17	0.42	0.84	2.02
326	0.68	0.02	0.38	1.28	3.38
327	0.62	0.06	0.24	0.59	2.41
328	0.58	0.18	0.36	0.84	2.22
329	0.52	0.32	0.45	0.66	2.39
330	0.44	0.22	0.50	1.08	2.47
331	0.64	0.09	0.18	0.68	3.00
332	0.50	0.23	0.46	0.65	2.35
333	0.44	0.31	0.38	0.62	1.92
334	0.72	0.11	0.22	1.11	1.94
335	0.35	0.23	0.31	0.73	1.88
336	0.57	0.14	0.26	1.00	3.78
337	0.74	0.09	0.22	1.22	2.91
338	0.68	0.16	0.41	1.00	3.14
339	0.54	0.14	0.39	1.07	3.07
340	0.71	0.18	0.25	1.11	2.71
341	0.66	0.17	0.55	1.31	4.21
342	0.47	0.09	0.32	0.77	3.32
343	0.48	0.19	0.44	1.08	4.36
344	0.51	0.19	0.38	0.81	2.36
345	0.59	0.14	0.25	0.96	2.49
346	0.55	0.17	0.39	1.08	3.00
347	0.67	0.03	0.10	0.23	2.63
348	0.40	0.09	0.27	0.87	2.53
349	0.81	0.00	0.05	0.81	5.05
350	0.70	0.03	0.03	0.91	3.82
351	0.80	0.08	0.12	1.28	3.68
352	0.73	0.07	0.19	1.08	2.38
353	0.77	0.07	0.19	1.26	2.94
354	0.48	0.07	0.23	0.97	3.39
355	0.85	0.04	0.20	0.93	4.09
356	0.66	0.12	0.40	1.04	3.34

357	0.89	0.04	0.22	1.52	3.19
358	0.77	0.07	0.16	1.13	2.87
359	0.72	0.03	0.08	0.89	3.31
360	0.61	0.13	0.30	0.83	2.87
361	0.71	0.00	0.04	1.11	2.75
362	0.63	0.04	0.17	1.09	3.02
363	0.64	0.00	0.04	1.23	3.77
364	0.79	0.00	0.04	1.43	3.00
365	0.83	0.04	0.13	1.09	2.87
366	0.80	0.00	0.40	1.40	5.20
367	0.65	0.12	0.35	1.12	4.06
368	0.58	0.04	0.24	1.02	2.96
369	0.87	0.04	0.26	1.30	2.13
370	0.47	0.32	0.61	0.79	2.45
371	0.52	0.16	0.26	1.10	3.23
372	0.63	0.06	0.31	1.06	3.75
373	0.68	0.05	0.05	0.79	3.84
374	0.55	0.13	0.41	1.09	2.86
375	0.80	0.00	0.07	1.33	5.03
376	0.72	0.00	0.04	1.28	4.64
377	0.60	0.03	0.09	1.06	3.14
378	0.85	0.00	0.10	1.07	3.20
379	0.84	0.03	0.13	0.87	3.29
380	0.92	0.00	0.13	1.13	3.38
381	0.69	0.00	0.00	0.96	3.35
382	0.58	0.07	0.26	0.95	2.93
383	0.64	0.05	0.25	0.80	3.29
384	0.79	0.00	0.07	1.07	3.50
385	0.75	0.05	0.13	0.94	3.63
386	0.83	0.00	0.19	1.33	3.22
387	0.77	0.14	0.26	1.06	2.51
388	0.65	0.20	0.47	0.79	2.94
389	0.73	0.13	0.27	1.00	3.30
390	0.82	0.00	0.02	0.84	2.31
391	0.74	0.00	0.07	0.93	2.90
392	0.82	0.00	0.00	0.82	2.63
393	0.82	0.00	0.00	0.87	2.95
394	0.86	0.00	0.00	0.75	2.28
395	0.40	0.15	0.25	0.80	2.70
396	0.92	0.00	0.08	1.11	3.36
397	1.00	0.00	0.00	0.93	3.00
398	0.74	0.17	0.39	1.17	3.35
399	0.72	0.00	0.07	0.86	3.17
400	0.72	0.07	0.28	0.90	3.31
401	0.75	0.09	0.22	1.00	3.94
402	0.77	0.04	0.09	0.91	3.32
403	0.81	0.04	0.15	0.85	2.78
404	0.88	0.00	0.00	1.25	4.38
405	0.75	0.00	0.10	1.40	3.60
406	0.39	0.11	0.22	0.72	2.50
407	0.62	0.00	0.05	1.19	3.48
408	0.35	0.17	0.44	0.63	2.13

Appendix 5E ("Shrunken"/Posterior Community Means)

Cluster No.	Proportion Currently Married	Proportion Current User	Proportion Ever User	Mean No. Children Born Last 5 Years	Mean No. Children Born Ever
101	0.68	0.14	0.26	0.93	3.51
102	0.61	0.04	0.10	1.06	3.03
103	0.69	0.02	0.14	1.12	3.30
104	0.80	0.02	0.12	1.09	4.50
105	0.62	0.03	0.05	0.98	2.61
106	0.68	0.08	0.28	0.99	4.18
107	0.75	0.08	0.16	0.96	4.02
108	0.65	0.05	0.20	1.03	3.70
109	0.79	0.02	0.09	1.03	3.96
110	0.77	0.05	0.10	0.93	3.27
111	0.82	0.03	0.20	1.05	3.90
112	0.79	0.03	0.18	0.96	3.78
113	0.78	0.07	0.14	1.09	3.67
114	0.73	0.10	0.27	0.99	3.19
115	0.78	0.04	0.17	1.15	3.53
116	0.90	0.02	0.07	0.94	3.47
117	0.76	0.02	0.06	0.93	3.52
118	0.53	0.12	0.20	1.08	3.25
119	0.62	0.15	0.24	1.02	3.17
120	0.56	0.20	0.25	0.82	2.67
121	0.46	0.10	0.28	1.03	3.10
122	0.70	0.12	0.36	1.11	3.39
123	0.60	0.13	0.28	1.02	2.84
124	0.62	0.14	0.26	0.98	2.89
201	0.80	0.02	0.09	1.06	3.53
202	0.74	0.09	0.12	0.99	4.38
203	0.77	0.03	0.12	0.91	3.63
204	0.76	0.02	0.09	0.98	3.11
205	0.72	0.02	0.17	1.06	3.97
206	0.70	0.08	0.23	0.90	2.51
207	0.64	0.05	0.17	0.94	3.20
208	0.75	0.08	0.24	0.91	4.82
209	0.70	0.11	0.28	1.09	3.79
210	0.85	0.05	0.14	0.97	2.92
211	0.78	0.02	0.13	0.96	2.87
212	0.61	0.11	0.33	1.05	2.62
213	0.60	0.09	0.19	1.04	3.01
214	0.71	0.05	0.20	1.17	4.44
215	0.77	0.02	0.14	1.19	4.15
216	0.73	0.02	0.13	0.92	3.46
217	0.69	0.04	0.21	1.10	4.28
218	0.88	0.02	0.06	1.27	4.33
219	0.88	0.03	0.07	1.11	3.72
220	0.71	0.05	0.19	1.05	3.58
221	0.80	0.02	0.03	0.96	4.39
222	0.69	0.05	0.09	1.01	3.80
223	0.78	0.07	0.33	1.16	4.76

224	0.80	0.02	0.12	1.06	3.66
301	0.85	0.03	0.06	1.14	3.80
302	0.81	0.05	0.10	1.01	3.41
303	0.79	0.05	0.08	1.02	3.62
304	0.81	0.03	0.07	1.09	3.73
305	0.60	0.11	0.31	1.04	3.67
306	0.81	0.04	0.08	1.01	3.14
307	0.65	0.06	0.28	0.93	3.23
308	0.57	0.02	0.06	0.87	2.47
309	0.62	0.02	0.13	0.84	3.04
310	0.50	0.23	0.47	0.70	2.44
311	0.63	0.11	0.42	0.72	2.79
312	0.90	0.03	0.08	1.10	3.10
313	0.81	0.03	0.04	0.99	3.33
314	0.85	0.03	0.09	1.01	2.80
315	0.65	0.07	0.19	0.98	2.91
316	0.56	0.14	0.40	0.87	2.78
317	0.82	0.02	0.09	0.99	3.89
318	0.69	0.04	0.09	1.06	3.63
319	0.54	0.13	0.41	1.04	2.91
320	0.87	0.05	0.12	1.12	3.96
321	0.55	0.23	0.38	0.78	2.75
322	0.74	0.02	0.07	1.01	3.19
323	0.58	0.08	0.20	0.96	2.62
324	0.62	0.17	0.30	0.80	2.80
325	0.60	0.15	0.39	0.92	2.44
326	0.68	0.04	0.35	1.13	3.31
327	0.64	0.06	0.23	0.71	2.75
328	0.60	0.16	0.34	0.90	2.52
329	0.56	0.26	0.41	0.82	2.68
330	0.51	0.18	0.44	1.03	2.77
331	0.66	0.09	0.19	0.88	3.11
332	0.56	0.18	0.40	0.87	2.76
333	0.50	0.23	0.35	0.71	2.42
334	0.71	0.10	0.22	1.03	2.67
335	0.46	0.18	0.28	0.90	2.53
336	0.61	0.11	0.25	0.99	3.49
337	0.72	0.08	0.21	1.07	3.07
338	0.68	0.15	0.38	0.99	3.16
339	0.58	0.12	0.35	1.02	3.14
340	0.71	0.14	0.24	1.04	2.95
341	0.67	0.14	0.47	1.12	3.75
342	0.50	0.09	0.31	0.86	3.29
343	0.54	0.16	0.39	1.02	3.87
344	0.54	0.15	0.35	0.89	2.63
345	0.61	0.12	0.25	0.97	2.72
346	0.57	0.16	0.36	1.04	2.97
347	0.67	0.05	0.12	0.63	2.89
348	0.46	0.09	0.26	0.93	2.77
349	0.76	0.03	0.09	0.92	4.06
350	0.69	0.04	0.07	0.95	3.56
351	0.76	0.08	0.14	1.10	3.45
352	0.72	0.08	0.20	1.02	2.78
353	0.75	0.07	0.20	1.10	3.06
354	0.54	0.07	0.22	0.98	3.31
355	0.81	0.05	0.20	0.96	3.78
356	0.67	0.12	0.37	1.02	3.30

357	0.83	0.05	0.22	1.20	3.20
358	0.75	0.07	0.17	1.05	3.02
359	0.71	0.04	0.11	0.94	3.27
360	0.64	0.11	0.28	0.93	3.05
361	0.71	0.03	0.07	1.04	2.96
362	0.64	0.05	0.17	1.05	3.08
363	0.65	0.02	0.06	1.12	3.58
364	0.76	0.03	0.07	1.17	3.10
365	0.78	0.06	0.15	1.02	3.05
366	0.72	0.06	0.28	1.03	3.55
367	0.67	0.10	0.30	1.03	3.56
368	0.62	0.05	0.24	1.01	3.05
369	0.81	0.06	0.25	1.10	2.69
370	0.53	0.25	0.53	0.90	2.75
371	0.57	0.13	0.25	1.04	3.22
372	0.64	0.07	0.29	1.02	3.52
373	0.69	0.07	0.10	0.93	3.49
374	0.60	0.11	0.35	1.05	3.05
375	0.77	0.03	0.10	1.13	4.22
376	0.71	0.03	0.08	1.10	3.94
377	0.62	0.04	0.11	1.02	3.17
378	0.81	0.02	0.12	1.03	3.20
379	0.80	0.05	0.15	0.94	3.26
380	0.84	0.03	0.15	1.04	3.29
381	0.69	0.03	0.05	0.98	3.28
382	0.61	0.07	0.25	0.97	3.03
383	0.65	0.06	0.25	0.88	3.27
384	0.74	0.04	0.12	1.01	3.32
385	0.75	0.07	0.15	0.97	3.42
386	0.80	0.02	0.20	1.15	3.22
387	0.75	0.12	0.25	1.02	2.80
388	0.66	0.17	0.42	0.90	3.05
389	0.72	0.11	0.25	0.99	3.26
390	0.79	0.02	0.05	0.92	2.63
391	0.73	0.02	0.09	0.96	3.02
392	0.78	0.02	0.05	0.91	2.86
393	0.79	0.02	0.04	0.93	3.05
394	0.82	0.02	0.04	0.88	2.65
395	0.51	0.12	0.24	0.93	2.98
396	0.86	0.02	0.11	1.05	3.30
397	0.90	0.02	0.05	0.97	3.10
398	0.72	0.14	0.34	1.06	3.28
399	0.71	0.03	0.10	0.94	3.19
400	0.71	0.07	0.26	0.95	3.27
401	0.73	0.09	0.22	0.99	3.68
402	0.76	0.05	0.11	0.94	3.29
403	0.77	0.05	0.16	0.94	2.98
404	0.76	0.05	0.10	1.03	3.50
405	0.72	0.03	0.14	1.12	3.35
406	0.51	0.10	0.22	0.91	2.91
407	0.65	0.03	0.09	1.06	3.33
408	0.41	0.16	0.42	0.78	2.43

Appendix 5F (Community-level Residuals)

Cluster No.	Response: Currently Married	Current User	Ever User	Children Born Last 5 Years	Children Born Ever
101	-0.03	1.09	0.47	-0.01	0.03
102	-0.22	-0.25	-0.38	0.10	-0.05
103	0.03	-0.35	0.04	0.14	-0.03
104	0.47	-0.58	-0.42	0.04	0.16
105	0.10	-0.42	-0.87	0.00	-0.11
106	0.05	0.41	0.58	0.14	0.12
107	0.06	0.64	0.49	-0.03	0.02
108	-0.02	-0.37	-0.33	0.06	0.10
109	0.41	-0.34	-0.26	0.12	0.03
110	0.33	-0.10	-0.35	-0.09	-0.03
111	0.69	-0.28	0.62	0.02	0.08
112	0.66	-0.42	-0.14	-0.05	0.08
113	0.41	0.82	0.42	0.13	0.07
114	0.37	0.53	0.41	-0.05	-0.00
115	0.62	-0.18	0.04	0.13	0.11
116	0.56	-0.37	-0.64	-0.10	0.03
117	0.62	-0.45	-0.70	0.03	0.05
118	-0.56	0.63	-0.22	0.05	0.10
119	-0.07	1.10	0.10	0.05	0.01
120	-0.10	1.20	0.45	-0.10	0.03
121	-0.85	0.05	-0.17	0.05	0.08
122	0.20	0.72	0.78	0.05	0.05
123	-0.10	0.96	0.43	0.01	-0.10
124	0.03	1.52	0.55	-0.01	0.02
201	0.39	-0.31	0.01	0.03	0.04
202	0.05	0.77	-0.24	-0.01	0.07
203	0.18	-0.29	-0.13	-0.15	-0.01
204	0.32	-0.40	-0.43	0.00	-0.13
205	0.00	-0.50	-0.00	0.06	-0.05
206	0.08	0.50	0.28	-0.23	-0.08
207	-0.09	-0.27	-0.36	-0.07	-0.03
208	-0.01	0.38	0.62	0.01	0.09
209	0.14	0.62	0.35	0.15	0.05
210	0.68	-0.09	-0.07	-0.07	-0.00
211	0.65	-0.72	-0.47	-0.06	-0.05
212	0.25	0.30	0.46	0.13	-0.02
213	-0.34	0.57	-0.14	-0.00	-0.03
214	-0.23	0.19	0.68	0.24	0.11
215	0.16	-0.39	-0.01	0.16	0.08
216	0.31	-0.37	0.09	-0.00	0.01
217	-0.17	-0.40	-0.14	0.04	0.09
218	0.93	-0.47	-0.79	0.23	0.11
219	0.79	-0.51	-0.93	-0.04	0.03
220	0.41	-0.25	-0.13	0.14	0.00
221	0.47	-0.48	-0.93	-0.00	0.11
222	-0.04	0.06	-0.27	0.08	0.01
223	0.33	0.06	0.62	0.13	0.19

224	0.65	-0.40	-0.28	0.11	0.01
301	0.24	-0.13	-0.37	0.09	0.13
302	0.34	-0.03	-0.11	-0.02	0.06
303	0.11	0.14	-0.43	0.06	0.02
304	-0.27	-0.15	0.02	0.02	0.14
305	-0.66	0.29	0.48	0.06	-0.05
306	0.10	-0.08	-0.23	0.02	-0.05
307	-0.10	-0.36	0.19	0.00	-0.06
308	-1.04	-0.27	-0.31	-0.09	-0.08
309	-0.57	-0.35	0.13	-0.13	-0.02
310	-0.28	0.66	0.84	-0.17	0.00
311	-0.18	0.60	1.66	-0.12	0.01
312	0.45	-0.11	0.11	-0.01	-0.05
313	0.06	-0.15	-0.47	-0.14	0.01
314	0.35	0.08	0.18	-0.07	-0.04
315	-0.57	0.34	0.41	0.01	-0.03
316	-0.01	0.45	0.77	-0.02	0.00
317	0.23	-0.21	-0.00	-0.01	0.08
318	-0.62	0.14	-0.11	0.07	0.09
319	-0.35	0.25	0.80	0.12	0.05
320	0.61	0.21	0.13	0.10	0.12
321	-0.23	0.74	0.37	-0.14	0.02
322	0.63	-0.65	-0.95	0.00	0.03
323	0.12	-1.11	-1.51	0.08	-0.06
324	0.13	0.31	-0.70	-0.01	-0.09
325	0.14	0.24	0.58	-0.04	-0.07
326	0.02	-0.79	0.02	0.07	-0.07
327	0.01	-0.58	-0.33	-0.08	-0.02
328	0.31	-0.28	-0.36	0.01	0.00
329	-0.11	0.59	0.23	-0.12	-0.04
330	-0.16	-0.28	-0.11	0.03	-0.02
331	0.06	0.09	-0.18	-0.13	0.08
332	-0.13	-0.08	-0.14	-0.15	-0.08
333	-0.27	0.89	0.10	-0.17	-0.05
334	-0.13	0.65	0.61	-0.02	-0.05
335	-0.66	0.27	-0.28	-0.09	-0.10
336	-0.40	0.34	0.13	0.01	-0.00
337	0.43	-0.23	-0.26	0.09	0.04
338	0.01	0.74	1.07	-0.02	0.11
339	-0.25	-0.06	0.32	0.08	0.03
340	0.29	0.08	-0.28	0.10	-0.03
341	0.28	0.04	0.68	0.16	0.15
342	-0.33	-0.57	-0.35	-0.06	0.06
343	-0.30	-0.03	-0.10	0.03	0.10
344	0.07	0.24	-0.32	-0.04	-0.01
345	0.20	-0.15	-0.55	-0.06	-0.01
346	0.05	0.34	0.41	0.07	0.04
347	-0.55	0.15	0.07	-0.35	-0.16
348	-0.74	-0.32	-0.38	0.01	0.01
349	-0.09	-0.14	0.03	-0.04	0.17
350	-0.19	-0.05	-0.69	0.01	0.07
351	0.25	0.66	0.07	0.14	0.09
352	0.13	0.40	0.32	-0.02	-0.03
353	0.23	-0.04	-0.19	0.04	-0.02
354	-0.88	0.13	0.26	0.07	-0.02
355	0.27	0.31	1.01	0.04	0.01
356	0.43	-0.26	0.07	0.04	0.11

357	0.54	0.05	0.75	0.14	0.06
358	0.32	0.21	-0.00	0.08	0.01
359	-0.46	0.07	0.02	-0.06	-0.05
360	-0.38	0.70	0.80	-0.06	0.02
361	-0.07	-0.30	-0.37	0.15	0.01
362	-0.57	0.30	0.78	0.06	0.04
363	-0.60	-0.40	-0.37	0.17	0.10
364	0.05	-0.21	-0.22	0.13	0.04
365	0.38	-0.01	-0.04	-0.03	-0.00
366	0.00	-0.18	0.33	0.04	0.04
367	-0.53	0.48	0.86	-0.07	0.04
368	-0.18	-0.28	0.06	0.04	-0.01
369	1.15	-0.38	-0.23	0.07	-0.01
370	0.16	-0.15	0.13	0.02	0.02
371	-0.27	0.01	-0.55	0.07	-0.02
372	-0.69	0.03	0.58	-0.00	0.02
373	0.90	0.34	-0.16	-0.10	-0.05
374	-0.12	-0.27	-0.05	0.06	-0.05
375	0.25	-0.18	0.14	0.14	0.20
376	-0.49	-0.19	-0.19	0.05	0.03
377	0.45	0.03	-0.21	-0.00	0.00
378	0.56	-0.25	0.26	0.00	-0.02
379	0.17	0.24	0.45	-0.14	-0.09
380	0.83	-0.37	-0.01	0.03	0.04
381	-0.14	-0.21	-0.61	-0.05	-0.03
382	-0.19	0.04	0.31	-0.00	-0.07
383	-0.10	-0.28	0.14	-0.12	0.07
384	0.12	-0.14	0.01	0.01	0.04
385	0.19	0.35	-0.11	-0.03	-0.07
386	0.54	-0.43	0.24	0.13	-0.05
387	0.11	1.00	0.57	0.02	-0.17
388	0.60	-0.42	-0.29	0.03	0.08
389	-0.08	0.92	0.48	-0.04	-0.02
390	0.16	-0.38	-0.52	-0.07	-0.22
391	0.02	-0.68	-0.61	-0.05	-0.12
392	0.33	-0.43	-0.83	-0.16	-0.10
393	-0.03	-0.38	-0.75	-0.11	-0.16
394	0.53	-0.25	-0.59	-0.10	-0.13
395	-0.57	0.11	-0.25	-0.05	-0.03
396	0.58	-0.36	-0.14	0.02	-0.01
397	0.80	-0.23	-0.62	-0.10	-0.09
398	0.82	-0.51	-0.44	0.16	0.03
399	-0.13	-0.39	-0.38	-0.06	-0.05
400	0.31	-0.23	-0.01	-0.01	0.01
401	0.18	0.20	0.16	0.11	0.05
402	-0.02	0.10	-0.15	-0.10	-0.01
403	0.32	0.04	0.14	-0.03	0.02
404	0.37	-0.10	-0.29	0.11	-0.00
405	0.21	-0.34	-0.35	0.12	0.02
406	-0.33	-0.11	-0.30	-0.06	0.01
407	-0.24	-0.27	-0.05	0.11	-0.05
408	-0.05	-0.38	-0.13	-0.03	-0.02

[1]These analyses are performed separately with univariate response variables. Fitting a single model with a multivariate response variable (e.g. Goldstein (1987, ch.5), Liang, Zeger and Qaqish (1991)) would have been preferable. The ML3 software has only very recently been adapted to offer a facility for such analyses (Goldstein (1992)). Investigation of this seems an interesting area for further research.

[2]Assuming other fixed explanatory variables and the value of the random effect for community are controlled for.

[3]This conclusion would be different if the data had not been weighted to produce nationally representative estimates.

[4]The precise form of how the significance of this parameter should be tested is a matter of some debate. Suggestions include comparison of the change in deviance to the (half-normal)^2, an equiprobable mixture of χ_0^2 and χ_1^2 and χ_1^2. However, in this case, as the change in deviance is greater than the 5% critical values of all three distributions the matter of which test is appropriate is irrelevent to this conclusion.

Appendix 5G

Figure 5.4.1 Histogram of Shrunken Means for Currently Married

Lower limit	N	
0.390	1	*
0.420	0	
0.450	3	**
0.480	4	
0.510	6	
0.540	8	
0.570	6	
0.600	12	
0.630	14	
0.660	9	
0.690	21	
0.720	16	
0.750	17	
0.780	17	
0.810	9	
0.840	5	
0.870	[illegible]	
[illegible]	[illegible]	
[illegible]	[illegible]	

Figure 5.4.2 Histogram of Shrunken Means for Currently Using Contraception

Lower limit	N	
0.0100	6	
0.0200	32	
0.0300	10	
0.0400	15	
0.0500	[illegible]	
0.0600	[illegible]	
0.0700	[illegible]	
0.0800	6	
0.0900	[illegible]	
0.1000	[illegible]	
0.110	11	
0.120	4	
0.130	5	
0.140	6	
0.150	4	
0.160	3	
0.170	3	
0.180	1	
0.190	1	
0.200	0	
0.210	0	
0.220	0	
0.230	2	**
0.240	1	*
0.250	2	**
0.260	0	

Figure 5.4.3 Histogram of [illegible]
Means of Ever Used Contraception

Lower Limit	Frequency
0.000	[illegible]
0.0400	20
0.0800	15
0.120	18
0.160	17
0.200	16
0.240	21
0.280	8
0.320	10
0.360	8
0.400	5
0.440	3
[illegible]	[illegible]
0.520	[illegible]
[illegible]	[illegible]

Figure 5.4.4 Histogram of Shrunken Means for Children Born 0-4 Years Before Survey

Lower Limit	Frequency
0.640	[illegible]
0.680	[illegible]
0.720	0
[illegible]	[illegible]

Figure 5.4.5 Histogram of Shrunken Means for Children Ever Born

Lower Limit	Frequency
[illegible]	[illegible]
[illegible]	[illegible]
2.600	13
2.700	10
2.800	5
2.900	9
3.000	15
3.100	15
3.200	18
3.300	5
3.400	5
3.500	11
3.600	7
3.700	9
3.800	4
3.900	3
4.000	2
4.100	2
4.200	2
4.300	3
4.400	1
4.500	1
4.600	0
4.700	1
4.800	1

Appendix 5H

Figure 5.5.1 Histogram of Community-level Residuals for Currently Married

lower limit	
-1.100	1
-1.000	0
-0.900	[illegible]
-0.800	1
-0.700	[illegible]
-0.600	[illegible]
-0.500	[illegible]
-0.400	[illegible]
-0.300	11
-0.200	[illegible]
-0.100	[illegible]
[illegible]	17
0.1000	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
[illegible]	[illegible]
0.800	[illegible]
0.900	1
1.000	0
[illegible]	1
[illegible]	0

Figure 5.5.2 Histogram of Community-level Residuals for Currently Using Contraception

lower limit	
-1.200	1
-1.000	0
-0.800	4
-0.600	13
-0.400	45
-0.200	24
0.000	22
0.200	16
0.400	8
0.600	11
0.800	4
1.000	4
1.200	0
1.400	1
1.600	0

Figure 5.5.3 Histogram of Community-level Residuals for Ever Used Contraception

Lower Limit	N	
-1.600	1	:
-1.400	0	:
-1.200	0	:
-1.000	5	: *****
-0.800	9	: *********
-0.600	10	: **********
-0.400	32	: ********************************
-0.200	26	: **************************
0.000	28	: ****************************
0.200	[illegible]	: [illegible]
0.400	17	: *****************
0.600	11	: ***********
0.800	[illegible]	: [illegible]
1.000	2	: **
1.200	0	:
1.400	0	:
1.600	1	: *
1.800	0	:

Figure 5.5.4 Histogram of Community-level Residuals for Children Born 0-4 Years Before Survey.

Lower Limit	N	
[illegible]	[illegible]	:
[illegible]	[illegible]	:
[illegible]	[illegible]	:
-0.240	1	:
-0.200	[illegible]	:
-0.160	11	: [illegible]
-0.120	11	: [illegible]
-0.0800	19	: [illegible]
-0.0400	23	: [illegible]
[illegible]e-017	29	: [illegible]
0.0400	24	: [illegible]
0.0800	12	: [illegible]
0.120	15	: [illegible]
0.160	4	: [illegible]
0.200	[illegible]	:
0.240	[illegible]	:

Figure 5.5.5 Histogram of Community-level Residuals for Children Ever Born.

Lower Limit	N	
-0.240	1	:
-0.210	0	:
-0.180	3	: ***
-0.150	3	: ***
-0.120	5	: *****
-0.0900	11	: ***********
-0.0600	20	: ********************
-0.0300	26	: **************************
[illegible]2e-017	30	: ******************************
0.0300	20	: ********************
0.0600	17	: *****************
0.0900	13	: *************
0.120	3	: ***
0.150	2	: **
0.180	2	: **
0.210	0	:

6 GHANA

6.1 Introduction

The republic of Ghana (formerly known as the Gold Coast) lies on the coast of West Africa. It is bordered to the west by Ivory Coast, to the east by Togo and to the north by Burkina Faso (see Map 5.1.1). The land area of Ghana is 238,537 square kilometers (approximately 92,100 square miles). Based on the 1984 census the population of Ghana is 12.3 million (source: Ghana Statistical Service (1987)). The population is growing rapidly despite large scale outmigration with an average annual rate of increase between 1980 and 1985 of 2.9% (source: McCourt et al. (1986))). The Crude Birth Rate is estimated to be 44 per thousand and the Crude Death rate is estimated to be 13 per thousand (Source: Population Reference Bureau (1990)). The largest urban area is the capital, Accra, with a population of 965,000 . Other major cities are Kumasi (489,000) , Tema (191,000), Tamale (168,000) and Sekondi-Takoradi (116,000) (the locations of these cities can be seen on Map 5.1.1). The populations of these larger urban areas have increased dramatically since 1948 as a result of widespread rural-urban migration (de Graft-Johnson (1974)).

Ghana has a hot, humid, tropical climate with two distinct seasons. The rainy season is between April and November and the dry season (when the Harmatton wind blows from the north-east) lasts the rest of the year. For the most part Ghana is covered by Savannah woodlands. The exceptions to this are the tropical rainforests in the south-west of the country and a belt of coastal scrub and grassland which broadens towards the east of the country.

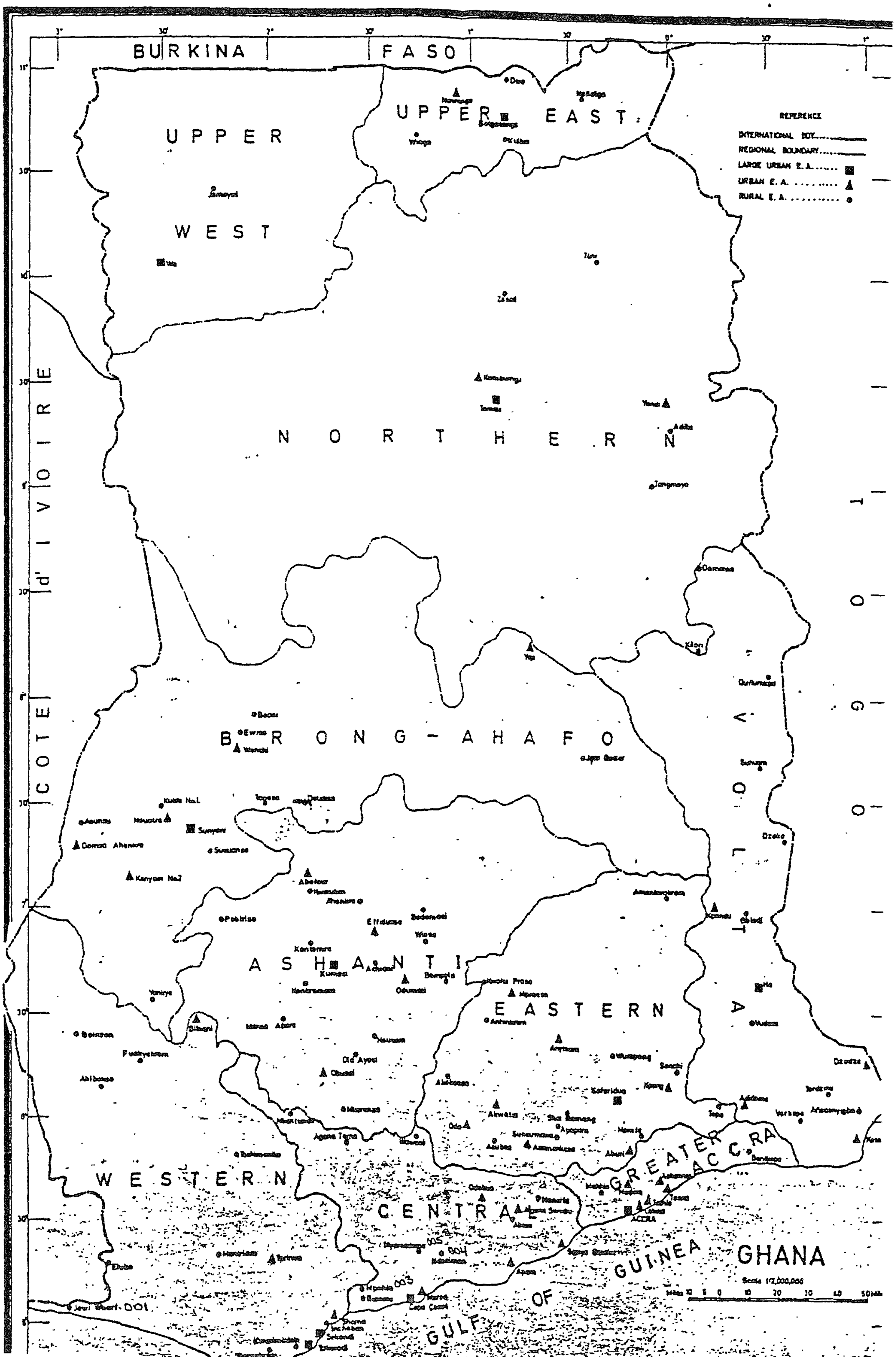
Ghana was granted full independence from Britain in 1957. Since independence it has been governed by a variety of both civilian-based and military-based governments and has been plagued by a succession of economic crises. The economy is predominantly agricultural with cocoa beans being the most valuable export (67% of all exports in 1978 (source: World Bank (1984))). Mining activities (in particular bauxite, gold, manganese and diamonds) also play an important role in Ghana's economy as does forestry. The economy has been in severe decline for over 20 years, and this decline was exacerbated during the early 1980s by the effects of a severe drought (the average fall in GDP between 1979 and 1982 was 6.1% per annum (source: World Bank (1984))). Unusually for a Sub-Saharan African country, the majority of the school age population (i.e. 56.5% of the population aged 6+ years old), and almost half the women of school age (49.3% of women aged 6+ years old) have attended school (source: Ghana Statistical Service (1987)). At present, Ghana remains an underdeveloped country with an estimated GDP per capita of $400 and an estimated infant mortality rate of 86 per thousand births (Source: Population Reference Bureau (1990)).

6.2 A Review of Research on Fertility in Ghana

6.2.1 Introduction

As in other West African countries (see Table 1.3.1), fertility levels in Ghana are high. The total fertility rate (TFR) is 6.3 and the crude birth rate is 44 (source: Population

Map 6.1.1: Ghana



Reference Bureau (1990)). These high fertility levels reflect a society which traditionally places a high value on children, with prolific childbearing being honoured and barren women being regarded with contempt and malicious pity (e.g. Fortes (1954), Bleek (1976), Oppong (1985)). In Ghanaian society belief systems involving a worship of lineage ancestors which can only be carried out through living descendents support mores for high fertility. Children can have significant economic value by assisting parents or other members of their kinship group in work such as farming or fishing and provide a means of financial security in old age. Furthermore, kinship structures act to ensure that the economic costs of children do not fall directly on the parents (e.g. women go to stay with relatives following childbirth and fosterage of children among the kin group is widespread (Oppong (1985, pp258-260))) thus lessening economic motives to restrict fertility. The desirability of having large numbers of children in Ghanaian society is reflected by the high mean (based on numeric answers only) ideal family size recorded for the Ghanaian Fertility Survey (GFS) of 5.6 children (Ageh-Gbede (1990)). Ideal family sizes tend to be smaller among young women than among older women, among women in urban areas than among women in rural areas, among more educated women and among Christian women as opposed to Muslim and women who follow traditional beliefs. There are also significant variations in ideal family size between ethnic groups (Ageh-Gbede (1990, p66)).

The 1988 Ghana Demographic and Health Survey (GDHS) provides current information on a comprehensive set of questions relating to fertility in Ghana. Analysis of data from this survey forms a central part of this thesis. A summary of these data is presented in Section 6.3. The results presented in this section were obtained through my own analyses of the data. Many of these findings, although by no means all, have been independently obtained and subsequently published in the first country report (see Ghana Statistical Service (1989)). Researchers can also draw from an extensive set of literature on fertility in Ghana compiled prior to this survey. Of particular note is the wealth of data collected by the GFS during 1979-80. In the following section (Section 6.2.2), I review literature on Ghanaian fertility collected prior to the 1988 GDHS. However, because some of the results of my analyses of the GDHS data have not as yet been published elsewhere and because reference to all such results (which may be useful when models which use these data are presented in Section 6.5) is easier if these results are presented in a separate section, the findings of the analyses of the GDHS data have not been incorporated into this literature review.

6.2.2 The Proximate Determinants of Fertility

6.2.2.1 Marriage

Marriage in Ghana takes traditional African forms as well as Christian and Islamic forms (n.b. in cases where a couple have married in a recognized Christian way or a recognized Islamic way they will most probably have married in a traditional way as well (e.g. Bleek (1976, p96)). The stages involved in traditional forms of marriage differ between regions and ethnic groups (Ayree

(1985, p17)). The climax of the process of traditional marriage typically involves the rendering of a bride-price by the groom's family to the bride's (e.g. Ageh-Gbede (1990)).

As in other African societies (see Table 1.3.1.1), marriage of one form or another (including consensual unions) is near universal in Ghana (in the GFS 99.8% of women aged 45-49 had ever married with never married women of this age only being found in Greater Accra (Ayree (1985, p20)). The marital bond is characterized as weak and considered to be less important than lineage (Bleek (1976, p88), (1987a)). Women tend to marry at young ages in Ghana. The SMAM for the GFS sample was 19.3, similar to that calculated for other African countries (see Table 1.3.1.2.). However, teenage marriage appears to be less common in Ghana than in other African countries (see Table 1.3.1.2). Men tend to marry at older ages than women and typically there is a large age difference between spouses (e.g Bhatia (1984) reported age at first marriage for husbands and wives in his study of rural Ghana to be 25.2 and 18.4 respectively with the average age difference between a husband and a wife of 9 years).

In Ghana, women in urban areas ((GFS) SMAM 20.0 years) tend to marry later than women in rural areas ((GFS) SMAM 18.9 years) (Ayree (1985, p20)). Women with at least secondary level education tend to marry later than women with primary level education only and women with no education (Ayree (1985, p20), Bhatia (1984), Nankunda (1990)). There is evidence that Muslim women marry at younger ages than other religious groups in Ghana. However, evidence of differentials in age at marriage between Christians and women with traditional beliefs is inconclusive.

The GFS found that Christian women tend to marry later than both Muslims and followers of traditional beliefs (Ayree (1985, p22)). However, Bhatia (1984) found that Christian wives had tended to marry at younger ages than wives with traditional beliefs with Muslim wives tending to marry at younger ages than both these groups. There is also evidence of significant differences in age at marriage both by region and by ethnicity (Ayree (1985, p20), WFS (1983, p37), Bhatia (1984)). Women in Greater Accra and Eastern regions tend to marry at comparatively high ages while women in the Upper and Northern regions tend to marry at comparatively low ages. Women from the Ga-Adangbe and Ewe ethnic groups have comparatively high ages at first marriage while women from the Mole-Dagbani and Other Akan ethnic groups tend to marry at comparatively early ages. Bhatia (1984) found a significant positive relationship between a woman's age at first marriage and her age at menarche in rural Ghana.

Polygyny is widespread in Ghana (35% of currently married women in the GFS reported that their husband had another wife, a similar proportion to that found in other West African countries - see Table 1.3.1.4). The GFS found that polygyny was more widespread in the Northern, Upper and Volta regions and less common in Greater Accra and Eastern regions. Generally, polygyny is more common in rural areas than in urban areas. Furthermore, the GFS found that polygyny was more prevalent among Muslims and among followers of traditional African beliefs than among Christians. Polygyny tends to be less common among educated women than among uneducated women (Ayree (1985, p44), Nankunda (1990)). Bhatia (1985) and (1986) found that the fertility of polygynously married

Ghanaian women tends to be lower than that of monogamously married women.

In view of the prevalence of polygyny, it is perhaps surprising to find that marital dissolution is more common in Ghana than in other African countries (see Table 1.4.1.3). The widespread practice of divorce in Ghana was observed by Bleek (1987a) who commented:

"Divorce among the Akan is easy and frequent: it is a normal occurrence which is likely to befall anyone at least once, probably twice" (p140).

The risk of marital dissolution has been shown to be directly related to the age at marriage with marriages at relatively older ages tending to be more stable and teenage marriages being particularly prone to break up (Ayree (1985, p33)). The GFS found significant differences in the extent of marital dissolution between the different regions of Ghana with the Northern and Upper regions having markedly lower levels of dissolution than elsewhere in Ghana. Muslims and followers of traditional beliefs were found to have significantly lower levels of marital dissolution than Christians. The Mole-Dagbani ethnic group was found to have significantly lower levels of marital dissolution than other ethnic groups (Ayree (1985, p33)). The impact of marital dissolution on fertility levels may not be particularly great due to a very high rate of remarriage among all sections of society (Ayree (1985, p38)). This is supported by regression models relating the fertility of rural Ghanaian married women to intermediate fertility variables which show no significant relationship between a woman's number of previous marriages and her fertility (see Bhatia (1986)).

Bleek (1976, chapters 4 and 6) describes a variety of categories of pre-marital and extra-marital relationships in Akan society. He concludes that sex, having children, bringing them up, earning a living, and belonging to a social group are not uniquely obtained through marriage (Bleek (1987a, p140)). Nevertheless, fertility levels of currently married (largely Akan) women have been found to be significantly higher than those of single women or women whose marriages have been dissolved (Nankunda (1990)).

6.2.2.2 Contraception

Family planning in Ghana can be traced back as far as 1956 when a family planning committee was established by the Pathfinder fund. In 1961 the Christian Council of Ghana started giving contraceptive advice and supplies as part of its activity promoting Christian marriage and family life. The Planned Parenthood Association of Ghana (a branch of the International Planned Parenthood Federation) started offering family planning services from 1965 onwards. The Ghana National Family Planning Programme was set up in 1969 to offer family planning services to couples who wanted to space or limit childbearing. Currently, all major family planning services are available in Ghana (Appiah (1985, p97)).

The GFS found that despite a majority of women (68% of the sample) being aware of a method of contraception fewer than half the women (32%) admitted to ever having used a method and only a small minority (12%) of "exposed", currently married women admitted to using a method of contraception currently (WFS (1983, p65)). Although the levels of contraceptive use in Ghana are low, they are still higher than in many other African countries (see Table 1.4.2.2). Among contraceptors a sizeable proportion only use "inefficient" methods. Data from the GFS indicated that only 18% of women had ever used an efficient method of contraception and only 7% of ("exposed", currently married) women were currently doing so (WFS (1983, p67)). The most widely used method was abstention, with the pill being the second most widely used method (WFS (1983, p67), Appiah (1985, p103-105). It should be noted that women who report using "pills" may not necessarily be using pills with proven contraceptive properties (Bleek (1976, p197)).

Regional variations in knowledge of contraception have been found to be considerable. The proportions of the women (in the GFS) knowing of a method of contraception ranged from 22% in Northern region to 93% in Volta region (WFS (1983, p69)). Knowledge of contraception was generally found to be more extensive in urban areas than in rural areas and to be more extensive with successively greater levels of education (WFS (1983, p69), Appiah (1985, p99)).

Levels of use of contraception have been found to vary considerably between regions in Ghana. In the GFS the proportions of women reporting having ever used contraception ranged from 5% in Northern region to 89% in Volta, whilst proportions of "exposed" currently married women currently using contraception ranged from 1% in the Northern region to 26% in Greater Accra (WFS (1983, p70-71)). Contraceptive use has been generally found to be more extensive in urban areas than in rural areas and to become more widespread with successively greater levels of education (WFS (1983, p70-71), Appiah (1985, p101)).

Bleek (1987a, p148) attributes low levels of family planning among Akans firstly to the traditional norm of high fertility and secondly to the inappropriateness of Ghanaian family planning propaganda. He found that when contraception is practised it is predominantly in pre-marital and extra-marital liasons (Bleek (1976, p241)).

6.2.2.3 <u>Abortion</u>

Abortion is illegal in Ghana and strongly disapproved of (Bleek (1976, p219-225)). Consequently accurate data on the extent of induced abortion is extremely difficult to obtain (Bleek (1978) and (1987b)). Nonetheless, abortion does take place in Ghana although the means used can frequently lead to sterility or even death (Bleek (1978) presents a list of methods "known" to cause abortion). Indeed, induced abortion may be fairly common in Ghana. Bleek (1978) asserts:

"Abortion is the most condemned method of birth control, but it is also the most widely used" (p118).

Lamptey *et al.* (1985) found that 25% of women hospitalized for a birth reported having had at least one induced abortion. Abortion was found to be most commonly used for first pregnancies and to have been most commonly undertaken among more educated women. This suggests that abortion is most commonly used to delay the first birth, particularly when a woman wishes to continue schooling. This is supported by the findings of Bleek (1978)

(albeit based on a very small sample) that abortion was most common among young women in a pre-marital sexual relationship and that a desire to complete education was the most common reason given for having had an abortion.

6.2.2.4 Postpartum Non-Susceptibility

6.2.2.4.1 Breastfeeding/ Amenorrhea

As in other West African countries (see Table 1.3.4.1), a long duration of breastfeeding is common in Ghana. A mean duration of breastfeeding of 17.9 months was calculated from GFS data (Singh and Ferry (1984)). Long durations of breastfeeding tend to produce lengthy durations of postpartum amenorrhea. A mean duration of amenorrhea of 12.4 months, higher than in any other Sub-Saharan African country in the WFS, was calculated for the GFS data (see Table 1.3.4.2).

Gaisie (1981a), (1981b) found significant differences in durations of breastfeeding by place of residence. The different ethnic groups found in the localities studied could be a factor in these differences. Gaisie found that educated women tended to practise significantly shorter durations of breastfeeding than uneducated women. Shorter durations of breastfeeding among more educated women have also been found within Tutu Akwapim district (Nasozi (1990)). Gaisie found that women who had ever used contraception had significantly shorter durations of breastfeeding than women who had not used contraception. These differentials in durations of breastfeeding are likely to result in a similar pattern of differentials in postnatal amenorrhea (see Section

1.3.4).

6.2.2.4.2 Abstinence

There is evidence that lengthy durations of postnatal sexual abstinence are observed in Ghana, although durations tend not to be as long as those observed in other West African countries (see Table 1.3.4.3). A mean duration of postnatal abstinence of 10 months was estimated from GFS data (Singh and Ferry (1984)). Gaisie (1981a), (1981b) reported considerable variation in durations of abstinence by place of residence. The different ethnic groups predominating in these places could be a factor in this (see Gaisie (1981a, pp103-104) for a review of customary durations of abstinence among various Ghanaian ethnic groups). Gaisie also found a shorter mean duration of abstinence among educated women than among uneducated women. Nasozi also found a shorter mean duration for abstinence among more educated women within Tutu Akwapim district. Gaisie found that women who had ever used contraception had a considerably shorter mean duration of abstinence than women who had not used contraception. This latter finding suggests that where contraception is adopted it is often as an alternative to abstinence as a method of achieving child-spacing.

6.2.2.4.3 Postpartum Non-Susceptibility

The combinations of lengthy durations of postnatal amenorrhea and of postnatal abstinence produce lengthy periods of postnatal non-susceptibility. A mean duration of non-susceptibility of 14.6 months was calculated from GFS data (Singh and Ferry (1984)).

This duration of non-susceptibility is similar to those estimated for other sub-Saharan African countries (see Table 1.3.5).

Gaisie (1981b) argues that most of the regional and urban-rural variations in fertility levels in Ghana (see Sections 6.2.2.1 and 6.2.2.2) can be explained by differences in postpartum non-susceptibility which in turn result from differences in breastfeeding and postpartum abstinence. Gaisie also reports shorter durations of postpartum non-susceptibility among educated women and contraceptors.

6.2.2.5 Sterility

Infertility is regarded as one of the greatest misfortunes that could befall a Ghanaian (e.g. Bleek (1976, pp177-181)). There is evidence that in Ghana levels of sterility are fairly low by African standards. In the GFS only 5.5% of women reported that they were infecund and had not reached menopause (WFS (1983, p86)).

6.2.2.6. Other Factors

Data from the GFS indicate that temporary spousal separations (which may cause reduced fertility - see Section 1.3.6) are unimportant as a determinant of fertility levels (WFS (1983, p84)).

6.2.3 Fertility Differentials

6.2.3.1 Urban-Rural Residence

As in other African countries (see Section 1.2.2.1), fertility levels in urban areas of Ghana tend to be lower than in rural areas of Ghana. In particular, fertility in large urban areas tends to be considerably below that in the rest of Ghana. This has been shown by data from the GFS which recorded TFRs of 6.65, 5.96 and 5.36 for rural areas, urban areas and large urban areas respectively (WFS (1983)). Lower fertility levels in urban areas at least in part reflect later marriage (see Section 6.2.2.1) and more use of modern methods of contraception (see Section 6.2.2.2) in these areas. Caldwell (1967) found that fertility differentials between large urban areas and rural areas reflected considerable differences between fertility in the élite neighbourhoods (i.e. tracts with high proportions of people in white-collar occupations and high mean levels of education) and rural areas and much lower differences between fertility in the poor urban neighbourhoods and rural areas. The lower fertility among the Ghanaian urban élite at least in part reflects the deferment of female marriage (Caldwell (1968)).

6.2.3.2 <u>Region</u>

Ghana is divided into nine regions (see Map 6.1.1 for the locations of these regions). The capital city Accra lies in Greater Accra region as does Tema, Kumasi lies in Ashanti region, Temale lies in Northern region and Sekondi-Takoradi lies in Western region.

The GFS found considerably lower fertility levels in Greater Accra than in other regions of Ghana. This region is heavily urbanized. Lower fertility levels in Greater Accra reflect later ages at first marriage (see Section 6.2.2.1) and higher levels of current use of contraception (see Section 6.2.2.2) in this region than in Ghana as a whole. Perhaps surprisingly, the GFS also found a low TFR in Upper region. This region is fairly remote and has a low age of entry into marriage (see Section 6.2.2.1). The Northern region had the highest fertility levels. This region has a low average age at first marriage (see Section 6.2.2.1) and the lowest levels for use of contraception of any region of Ghana (see Section 6.2.2.2). The TFRs for each region recorded by the GFS are shown Table 6.2.3.2:

Table 6.2.3.2: Total Fertility Rates for Regions (GFS)

Region	T.F.R. (Women Aged 15-44)
Western	7.13
Central	7.11
Greater Accra	5.18
Eastern	6.26
Volta	6.32
Ashanti	6.04
Brong Ahafo	6.65
Northern	7.86
Upper	5.75

Source: WFS (1983). *Ghana Fertility Survey 1979-1980: First Report*. Central Bureau of Statistics, Accra, Ghana.

6.2.3.3 Ethnicity

Ethnic groups in Ghana are identified primarily by a common language or dialect. The Akans form the largest language group. Within this group the Twi and Fante dialect groups are of considerable size. Other major ethnic groups are Ga-Adangbe, Ewe, Guan, and Mole-Dagbani.

The largest ethnic group, the Twi, forms the majority of the population in Ashanti, Brong-Ahafo and Eastern regions. The Fante form the majority of the population in Central region. The other Akans are concentrated in Western region. The Ga-Adangbe form the largest ethnic group in Greater Accra. The Ewe form the majority of the population in Volta region near the border with Togo. The Mole-Dagbani ethnic group forms the majority of the population in the Upper, West and East and Northern area.

The GFS found that among ethnic groups only the Other Akans (with a TFR of 7.3) had significantly above average fertility whilst only the Twi (with a TFR of 6.1) had significantly below average fertility (WFS (1983)). The Other Akans are largely found in Western and Central regions both of which had above average fertility levels. The high fertility of the Other Akans at least in part reflects comparatively early ages at first marriage (see Section 6.2.2.1). TFRs by ethnic group for the GFS are presented in Table 6.2.3.3;

Table_6.2.3.3:_Total_Fertility_Rates_for_Ethnic_Groups_(GFS)

Ethnic Group	T.F.R. (women aged 15-44)
Twi	6.1
Fante	6.3
Other Akan	7.3
Ewe	6.4
Ga-Adangbe	6.4
Guan	6.4
Mole-Dagbani	6.4
Other	6.6

Source: WFS (1983). *Ghana Fertility Survey 1979-1980: First Report*. Central Bureau of Statistics, Accra, Ghana.

6.2.3.4 Education

Fertility levels in Ghana have been found to be inversely correlated with the length of time spent in education. The GFS found TFRs of 6.75, 6.61, 5.58, and 3.94 for women with no schooling, 1-6 years of education, 7-10 years of education and 11+ years of education respectively (WFS (1983)). The association of lower fertility with higher levels of female education has also been shown to exist within Tutu Akwapim district (Nankunda (1990)). Lower fertility levels among more educated women reflect delayed first marriages (and first births) to allow completion of education (see Section 6.2.2.1) and more widespread use of contraception (see Section 6.2.2.2).

6.3 The Ghana Demographic and Health Survey

6.3.0 Introduction

The Ghana Demographic and Health Survey (GDHS) was conducted during 1988. One hundred and fifty census enumeration areas were selected for the sample (information on the locations of these clusters and the numbers of women sampled in each cluster are presented in Appendix 6B, and the locations of these clusters can be seen from Map 6.1.1) and 4488 women aged between 15 and 49 years old were surveyed. The women came from 4406 households. The sample was designed to be a nationally representative, stratified and self-weighting sample of women between 15 and 49 (Ghana Statistical Service (1989)). This survey provides extensive, up-to-date data on a wide range of questions on fertility-related behaviour.

This section describes differentials in women's fertility by socioeconomic, cultural and environmental characteristics. Differentials in women's fertility between communities/neighbourhoods as represented by clusters (i.e. census enumeration areas) are presented elsewhere (see Section 6.4) because the different method used to summarise these differentials warrants explanation. In Section 6.3.1 I present the distribution of the sample by the chosen socioeconomic, cultural and environmental ("background") characteristics. In Section 6.3.2 I present levels and differentials of the proximate determinants of fertility. In Section 6.3.3.1 I describe how fertility levels differ according to the values of these proximate determinants. In Section 6.3.3.2 I describe the differentials in fertility levels by the background characteristics and draw from the previously presented differentials in the distribution of the proximate determinants and the relationships between the proximate determinants and fertility levels to explain these.

6.3.1 Background Characteristics of the Women Surveyed

The current ages reported by the women showed considerable heaping on to ages which are a multiple of five. The unreliability of the data for age which results from heaping onto ages which are a multiple of five can be estimated by Whipple's Index (e.g. Newell (1988, pp23-24)). This Index (based on women who report ages of 23-47) has a value of 141, indicating that the reported current ages should be regarded as being only roughly reliable.

As is standard practice, the reported ages are presented in five year age groups with the lower bounds being the ages which are a multiple of five. The distribution of the women by five year age groups is shown in Table 6.3.1.1

Table 6.3.1.1: GDHS Distribution by Age Group

Age	Frequency	Percent n=4488
15-19	849	18.9
20-24	867	19.3
25-29	867	19.3
30-34	644	14.3
35-39	531	11.8
40-44	364	8.1
45-49	366	8.2
	4488	100.0

The distribution of the women by region is presented in Table 6.3.1.2 (the locations of these regions can be seen from Map 6.1.1). A comparison between the proportions of women sampled for the GDHS and the proportions recorded by the 1984 census for each area shows that too few women from Upper West,Upper East and Northern regions were interviewed in the GDHS.

Table 6.3.1.2: Distributions by Region - GDHS and 1984 Census

Region	Frequency	Percent (GDHS) n=4488	Percent (1984 census)
Western	392	8.7	9.1
Central	464	10.3	9.4
Greater Accra	598	13.3	11.6
Eastern	703	15.7	13.8
Volta	500	11.1	9.8
Ashanti	823	18.3	17.1
Brong Ahafo	500	11.1	9.7
Upper W,E & North.	508	11.3	19.3
	4488	100.0	100.0

The distribution of the women by ethnic group is shown in Table 6.3.1.3:

Table 6.3.1.3: GDHS Distribution by Ethnic Group

Ethnic Group	Frequency	Percent n=4485
Twi	1623	36.2
Fante	566	12.6
Other Akan	190	4.2
Ga-Adangbe	397	8.9
Ewe	718	16.0
Guan	104	2.3
Mole-Dagbani	492	11.0
Other Ghanaian	209	4.7
Other African	186	4.1
	4485	100.0

Christianity is the predominant religion in Ghana. Catholics form about a sixth of the sample. Moslems form about one tenth of the sample and followers of traditional belief form about one twelfth of the sample. The distribution of the women by religious affiliation is presented in Table 6.3.1.4:

Table 6.3.1.4: GDHS Distribution by Religion

Religion	Frequency	Percent n=4485
Catholic	765	17.1
Other Christian	2380	53.1
Moslem	445	9.9
Traditional	351	7.8
No religion	529	11.8
Other	12	0.3
	4485	100.0

Christianity is the predominant religion in all regions of Ghana except for the Upper, West and East and Northern area of the country where Islam and traditional beliefs predominate. Christianity is the predominant faith among the Twi, Fante, Other Akan, Ga-Adangbe, Ewe and Guan ethnic groups whilst Islam is the most widespread belief among the Mole-Dagbani and the Other African ethnic groups. Traditional belief is most widespread among the Other Ghanaian ethnic group.

One third of the women surveyed lived in urban areas. Only 12% of the women in the DHS survey reported having been brought up in a city. The distributions of the DHS sample by current type of place of residence and childhood place of residence are presented in Table 6.3.1.5 and Table 6.3.1.6 respectively:

Table 6.3.1.5: GDHS Distribution by Type of Place of Residence

Type of Place of Residence	Frequency	Percent n=4488
All Urban	1523	33.9
Rural	2965	66.1
Accra City	442	9.8
Kumasi City	239	5.3

Table 6.3.1.6: GDHS Distribution by Childhood PLace of Residence

Childhood Place of Residence	Frequency	Percent n=4483
City	540	12.0
Town	1832	40.9
Countryside	2111	47.1
	4483	100.0

The fact that over half the women surveyed reported being unable to read indicates that illiteracy is still widespread in Ghana.. An explanation for this is that nearly 40% of the women have never attended school. The proportion of women who have had primary level or above education (60.3%) is high by African standards. However, only a small proportion of women (7.5%) have had secondary level or above education and the number of women who have had higher education is negligible, comprising less than 1% of the sample. The distributions of the sample by literacy and highest level of education are shown in Tables 6.3.1.7 and 6.3.1.8 respectively:

Table 6.3.1.7: GDHS Distribution by Literacy

Literacy	Frequency	Percent n=4488
Reads easily	1990	44.3
Reads with difficulty	177	3.9
Cannot read	2321	51.7
	4488	100.0

Table 6.3.1.8: GDHS Distribution by Highest Educational Level

Highest Educational Level	Frequency	Percent n=4488
No education	1783	39.7
Primary	2369	52.9
Secondary	296	6.6
Higher	40	0.9
	4488	100.0

6.3.2 The Proximate Determinants of Fertility

6.3.2.1 Marriage

The GDHS data show that marriage in Ghana still is almost universal (c.f. Section 6.2.2.1). All the women aged between 45 and 49 had either married or lived with a man at some point in their life and only 0.3% of the women aged between 40 and 44 had never married or lived with a man. First marriage tends to occur at young ages, although a comparison with data from the GFS suggests that teenage marriage appears to be becoming less popular (only 24.3% of 15-19 year old women in the sample had ever married compared with 30.9% in the WFS sample). Formal marriage (64.8% of the sample) is much more common than for couples to be "living together" (5.5% of the sample). There are high levels of marital dissolution with 45.7% of ever married women having had their first marriage dissolved (c.f. Table 1.4.1.4.1). This represents a marked increase in marital dissolution since the GFS was conducted 8 years earlier (see Section 6.2.2.1). However, remarriage is a fairly common occurrence with one third of the women who had ever married or lived with a man reporting a previous union. The proportions ever married by age and the distribution of the sample by marital status are shown in Tables 6.3.2.1.1 and 6.3.2.1.2:

Table 6.3.2.1.1: GDHS Percent Ever Married or Lived with a Man by Age

Age	Percent Ever Married or Lived With a Man	Number of Women
15-19	24.3	848
20-24	77.4	867
25-29	95.5	867
30-34	98.8	641
35-39	99.4	531
40-44	99.7	364
45-49	100.0	366

Table 6.3.2.1.2: GDHS Distribution by Current Marital Status

Marital Status	Frequency	Percent n=4487
Single	889	19.8
Married	2908	64.8
Living Together	248	5.5
Widowed	69	1.5
Divorced	250	5.6
Not Living Together	123	2.7
	4487	100.0

Marriage patterns differ considerably between regions. In Brong Ahafo, Upper, East and West and Northern regions all of the women surveyed aged over 25 are unmarried and in all these regions the proportions of women aged 15-19 who have ever married are considerably above average. In Greater Accra and Eastern regions the proportions of women ever married by age indicate relatively high ages for marriage and, in particular, teenage marriage is comparatively rare. There are almost no divorced women in the Upper/Northern area. Divorce is most common in Ashanti region.

The differentials in marriage patterns by ethnicity to some extent mirror differences in marriage patterns by the regions in which these ethnic groups are concentrated. The Other Akan, Mole-Dagbani and Other Ghanaian ethnic groups have relatively low proportions of never married women whereas among the Ga-Adangbe a comparatively high proportion of the women have never married. The proportions of divorced women are lowest among the Mole-Dagbani and the "Other Ghanaians" and highest among the Twi and Fante.

There are very low levels of never marriage among followers of traditional beliefs and women with no religion. Teenage marriage among Muslim women is comparatively rare and no Muslim women aged over 25 have not married. Never marriage is most common among women in the Other Christian category. There are low proportions of divorced women among followers of traditional beliefs and among Muslims.

Women in urban areas, particularly women from Accra City, are more likely to be single than women in rural areas. Women who were brought up in urban areas are more likely to be single than women who were brought up in the countryside. Women in urban areas, and in particular women from Kumasi, are more likely to be divorced than their rural counterparts.

Being single is more common among literate women than among illiterate women. Moreover, never-marriage is increasingly more common with increasing levels of education. Teenage marriage is very rare among women with secondary level education or above.

The distribution of the sample by current marital status by background characteristics is shown in Table 6.3.2.1.3

Table 6.3.2.1.3: GDHS Current Marital Status by Background Characteristics

Characteristic	% Single	% Married	% Living Together	% Widow	% Divorced	% Not Living Together	n
Age							
15-19	75.7	17.0	3.5	0.1	1.3	2.4	848
20-24	22.6	62.3	6.1	0.1	5.2	3.7	867
25-29	4.5	80.9	5.9	0.8	5.8	2.2	867
30-34	1.2	81.1	7.3	1.6	6.1	2.8	644
35-39	0.6	84.9	4.1	1.5	6.0	2.8	531
40-44	0.3	78.3	6.9	4.4	7.1	3.0	364
45-49	0.0	72.4	5.5	7.1	12.8	2.2	366
Region							
Western	19.4	68.9	2.3	1.3	7.7	0.5	392
Central	16.4	58.6	12.3	1.5	6.3	5.0	464
Gr. Accra	30.2	57.6	2.7	1.2	5.0	3.4	597
Eastern	26.3	61.3	2.4	1.1	5.8	3.0	703
Volta	20.8	61.6	9.6	0.8	3.2	4.0	500
Ashanti	20.0	58.2	8.9	1.5	8.5	2.9	823
Brong Ahafo	11.8	76.8	3.4	0.6	6.4	1.0	500
Upper/North.	8.7	82.7	2.2	4.5	0.4	1.6	508
Ethnicity							
Twi	20.6	61.4	6.2	0.8	8.1	3.0	1623
Fante	21.7	56.4	8.8	1.6	7.8	3.7	566
Oth. Akan	16.3	73.7	2.1	1.1	6.3	0.5	190
Ga-Adangbe	26.7	61.5	2.8	2.3	3.0	3.8	397
Ewe	23.8	61.3	6.7	1.0	3.8	3.5	718
Guan	19.2	68.3	4.8	0.0	6.7	1.0	104
Mole-Dagbani	7.3	84.1	1.8	3.7	1.2	1.8	492
Oth. Ghanaian	12.0	78.0	4.3	2.9	2.4	0.5	205
Oth. African	22.2	64.3	6.5	2.7	3.2	1.1	185

Characteristic	% Single	% Married	% Living Together	% Widow	% Divorced	% Not Living Together	n
Religion							
Catholic	22.2	61.3	7.1	1.8	5.5	2.1	765
Oth. Christ.	23.8	59.7	5.4	1.1	6.5	3.4	2381
Muslim	14.2	73.9	4.5	2.0	3.4	2.0	444
Trad/Oth.	6.8	80.3	6.8	2.3	2.0	1.7	363
None	11.6	75.0	3.9	2.0	5.7	1.8	531
Place of Residence							
Rural	16.6	68.0	6.0	1.5	5.3	2.6	2965
All Urban	26.1	58.5	4.6	1.6	6.0	3.1	1522
Accra	34.3	53.3	2.4	1.2	5.2	3.6	441
Kumasi	28.5	53.1	7.5	1.3	6.7	2.9	239
Childhood Residence							
City	25.2	55.4	6.3	2.4	7.2	3.5	540
Town	21.2	63.0	5.0	1.5	6.1	3.2	1831
Countryside	17.2	68.8	5.8	1.4	4.7	2.2	2111
Literacy							
Literate	30.8	54.5	5.1	0.6	5.3	3.6	1989
Semi-lit.	16.9	64.4	7.3	2.8	7.3	1.1	177
Illiterate	10.6	73.7	5.7	2.2	5.6	2.1	2321
Education							
None	7.5	76.5	5.8	2.9	5.2	2.1	1782
Primary	26.7	58.4	5.4	0.6	5.8	3.1	2369
Secondary +	36.6	47.9	5.1	0.9	6.0	3.6	336

Polygyny is widespread but far from the norm with roughly one in three (32.8%) currently married women (including women in consensual unions) in the GDHS sample reporting that their husband had another "wife" a proportion which is broadly similar to that of the earlier GFS sample (34.6% - see Section 6.2.2.1). The number of other "wives" reported by the women in the GDHS sample is shown in Table 6.3.2.1.3:

Table_6.3.2.1.3:_GDHS_Number_of_Other_Wives

Number of other wives	Frequency	Percent n=3150
No other wives	2118	67.2
1	310	9.8
2	592	18.8
3	99	3.1
4	19	0.6
5	5	0.2
6	4	0.1
Don't Know	3	0.1
	3150	100.0

The GDHS data show that polygyny is most widespread in Volta (where 43.8% of currently married women are in polygynous unions) and Upper East and West and Northern regions (where 48.3% of currently married women are in polygynous unions). Among ethnic groups, polygyny is most common among the Other Ghanaian (46.5%), Mole-Dagbani (41.4%) and the Other African (41.2%) categories and least common among the Twi (26.6%), the Fante (26.6%) and the Other Akan (26.4%) categories. Polygynous marriage is the norm among women with traditional beliefs (51.6% of currently married women) and is also comparatively common among Muslims (43.2%) and women with no religion (38.7%). Moreover, despite the Christian churches' disapproval of polygyny a sizeable minority of Christian women (28.6% of Catholics and 26.2% of Other Christians) are in polygynous unions. Polygyny is less common in urban areas (28.3%) than in rural areas (34.6%). Polygyny is more common among illiterate women (37.3%) than among literate (26.1%) or semi-literate (26.8%) women. Furthermore, the prevalence of polygyny declines with increasing levels of female education. Generally, these findings are similar to those of the GFS (see Section 6.2.2.1).

Spousal separation is fairly common in Ghana with 33.5% of the women who were either currently married or in a consensual union reporting that their "husband" was not staying in the same house as they were. Spousal separation is more common in Ashanti region, among the Twi, among Christians, in urban areas and among comparatively highly educated women and is seldom found in Upper, West and East and Northern regions, among the Other Ghanaian and Mole-Dagbani ethnic groups or among followers of traditional beliefs. Spousal separation is equally prevalent for monogamously and polygynously married women.

6.3.2.2 Contraception

The GDHS data reveal that levels of contraceptive use in Ghana are still low (c.f. Section 6.2.2.2). Only 12.3% of the women surveyed reported currently using a method of contraception and of these only one third (4.7% of the sample) reported currently using one of the so-called modern methods of contraception (i.e. pill, IUD, injections, diaphragm, condom, or sterilization of either partner). Although these levels of current use of contraception are not directly comparable with those calculated for the GFS (in which current use of contraception was only asked of currently married "exposed" women - see Section 6.2.2.2), they give some justification for believing that current levels of contraceptive use have increased slightly since the GFS was carried out 8 years earlier. Only one third (33.9%) of the women surveyed reported having ever used a method of contraception and only one fifth of the women (20.9%) reported having ever used a so-called modern method of contraception. These levels of ever use of contraception are virtually the same as those recorded by the GFS (see Section 6.2.2.2), although the proportion reporting ever use of a modern method of contraception in the GDHS sample is slightly higher (20.9% compared to 17.7% in the GFS). The low levels of contraceptive use among the women surveyed occur despite over three quarters of the women (76.2%) knowing of a method of contraception with almost the same proportion (73.8%) knowing of a modern method (in the GFS sample 68% knew of any method of contraception and 59.3% knew of a modern method of contraception). The percentages of the sample knowing of or using contraception are presented in Table 6.3.2.2.1:

Table 6.3.2.2.1: GDHS Knowledge and Use of Contraception

Contraceptive knowledge/Use	Frequency	Percent n=4488
Knows any method	3420	76.2
Knows modern method	3310	73.8
Ever used any method	1221	33.9
Ever used modern(*) method	918	20.5
Currently Using any method	550	12.3
Currently Using modern(*) method	209	4.7

(*) i.e. Pill, IUD, injections, diaphragm, condom, or sterilization of either partner,

Women in the 40-44 years age group have the highest levels of current use of contraception (16.5% of these women are using a method, including the 8.2% who are using a modern method). These women are presumably using contraception to limit their family size ("stopping"). The lowest current levels of contraceptive use are among women aged 15-19 and women aged 45-49. The low proportion of 15-19 year olds admitting to using contraception is presumably because of non-marriage among this group whilst the low recorded levels of contraceptive use among women aged 45-49 are presumably because of terminal sexual abstinence and sub-fecundity among this group. Levels of "ever use of contraception" are markedly low among 15-19 year old women and are fairly low among women aged 45-49 but are roughly constant over the other five year age groups.

The highest levels of contraceptive use are found in the Greater Accra region. The area containing Upper East and West and Northern regions has below average levels of contraceptive use and, in particular, levels of use of modern methods of contraception in this area are negligible.

Among ethnic groups, the Ga-Adangbe have the highest levels of contraceptive use. The Mole-Dagbani, Other Ghanaian and Other African ethnic categories tend to have the lowest levels of contraceptive use.

Christian women have higher levels of contraceptive use than women in the other religious categories. Women with traditional beliefs make very little use of modern methods of contraception, but a comparatively large number use other methods. The lowest levels of use of any method of contraception are among Muslim women and women with no religion.

As in other African countries (see Section 1.3.2.3), women in urban areas make more use of contraception than their rural counterparts. In particular women from Accra City have relatively high levels of contraceptive use.

As in other sub-Saharan African countries (see Section 1.3.2.3), the prevalence of contraceptive use. increases considerably with increasing levels of education. Women with no education have low levels of contraceptive use, women with primary level education only have higher levels of contraceptive use, however, among women with secondary level education or higher education levels of contraceptive use are considerably higher.

The percentages of women who have ever used any method of contraception, have ever used a modern method of contraception, currently use any method of contraception and currently use a modern method of contraception by background characteristics are presented in Table 6.3.2.2.3:

Table 6.3.2.2.3: GDHS Contraceptive Use by Background Characteristics

Characteristic	% Ever Used Any	% Ever Used Modern	% Currently Using Any	% Currently Using Modern	n
Age					
15-19	12.6	6.1	5.8	1.3	849
20-24	35.4	19.5	13.5	4.0	867
25-29	42.7	26.1	14.1	4.6	867
30-34	42.4	28.0	14.9	6.8	644
35-39	40.9	24.9	14.5	5.8	531
40-44	37.9	26.6	16.5	8.2	364
45-49	29.8	16.9	7.9	4.9	366
Region					
Western	28.3	15.8	9.4	3.8	392
Central	25.7	16.0	9.5	4.3	464
Gr. Accra	49.3	33.3	22.1	7.9	598
Eastern	37.4	22.2	12.0	4.7	703
Volta	39.4	20.6	12.8	4.0	500
Ashanti	29.5	22.2	9.1	5.6	823
Brong Ahafo	33.6	23.6	12.2	4.6	500
Upper/North.	24.6	4.5	10.4	1.0	508
Ethnicity					
Twi	37.2	25.9	13.2	5.9	1623
Fante	30.2	19.6	12.9	5.1	566
Oth. Akan	26.3	13.7	7.9	3.2	190
Ga-Adangbe	46.1	28.0	16.9	7.1	397
Ewe	39.0	21.5	12.5	4.3	718
Guan	41.4	27.9	10.6	3.9	104
Mole-Dagbani	22.4	6.1	8.3	1.6	492
Oth. Ghanaian	19.6	6.2	11.0	1.9	209
Oth. African	21.0	12.9	8.6	1.6	186

	% Ever Used		% Currently Using		
Characteristic	Any	Modern	Any	Modern	n
<u>Religion</u>					
Catholic	37.0	23.1	14.5	5.8	765
Oth. Christ.	38.4	25.1	13.3	5.1	2381
Muslim	24.0	14.2	9.9	4.3	445
Trad/Oth.	29.9	7.7	12.0	2.3	363
None	20.3	9.9	6.8	3.0	531
<u>Place of Residence</u>					
Rural	30.0	16.8	9.8	3.8	1523
All Urban	41.4	27.6	17.0	6.3	2965
Accra	52.5	39.0	24.9	8.6	442
Kumasi	35.1	28.5	12.6	7.5	239
<u>Childhood Residence</u>					
City	37.8	25.9	13.5	5.4	540
Town	38.2	24.2	14.8	5.8	1832
Countryside	29.1	15.8	9.7	3.5	2111
<u>Literacy</u>					
Literate	45.0	29.5	17.1	5.9	1990
Semi-lit.	40.7	27.1	13.6	7.4	177
Illiterate	23.8	12.2	8.0	3.4	2321
<u>Education</u>					
None	22.0	10.4	7.7	3.0	1783
Primary	38.6	24.7	13.9	5.5	2369
Secondary +	63.7	43.8	25.3	7.7	336

Among specific methods of contraception the most widely used method is periodic abstinence (also known as the rhythm method). The most widely used modern method is the pill. The percentages of the women surveyed that knew of, had ever used, or were currently using each specific method of contraception are presented in Table 6.3.2.2.3:

Table 6.3.2.2.3: GDHS Knowledge and Use of Specific Methods

Method	% Knowing of n=4488	% Ever Used n=4488	% Current User n=4488
Pill	59.8	12.8	1.6
IUD	36.7	1.2	0.5
Injections	42.7	0.9	0.2
Vaginal Methods	36.6	7.9	1.2
Condom	48.6	4.5	0.3
Female Sterilization	54.2	0.9	0.8
Male Sterilization	10.8	0.0	0.0
Periodic Abstinence	39.0	18.3	6.1
Withdrawal	31.1	7.8	0.8
Other	8.6	2.7	0.9

6.3.2.3 Postpartum Non-Susceptibility

Durations of breastfeeding, postpartum amenorrhea and postpartum sexual abstinence are long even by comparison with other sub-Saharan African countries. A consequence of these long durations of amenorrhea and abstinence is that long durations of postpartum non-suceptibility are found in Ghana. The retrospectively reported durations for the most recent periods of breastfeeding, postpartum amenorrhea, and postpartum abstinence show a heavy amount of heaping on to half-yearly periods, indicating that the information is not particularly accurate.

However, more reliable estimates for these periods were obtained by calculating the proportions breastfeeding, amenorrheic, and abstaining at the time of interview by the time since a "birth" (multiple births being treated as a single event/"birth"). Similarly, durations of non-susceptibility can be estimated by calculating the proportions of women who are either amenorrheic or abstaining by the time from "birth" to interview. The proportions breastfeeding, amenorrheic, abstaining and non-susceptible by the time from the "birth" until the interview are presented in Table 6.3.2.3.1 and are illustrated by Figure 6.3.2:

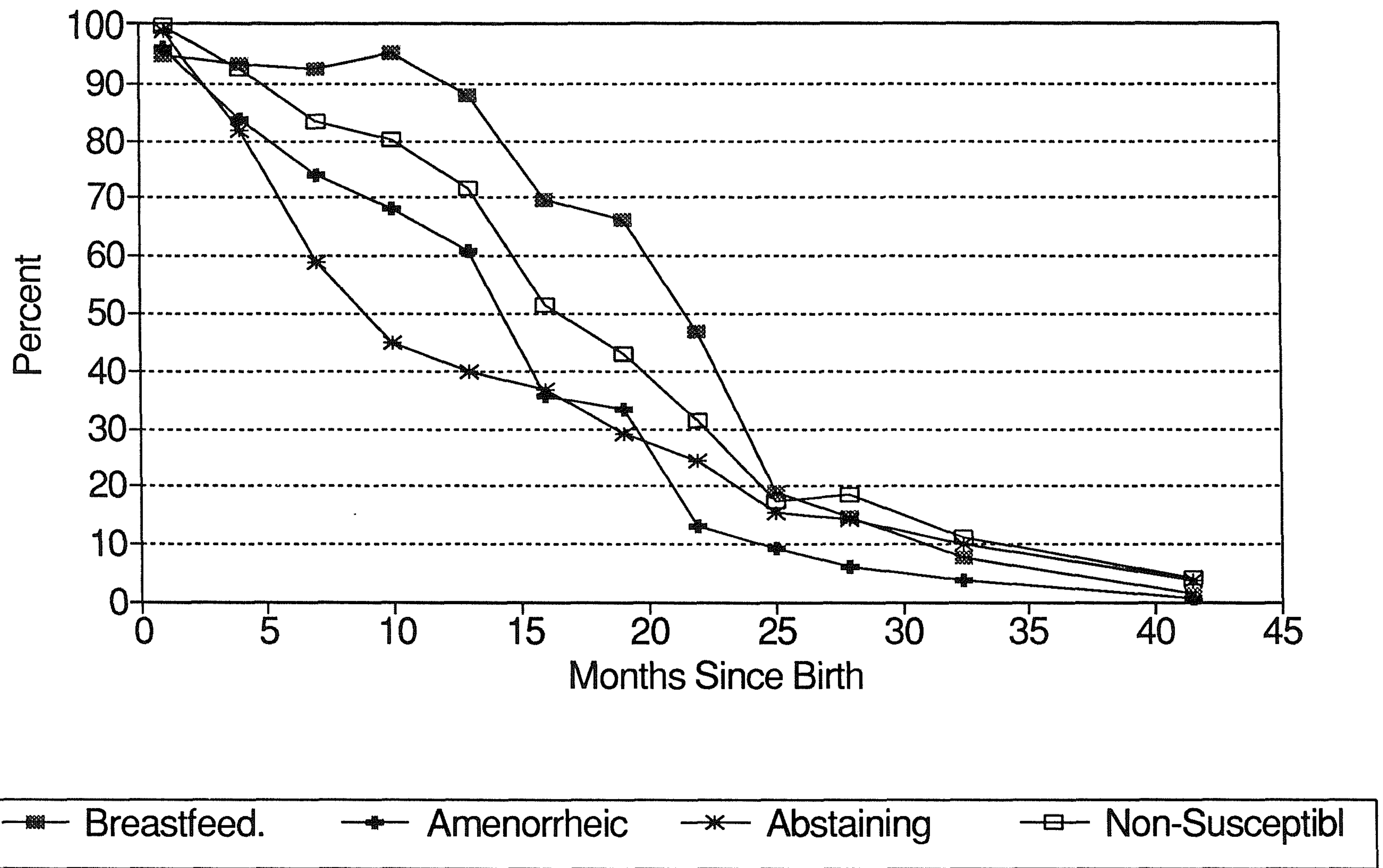
Table 6.3.2.3.1: GDHS Percent Breastfeeding, Amenorrheic, Abstaining and Non-Susceptible by Months Since Birth

Months Since Birth	% Breastfeed	% Amenorrheic	% Abstain	% Non-Susceptible	No.of Cases
0-2	95.1	96.2	98.9	99.5	185
3-5	93.4	83.8	81.7	92.9	197
6-8	92.6	74.1	58.8	83.3	216
9-11	95.3	68.4	44.8	80.2	212
12-14	88.0	60.7	40.1	71.5	242
15-17	69.8	35.8	36.8	51.4	212
18-20	66.3	33.2	28.8	42.9	184
21-23	46.8	12.9	24.4	31.3	201
24-26	18.8	9.2	15.6	17.2	250
27-29	14.8	6.0	14.2	18.6	183
30-35	7.5	4.0	9.9	11.1	425
36-47	1.5	0.7	3.7	4.1	749

The median duration of breastfeeding (using the current status method) is 22 months (this compares with 18 months for the GFS sample - source: WFS (1983)). That of postpartum amenorrhea is 15 months (GFS 11 months). The median duration of postpartum

Figure 6.3.2

Postpartum Non-Susceptibility (Ghana)



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sexual abstinence is 10 months (GFS 5 months). The median duration of postpartum non-susceptibility is 16 months.

Durations of breastfeeding are markedly longer than average in the area comprising Upper, East and West and Northern regions (the median duration is around 27 months) and are markedly shorter than average in the Greater Accra region (around 16 months). Among ethnic groups, very long durations of breastfeeding can be observed for the Mole-Dagbani and the "Other Ghanaian" groups (median durations are around 27 months for both these groups). Among religious categories only the followers of traditional beliefs (with a median of around 27 months) have durations of breastfeeding which differ markedly from the overall pattern. Durations of breastfeeding tend to be longer in rural areas than in urban areas (19 months). Durations of breastfeeding decline noticeably as a woman's education increases (median durations are 23 months for uneducated women, 20 months for women with primary level education only and 18 months for women with secondary or above education). For a multivariate proportional hazards analysis of these data see Bonzie-Caiquo (1991).

The variations in median durations of amenorrhea between subsections of the population are much less pronounced than the variations in durations of breastfeeding, reflecting the diminishing effect of increasing the duration of breastfeeding on the length of amenorrhea (see Section 1.3.4). Among regions, only the women in the area comprising Upper, East and West and Northern regions have markedly longer than the national average durations of amenorrhea (median around 18 months) (a noticeably short mean duration of amenorrhea has been found for Greater Accra region (Ghana Statistical Service (1989, p15)). The only other groups with significantly longer than average durations of amenorrhea are Mole-Dagbani (median around 20 months) and the "Other Ghanaian" (median around 19 months) ethnic categories whilst only women with at least secondary level education (median around 12 months) have a noticeably shorter median duration of amenorrhea.

Durations of postpartum abstinence differ considerably between the regions of Ghana. In the area comprising Upper, East and West and Northern regions durations of abstinence tend to be very long (median around 27 months) with the resumption of sexual relations within 2 years of a birth being virtually non-existent. Volta region also has longer than average durations of abstinence (median 16 months) whilst in Western (median around 7months), Central, Greater Accra, and Ashanti (medians around 8 months) and Brong Ahafo (9 months) regions durations of abstinence tend to be comparatively short. Among ethnic groups, the Mole-Dagbani (median around 27 months) and the Other Ghanaians (27 months) practise very long periods of post-natal abstinence whilst the Twi (6 months), Other Akan (7 months) and Ga-Adangbe (9 months) have shorter than average periods of abstinence. Followers of traditional beliefs (median around 27 months) and Muslims (18 months) have the long durations of abstinence whilst Catholics (6 months) and "Other Christians" (7 months) tend to have the relatively short durations. Durations of abstinence tend to be shorter in urban areas than in rural areas and decrease considerably with increasing levels of female education (median durations are 16 months no education, 9 months for primary level education only and 7 months secondary or above education). Women aged 25-29 are practising noticeably shorter durations of abstinence (median around 7 months) than other age groups. This could partly reflect a higher than average proportion of births to educated women in this age group.

Durations of postpartum non-susceptibility are longest in the area comprising Upper, East and West and Northern regions (median around 31 months) and in Volta region (21 months) whilst the shortest durations of non-susceptibility are found in Western region (13 months) and Greater Accra (14 months). Only the Mole-Dagbani (median around 29 months) and "Other Ghanaian" (around 27 months) ethnic groups have median durations of non-susceptibility which differ greatly from the overall median. The followers of traditional beliefs (median around 27 months) and Muslims (around 24 months) have markedly long durations of non-susceptibility. Durations of non-susceptibility are longer in rural areas (median 19 months) than in urban areas (15 months). Moreover, the median duration of non-susceptibility decreases considerably with increasing levels of education (21 months for no education, 15 months for primary education only and 12 months for secondary education or above).

In the majority of cases the duration of postpartum non-susceptibility is determined principally by the duration of amenorrhea. However, in Upper East and West and Northern regions, for women from the Mole-Dagbani or "other Ghanaian" ethnic groups or for women of traditional African or Moslem beliefs it is principally abstinence which is the limiting factor for postpartum non-susceptibility.

The GDHS data provide evidence that women who have ever used a method of contraception have shorter periods of breastfeeding, amenorrhea and abstinence and non-susceptibility than women who have not used contraception (seeTable 6.3.2.3.2), suggesting that contraception is sometimes employed as an alternative method of achieving child-spacing (c.f. Section 1.3.4).

Table 6.3.2.3.2: GDHS Median Durations of Breastfeeding, Amenorrhea Abstinence and Non-Susceptibility by Contraceptive Use

Contraceptive	Median Duration (months)			
Use	Breastfeeding	Amenorrhea	Abstinence	Non-Susceptible
Ever Used	20	14	7	15
Not Used	22	15	11	20

6.2.3.4 Sterility

There is little evidence of primary sterility among the women surveyed. Only 1.7% of ever married women aged 40-44 and only 1.6% of ever married women aged 45-49 are childless. Comparable figures from the earlier GFS are slightly higher with 2.8% for women aged 40-44 and 1.7% for women aged 45-49 being childless.

The supposedly sterile women (i.e. the 8 childless, ever married women aged over 40) are all illiterate and with one exception did not attend primary school.

6.3.3 Fertility Differentials

6.3.3.0 Introduction

The GDHS data show that Ghana still has high levels of fertility. The TFR (based on births in the five years preceding the survey to women aged 15-49) for the GDHS sample is 6.3, and is virtually identical to that recorded eight years earlier by the GFS (6.3).

The mean number of children ever born for the women surveyed is 3.2, a figure that is slightly higher than the comparable figure for the GFS (3.0). For those women who had completed childbearing (i.e. those women aged 45-49) the mean number of children ever born is 7.3 (GFS 6.7). The P/F ratio (i.e. the ratio of the number of children ever born to women at the end of childbearing (i.e. women aged 45-49) to the TFR) can be used to infer whether fertility is changing over time (see van de Walle and Foster (1990) for a discussion). The P/F ratio is 1.13 which could suggest a modest decline in fertility over time.

6.3.3.1 Fertility and the Proximate Determinants

6.3.3.1.1 Marriage

The GDHS sample shows very low levels of fertility among single women. Married women have a higher TFR than women in a consensual union. Widows have a high TFR. However, this reflects high estimates of current fertility for the two youngest age groups which each contain only one woman. Widows also have a higher mean number of children ever born and a higher standardized mean number of children ever born than any other category for current marital status. Women who are divorced have lower current and past fertility levels than women who are still married. Women who are formerly in a consensual union have a lower current and past fertility levels than women who are still in this type of union. Mean numbers of births in the five years preceding the survey, total fertility rates, mean numbers of children ever born and standardized mean numbers of children ever born by women's current marital status are shown in the Table 6.3.3.1.1:

Table 6.3.3.1.1: GDHS Fertility Levels by Marital Status

Marital Status(+)	M.N.B.5Y (a)	T.F.R. (b)	M.C.E.B. (c)	S.M.C.E.B. (d)
Never Married	0.10	0.6(*)	0.1	0.5(**)
Married	1.20	7.4	4.0	3.4
Living Together	1.05	6.7	3.5	3.3
Widowed	0.58	6.8	5.6	3.8
Divorced	0.67	4.8	3.6	2.8
Not Living Together	0.83	5.3	2.8	2.9

(+) The number of women in each category is as appears in Table 6.3.2.1.2.

(a) Mean Number of Children Born in 5 Years before survey.

(b) Total Fertility Rate (women aged 15-49).

(c) Mean Number of Children Ever Born.

(d) Standardized Mean Number of Children Ever Born.

(*) The T.F.R. for never married women is based on an assumed number of births 0-4 years before the survey for never married women aged 45-49 of zero (there were no never married women in this age group).

(**) The standardized mean number of children ever born for never married women is based on an assumed number of children ever born for never married women aged 45-49 of 1 birth (i.e. the mean number of births for never married women aged 40-44).

Women in polygynous "marriages" (including consensual unions) have slightly higher current fertility levels than women in monogamous marriages. However, standardized mean numbers of children ever born in these categories are the same. This is shown in Table 6.3.3.1.2:

Table 6.3.3.1.2: GDHS Marital Fertility by Polygyny

Husband has other Wives	M.B.L.5Y. (a)	T.F.R. (b)	M.C.E.B. (c)	S.M.C.E.B. (d)
Yes (n=1032)	1.20	7.5	4.4	3.4
No (n=2118)	1.18	7.3	3.7	3.4

(a) Mean Number of Children Born in 5 Years before survey.
(b) Total Fertility Rate (women aged 15-49).
(c) Mean Number of Children Ever Born.
(d) Standardized Mean Number of Children Ever Born.

There is some evidence that within "marriage" spousal separation is associated with reduced fertility. The TFR for women who live with their husband is slightly higher than for women who live separately from him and the standardized mean number of children ever born for the former group is noticeably higher, perhaps because the effect of separation has been compounded over time. This is shown by Table 6.3.3.1.3:

Table 6.3.3.1.3: GDHS Marital Fertility by Spousal Separation

Husband lives in House	M.B.L.5Y. (a)	T.F.R. (b)	M.C.E.B. (c)	S.M.C.E.B. (d)
Yes (n=2095)	1.20	7.4	4.2	3.5
No (n=1056)	1.16	7.3	3.4	3.2

(a) Mean Number of Children Born in 5 Years before survey.
(b) Total Fertility Rate (women aged 15-49).
(c) Mean Number of Children Ever Born.
(d) Standardized Mean Number of Children Ever Born.

6.3.3.1.2 Contraception

Women who have ever used or are currently using of modern methods of contraception have lower current fertility levels than women who have not used contraception. However, it is interesting to note that women who have only ever used traditional methods of contraception or are currently using a traditional method of contraception tend to have higher current fertility than women who have never used contraception. Furthermore, perhaps surprisingly, women who are current users of a method of contraception or have ever used any method of contraception tend to have higher numbers of children ever born than women who have not used contraception. Similar findings to this have been reported by the Caldwells (1981) for Ibadan, Nigeria and Bhatia (1986) for rural Ghana. The Caldwells explained their finding by the shorter durations for breastfeeding and abstinence practised by contraceptors (as reported earlier shorter durations of breastfeeding, amenorrhea and abstinence also occur for Ghanaian women who practise contraception). Bhatia states that in developing countries contraception is generally sought by the couples that have already been burdened by a large number of children. Standardizing the mean numbers of children ever born by age shows that the older ages of the contraceptors partially explains their larger numbers of children. Nevertheless, even after standardization, the mean number of children ever born to women who had ever used or were currently using a method of contraception is higher than the standardized mean number of children ever born to women who had not used contraception (see Table 6.3.3.1.4):

Table 6.3.3.1.4: GDHS Fertility by Contraceptive Use

Contraceptive Use(+)	M.B.L.5Y. (a)	T.F.R. (b)	M.C.E.B (c)	S.M.C.E.B. (d)
Never Used	0.86	6.3	2.9	3.1
Ever Used Traditional Only	1.08	6.8	3.4	3.3
Ever Used Modern(*)	1.03	6.0	3.8	3.3
Current User Traditional	1.10	7.0	3.2	3.2
Current User Modern(*)	0.94	5.6	4.3	3.4

(+) The numbers of women in each category are the same as those in Table 6.3.2.2.1.

a) Mean Number of Children Born in 5 Years before survey.

(b) Total Fertility Rate (women aged 15-49).

(c) Mean Number of Children Ever Born.

(d) Standardized Mean Number of Children Ever Born.

(*) i.e. Pill, IUD, injections, diaphragm, or sterilization of either partner.

6.3.3.2 Fertility Differentials by Background Characteristics

The mean numbers of births 0-4 years before the survey by age group show that the peak reproductive ages are between 20 and 40. These mean numbers of births 0-4 years before the survey show that levels of recent fertility among teenagers are comparatively low. This would reflect most of these women being single (i.e. never married) for some or all of the five years (see Table 6.3.2.1.1). Recent fertility levels are also comparatively low among women aged between 40 and 49. This would reflect some of these women having become subfecund (see Section 1.3.6) or having voluntarily decided to cease childbearing (see Section 1.3.4.4.2). Low fertility for women aged 40-44 also partly reflects the high proportion of these women currently using contraception (see Section 6.3.3.2).

A comparison of the mean numbers of children born in the last five years by age group recorded for the GDHS with those found by the earlier GFS shows that broadly speaking the pattern of childbearing by age has remained the same. There has been a slight decline in current fertility among the 15-19, and 20-24 age groups and a slight increase in current fertility in the 25-29 and 35-39 age groups. There has also been a slight decrease in current fertility among the 40-44 and 45-49 age groups.

Differences in the mean numbers of children for each age group reflect both the longer exposures to the risk of childbearing of older groups and differences in childbearing behaviours of different cohorts. The GDHS data show low numbers of children ever born to teenage women in Ghana. The mean numbers of children ever born increase considerably between the age groups 20-24, 25-29, 30-34, 35-39 and 40-44. The increase in the mean number of children ever born between the 40-44 and 45-49 age groups is less dramatic (although far from negligible) reflecting the low age specific fertility rate for this age group reported earlier. It is possible that the true underlying level of fertility in Ghana is higher than is shown by the data as a result of underreporting of the numbers of children ever born. However, the sizes of the increases in the mean numbers of children ever born at the older ages indicate good quality data and suggest that underreporting is unlikely to be a major factor.

The mean numbers of children ever born recorded by the GDHS are similar to those recorded by the earlier GFS for ages below 40. However, the mean numbers of children ever born are markedly higher for the GDHS than for the GFS for the 40-44 and 45-49 age groups. This could indicate that the GDHS data are of better quality.

The mean numbers of births 0-4 years before the survey and mean numbers of children ever born by five year age group for both the GDHS and the GFS are presented in Table 6.3.3.2.1:

Table 6.3.3.2.1: GDHS and GFS Fertility by Age

Age	Mean No. of Births in last 5 years		Mean Number of Children Ever Born		n for GDHS
	GDHS	GFS	GDHS	GFS	
15-19	0.2	0.2	0.2	0.2	849
20-24	1.0	1.1	1.3	1.4	867
25-29	1.4	1.3	2.7	2.7	867
30-34	1.3	1.3	4.2	4.0	644
35-39	1.2	1.1	5.5	5.4	531
40-44	0.8	0.8	6.6	6.1	364
45-49	0.4	0.5	7.3	6.7	366

Source: WFS (1983). *Ghana Fertility Survey 1979-1980: First Report*. Central Bureau of Statistics, Accra, Ghana.

Fertility levels in the Greater Accra region are considerably lower than those in other parts of the country. This would reflect the relatively high proportion of unmarried women (see Section 6.3.2.1) and the high levels of contraceptive use (see Section 6.3.2.2) in this region. The area consisting of Upper West and East and Northern regions and Volta region have the highest TFRs. The high level of current fertility in Upper/Northern reflects the low proportion of never married women and the very low proportion of divorced women (see Section 6.3.2.1) and the almost negligible use of modern methods of contraception in this area (see Section 6.3.2.2). These regions are the least urbanized areas of the country. A comparison of these TFRs with those recorded for the GFS (see Table 6.2.2.2) shows that fertility has generally declined in the "coastal" areas of Ghana (i.e. Western, Central, Eastern and Greater Accra regions) but has remained stable or has increased in the rest of Ghana. In particular, fertility appears to be increasing in Volta region. Past fertility of the women is shown by their mean numbers of children ever born and standardized mean numbers of children ever born (in which the effects of differing age structures in the populations are controlled for). These show low levels of past childbearing in Greater Accra region and below average levels of past childbearing in Volta region. This latter finding indicates that the higher current fertility in Volta region recorded by the GDHS compared to that recorded by GFS reflects a genuine increase in fertility over time rather than being attributable to sampling error. The low level of past childbearing in Greater Accra reflects the low proportion of ever married women and high level of "ever use of contraception" in this region (see Sections 6.3.2.1 and 6.3.2.2).

The GDHS data show that current fertility levels vary between ethnic groups. The Other Ghanaian, Other African, Other Akan and Mole-Dagbani ethnic groups have the highest current fertility levels while the Fante, Ga-Adangbe and Guan ethnic groups have the lowest levels of current fertility. The Mole-Dagbani, Other Ghanaian and Other Akan groups all have high proportions of currently married women (see Section 6.3.2.1) and the Mole-Dagbani, Other Ghanaian and Other African groups all have low levels of contraceptive use (see Section 6.3.2.2.). Another factor behind the comparatively high fertility of the Other Akan group are the comparatively short durations of post-natal non-susceptibility of this group (see Section 6.3.2.3). Low current fertility among the Ga-Adangbe reflects the high proportion of single women (see Section 6.3.2.1) and high levels of contraceptive use (see Section 6.3.2.2) in this group. A comparison with TFRs from the GFS (see Section 6.2.2.3) shows that fertility has declined among the Fante, Other Akan, Ewe, Ga-Adangbe and Guan ethnic groups and has increased in the "other" ethnic group categories. Standardized numbers of children ever born indicate that past fertility is highest among the Other Akan reflecting the absence of permanent celibacy among this group (c.f. Section 6.2.2.3). Women with traditional beliefs have considerably higher current fertility than women from other major religious groups. This reflects the low proportions of single women and divorced women and the very low levels of use of modern methods of contraception in this category. Christian women tend to have the lowest levels of fertility (c.f. Section 1.3.2.3). This reflects the relatively high proportions of single women and divorced women and the relatively high levels of contraceptive use in these categories (see Sections 6.3.2.1 and 6.3.2.2). Women living in urban areas have considerably lower fertility levels than women living in rural areas (a similar pattern was found for the GFS - see Section 6.2.2.1) (c.f Section 1.2.2.1). This reflects the higher proportion of single women and the more extensive use of contraception in the urban areas (see Sections 6.3.2.1 and 6.3.2.2). Moreover, women who live in the larger urban areas (i.e. Accra and Kumasi) have considerably lower fertility than women living elsewhere. Women whose childhood residence was in an urban area have lower levels of fertility than women who have been brought up in rural areas. Illiterate women tend to have substantially higher fertility than literate women. Furthermore, the GDHS data show an "inverse" relationships between a woman's highest educational level and her current and past fertility (c.f. Section 1.2.2.2). Women who have had at least secondary level education have particularly low fertility. The lower levels of fertility with increasing levels of education reflect the increasing proportions of single women and the more extensive use of contraception with increasing levels of education (see Sections 6.3.2.1 and 6.3.2.2). The GFS also found an inverse relationship between current fertility and education (see Section 6.2.2.4). However, the reduction of fertility with increasing levels of education is more pronounced for the GDHS sample. Compared to the GFS results, fertility has declined significantly among women with secondary or above education and among women with primary level education only, but has increased among uneducated women. Differences in the mean number of children born to a woman less than five years before the survey, TFRs, mean numbers of children ever born and standardized mean numbers of children ever born by background characteristics are shown in Table 6.3.3.2.2:

Table 6.3.3.2.2: GDHS Fertility by Background Characteristics

Characteristic (+)	M.B.L.5Y. (a)	T.F.R. (b)	M.C.E.B. (c)	S.M.C.E.B. (d)
Region				
Western	0.93	6.4	3.1	3.2
Central	1.01	6.8	3.5	3.4
Greater Accra	0.67	4.7	2.5	2.6
Eastern	0.85	5.8	3.1	3.2
Volta	1.01	7.0	3.0	3.1
Ashanti	0.86	6.0	3.1	3.2
Brong Ahafo	1.08	6.9	3.3	3.3
Upper,W,E& Northern	1.08	7.1	3.7	3.3
Ethnic Group				
Twi	0.90	6.1	3.1	3.2
Fante	0.89	5.8	3.1	3.1
Other Akan	0.98	6.8	3.4	3.5
Ga-Adangbe	0.84	5.8	2.9	3.0
Ewe	0.88	6.2	2.9	3.0
Guan	0.82	5.9	3.5	3.0
Mole-Dagbani	1.06	6.8	3.5	3.1
Other Ghanaian	1.14	7.7	3.6	3.4
Other African	0.96	6.9	3.2	3.4
Religion				
Catholic	0.89	6.2	3.0	3.2
Other Christian	0.86	5.8	2.9	3.1
Moslem	1.00	6.7	3.6	3.4
Traditional	1.16	7.7	4.1	3.4
No religion/Other	1.01	6.8	3.5	3.3
Type of Place of Residence				
Rural	1.02	6.8	3.4	3.4
All Urban	0.74	5.2	2.7	2.8
Accra	0.61	4.3	2.2	2.5
Kumasi	0.60	4.2	2.4	2.6

Characteristic (+)	M.B.L.5Y. (a)	T.F.R. (b)	M.C.E.B. (c)	S.M.C.E.B. (d)
<u>Type of Place of Childhood Residence</u>				
City	0.84	5.8	2.7	2.9
Town	0.85	5.7	3.0	3.0
Countryside	1.00	6.8	3.5	3.6
<u>Literacy</u>				
Reads easily	0.82	5.5	2.1	2.8
Reads with difficulty	0.88	6.0	3.5	3.3
Cannot read	1.01	6.9	4.0	3.4
<u>Highest Level of Education</u>				
No education	1.04	6.9	4.3	3.4
Primary	0.87	6.1	2.5	3.1
Secondary/Higher	0.61	3.4	1.5	1.8

(+) The numbers of women in each category are the same as those in Tables 6.3.1.1. to 6.3.1.8.

(a) Mean Number of Children Born in 5 Years before survey.

(b) Total Fertility Rate (women aged 15-49).

(c) Mean Number of Children Ever Born.

(d) Standardized Mean Number of Children Ever Born.

6.4 Differentials in Fertility Between Communities

6.4.0 Introduction

In this section I describe differentials in fertility between communities/neighbourhoods in Ghana using data from the GDHS. The clusters (i.e. census enumeration areas) used as part of the sampling scheme are used as a representation of communities. As mentioned in Section 6.3.0, 150 such clusters were included in the GDHS sample. Information on the locations of the communities sampled and the number of women sampled in each community is presented in Appendix 6B. The locations of the communities can be seen from Map 6.1.1.

Due to the large number of communities sampled, description of between-community differentials using the mean values of measures of fertility and proximate determinants of fertility would be cumbersome. These differentials are better summarised by the estimated mean and variance of the distribution of the population of such within-community means. It should be noted that the mean and variance of the set of actual ("raw") estimates of within-community means are not the best estimates of the mean and variance of the population of such within-community means because some of the variance between the raw within-community means is attributable to sampling error and because the reliability of these estimates varies due to the different numbers of women sampled in each community. The appropriate method for estimating the mean and "true" variance of the within-community means is a random effects analysis of variance (see Chapter 2). Moreover, the values of measures of fertility or proximate determinants of fertility for individual communities are unlikely to be of interest. However, identifying those communities with the highest or lowest fertility is undoubtedly of interest. It is to be noted that the ordering of the estimated (raw) within-community means is highly susceptible to the effects of sampling, with communities containing few observations being prone to a high or low estimated mean. However, the ordering of the so-called posterior/shrunken means, estimated as part of a random effects analysis of variance should be less susceptible to the effects of sampling (see Chapter 2,). Laird and Louis (1989) discuss this issue at length and propose a method of ranking based the expectation of the posterior rank. Time constraints prohibit investigation of their method. For this reason communities are identified as having unusually high or low values of a measure of current or past fertility or a measure of proximate determinants of fertility based on the ordering of the posterior/shrunken community means.

6.4.1 Differentials In The Proximate Determinants of Fertility Between Communities

6.4.1.1 Marriage

The random effects ANOVA model shows significant variation in the proportion of women in a cluster who are currently "married" (women who are cohabiting are classed as "married"). The estimated true variance of the population of within-community means is 0.01 (standard deviation = 0.1), and constitutes roughly 5% of the total variance. The between-community variance is clearly significant, as its estimate is five times the size of its estimated standard error (0.002). The shrunken community means follow a normal distribution (see Figure 6.4.1 in Appendix 6H). This implies that, over the population of communities, in roughly 68% of communities the "true" proportion of women who are currently married will lie in the range (0.6, 0.8) and in roughly 95% of communities the "true" proportion of women who are currently married will lie in the range (0.5, 0.9). The parameter estimates for the random effects ANOVA are presented in Table 6.4.1:

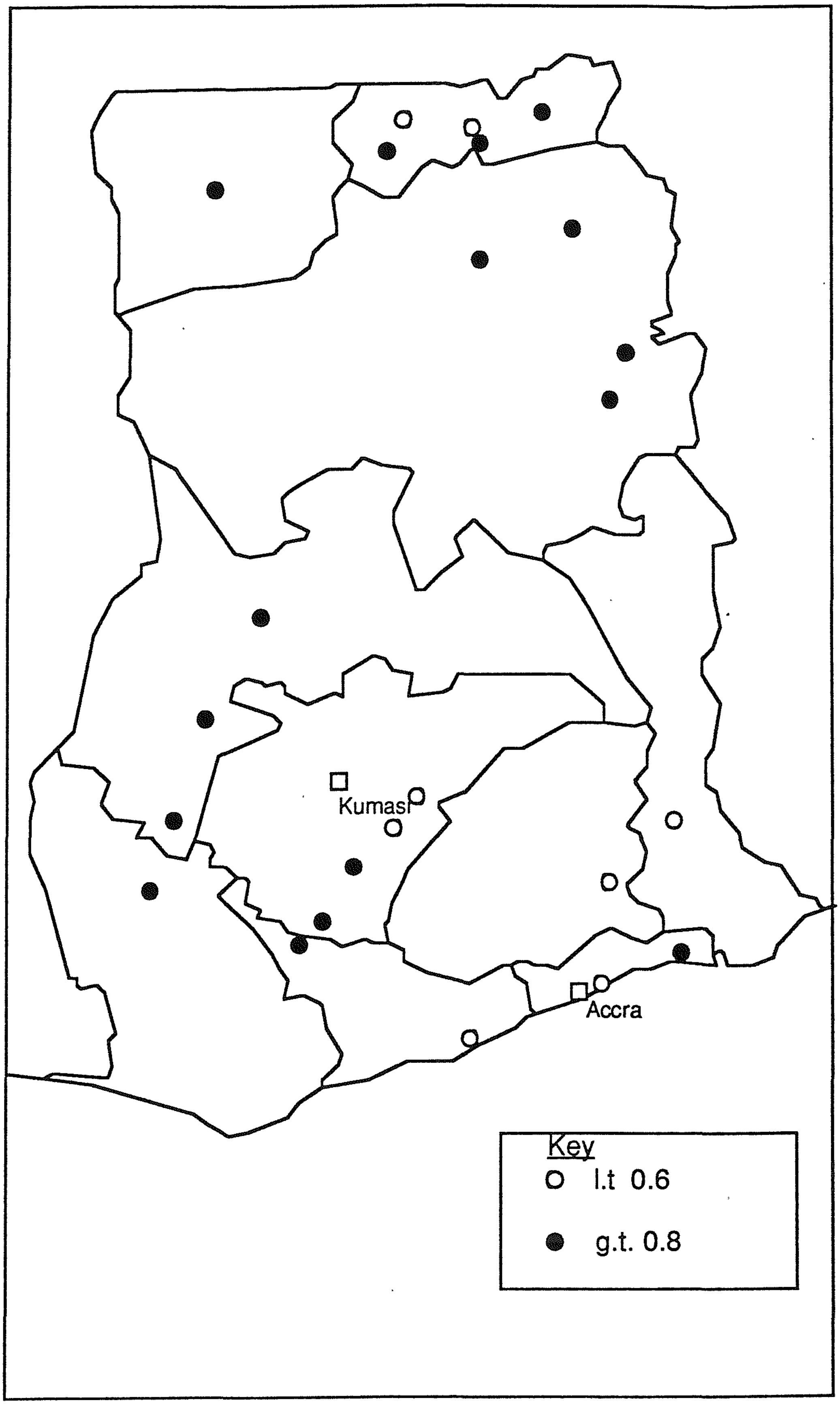
Table 6.4.1: Random Effects ANOVA for Currently Married

Parameter	Estimate	St. Error
Fixed		
Constant	0.70	0.01
Random		
Between-community	0.01	0.002
Within-community	0.20	0.004

Intra-cluster correlation 0.05

The shrunken proportions currently married tend to be lower than average in urban centres in the southern half of the country and are most noticeably below average in and around Accra, and higher than average in rural communities, especially those in the north and west of Ghana. Map 6.4.1 shows those communities with a shrunken proportion currently married below 60% or above 80% (these cut off points correspond to one standard deviation below and above the overall mean of the distribution of posterior means respectively). The shrunken proportions of women who are currently married of all the communities in the GDHS sample are presented in Appendix 6D. The raw proportions of women in each community who are currently married are presented in Appendix 6C.

Map 6.4.1 **Shrunken Cluster Means for Currently Married**



A cursory glance at this table should reveal that using the set of raw community means is a cumbersome way to summarise the data.

None of the communities included in the sample, is a marked outlier to the distribution of shrunken means. The communities with the lowest and highest shrunken proportions of women who are currently married are presented in Table 6.4.2:

Table_6.4.2:_Communities_with_the_Highest/Lowest_Shrunken_Mean Currently_Married

Rank	Cluster No.	Town	Region	Shrunken Mean
1	45	Labadi	Gr. Accra	0.46
2	110	Kumasi	Ashanti	0.48
3	27	Apam	Central	0.51
4	47	Accra	Gr. Accra	0.54
5	42	Accra	Gr. Accra	0.54
146	81	Yankye	Brong Ahafo	0.84
147	142	Yendi	Northern	0.87
148	133	Jamayiri	Upper West	0.89
149	126	Wenchi	Brong Ahafo	0.89
150	132	Tunni	Northern	0.92

6.4.1.2 Contraception

Current_Use_of_Contraception

The random effects ANOVA model shows that the level of current use of any method contraception varies significantly between communities. The estimated true variance of the population of within-community means (0.004, standard deviation = 0.06) is over four times the size of its estimated standard error (0.001), and constitutes roughly 4% of the total variance. The distribution of the shrunken community means (see Figure 6.4.2 in

Appendix 6H)has a marked positive skew and so estimating the proportions of the population of communities with certain true values for the proportions of women currently using a method of contraception from a normal distribution cannot be justified. The parameter estimates for the random effects ANOVA are presented in Table 6.4.3:

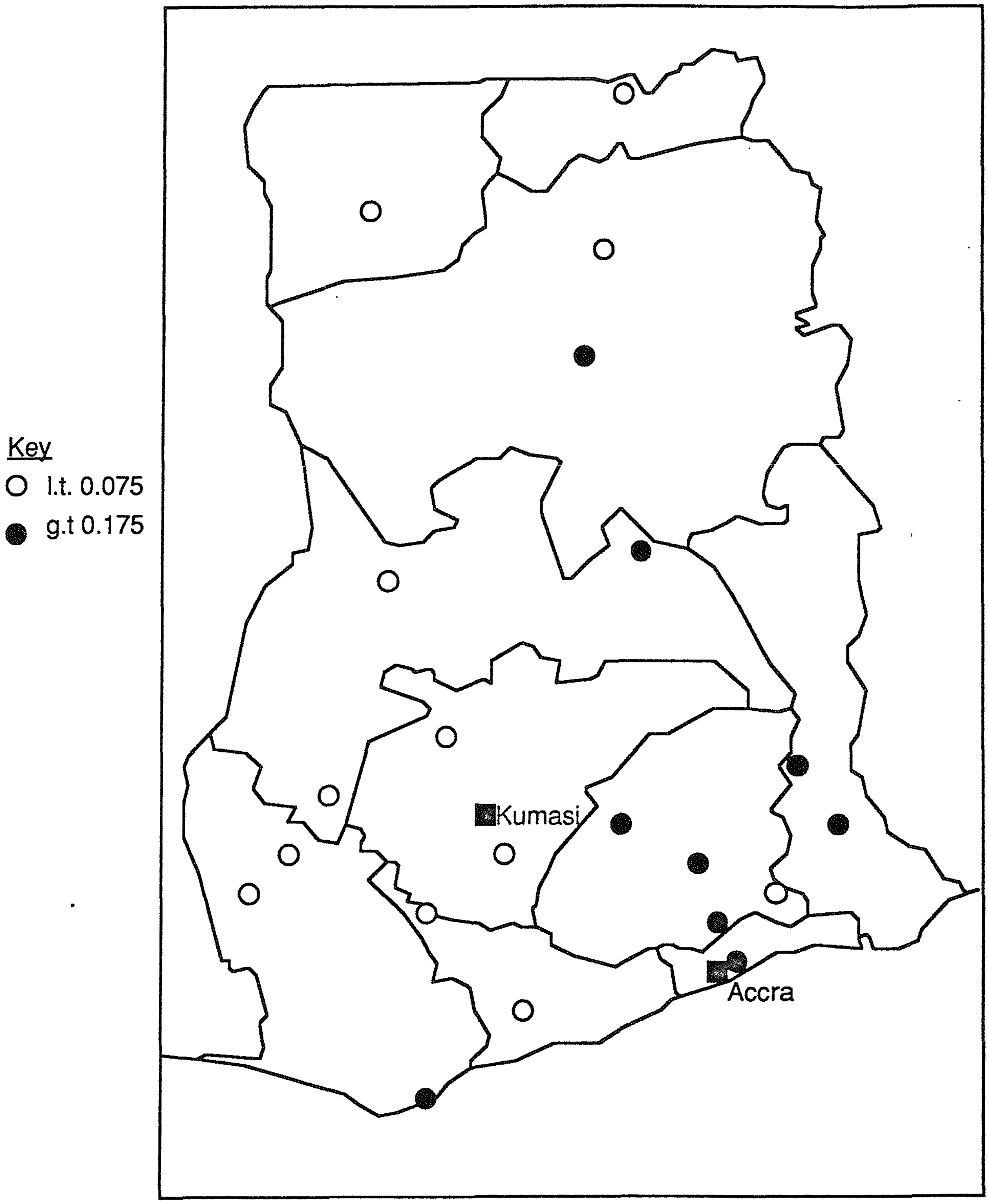
Table_6.4.3:_Random_Effects_ANOVA_for Currently_Using_Contraception

Parameter	Estimate	St. Error
Fixed		
Constant	0.13	0.007
Random		
Between-community	0.004	0.001
Within-community	0.10	0.002

Intra-cluster correlation 0.04

The level of "current use of contraception" tends to be highest in and around Accra, particularly the west of Accra. Only one cluster in Kumasi has a shrunken mean above 17.5%. In rural settlements in the forest near the border with the Ivory Coast and in some of the rural settlements in the northern savannah current use of contraception is either negligible or zero. Map 6.4.2 identifies those communities with a shrunken proportion of women currently using contraception below 7.5% or above 17.5%. Raw and shrunken proportions of women currently using any method of contraception for all the communities in the sample are presented in Appendices 6C and 6D. The difference between the raw and shrunken means is particularly pronounced for cluster 148 (Tamale) which has the highest actual proportion of women

Map 6.4.2 **Shrunken Cluster Means for Current Use of Contraception**



currently using contraception (57%) but a very small sample size (7 women).

The communities with the lowest and highest shrunken proportions of women who are currently using contraception are shown in Table 6.4.4:

Table 6.4.4: Communities with Highest/Lowest Shrunken Mean Currently Using Contraception

Rank	Cluster No.	Town	Region	Shrunken Mean
1	126	Wenchi	Brong Ahafo	0.04
2	121	Wurapong	Eastern	0.04
3	9	Topo	Eastern	0.05
4	63	Fuakyekrom	Western	0.05
5	133	Jamayiri	Upper West	0.06
146	18	Mamfe	Eastern	0.24
147	32	Accra	Gr. Accra	0.25
148	38	Accra	Gr. Accra	0.25
149	33	Accra	Gr. Accra	0.25
150	36	Accra	Gr. Accra	0.26

Ever Use of Contraception

There is considerable variation between communities in the proportion of women in a community who have ever used a method of contraception. The estimated true variance of the population of within-community means is 0.015 (standard deviation = 0.12), constituting roughly 7% of the total variance.. The between-community variance is clearly significant as its estimate is over five times the size of its estimated standard error (0.003). The distribution of the shrunken community means has a slight positive skew (see Figure 6.4.3 in Appendix 6H), but can reasonably be assumed normal. Thus, over the population of clusters, in roughly 68% of clusters the "true" proportion of women who have ever used a method of contraception will lie in the range (0.23, 0.47) and in roughly 95% of clusters the "true" proportion of women who have ever used a method of contraception will lie in the range (0.11, 0.79). The parameter estimates for the random effects ANOVA are presented in Table 6.4.5:

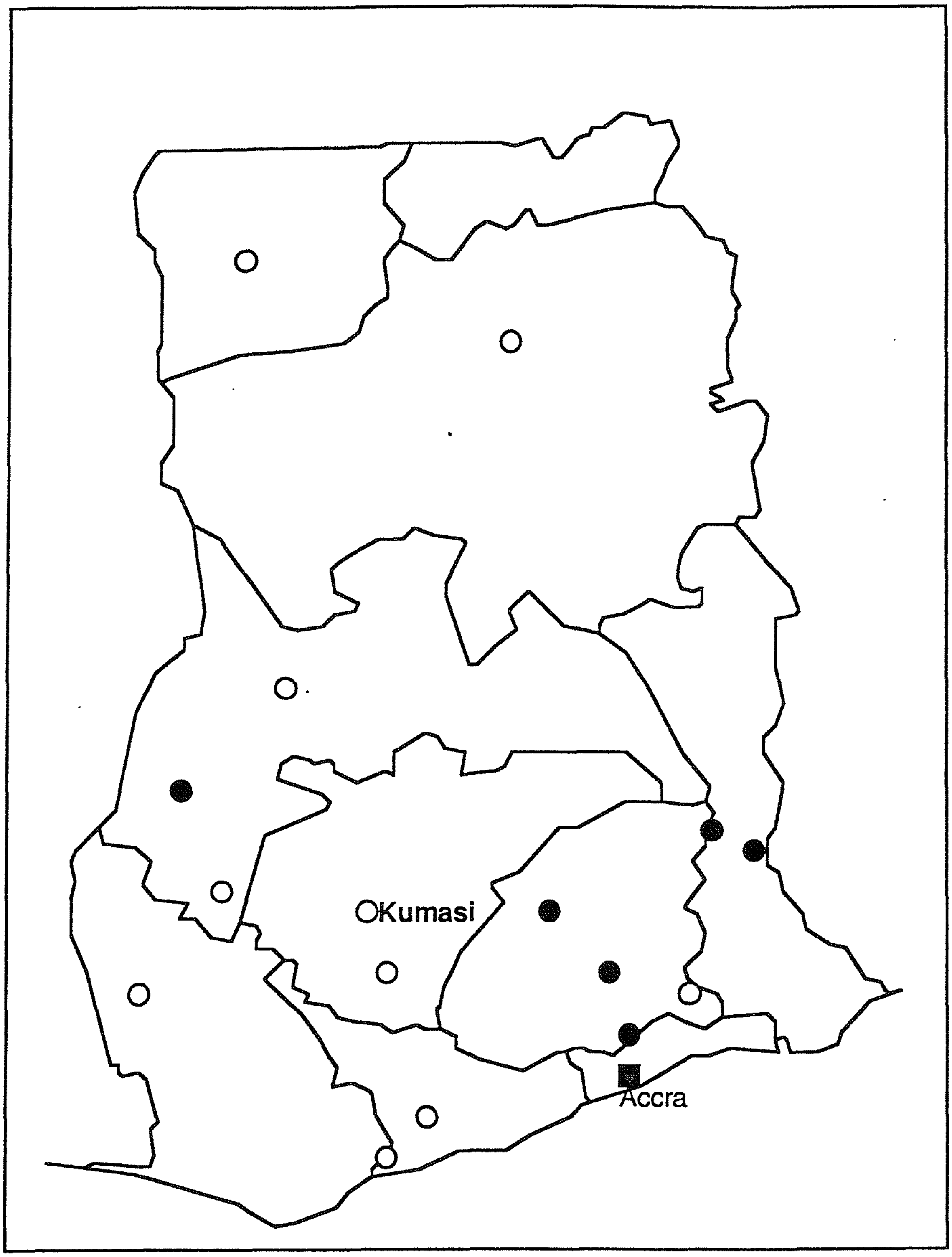
Table 6.4.5: Random Effects ANOVA for Ever Use of Contraception

Parameter	Estimate	St. Error
Fixed		
Constant	0.35	0.01
Random		
Between-Cluster	0.015	0.003
Within-Cluster	0.21	0.005

Intra-cluster Correlation 0.07

There are no outliers to the distribution of the shrunken means. The communities with a high shrunken proportion of women for "ever used contraception" are mostly located in the south-east of Ghana, particularly in the western part of Accra city, whilst those with a low shrunken proportion for "ever used contraception" are predominantly in the south-west. Map 6.4.3 shows the location of those communities with a shrunken mean below 0.2 or above 0.5. It should be noted that only one cluster in Kumasi has a shrunken mean below 0.2 (all the others fall in the range 0.2 to 0.5). For each community in the GDHS sample the shrunken proportion of women who have ever used a method of contraception is presented in Appendix 6D and the raw proportion of women who have ever used any method of contraception is presented in Appendix 6C.

Map 6.4.3 **Shrunken Cluster Means for Ever Use of Contraception**



Key
○ l.t. 0.2
● g.t. 0.5

The communities with the lowest and highest shrunken proportions of women for "ever used a method of contraception" are shown in Table 6.4.6:

Table 6.4.6: Communities with Highest/Lowest Shrunken Mean for Ever Use of Contraception

Rank	Cluster No.	Town	Region	Shrunken Mean
1	126	Wenchi	Brong Ahafo	0.07
2	133	Jamayiri	Upper West	0.09
3	131	Zosali	Northern	0.14
4	9	Topo	Eastern	0.16
5	5	Fuakyekrom	Western	0.18
146	33	Accra	Gr. Accra	0.54
147	31	Mamfe	Eastern	0.54
148	89	Accra	Gr. Accra	0.55
149	34	Accra	Gr. Accra	0.61
150	39	Accra	Gr. Accra	0.62

6.4.2 Differentials In Fertility Between Communities

6.4.2.1 Current Fertility

The random effects ANOVA model shows significant variation between communities. The estimated variance of the population of community means of births in the last five years is 0.04 (standard deviation = 0.20), constituting roughly 5% of the total variance. The size of the estimated between-community variance relative to its estimated standard error (0.008) suggests that the probability of the underlying value of this parameter being zero is not significant. The shrunken community means follow a normal distribution (see Figure 6.4.4 in Appendix 6H). Hence, over the population of communities, in roughly 68% of communities the mean number of births in the last five years to a woman aged 15-49 would be in the range (0.71, 1.10) and in roughly 95% of communities the mean number of births would be in the range (0.52, 1.30). Thus the observed variation between the estimated raw mean numbers of recent births for the communities is attributable to a considerable degree to sampling variation. The fairly small intra-cluster correlation for the number of recent births also indicates the that the loss of efficiency from using a clustered sample design as opposed to a simple random sample for the estimation of the population mean number of births in the last five years is slight (e.g Skinner, Holt, and Smith (1989, ch.2), Holt (1991)). The parameter estimates of the random effects ANOVA are presented in Table 6.4.7:

Table 6.4.7: Random Effects ANOVA for Children Born in the Last Five Years

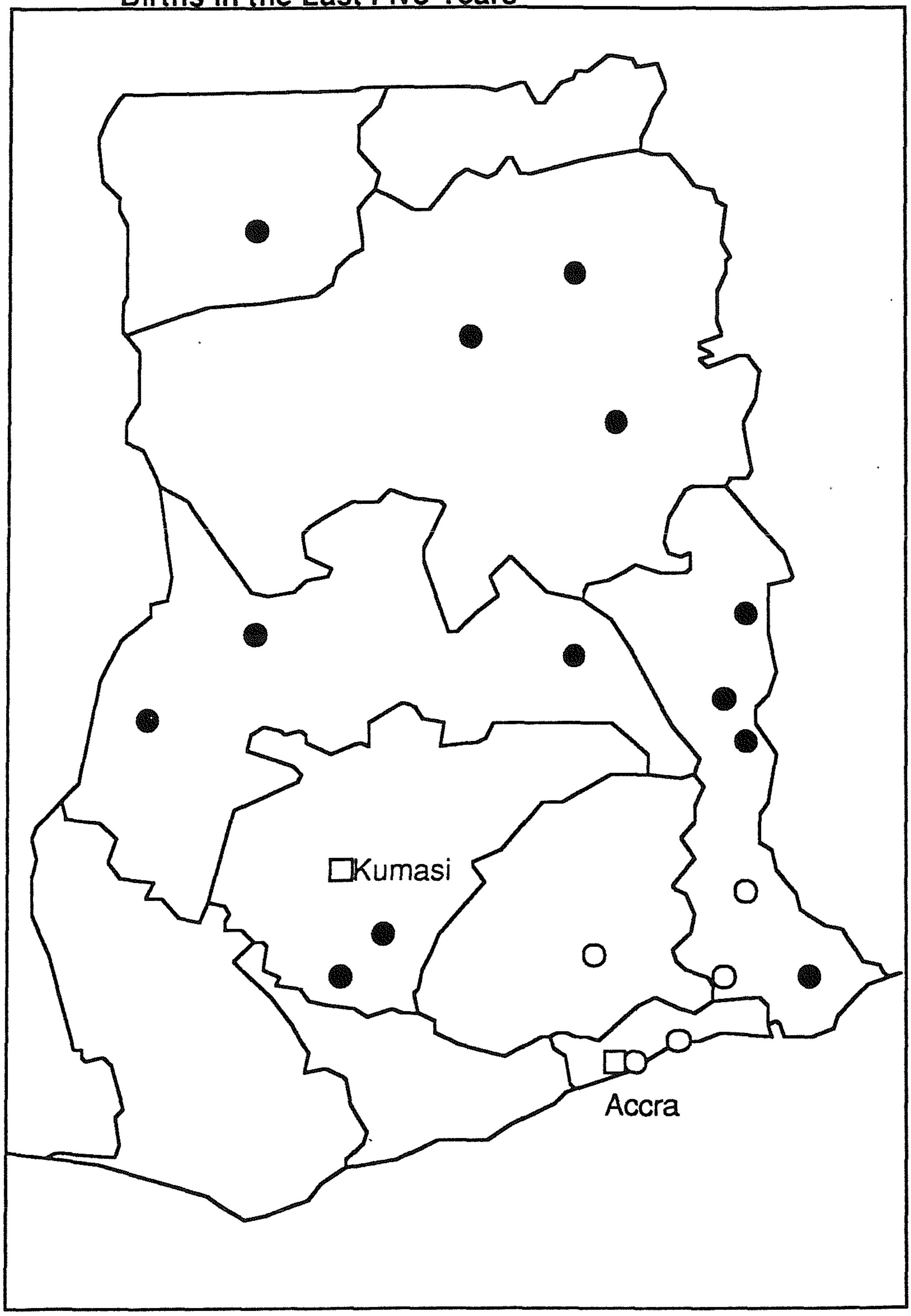
Parameter	Estimate	St. Error
Fixed		
Constant	0.90	0.02
Random		
Between-community	0.04	0.008
Within-community	0.76	0.02

Intra-cluster correlation 0.05

The shrunken means and the raw means for all the communities in the sample are presented in Appendices 6.D and 6.C respectively. Map 6.4.4 shows the locations of communities with a shrunken mean above 1.1 or below 0.7. This map shows that communities with high shrunken means, indicating high current fertility, tend to be rural communities in the northern savannah areas, and that

Map 6.4.4

Shrunken Cluster Means for Births in the Last Five Years



Key

O l.t. 0.7

● g.t 1.1

community with low shrunken means, indicating low current fertility, tend to be urban communities in the coastal belt particularly in Accra or Kumasi. The communities situated in Accra or Kumasi almost universally have below average fertility.

Based on the ordering of the shrunken means, the five communities from the sample with the lowest level of current fertility (as measured by the number of births to a woman) and the five communities in the sample with the highest level of current fertility are those shown in Table 6.4.8:

Table 6.4.8: Communities with the Highest/Lowest Shrunken Mean Children Born in the Last Five years

Rank	Cluster No.	Town	Region	Shrunken Mean
1	45	Labadi	Gr. Accra	0.55
2	41	Accra	Gr. Accra	0.58
3	52	Tema	Gr. Accra	0.59
4	106	Kumasi	Ashanti	0.61
5	144	Ho	Volta	0.63
146	85	Nkontunse	Central	1.17
147	125	Duflumkpa	Volta	1.19
148	75	Nsuamen	Ashanti	1.22
149	132	Tunni	Northern	1.32
150	71	Dzoko	Volta	1.33

6.4.2.2 Cumulative Fertility

The random effects ANOVA model shows slight but significant variation between communities in the number of children ever born. The estimated variance of the population of community means children ever born (0.25, standard deviation = 0.50) is four times its estimated standard error (0.06), but constitutes only roughly 3% of the total variance. The shrunken community means follow a normal distribution (see Figure 6.4.5 in Appendix 6H). This implies that, over the population of communities, in roughly 68% of communities the mean number of children ever born to a woman aged 15-49 is in the range (2.64, 3.63) and in roughly 95% of communities the mean number of children ever born is in the range (2.14, 4.12). The parameters of the random effects ANOVA are presented in Table 6.4.9:

Table 6.4.9: Random Effects ANOVA for Children Ever Born

Parameter	Estimate	St. Error
Fixed		
Constant	3.14	0.06
Random		
Between-community	0.24	0.06
Within-community	8.24	0.18

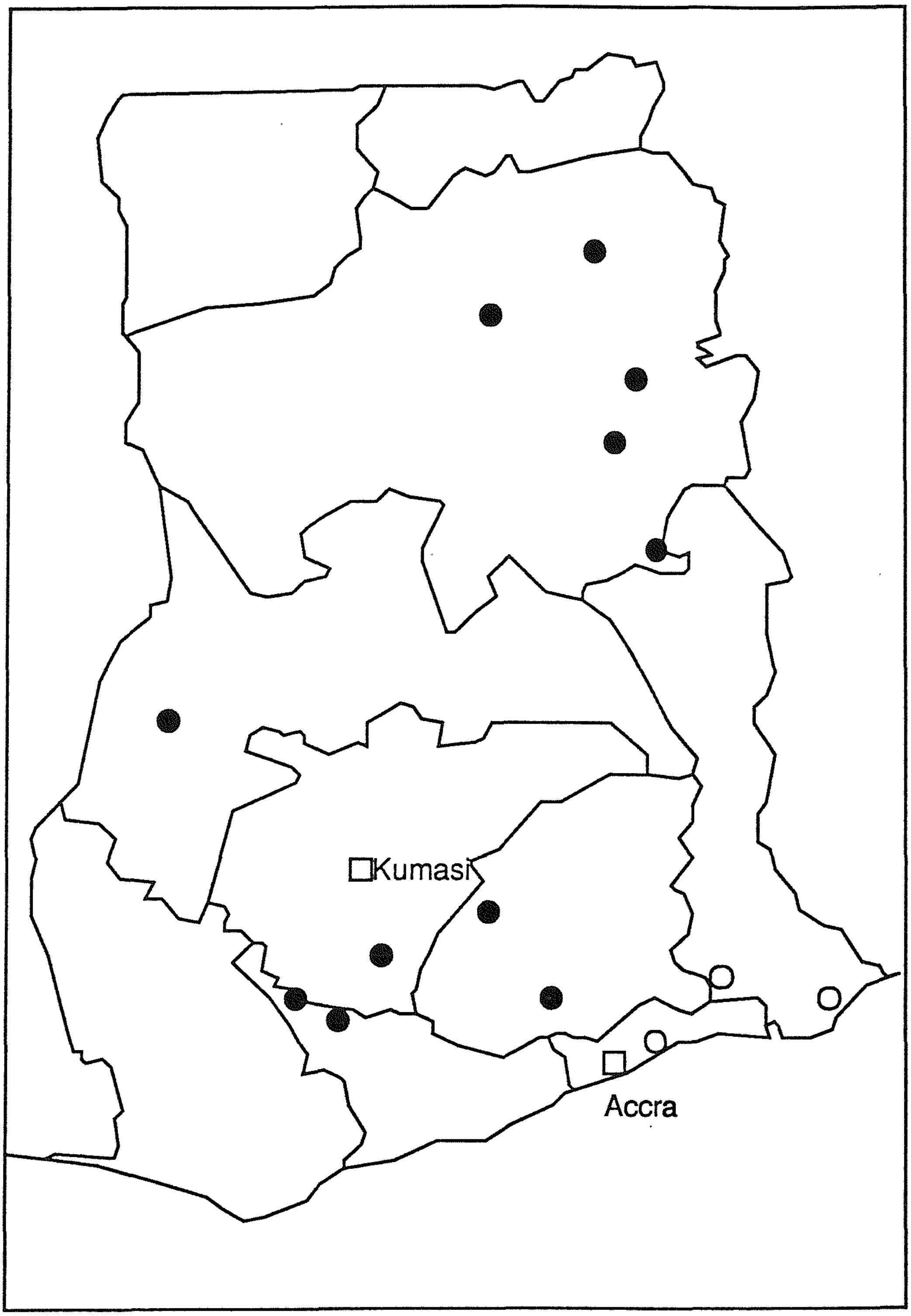
Intra-cluster correlation 0.03

Map 6.4.5 shows the locations of communities with a shrunken mean number of children ever born below 2.6 or above 3.6. This shows that the communities with a high mean number of children ever born are all rural and are almost all in one of two areas; the eastern part of the Northern region or the forests to the south of Kumasi. The communities with a low mean number of children ever born are either in the south-east of Ghana or in one of the main urban centres: Accra and Kumasi. The raw means and the shrunken means for all the communities in the sample are presented in Appendices 6C and 6D respectively. Based on the ordering of the shrunken means, the five communities in the sample with the lowest level of cumulative fertility (as measured by the

Map 6.4.5

Cluster Shrunken Means for

Children Ever Born



Key

○ l.t. 2.6

● g.t. 3.6

number of children ever born to a woman) and the five communities in the sample with the highest level of cumulative fertility are as in Table 6.4.10:

Table 6.4.10: Communities with the Highest/Lowest Shrunken Means for Children Ever Born

Rank	Cluster No.	Town	Region	Shrunken Mean
1	110	Kumasi	Ashanti	2.23
2	41	Accra	Gr. Accra	2.30
3	52	Tema	Gr. Accra	2.39
4	42	Accra	Gr. Accra	2.45
5	11	Keta	Volta	2.55
146	82	Kutre	Brong Ahafo	3.75
147	130	Tangmaya	Northern	3.87
148	132	Tunni	Northern	3.89
149	142	Yendi	Northern	3.89
150	75	Nsuamen	Ashanti	4.00

6.5 Multilevel Models of Fertility in Ghana

6.5.0 Introduction

In this section I present multilevel models of current and cumulative fertility in Ghana, as measured by the number of children born to a woman in the last five years and the number of children ever born to a woman respectively, using the GDHS data. These models assess the effects both of socio-economic and cultural characteristics of a woman and of characteristics of the community (as defined by cluster) in which she lives on her fertility. The effects of such variables are indirect in the sense that they operate via their effects on the proximate determinants of fertility. Consequently, multivariate multilevel analyses of some measures of the proximate determinants of fertility are also presented in this section. The case for using a multivariate analysis of fertility differentials has been discussed at greater length in Section 5.5.0 and a case for models of fertility to be multilevel has been made in Chapter 4.

The results of the analyses are presented in Section 6.5.2. Issues considered prior to the estimation of models are considered in Section 6.5.1.

6.5.1 Preliminary Considerations

The analyses presented in Section 6.5.2 parallel those for Liberia (see Section 5.5.2) and so, to avoid duplication of text, for discussions of many of the pre-output considerations the reader is referred to the appropriate section in Chapter 5.

6.5.1.1 The Choice of Response Variables

Two woman-level measures of fertility are analysed; the number of children born to a woman during the five-year period before the survey and the number of children ever born to a woman. Of the proximate determinants of fertility, one woman-level measure of nuptiality, whether or not a woman is "married", and two woman-level measures of contraceptive use, whether a woman is currently using a method of contraception and whether a woman has ever used contraception, are analysed. Issues concerning the analysis of all these response variables have been discussed in Section 5.5.2.1.

In the case of Ghana, the analysis of a measure of current as distinct from past or cumulative fertility would seem to be particularly pertinent. This is because in some areas of Ghana there is strong evidence that fertility decline is underway. In particular, in Accra and Kumasi cities comparatively low TFRs (4.3 and 4.2 respectively) and high P/F ratios (1.42 and 1.60 respectively) indicate that fertility decline is underway. Analysis of past fertility is likely to be much less able than analysis of recent fertility to provide variables which can be used to describe and predict such fertility declines.

6.5.1.2 The Choice of Explanatory Variables

The explanatory variables include both variables measured at the individual/woman level and the community/cluster level. The effect of community is modelled using a random effect (for reasons for using this approach see Section 5.5).

The following explanatory variables were chosen:

A) Individual Level:

1) Woman's age. Six (0,1) dummy variables are used to indicate whether a woman is from the 15-19, 20-24, 25-29, 30-34, 35-39, 40-44 or 45-49 age group with women aged 15-19 forming the reference category.

2) Woman's highest level of education. Three (0,1) dummy variables are used to indicate whether a woman's highest level of education is no schooling, primary, secondary or higher with women with no schooling forming the reference category.3) A woman's religion. Four (0,1) dummy variables are used to indicate whether a woman is Catholic, Other Christian, Muslim, traditional/other or of no "religion". Catholic women form the reference category.

4) Woman's ethnicity. Four (0,1) dummy variables are used to

indicate whether a woman's ethnicity is Akan (including Guans), Ga-Adangbe, Ewe, Mole-Dagbani and "other", with Akan women forming the reference category.

B) Community level:

5) Urban-rural. This is a (0,1) variable indicating whether the cluster is in an urban area.

6) The levels of education in a community: This is measured by the following two variables;

a) the (estimated) proportion of women in a community with primary-level schooling only, and

b) The (estimated) proportion of women in a community with secondary-level or higher level education.

These two variables have been estimated from individual-level data from the survey. The interpretation of these variables has been discussed in Section 5.5.1.2.

7) A random effect for community.

The explanatory variables are all indirect as opposed to proximate determinants of fertility (see Section 1.1).

6.5.1.3 Choice of Hierarchy

The models fitted are two-level models using individual women as the level 1 units and the clusters (i.e. census enumeration areas) in which the women currently live as level 2 units. The GDHS obtained responses from 4488 women (level 1 units) living in 150 clusters (level 2 units).

The level 2 units were chosen to give an approximate representation of communities. Whilst I have argued in Chapter 4 that community characteristics are relevant to the determination of fertility patterns, qualifications need to be made regarding this choice of representation of communities in the modelling of numbers of births. These have been discussed at greater length in Section 5.5.1.3.

Firstly, the representation of communities is by arbitrary spatial areas chosen as part of the sampling scheme because of fieldwork considerations rather than because they were deemed to be meaningful sociological entities. Secondly, there are the effects of changes over time. Some of the women previously will have lived in other enumeration districts and all areas will have changed over time. Furthermore, the cluster in which a woman lives may reflect "self-selection" whereby the woman has migrated to an area which suits her (and possibly also her family). A further point to be made regarding the choice of hierarchy is that the assumption of community-level errors being independent (i.e. what Mason (1989) calls the assumption of no spatial autocorrelation), made for the purposes of estimating multilevel models, is invalid. Social interaction between individuals living in different communities should imply that the errors in communities from which these individuals come are correlated. An example of social interaction outside the cluster in which an individual lives is when individuals living in different scattered suburbs of Accra commute to workplaces in the city centre (see Abane (1992) for details of travel to work patterns in the Accra area).

6.5.1.4 <u>The Choice of Link Functions</u>

Issues regarding the choice of link functions for the chosen response variables have been discussed in Section 5.5.1.5.

6.5.1.5 The Choice of Software

VARCL and ML3 were used for the analyses. The merits of these two software packages have been discussed in Section 5.5.1.7.

6.5.2 Results

In this section I present models of fertility, marriage and contraceptive use using the GDHS data. Analyses of the chosen measures of marriage and contraceptive use are presented in Section 6.5.2.1 and analyses of the chosen measures of current and cumulative fertility are presented in Section 6.5.2.2.

6.5.2.1 Proximate Determinants of Fertility

6.5.2.1.1 Marriage

Parameter Estimates

A binary variable indicating whether or not a woman is currently "married" (women who live with a partner are counted as "married") is analysed. Listwise deletion is used for missing data and 4481 women from 150 clusters are included for analysis.

Table 6.5.1 presents the parameter estimates for the full set of explanatory variables described in Section 6.5.1.2, and Table 6.5.2 presents the parameter estimates for a more parsimonious model obtained by removing the non-significant parameter contrasts from the previous model.

The parameter estimates show that:

1) the probability of a women being married increases with age

between 15-19 and 35-39 years but decreases with age between 35-39 and 45-49[1]. However, the differences between the coefficents for age groups from 25-29 to 40-44 are not significant. The lower levels of marriage among younger women are because of many of these women being single and the lower proportion of women aged 45-49 being married reflects the higher proportion of these women who are "divorced" or widowed.

2) The probability of a woman being married decreases as her level of education increases. The contrast between women with secondary level or above education and below secondary level education is significant[1].

3) The probability of a Christian woman being married is significantly lower than that of a non-Christian woman being married[1]. The lower levels of polygyny among Christian women may contribute to this (see Table 5.3.2.1.4).

4) The effects of ethnicity are not significant[1].

5) The urban-rural contrast is not significant[1].

6) The probability of a woman being married decreases significantly as the proportion of women in her community with primary level education or above increases[1]. The coefficents for the proportion primary and the proportion secondary and above are both negative and significantly different from zero, but are not significantly different from each other.

7) The random effect for community is significant[2,3]. The change in deviance when the random effect is omitted from the model containing the full set of explanatory variables is 10.2.

Table 6.5.1: Full Multilevel Logistic Model of Currently Married

Fixed Parameter	$\hat{\beta}$	S.E.($\hat{\beta}$)	exp($\hat{\beta}$)
Level 1			
15-19	-0.70	n.a.	0.50
20-24	2.18**	0.12	8.85
25-29	3.31**	0.14	27.39
30-34	3.42**	0.16	30.57
35-39	3.48**	0.17	32.46
40-44	3.10**	0.18	22.20
45-49	2.48**	0.16	11.94
No Education	0.00	n.a.	1.00
Primary	-0.10	0.11	0.90
Secondary	-0.67**	0.18	0.51
Higher	-1.24**	0.37	0.29
Catholic	0.00	n.a.	1.00
Other Christian	-0.16	0.11	0.85
Muslim	0.21	0.20	1.23
Traditional/Other	0.51*	0.22	1.67
No Religion	0.22	0.17	1.25
Akan/Guan	0.00	n.a.	1.00
Ga-Adangbe	-0.05	0.15	0.95
Ewe	-0.07	0.13	0.93
Mole-Dagbani	0.27	0.21	1.31
Other	0.04	0.21	1.04
Level 2			
Urban	0.00	n.a.	1.00
Rural	0.18	0.12	1.20
Prop. Primary	-1.02**	0.32	0.36
Prop Second/High	-1.44**	0.53	0.24

Random Parameter	$\hat{\sigma}^2$	$\hat{\sigma}$	S.E.($\hat{\sigma}$)
Level 2			
Constant	0.09	0.31	0.06
Level 1			
Constant	1.00	1.00	n.a.

Model Statistics

Deviance	3920.1

Key
n.a. Not Applicable
* $0.01 < p \le 0.05$
** $p \le 0.01$.
+ $2.71 \le$ Change in Deviance < 3.84
++ $3.84 \le$ Change in Deviance

Table 6.5.2: Simplified Multilevel Logistic Model of Currently Married

Fixed Parameter	$\hat{\beta}$	S.E.($\hat{\beta}$)	exp($\hat{\beta}$)
Level 1			
15-19	-0.47	n.e.	0.63
20-24	2.20**	0.12	9.03
25-44	3.35**	0.11	28.50
45-49	2.53**	0.16	12.55
None/Primary	0.00	n.a.	1.00
Secondary/Higher	-0.71**	0.14	0.49
Christian	0.00	n.a.	1.00
Non-Christian	0.43**	0.11	1.54
Level 2			
Prop. Prim/Sec/Hi	-1.56**	0.24	0.21

Random Parameter	$\hat{\sigma}^2$	$\hat{\sigma}$	S.E.($\hat{\sigma}$)
Level 2			
Constant	0.10++	0.32	0.06
Level 1			
Constant	1.00	1.00	n.a.

Model Statistics

Deviance 3938.6

Key

n.a. Not Applicable

* $0.01 < p \leq 0.05$

** $p \leq 0.01$.

\+ $2.71 \leq$ Change in Deviance < 3.84

++ $3.84 \leq$ Change in Deviance

Community Effects

The histogram in Figure 6.5.1 (see Appendix 6I) shows that the distribution of the community effects for the model with all explanatory variables fitted (i.e. Model 6.5.1) is roughly a normal distribution, although it is noticeable that the distribution is light-tailed with few communities having a standardised residual greater than 1.5, and no outlying community effects. The implication of normality for the community effects is that, over the population of all communities, roughly 68% of community effects will lie in the range (-0.31, 0.31) and roughly 95% will lie in the range (-0.62, 0.62) or, equivalently, for a given value of the fixed effects, in roughly 68% of communities the odds of a woman being married will be between 0.73 and 1.36 times that value, and in roughly 95% of communities the odds of her being married will be between 0.54 and 1.85 times that value.

Map 6.5.1 shows that the larger community effects (i.e. those of magnitude greater than 0.3 - approximately one standard deviation) tend to be for rural communities in the south of the country. Appendix 6.E presents the residual community effects for the communities included in the sample for the model with all explanatory variables fitted (i.e. the "full" model). These community effects are measured on the logit scale. The five communities with the highest value of the random effect and the five communities with the lowest value of the random effect are shown in Table 6.5.3:

Map 6.5.1 Cluster-level Residuals to Model 6.5.1

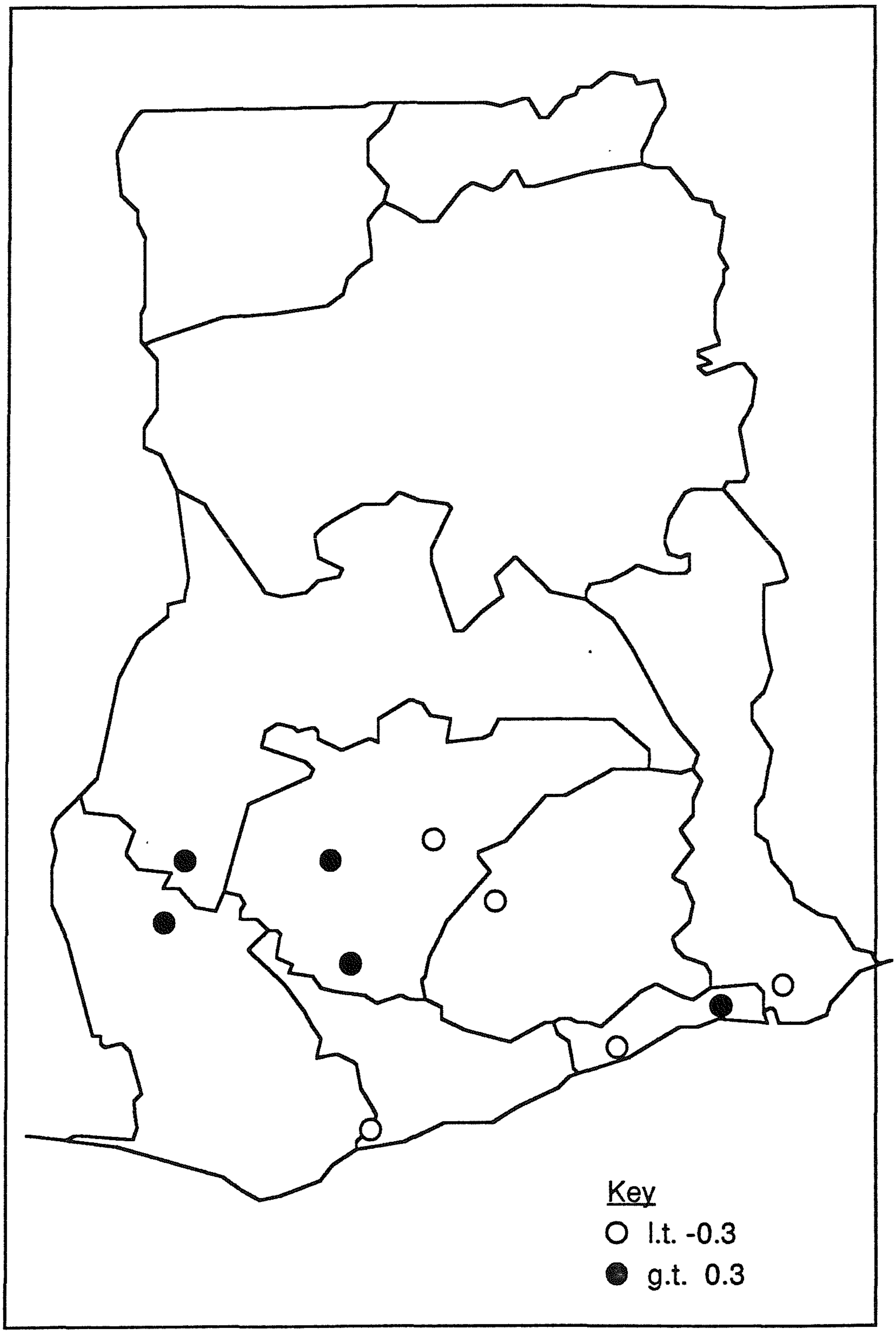


Table 6.5.3: Highest/Lowest Values of the Random Effect for Community for the "Full" Model of Currently Married

Rank	Cluster No.	Town	Region	Residual
1	10	Verkope	Volta	-0.47
2	15	Besease	Central	-0.41
3	78	Wioso	Ashanti	-0.38
4	47	Accra	Gr. Accra	-0.35
5	122	Senchi	Eastern	-0.34
146	72	Konkromase	Ashanti	0.31
147	63	Funkyekrom	Western	0.37
148	76	Nkoranza	Ashanti	0.38
149	8	Bonikope	Gr. Accra	0.38
150	81	Yankye	Brong Ahafo	0.44

6.5.2.1.2 Contraceptive Use

Current Use of Contraception

A binary variable indicating whether or not a woman is currently using a method of contraception is the response variable. Listwise deletion is used for missing data and so 4481 women from 150 clusters are included for analysis.

Table 6.5.4 presents the parameter estimates for the full set of explanatory variables described in Section 6.5.1.2. Table 6.5.5 presents the parameter estimates for a more parsimonious model obtained by removing the non-significant parameter contrasts from the previous model.

The parameter estimates show:

1) the effects of woman's age on her probability of currently using contraception are highly significant. Women aged 15-19 have the lowest probability of using contraception[1], and women aged 40-44 have the highest[1]. The probabilities of using contraception

do not vary significantly between the ages of 20 and 40[1]. The finding that current use of contraception is highest among the 40-44 age group is interesting as it could indicate "stopping" behaviour by some women in this group.

2) The probability of a woman currently using contraception is significantly greater for women whose highest level of education is primary than for women with no education and, in turn, is significantly higher for women with secondary-level or above education than for women with primary-level education only[1].

3) The contrast between Catholic/traditional/"other" religions and Other Christian/Muslim/No religion is significant with the former category having the higher probability of current use of contraception[1]. The methods of contraception used by traditional/other women are almost entirely non-modern methods of contraception (see Table 6.3.2.2.3).

4) Effects of ethnicity on current use of contraception are not significant[1].

5) the urban-rural contrast is significant with residence in a rural community significantly decreasing the probability of a woman currently using contraception[1].

6) Neither the variable for the effect of the proportion of women with primary-level education nor the effect of the proportion of women with secondary-level or above education is significant[1]. Measurement error resulting from using within-sample estimates for this variable is one explanation for this.

7) The random effect for community is significant[2,3]. The change in deviance from omitting the random effect is 18.0.

Table 6.5.4: Full Multilevel Logistic Model of Currently Using Contraception

Fixed Parameter	$\hat{\beta}$	S.E.($\hat{\beta}$)	exp($\hat{\beta}$)
Level 1			
15-19	-3.15	n.e.	0.04
20-24	1.02**	0.18	2.77
25-29	1.09**	0.18	2.97
30-34	1.22**	0.19	3.39
35-39	1.27**	0.20	3.56
40-44	1.53**	0.21	4.61
45-49	0.77**	0.25	2.16
No Education	0.00	n.a.	1.00
Primary	0.69**	0.13	1.99
Secondary	1.19**	0.20	3.29
Higher	1.01*	0.40	2.75
Catholic	0.00	n.a.	1.00
Other Christian	-0.29*	0.13	0.75
Muslim	-0.29	0.23	0.75
Traditional/Other	0.18	0.22	1.20
No Religion	-0.57**	0.21	0.57
Akan/Guan	0.00	n.a.	1.00
Ga-Adangbe	0.29	0.18	1.34
Ewe	0.02	0.16	1.02
Mole-Dagbani	-0.15	0.24	0.86
Other	0.09	0.24	1.09
Level 2			
Urban	0.00	n.a.	1.00
Rural	-0.43**	0.14	0.65
Prop. Primary	0.16	0.39	1.17
Prop Second/High	0.70	0.62	2.01

Random Parameter	$\hat{\sigma}^2$	$\hat{\sigma}$	S.E.($\hat{\sigma}$)
Level 2			
Constant	0.18++	0.43	0.07
Level 1			
Constant	1.00	1.00	n.a.

Model Statistics	
Deviance	3108.6

Key
n.a. Not Applicable
* $0.01 < p \le 0.05$
** $p \le 0.01$.
+ $2.71 \le$ Change in Deviance < 3.84
++ $3.84 \le$ Change in Deviance

Table 6.5.5: Simplified Multilevel Logistic Model of Currently Using Contraception

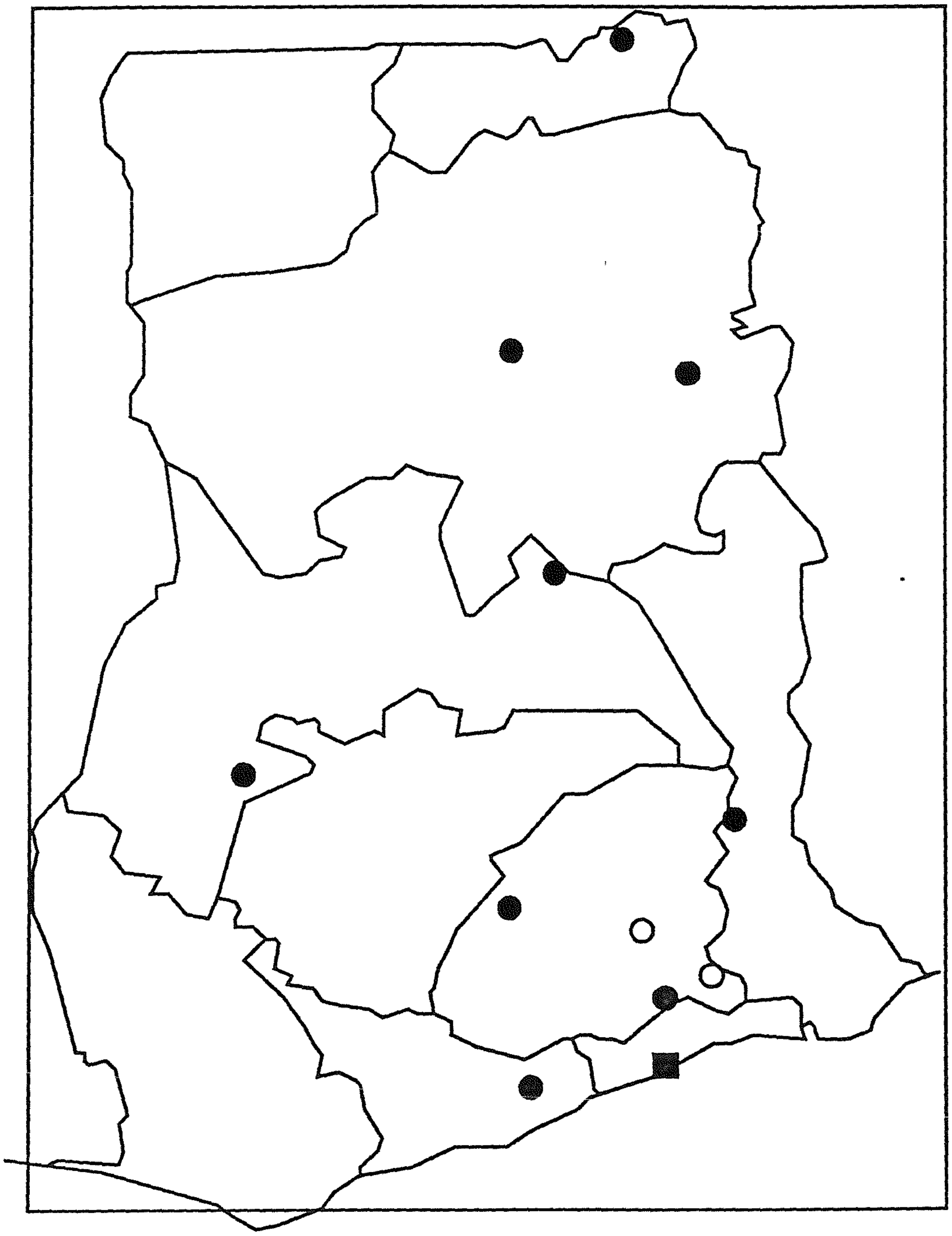
Fixed Parameter	$\hat{\beta}$	S.E.($\hat{\beta}$)	exp($\hat{\beta}$)
Level 1			
15-19	-3.25	n.e.	0.04
20-40	1.12**	0.16	3.06
40-44	1.52**	0.21	4.57
45-49	0.76**	0.25	2.14
No Education	0.00	n.a.	1.00
Primary	0.73**	0.12	2.08
Secondary/Higher	1.25**	0.17	3.49
Oth. Chr./Muslim/No.	0.00	n.a.	1.00
Catholic/Trad/Oth	0.34**	0.11	1.40
Level 2			
Urban	0.00	n.a.	1.00
Rural	-0.53**	0.12	0.59

Random Parameter	$\hat{\sigma}^2$	$\hat{\sigma}$	S.E.($\hat{\sigma}$)
Level 2			
Constant	0.19	0.44	0.07
Level 1			
Constant	1.00	1.00	n.a.
Model Statistics			
Deviance	3121.8		

Community Effects

The histogram of residual community effects for the full model (i.e. Model 6.5.4) (see Figure 6.5.2 insee Appendix 6I) has a positive skew. However, the skew does not seem to be sufficiently great to reject the assumption that the community effects follow a normal distribution. The implication of normality is that, over the population of all communities, roughly 68% of community effects will lie in the range (-0.44, 0.44) and roughly 95% will lie in the range (-0.88, 0.88) or, equivalently, that for a given value of the fixed effects, in roughly 68% of communities the odds of a woman using contraception will be between 0.64 and 1.55 times that value, and in roughly 95% of communities the odds of her using contraception will be between 0.41 and 2.41 times that value. Only one community (Antiwokram) is an outlier whereas, over a sample of 150 communities one would expect 7 or 8 such communities. Map 6.5.2 shows that the communities with "effects" greater than 0.4 (approximately one standard deviation), indicating greater than expected contraceptive use, are spread fairly evenly over the whole country, but that the two communities with "effects" less than -0.4 are both in Eastern region. The five communities with the highest value of the random effect and the five communities with the lowest value of the random effect are shown in Table 6.5.6. Appendix 6E shows value of the random effect for each community in the sample.

Map 6.5.2 Cluster-level Residuals to Model 6.5.4



Key
○ l.t. -0.4
● g.t. 0.4

Table 6.5.6: Highest/Lowest Values of the Random Effect for Community For the "Full" Model of Currently Using Contraception

Rank	Cluster No.	Town	Region	Community Effect
1	121	Wurapong	Eastern	-0.52
2	9	Topo	Eastern	-0.45
3	41	Accra	Gr. Accra	-0.40
4	122	Senchi	Eastern	-0.39
5	11	Keta	Volta	-0.39
146	33	Accra	Gr. Accra	0.62
147	132	Tunni	Northern	0.66
148	36	Accra	Gr. Accra	0.66
149	18	Mamfe	Eastern	0.75
150	69	Antiwokram	Eastern	0.81

Ever Use of Contraception

A binary variable indicating whether or not a woman has ever used a method of contraception is analysed. Listwise deletion is used for missing data and so 4481 women from 150 clusters are included for analysis.

Table 6.5.7 presents the parameter estimates for the full set of explanatory variables described in Section 6.5.1.2. and Table 6.5.8 presents the parameter estimates for a more parsimonious model obtained by removing the non-significant parameter contrasts from the previous model.

The parameter estimates show:

1) the probability of ever having used contraception increases significantly between the 15-19 age group and the 20-24 year age and between the 20-24 age group and the 25-29 age group. The probability of ever having used contraception doesn't increase significantly between the ages of 25 and 49[1].

2) The probability of a woman having ever used contraception increases with her highest level of education. Moreover, the differences between no education and primary level education and between primary level and secondary/higher education are significant[1].

3) The contrast between women with no religion and the other religious categories is significant with the former having the lower probability of ever use[1].

4) The contrast between Ga-Adangbe/Ewe and Akan/Mole-Dagbani/"other" is significant with the former group having the higher probability of having ever used contraception[1].

5) Residence in a rural community significantly reduces the probability of ever use[1].

6) The proportion of women with primary level education or above significantly increases the probability of ever use[1].

7) The random effect for community is highly significant[2,3]. The change in deviance from omitting the random effect is 42.6.

Table 6.5.2.7: Full Multilevel Logistic Model of Ever Used Contraception

Fixed Parameter	$\hat{\beta}$	S.E.($\hat{\beta}$)	exp($\hat{\beta}$)
Level 1			
15-19	-3.07**	n.a.	0.05
20-24	1.53**	0.13	4.62
25-29	1.93**	0.13	6.89
30-34	2.01**	0.14	7.46
35-39	2.02**	0.15	7.54
40-44	2.04**	0.16	7.69
45-49	1.74	0.17	5.70
No Education	0.00**	n.a.	1.00
Primary	0.88**	0.09	2.41
Secondary	1.73**	0.16	5.64
Higher	1.96	0.41	7.10
Catholic	0.00	n.a.	1.00
Other Christian	-0.11	0.10	0.90
Muslim	-0.22	0.17	0.80
Traditional/Other	0.10**	0.16	1.11
No Religion	-0.55	0.15	0.58
Akan/Guan	0.00**	n.a.	1.00
Ga-Adangbe	0.51**	0.15	1.67
Ewe	0.31	0.12	1.36
Mole-Dagbani	0.01	0.18	1.01
Other	-0.15	0.18	0.86
Level 2			
Urban	0.00*	n.a.	1.00
Rural	-0.23*	0.12	0.79
Prop. Primary	0.64	0.31	1.90
Prop Second/High	0.63	0.54	1.88

Random Parameter	$\hat{\sigma}^2$	$\hat{\sigma}$	S.E.($\hat{\sigma}$)
Level 2			
Constant	0.17	0.41	0.05
Level 1			
Constant	1.00	1.00	n.a.

Model Statistics

Deviance 4967.0

Key

n.a. Not Applicable

* 0.01 < p ≤ 0.05
** p ≤ 0.01.
+ 2.71 ≤ Change in Deviance < 3.84
++ 3.84 ≤ Change in Deviance

Table 6.5.2.8: Simplified Multilevel Logistic Model of Ever Used Contraception

Fixed Parameter	$\hat{\beta}$	S.E.($\hat{\beta}$)	exp($\hat{\beta}$)
Level 1			
15-19	-3.22	n.a.	0.04
20-24	1.54**	0.13	4.66
25-49	1.97**	0.12	7.17
No Education	0.00	n.a.	1.00
Primary	0.91**	0.08	2.48
Secondary/Higher	1.79**	0.15	5.99
Chr./Muslim/Tr/Oth	0.00	n.a.	1.00
No Religion	-0.49**	0.12	0.61
Akan/Guan/M-ODa/Oth	0.00	n.a.	1.00
Ga-Adangbe/Ewe	0.42**	0.10	1.52
Level 2			
Urban	0.00	n.a.	1.00
Rural	-0.20*	0.11	0.82
Prop. Prim/Sec/Hi	0.63*	0.25	1.88

Random Parameter	$\hat{\sigma}^2$	$\hat{\sigma}$	S.E.($\hat{\sigma}$)
Level 2			
Constant	0.16	0.41	0.05
Level 1			
Constant	1.00	1.00	n.a.

Model Statistics

Deviance	4977.8

Community Effects

The histogram of the community effects for Model 6.5.7 (see Figure 6.5.3 in Appendix 6I) shows a slight positive skew, however, this does not seem to be sufficiently great to reject the assumption that the community effects follow a normal distribution. Hence, over the population of all communities, roughly 68% of community effects will lie in the range (-0.41, 0.41) and roughly 95% will lie in the range (-0.82, 0.82) or, equivalently, for a given value of the fixed effects, in roughly 68% of communities the odds of a woman having ever used contraception will be between 0.66 and 1.51 times that value, and in roughly 95% of communities the odds of her having ever used contraception will be between 0.44 and 2.27 times that value. There are no outliers to the distribution of the random effect.

The communities with relatively large negative effects are mostly in the south-west of Ghana, whereas those with large positive residuals are spread over the whole country (see Map 6.5.3). The five communities with the highest value of the random effect and the five communities with the lowest value of the random effect are shown in Table 6.5.9. Appendix 6E shows the effects for each community in the sample.

Map 6.5.3

Cluster-level Residuals to Model 6.5.7

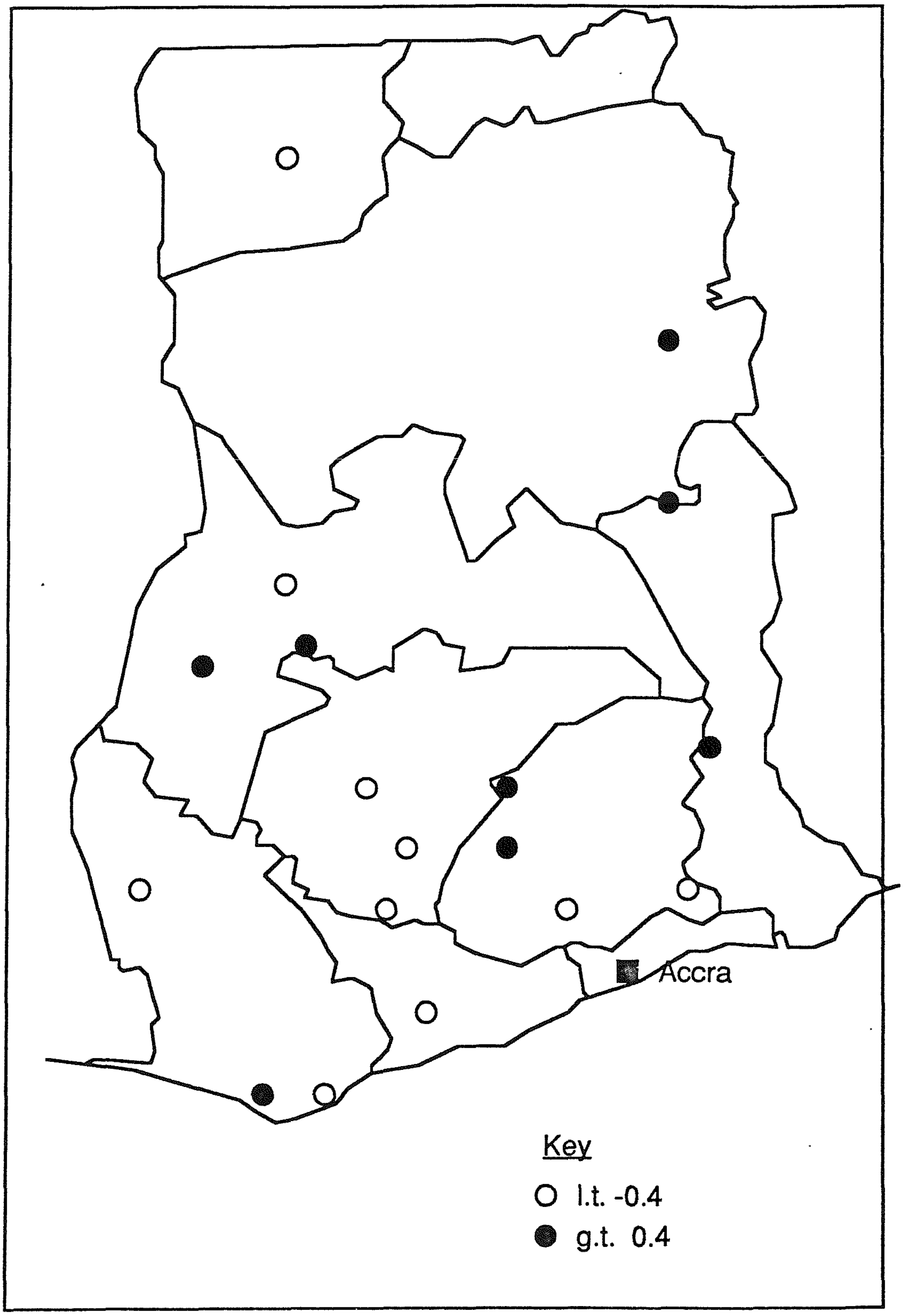


Table_6.5.9:_Highest/Lowest_Values_of_the_Random_Effect_for Community_for_the_"Full"_Model_of_Ever_Used_Contraception

Rank	Cluster No.	Town	Region	Cluster Effect
1	126	Boasi	Brong Ahafo	-0.67
2	110	Kumasi	Ashanti	-0.62
3	9	Topo	Eastern	-0.57
4	133	Jayamari	Upper West	-0.53
5	68	Shia Mameng	Eastern	-0.52
146	89	Kpando	Volta	0.57
147	88	Kwahu Praso	Eastern	0.58
148	69	Antiwokram	Eastern	0.58
149	39	Accra	Gr. Accra	0.68
150	2	Bonzokrom	Western	0.81

6.5.2.2 Fertility

6.5.2.2.1 Current_Fertility

The number of children born to a woman in the five years before the survey is the response variable. Listwise deletion is used for missing data and so 4482 women from 150 clusters are included for analysis.

There is significant extra-Poisson level 1 variation. The unconstrained level 1 variance term (0.73, standard error 0.02) is significantly different from 1. The unconstrained level 1 variance term indicates that the observed level 1 variance is less than that expected under a Poisson assumption for the level 1 variance (i.e. there is underdispersion). This is because the observed numbers of women with values of numbers of children born close to the the expected numbers of births (usually 1 or 2) tend to exceed the numbers expected under a Poisson assumption and the observed numbers of women with 3 or more children born in the last 5 years tend to be less than would be predicted by a Poisson distribution. This could be explained by the effects of birth spacing practises reducing a woman's exposure to the risk of conceiving again.

Table 6.5.10 presents two sets of parameter estimates for the "full" model: the first set of parameters is that estimated when a Poisson distribution is assumed and the second set is that estimated when extra-Poisson variation is allowed. A comparison of the two sets of parameters shows that allowing for extra-Poisson variation has little effect on the parameter estimates, but that the standard errors of parameters are generally smaller when the Poisson level 1 variance constraint is removed. Table 6.5.11 presents the parameter estimates for a more parsimonious model obtained by removing the "non-significant" parameter contrasts from the model with extra-Poisson variation (in the case of the random effect for community the criteria by which "non-significance" was judged was that the change in deviance when this effect was omitted is less than 3.84).

The parameter estimates of the models which allow for extra-Poisson variation show:

1) there are highly significant differences in current fertility between different age groups ($\chi_6^2 = 1061.7$,$p < 0.001$). A woman being aged between 25 and 34 is associated with her having a very high recent level of childbearing. A woman being from the 35-39 or the 20-24 age groups is also associated with her having a relatively high recent level of childbearing. A woman being from the 45-49 or the 15-19 age group is associated with her having a

low level of fertility. Women in the 40-44 age group also have comparatively low fertility. The major reason for low fertility in the 15-19 age group is the low proportion of women who are married in this age group (see Section 6.5.2.1.1). A contributory factor to low fertility in the 45-49 age group are the lower proportion of women who are still married in this group (see Sections 6.5.2.1.1), although perhaps the main factors behind low fertility in this age group are the effects of women becoming subfecund (see Section 1.3.6) or voluntarily deciding to cease childbearing (see Section 1.3.4.4). A factor contribution to low fertility in the 40-44 age group is the comparatively high level of contraceptive use in this group (see Section 6.5.2.1.2) (also see Section 6.3.2 for a discussion of the reasons for differing levels of childbearing with age).

2) Differences in current fertility by a woman's highest level of education are also highly significant ($\chi_3^2 = 18.4$, $p < 0.001$). Moreover, there is an "inverse" relationship between a woman's highest level of education and her current fertility, with women with secondary or higher levels of education having considerably (roughly 30%) lower fertility than women with no education[1] and women with primary level education having slightly lower fertility than women with no education[1] (this effect is not significant at the 5% level). Contributory factors to the lower fertility of women with secondary level or above education are the lower proportion of these women who are married[1] (see Section 6.5.2.2.1) and the higher proportion of these women who use contraception (see Section 6.5.2.2.2).

3) Of the religious categories, women with traditional or "other" beliefs have higher levels of current fertility than women from other religious categories[1] and Christian women have the lowest fertility levels[1]. The "effects" of religion, as measured by these five categories, on current fertility levels are not (collectively) significant at the 5% level ($\kappa_4^2 = 4.2$, $p = 0.38$). However, simplifying the representation of religion to Christian and Non-Christian produces a significant contrast. A contributory factor to the lower fertility of Christian women is the lower proportion of these women who are married[1] (see Section 6.5.2.2.1). It is interesting to note that a woman having traditional/other beliefs is associated with her having high fertility[1] and with her having a high probability of currently using contraception[1] (see Section 6.5.2.1.2). This would reflect the inefficient methods which are used by this group.

4) The effects of ethnic group on current fertility are non-significant ($\kappa_4^2 = 3.5$, $p = 0.48$)[1]. Among the ethnicity categories the Mole-Dagbani has the lowest fertility and the "other" ethnic category has the highest fertility.

5) Women who live in an urban area have significantly lower fertility than women who live in a rural area ($\chi_1^2 = 10.3$, $p = 0.001$)[1]. A contributory factor to the lower fertility in urban areas is the higher level of contraceptive use in these areas.

6) The coefficient of the variable for the proportion of women in a cluster with secondary or above level education shows that current fertility declines significantly ($\chi_1^2 = 15.3$, $p < 0.001$) as the proportion of women with secondary level education or above increases[1]. The coefficient for the proportion of women in a

cluster with primary level education only shows that fertility declines where the proportion of women with primary level education only increases[1], but this relationship is not significant ($\chi_1^2 = 1.5$, $p = 0.22$). One factor which could contribute to this lack of significance is measurement error in this variable which results from the estimation of the proportion of women with primary level education from a sample of women in a cluster (n.b. this also is true for the proportion of women with secondary plus education). This sampling/measurement error can produce a biased estimate of the relationships between the variables for the contextual level of education and current fertility and it is to be expected that the true underlying relationships have greater significance (Holt (1991)). A contributory factor to the lower fertility with an increase in the proportion of women with secondary level or above education[1] is the lower proportion of women who are married in communities with a higher proportion of of women with secondary level or above education[1] (see Section 6.5.2.1.1).

7) The random effect for community is of no great significance[2]. The change in deviance for the model with extra-Poisson variation if the random effect is constained to zero is 3.1. For a change in deviance of this amount the issue of which distribution the change in deviance should be compared against will affect whether or not the null hypothesis that this effect is zero is accepted at the 5% level. In the Poisson model this parameter is estimated as zero.

Table 6.5.10: Full Multilevel Log-Linear Models of Children Born in the Last Five Years (With and Without Poisson Constraint)

Fixed Parameter	$\hat{\beta}$ Poi	$\hat{\beta}$ Ex-Poi	S.E.($\hat{\beta}$) Poi	S.E.($\hat{\beta}$) Ex-Poi	exp($\hat{\beta}$) Poi	exp($\hat{\beta}$) Ex-Poi
Level 1						
15-19	-1.31**	-1.32**	0.10	0.09	0.27	0.27
20-24	1.53**	1.53**	0.08	0.07	4.62	4.62
25-29	1.82**	1.82**	0.08	0.07	6.17	6.17
30-34	1.78**	1.78**	0.09	0.07	5.93	5.93
35-39	1.65**	1.65**	0.09	0.08	5.21	5.21
40-44	1.24**	1.24**	0.10	0.10	3.46	3.46
45-49	0.60	0.60	0.11	0.10	1.82	1.82
No Education	0.00	0.00	n.a.	n.a.	1.00	1.00
Primary	-0.02**	-0.02**	0.04	0.03	0.98	0.98
Secondary	-0.34	-0.34	0.09	0.07	0.71	0.71
Higher	-0.32	-0.32	0.21	0.18	0.73	0.73
Catholic	0.00	0.00	n.a.	n.a.	1.00	1.00
Other Christian	-0.02	-0.02	0.05	0.04	0.98	0.98
Muslim	0.06	0.07	0.07	0.06	1.06	1.07
Traditional/Oth.	0.10	0.11	0.07	0.06	1.11	1.12
No Religion	0.03	0.04	0.06	0.05	1.03	1.04
Akan/Guan	0.00	0.00	n.a.	n.a.	1.00	1.00
Ga-Adangbe	-0.01	-0.01	0.06	0.05	0.99	0.99
Ewe	-0.04	-0.04	0.05	0.04	0.96	0.96
Mole-Dagbani	-0.10	-0.09	0.07	0.06	0.90	0.91
Other	0.02	0.02	0.07	0.06	1.02	1.02
Level 2						
Rural	0.00**	0.00**	n.a.	n.a.	1.00	1.00
Urban	-0.13	-0.14	0.04	0.04	0.88	0.87
Prop. Primary	-0.13**	-0.12**	0.10	0.10	0.88	0.89
Prop Second/High	-0.81	-0.81	0.21	0.20	0.44	0.44

Random Parameter	$\hat{\sigma}^2$ Poi	$\hat{\sigma}^2$ Ex-Poi	$\hat{\sigma}$ Poi	$\hat{\sigma}$ Ex-Poi	S.E.($\hat{\sigma}^2$) Poi	S.E.($\hat{\sigma}^2$) Ex-Poi
Level 2						
Constant	0.00	0.006+	0.00	0.08	n.a	0.004
Level 1						
Constant	1.00	0.731	1.00	0.85	n.a.	0.016

Model Statistics	Poi	Ex-Poi
Deviance	7697.6	7694.5

Key
n.a. Not Applicable
* $0.01 < p \le 0.05$
** $p \le 0.01$.
+ $2.71 \le$ Change in Deviance < 3.84
++ $3.84 \le$ Change in Deviance

Table 6.5.11: Simplified Multilevel Log-Linear Model of Children Born in the Last Five Years (No Poisson Constraint)

Fixed Parameter	$\hat{\beta}$	S.E.($\hat{\beta}$)	exp($\hat{\beta}$)
Level 1			
15-19	-1.43	0.07	0.29
20-24	1.53**	0.07	4.62
25-34	1.81**	0.07	6.11
35-39	1.66**	0.07	5.26
40-44	1.25**	0.08	3.49
45-49	0.61**	0.09	1.84
No Education/Primary	0.00	n.a.	1.00
Secondary/Higher	-0.31**	0.07	0.73
Christian	0.00	n.a.	1.00
Non-Christian	0.09**	0.03	1.09
Level 2			
Rural	0.00	n.a.	1.00
Urban	-0.15**	0.03	0.87
Prop Second/Higher	-0.83**	0.18	0.42

Random Parameter	$\hat{\sigma}^2$	$\hat{\sigma}$	S.E.($\hat{\sigma}^2$)
Level 2			
Constant	0.00	0.00	n.a.
Level 1			
Constant	0.74	0.86	0.02
Model Statistics			
Deviance	7704.7		

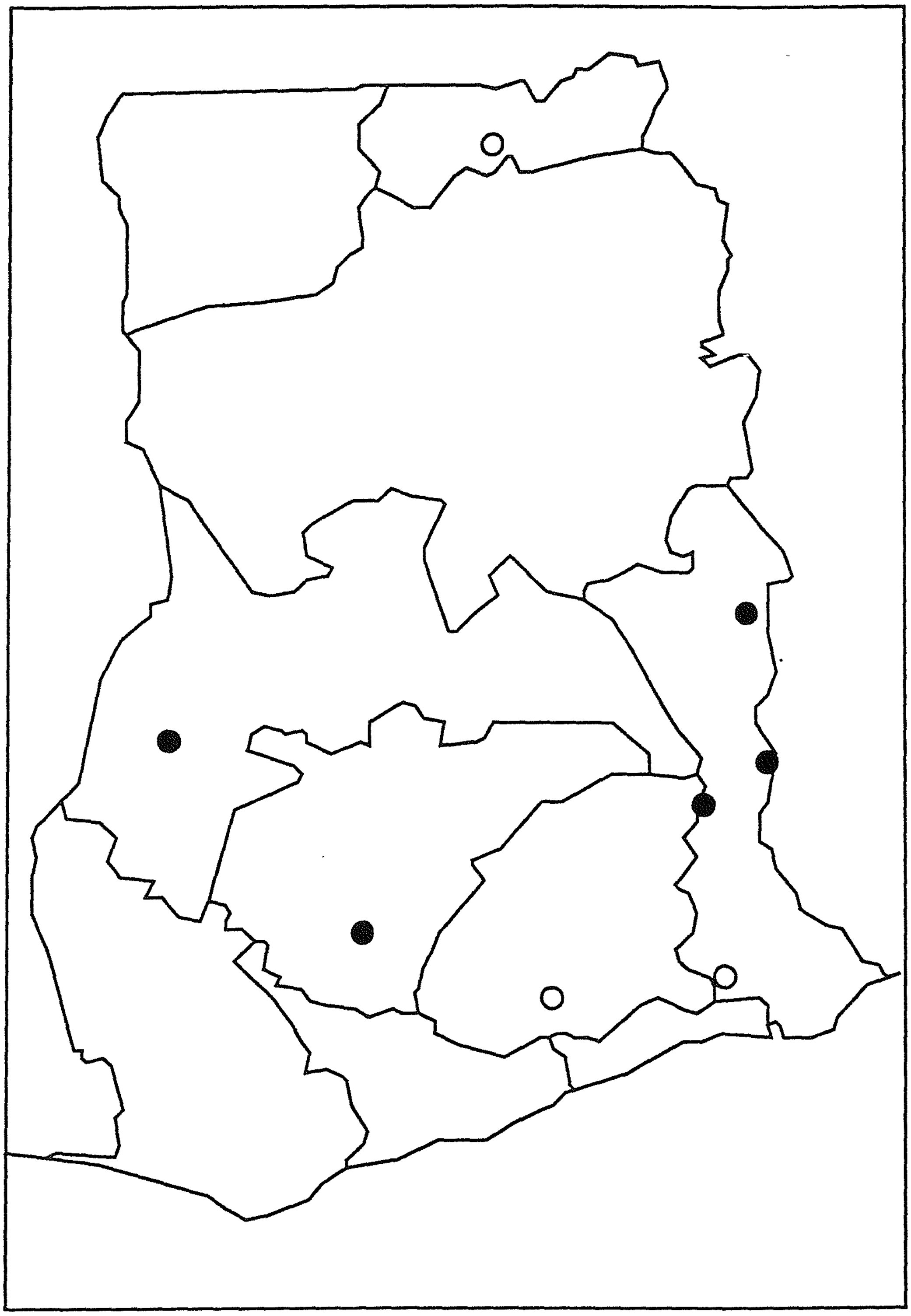
Community Effects

The residual community effects for the model with all explanatory variables fitted and extra-Poisson variation allowed for are measured on the log scale. The histogram in Figure 6.5.4 (see Appendix 6I) has a slight positive skew and is noticeably light-tailed. However, the assumption of normality for the distribution of community effects does not seem unreasonable. There are no outliers to the distribution of community effects. The implication of normality is that, over the population of all communities, roughly 68% of community effects will lie in the range (-0.08, 0.08) and roughly 95% will lie in the range (-0.16, 0.16) or, equivalently, for a given value of the fixed effects, in roughly 68% of community the number of children born to a woman during the last five years will be between 0.92 and 1.08 times that value, and in roughly 95% of communities the number of children born in the last five years will be between 0.85 and 1.17 times that value.

The locations of the few communities with a value of the random effect above 0.08 or below -0.08 (i.e. ± one standard deviation) are shown in Map 6.5.2.4. The five communities with the highest value of the random effect and the five communities with the lowest value of the random effect are shown in Table 6.5.12. The values of the random effect for all the communities in the sample are shown in Appendix 6E.

Map 6.5.4

Cluster-level Residuals to Model 6.5.10



Key

○ l.t. -0.08

● g.t. 0.08

Table 6.5.12: Highest/Lowest Values of the Random Effect for Community for "Full" Model (No Poisson Constraint) of Children Born in the Last Five Years

Rank	Cluster No.	Town	Region	Cluster Effect
1	87	Apapam	Eastern	-0.09
2	136	Kulbia	Upper East	-0.09
3	19	Adidome	Volta	-0.08
4	134	Wiaga	Upper East	-0.07
5	52	Tema	Gr. Accra	-0.07
146	82	Kutre	Brong Ahafo	0.09
147	125	Duflumka	Volta	0.10
148	89	Kpando	Volta	0.10
149	75	Nsuamen	Ashanti	0.10
150	71	Dzoko	Volta	0.15

5.5.2.2.2 Children Ever Born

The number of children ever born to a woman is analysed. Listwise deletion is used for missing data and so 4482 women from 150 clusters are included for analysis.

Extra-Poisson variation was tested for. The unconstrained level 1 variance term (0.86, standard error 0.02) was significantly different from 1. Hence, the assumption that the level 1 variance is Poisson is rejected. The level 1 variance term indicates underdispersion in the data. The likely major explanation for this is birth spacing. "Stopping" behaviour would also lead to underdispersion although the comparatively small proportion of women who don't want any more children would seem to indicate that the influence of stopping is not a major consideration.

Table 6.5.13 presents two sets of parameter estimates for the full set of explanatory variables described in Section 6.5.1.2, the first set is that estimated when it is assumed that the level 1 variance is Poisson and the second set is that estimated when extra-Poisson variation is estimated. The two sets of parameters are virtually identical but the standard errors of the parameters are slightly smaller when extra-Poisson variation is allowed. Table 6.5.14 presents the parameter estimates for a more parsimonious model obtained by removing the non-significant parameter contrasts from the model which allows for extra-Poisson variation.

The parameter estimates show:

1) the most significant differentials are between age groups with exponentiated parameter estimates showing, not surprisingly, that the number of children ever born to a woman increases significantly between successive age groups. This would reflect the greater exposure over time to the risk of giving birth of older women.

2) There are also highly significant effects for a woman's highest level of education, with women with primary level education only having significantly lower fertility than women with no education and women with at least secondary level education having significantly lower fertility than both these groups. Contributory factors to the lower fertility of more educated women are the lower proportion of these women who are married (see Section 6.5.2.1.1) and the higher proportion of these women who have used contraception (see Section 6.5.2.1.2).

3) Muslims have a higher number of children ever born than women in other religious categories[1], differences between the other categories of religion are insignificant[1]. A contributory factor

to the higher number of children ever born to muslim women is the high proportion of these women who are married[1].

4) The Akan and Ga-Adangbe have the lowest number of children ever born[1] and the Mole-Dagbani have the highest[1]. Collapsing the ethnicity categories into Akan/Ga-Adangbe, Ewe/Other and Mole-Dagbani produces a three category representation of ethnicity for which all the possible contrasts are significant[1]. The low number of children ever born among the Ga-Adangbe[1] would at least partly reflect the high level of ever use of contraception in this group[1] (see Section 6.5.2.2.2).

5) The urban-rural contrast is significant with rural areas having the higher fertility[1]. Contributory factors to this are the higher proportion of rural women being married[1] (see Section 6.5.2.2.1 and the lower proportion of women who have used contraception in rural areas[1] (see Section 6.5.2.2.2).

6) There is a significant decrease in the number of children ever born with higher proportion of women in a community with secondary level education or above[1].

7) The random effect for community is significant[2,3]. The change in deviance when this term is constrained to be zero is 5.9.

Table 6.5.13: Full Multilevel Log-Linear Models

(With and Without Poisson Constraint) of Children Ever Born

Fixed Parameter	$\hat{\beta}$ Poi	$\hat{\beta}$ Ex-Poi	S.E.($\hat{\beta}$) Poi	S.E.($\hat{\beta}$) Ex-Poi	exp($\hat{\beta}$) Poi	exp($\hat{\beta}$) Ex-Poi
Level 1						
15-19	-1.46**	-1.47**	0.09	0.08	0.23	0.23
20-24	1.75**	1.75**	0.08	0.07	5.75	5.75
25-29	2.49**	2.49**	0.08	0.07	12.06	12.06
30-34	2.93**	2.93**	0.08	0.07	18.73	18.73
35-39	3.20**	3.20**	0.08	0.07	24.53	24.53
40-44	3.37**	3.37**	0.08	0.07	29.08	29.08
45-49	3.44	3.44	0.08	0.07	31.19	31.19
No Education	0.00**	0.00**	n.a.	n.a.	1.00	1.00
Primary	-0.06**	-0.06**	0.02	0.02	0.94	0.94
Secondary	-0.51**	-0.51**	0.06	0.05	0.60	0.60
Higher	-0.47	-0.47	0.11	0.10	0.63	0.63
Catholic	0.00	0.00	n.a.	n.a.	1.00	1.00
Other Christ.	-0.03*	-0.02**	0.02	0.02	0.97	0.98
Muslim	0.09	0.09	0.04	0.03	1.09	1.09
Traditl./Other	0.03	0.03	0.04	0.03	1.03	1.03
No Religion	-0.02	-0.02	0.03	0.03	0.98	0.98
Akan/Guan	0.00	0.00	n.a.	n.a.	1.00	1.00
Ga-Adangbe	-0.03*	-0.03*	0.03	0.03	0.97	0.97
Ewe	-0.07**	-0.07**	0.03	0.03	0.93	0.93
Mole-Dagbani	-0.14	-0.14	0.04	0.04	0.87	0.87
Other	-0.06	-0.06	0.04	0.04	0.94	0.94
Level 2						
Urban	0.00**	0.00**	n.a.	n.a.	1.00	1.00
Rural	0.11	0.11	0.02	0.02	1.12	1.12
Prop. Primary	0.02**	0.03**	0.06	0.06	1.02	1.03
Prop Sec./High	-0.50	-0.50	0.12	0.12	0.61	0.61

Random Parameter	$\hat{\sigma}^2$ Poi	$\hat{\sigma}^2$ Ex-Poi	$\hat{\sigma}$ Poi	$\hat{\sigma}$ Ex-Poi	S.E.($\hat{\sigma}^2$) Poi	S.E.($\hat{\sigma}^2$) Ex-Poi
Level 2						
Constant	0.001++	0.003++	0.04	0.05	0.02	0.001
Level 1						
Constant	1.00	0.86	1.00	0.93	n.a.	0.018

Model Statistics

	Poi	Ex-Poi
Deviance	13451.5	13456.1

Key

n.a. Not Applicable
* 0.01 < p ≤ 0.05
** p ≤ 0.01.
+ 2.71 ≤ Change in Deviance < 3.84
++ 3.84 ≤ Change in Deviance

Table 6.5.14: Simplified Multilevel Log-Linear Model (No Poisson Constraint) of Children Ever Born

Fixed Parameter	$\hat{\beta}$	S.E. ($\hat{\beta}$)	exp ($\hat{\beta}$)
Level 1			
15-19	-1.48**	0.07	0.23
20-24	1.75**	0.07	5.75
25-29	2.49**	0.07	12.06
30-34	2.94**	0.07	18.73
35-39	3.20**	0.07	24.29
40-44	3.38**	0.07	29.08
45-49	3.45**	0.07	31.50
No Education	0.00	n.a.	1.00
Primary	-0.06**	0.02	0.95
Secondary/Higher	-0.51**	0.05	0.60
Christ./Tr/Oth/None	0.00	n.a.	1.00
Muslim	0.10**	0.03	1.09
Akan/Guan/Ga-Adan.	0.00	n.a.	1.00
Dagbani	-0.13**	0.03	0.88
Ewe/Other	-0.05*	0.02	0.93
Level 2			
Urban	0.00	n.a.	1.00
Rural	0.11**	0.02	1.12
Prop Second/Higher	-0.51**	0.11	0.61

Random Parameter	$\hat{\sigma}^2$	$\hat{\sigma}$	S.E. ($\hat{\sigma}^2$)
Level 2			
Constant	0.003++	0.05	0.001
Level 1			
Constant	0.86	0.93	0.019

Model Statistics	
Deviance	13440.4

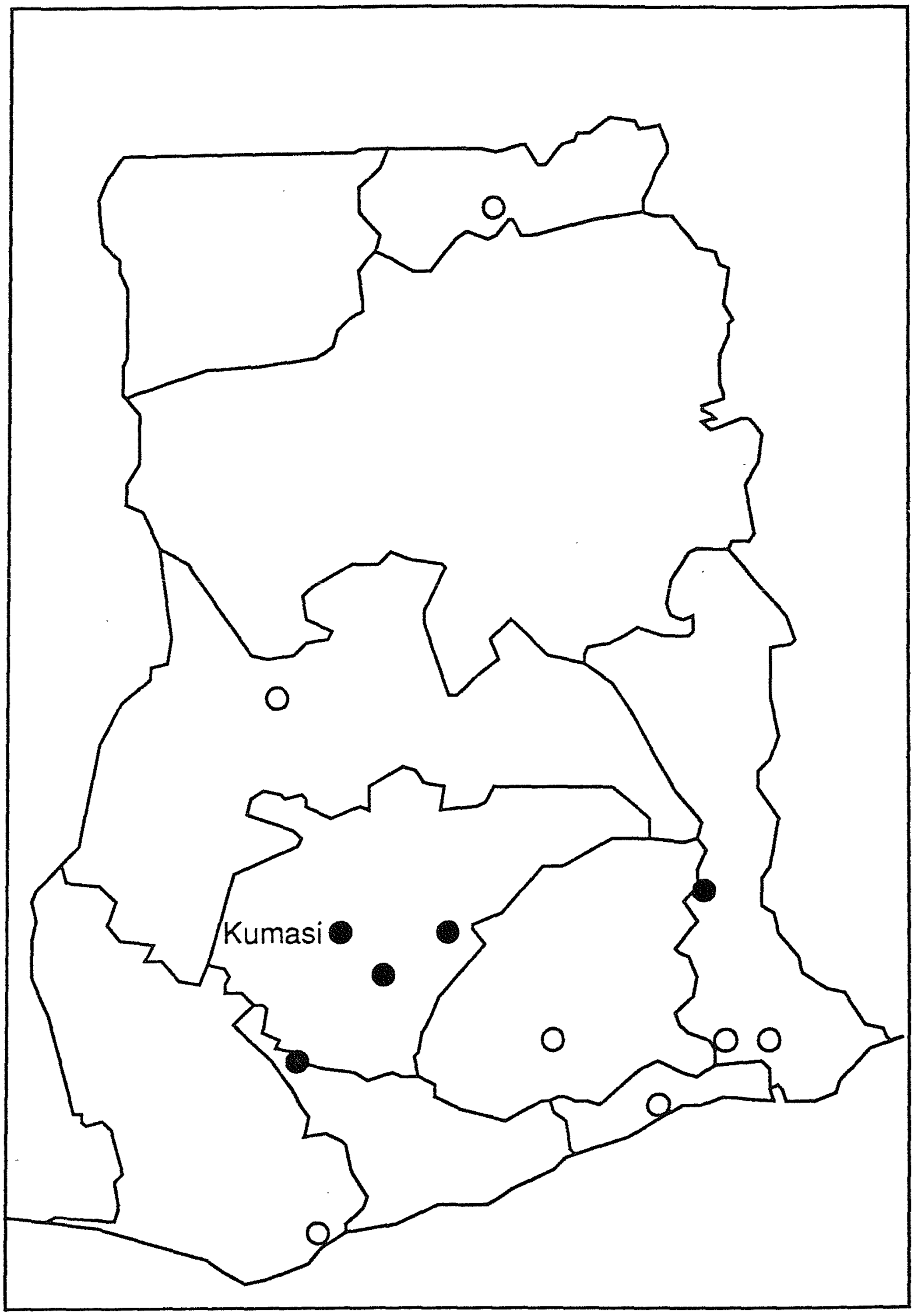
Community_Effects

The histogram in Figure 6.5.5 (see Appendix 6I) shows that the distribution of the community effects to the model with all explanatory variables fitted and extra-Poisson variation is noticeably light-tailed, but assuming normality would still seem reasonable. Hence, over the population of all communities, roughly 68% of community effects will lie in the range (-0.05, 0.05) and roughly 95% will lie in the range (-0.10, 0.10) or, equivalently, for a given value of the fixed effects, in roughly 68% of communities the expected number of children ever born to a woman will be between 0.95 and 1.05 times that value, and in roughly 95% of communities the expected number of children ever born will be between 0.85 and 1.11 times that value. There are no outliers to the distribution of community effects.

The communities with a value for the random effect above 0.05 (i.e. +1 standard deviation), indicating a higher than predicted number of children are concentrated to the south of Kumasi, whilst those with a value for the random effect below -0.05, indicating a lower than predicted number of children ever born, are concentrated to the north and the east of Accra (see Map 6.5.5). The five communities with the highest values of the random effect and the five communities with the lowest values of the random effect are shown in Table 6.5.15:

Map 6.5.5

Cluster-level Residuals to Model 6.5.13



Key

○ l.t -0.05

● g.t. 0.05

Table 6.5.15: Highest/Lowest Values of the Random Effect for the "Full" Model of Children Ever Born (No Poisson Constraint)

Rank	Cluster No.	Town	Region	Cluster Effect
1	52	Tema	Gr. Accra	-0.08
2	14	Inchaban	Western	-0.07
3	10	Verkope	Volta	-0.07
4	87	Apapam	Eastern	-0.06
5	126	Boase	Brong Ahafo	-0.06
146	89	Kpando	Volta	0.05
147	92	Bompata	Ashanti	0.06
148	85	Temale	Northern	0.06
149	107	Kumasi	Ashanti	0.06
150	75	Nsuamen	Ashanti	0.06

6.6 Discussion

The following variables have been analysed: "currently married", "currently using contraception", "ever used contraception", "children born 0-4 years before survey" and "children ever born". In Section 6.4 it is shown that for each of these variables the variation between communities is significant. Moreover, in the analyses in Section 6.5, significant community-level effects are found for each of these variables even after controlling for woman's age, education, religion and ethnicity.

It should also be noted that in each analysis if a random effect for community was not fitted then, as well as the loss of the information on the community effects, the estimates of the fixed parameters and of their standard errors of the model would be affected. For example, in the case of the analysis of "currently married", a comparison of the parameter estimates of the multilevel logistic analyses (see Table 6.5.1) with shows those of the single-level analogue of the model (see Appendix 6F) shows:

1) in the analysis with a random effect for community the fixed parameter estimates (other than the intercept) are generally closer to zero (i.e. they are attenuated - see Neuhaus *et al.* (1991)).

2) the standard errors of fixed effects in the multilevel analysis tend to be larger than in those for the single-level analysis. Moreover, the difference in the standard errors between the two models is more pronounced for variables with a high intra-cluster correlation, most noteably variables measures at the community-level (c.f. results derived for the linear case in Holt and Scott (1981)).

Similar findings would be expected if the random effect for community were omitted from the other logistic-type analyses.

Likewise, if random effect for community was not fitted for the log-linear model with extra-Poisson variation of the number of children born 0-4 years before survey then, as well as the loss of the information on the community effects, the estimates of the fixed parameters and of their standard errors of the model would be affected. Appendix 6G shows the parameter estimates of the single-level analogue of the model. Comparison of Table 6.5.10 with Appendix 6G shows:

1) in the multilevel model some of the fixed parameter estimates are closer to zero (i.e. they are attenuated), although generally the differences are very slight.

2) the standard errors of fixed effects in the multilevel model

tend to be larger than in the single-level model. However, these differences are generally very slight. The likely reason for this is the small intra-community correlation (c.f. results derived by Holt and Scott (1981) for the linear case). Moreover, the difference in the standard errors between the multilevel and single-level models is more pronounced for variables with a high intra-cluster correlation, most noteably variables measures at the community-level (c.f. Holt and Scott (1981)).

Similar findings would be expected for if the random effect for community were omitted from the analysis of children ever born.

Issues regarding the linking of the community effects for the various responses have been discussed in Section 5.6.

Appendix 6A

Estimates of Bongaarts' Intermediate Fertility Variable Indices

In this section I present estimates, based on the GDHS data, of the indices suggested by Bongaarts for quantifying the fertility-inhibiting effects of the intermediate fertility variables (see Section 1.2 for details of Bongaarts' model).

The estimates of the indices suggest that in Ghana post-natal non-susceptibility has a larger fertility-inhibiting impact than either non-marriage or contraceptive use. The index for contraceptive use indicates that the fertility-inhibiting impact of contraception is slight. This reflects the low level of contraceptive use and that a high proportion of the methods used are inefficient methods. Many of the assumptions underlying the estimation of all three indices are questionable (see Appendix 5.3.B), however, the high total fertility rates for the various categories of formerly married women suggest that the index for the fertility inhibiting effect of non-marriage is particularly inappropriate. The index for the fertility inhibiting effect of abortion has not been estimated because no data on this subject were collected by the GDHS (n.b. abortion is illegal in Ghana - see Section 6.2.2.3). The estimates of the indices are presented in Table 6.A.1:

Table 6.A.1: Estimates of Bongaarts' Intermediate Fertility Variable Indices for Ghana

Index	Estimate
Proportion Married (C_m)	0.75 (a)
Contraception (C_c)	0.90 (b)
Post-natal Non-susceptibility (C_i)	0.58 (c)
$C_m \times C_c \times C_i$	0.39

(a) The age-specific proportions of women currently married, m(a), and the assumed age-specific marital fertility rates, g(a), (i.e. those estimated by Eaton and Mayer (1954) for the Hutterites - c.f. Caldwell and Caldwell (1977) cited in Bongaarts (1981, p118)) are presented in Table 6.A.2:

Table 6.A.2: Age-specific Proportions Married and Assumed Age-Specific Marital Fertility Rates Used to Calculate Bongaarts' Index for Marriage

Age	m(a)	g(a)
15-19	0.21	0.30
20-24	0.68	0.55
25-29	0.87	0.50
30-34	0.88	0.45
35-39	0.89	0.41
40-44	0.85	0.22
45-49	0.78	0.06

(b) The index of contraception is based on an the proportion of all women surveyed who are currently using a method of contraception (u = 0.123 - see Table 6.3.2.2.1) and an estimated average use-effectiveness of 0.76, which, in turn, is based on the proportions of all current users using each method (see Table 6.3.2.2.2) and assumed use-effectiveness for each method are as in Table 6.A.3:

Table 6.A.3: Assumed Use-Effectiveness for Each Method of Contraception Used to Calculate Bongaarts' Index for Contraception

Method	Assumed Use-Effectiveness
Sterilization	1.00
IUD	0.95
Injections	0.95
Pill	0.85
Condom	0.80
Diaphragm/foam/jelly	0.80
Periodic Abstinence	0.70
Withdrawal	0.70
Other	0.70

(c) The index of post-natal non-susceptibility is based on an estimated median duration of non-susceptibility of 17 months (see Section 5.3.2.3).

It is interesting to note that the indices estimated for the GDHS data are almost identical to those estimated by Gaisie (1981) using data from the GFS pilot study (Gaisie's estimates were $C_m = 0.75$, $C_c = 0.90$, $C_i = 0.60$).

Appendix 6B (Locations of Clusters)

Cluster No.	No. of Women Sampled	Region	Town/Area
1	26	Western	Jewi Wharf
2	34	Western	Bonzokrom
3	31	Central	Mpehin
4	23	Central	Ndasiman
5	43	Central	Nyamedome
6	47	Central	Nantsifa
7	37	Gr. Accra	Mahnia
8	31	Gr. Accra	Bonikope
9	42	Eastern	Topo
10	44	Volta	Verkope
11	53	Volta	Keta
12	40	Volta	Tordzinhu
13	25	Western	Elubo
14	28	Western	Inchaban
15	29	Central	Besease
16	29	Central	Sunkwa
17	30	Central	Aboso
18	34	Eastern	Mamfe
19	36	Volta	Adidome
20	16	Western	Kwesimintsin
21	22	Western	Sekondi-Takoradi
22	18	Western	Sekondi-Takoradi
23	16	Western	Shama
24	16	Central	Cape Coast
25	19	Central	Moree
26	22	Central	Odoben
27	24	Central	Apam
28	33	Central	Senya Breku
29	15	Central	Agona Swedru
30	21	Gr. Accra	Accra
31	17	Gr. Accra	Accra
32	20	Gr. Accra	Accra
33	23	Gr. Accra	Accra
34	22	Gr. Accra	Accra
35	24	Gr. Accra	Accra
36	18	Gr. Accra	Accra
37	23	Gr. Accra	Accra
38	23	Gr. Accra	Accra
39	15	Gr. Accra	Accra
40	22	Gr. Accra	Accra
41	27	Gr. Accra	Accra
42	18	Gr. Accra	Accra
43	20	Gr. Accra	Teshi
44	19	Gr. Accra	Teshi
45	33	Gr. Accra	Labadi
46	20	Gr. Accra	Accra
47	20	Gr. Accra	Accra
48	17	Gr. Accra	Accra
49	20	Gr. Accra	Accra
50	20	Gr. Accra	Accra
51	24	Gr. Accra	Tema

52	28	Gr. Accra	Tema
53	18	Gr. Accra	Tema
54	18	Gr. Accra	Ashiaman
55	13	Eastern	Aburi
56	18	Eastern	Koforidua
57	19	Eastern	Koforidua
58	26	Volta	Afiodenyigba
59	31	Volta	Dzodze
60	42	Western	Mantriam
61	31	Western	Techimantia
62	30	Western	Ahibenso
63	33	Western	Funkyekrom
64	34	Central	Wawasi
65	35	Central	Agona Tema
66	46	Eastern	Asuboa
67	46	Eastern	Sunsumawa
68	54	Eastern	Shai Mameng
69	49	Eastern	Antiwikrom
70	33	Volta	Gbledi
71	29	Volta	Dzoko
72	46	Ashanti	Konkromase
73	42	Ashanti	Kumasi
74	44	Ashanti	Kontomire
75	42	Ashanti	Nsuamen No. 1
76	32	Ashanti	Nkoranza
77	25	Ashanti	Old Ayasi
78	51	Ashanti	Wioso
79	26	Ashanti	Kwakoben
80	34	Ashanti	Pobirso
81	30	Brong Ahafo	Yankye
82	34	Brong Ahafo	Kutre No. 1
83	38	Brong Ahafo	Asunsu No. 1
84	43	Western	Bolizan
85	34	Central	Nkontunse
86	40	Eastern	Akokoaso
87	59	Eastern	Apapam
88	37	Eastern	Kwahu Praso
89	35	Volta	Kpandu
90	56	Ashanti	Achiasi
91	31	Ashanti	Manso Abore
92	27	Ashanti	Bompata
93	47	Ashanti	Bodomas
94	28	Ashanti	Ahenkro
95	42	Brong Ahafo	Susuanso
96	39	Brong Ahafo	Tanoso
97	15	Western	Tarkwa
98	13	Western	Bibiani
99	16	Eastern	Oda
100	22	Eastern	Akwatia
101	27	Eastern	Asamankese
102	23	Eastern	Anyiman
103	24	Eastern	Mpraeso
104	25	Volta	Kpando
105	27	Ashanti	Kumasi
106	28	Ashanti	Kumasi
107	30	Ashanti	Kumasi
108	19	Ashanti	Kumasi

109	20	Ashanti	Kumasi
110	33	Ashanti	Kumasi
111	16	Ashanti	Kumasi
112	24	Ashanti	Kumasi
113	15	Ashanti	Obuasi
114	22	Ashanti	Odumasi
115	24	Ashanti	Effiduasi
116	34	Ashanti	Abofour
117	24	Brong Ahafo	Kenyasi
118	15	Brong Ahafo	Sunyani
119	24	Brong Ahafo	Nsuatre
120	16	Brong Ahafo	Domaa Ahenkro
121	43	Eastern	Wurapong
122	38	Eastern	Senchi
123	41	Volta	Vudese
124	22	Volta	Suhum
125	35	Volta	Duflumkpa
126	67	Brong-Ahafo	Boasi
127	50	Brong-Ahafo	Dotobaa
128	48	Brong-Ahafo	Tato-Batoor
129	39	Northern	Kitare
130	34	Northern	Tangmaya
131	29	Northern	Zosali
132	63	Northern	Tunni
133	66	Upper West	Jamayiri
134	30	Upper East	Wiagwa
135	34	Upper East	Navrongo
136	41	Upper East	Kulbia
137	24	Upper East	Dua
138	32	Upper East	Nafkoliga
139	37	Western	Amankwakrom
140	25	Volta	Damanko
141	33	Brong Ahafo	Awisa
142	48	Northern	Adibo
143	16	Eastern	Kpong
144	25	Volta	Ho
145	22	Brong Ahafo	Wenchi
146	18	Brong Ahafo	Yeji
147	17	Northern	Yendi
148	7	Northern	Temale
149	17	Northern	Kumbungu
150	27	Upper East	Bolgatungu

Source: 1988 Ghana Demographic and Health Survey Enumerators File. Unpublished documents.

Appendix 6C ("Raw" Community Means)

Cluster No.	Proportion "Married"	Proportion Contraceptive Use Current	Proportion Contraceptive Use Ever	Mean Children Born in Last 5 Years	Mean Children Born Ever
1	0.73	0.04	0.39	0.88	3.23
2	0.79	0.09	0.44	1.12	3.79
3	0.74	0.10	0.19	1.00	3.97
4	0.78	0.04	0.17	0.87	3.70
5	0.63	0.02	0.12	0.91	2.98
6	0.77	0.19	0.40	1.09	3.78
7	0.68	0.16	0.49	1.00	3.97
8	0.87	0.07	0.39	1.12	3.48
9	0.67	0.00	0.10	1.02	3.10
10	0.64	0.07	0.30	1.02	3.07
11	0.60	0.06	0.34	0.87	2.19
12	0.83	0.10	0.40	1.30	3.68
13	0.72	0.16	0.20	0.88	1.92
14	0.75	0.07	0.36	0.89	2.71
15	0.59	0.14	0.17	0.83	3.28
16	0.66	0.07	0.35	1.00	4.28
17	0.67	0.13	0.30	0.83	3.60
18	0.62	0.32	0.56	0.97	2.44
19	0.58	0.11	0.42	0.50	2.11
20	0.81	0.13	0.44	0.81	3.56
21	0.59	0.27	0.46	0.73	2.41
22	0.61	0.11	0.11	0.67	3.00
23	0.63	0.06	0.38	0.94	3.19
24	0.63	0.13	0.25	1.13	3.50
25	0.74	0.05	0.16	1.16	3.05
26	0.73	0.14	0.23	1.09	3.73
27	0.38	0.08	0.33	0.63	2.04
28	0.70	0.09	0.36	0.97	2.82
29	0.80	0.07	0.47	1.13	2.87
30	0.71	0.19	0.43	0.95	3.00
31	0.71	0.29	0.77	1.18	2.53
32	0.50	0.40	0.50	0.40	2.35
33	0.57	0.39	0.61	0.70	3.09
34	0.59	0.36	0.77	0.68	2.27
35	0.63	0.25	0.50	0.67	2.17
36	0.56	0.44	0.61	0.61	1.78
37	0.48	0.13	0.48	0.65	1.78
38	0.56	0.39	0.57	0.43	2.26
39	0.47	0.20	0.87	0.53	2.00
40	0.64	0.18	0.36	0.82	2.36
41	0.44	0.11	0.44	0.33	1.26
42	0.39	0.17	0.44	0.44	1.17
43	0.65	0.35	0.40	0.65	1.90
44	0.68	0.26	0.53	0.74	2.32
45	0.33	0.18	0.52	0.33	2.09
46	0.55	0.20	0.35	0.60	2.05
47	0.40	0.20	0.60	0.80	2.45

48	0.59	0.18	0.47	0.53	2.35
49	0.84	0.15	0.20	0.70	2.90
50	0.75	0.20	0.50	0.65	3.75
51	0.63	0.17	0.46	0.71	3.38
52	0.57	0.14	0.46	0.36	1.50
53	0.83	0.17	0.33	0.78	3.17
54	0.72	0.22	0.28	0.72	2.94
55	0.62	0.23	0.31	1.00	2.77
56	0.56	0.22	0.50	0.44	2.78
57	0.63	0.16	0.37	0.47	1.74
58	0.77	0.08	0.27	0.77	3.23
59	0.74	0.07	0.32	0.90	2.90
60	0.67	0.12	0.21	1.05	2.69
61	0.68	0.16	0.32	0.84	2.74
62	0.77	0.00	0.10	1.13	3.57
63	0.88	0.00	0.18	1.18	3.64
64	0.79	0.06	0.29	1.21	3.91
65	0.91	0.14	0.23	1.14	4.17
66	0.76	0.04	0.26	0.96	3.09
67	0.63	0.13	0.30	0.80	3.83
68	0.67	0.11	0.28	1.02	3.07
69	0.61	0.25	0.49	0.90	3.92
70	0.73	0.12	0.58	1.03	2.18
71	0.76	0.03	0.31	1.62	3.34
72	0.78	0.07	0.26	0.89	3.09
73	0.64	0.24	0.43	0.69	2.29
74	0.82	0.09	0.21	1.09	3.80
75	0.86	0.02	0.17	1.36	4.69
76	0.88	0.06	0.13	1.22	2.91
77	0.68	0.04	0.28	0.84	3.64
78	0.53	0.10	0.28	0.92	2.92
79	0.77	0.00	0.15	1.08	3.46
80	0.79	0.09	0.29	1.18	4.00
81	0.93	0.00	0.10	0.97	3.03
82	0.79	0.18	0.35	1.32	4.35
83	0.90	0.11	0.42	1.11	3.37
84	0.70	0.09	0.28	0.91	3.91
85	0.77	0.03	0.12	1.32	4.09
86	0.63	0.08	0.35	0.90	3.33
87	0.63	0.15	0.39	0.61	2.69
88	0.57	0.08	0.51	0.97	3.65
89	0.60	0.23	0.63	1.06	3.46
90	0.59	0.11	0.32	0.80	3.41
91	0.64	0.07	0.23	0.84	3.94
92	0.56	0.07	0.37	0.96	3.63
93	0.60	0.06	0.26	0.87	3.47
94	0.82	0.14	0.50	0.89	4.07
95	0.86	0.26	0.48	1.14	2.93
96	0.62	0.15	0.44	0.87	2.64
97	0.53	0.07	0.20	0.53	3.13
98	0.62	0.08	0.23	0.69	3.23
99	0.63	0.19	0.31	0.63	3.13
100	0.77	0.18	0.27	0.82	3.82
101	0.59	0.19	0.48	0.93	3.04
102	0.70	0.13	0.57	1.09	2.57
103	0.79	0.13	0.63	0.67	3.08
104	0.68	0.32	0.48	0.80	2.36

105	0.67	0.15	0.37	0.85	3.30
106	0.63	0.21	0.54	0.39	1.89
107	0.60	0.10	0.50	0.53	3.30
108	0.63	0.05	0.21	0.53	2.58
109	0.69	0.10	0.25	0.45	3.05
110	0.36	0.06	0.15	0.48	1.30
111	0.69	0.06	0.06	0.88	2.69
112	0.67	0.04	0.46	0.67	1.75
113	0.67	0.00	0.20	0.87	2.13
114	0.55	0.09	0.41	0.50	2.55
115	0.71	0.13	0.38	0.88	2.79
116	0.65	0.12	0.29	1.06	3.00
117	0.79	0.13	0.33	1.21	4.17
118	0.67	0.20	0.53	0.60	2.87
119	0.79	0.17	0.58	1.00	3.33
120	0.75	0.06	0.31	1.00	3.38
121	0.65	0.00	0.33	0.93	2.95
122	0.47	0.03	0.47	0.66	2.68
123	0.81	0.20	0.44	0.98	3.58
124	0.86	0.18	0.50	1.32	4.05
125	0.83	0.11	0.26	1.34	3.83
126	0.94	0.02	0.02	1.19	3.16
127	0.70	0.08	0.34	1.06	3.00
128	0.79	0.06	0.29	1.23	3.50
129	0.77	0.13	0.36	0.97	4.10
130	0.88	0.09	0.24	1.29	4.59
131	0.93	0.00	0.03	1.21	4.24
132	0.98	0.16	0.24	1.44	4.29
133	0.94	0.03	0.03	1.18	3.53
134	0.90	0.07	0.27	0.83	3.40
135	0.53	0.12	0.27	0.76	2.50
136	0.90	0.07	0.27	0.83	3.20
137	0.79	0.00	0.25	1.00	3.50
138	0.88	0.19	0.31	1.09	3.69
139	0.62	0.05	0.30	0.86	3.78
140	0.84	0.04	0.16	1.24	3.36
141	0.76	0.15	0.46	1.06	4.06
142	0.94	0.15	0.29	1.08	4.42
143	0.56	0.06	0.25	0.75	2.69
144	0.52	0.32	0.56	0.40	2.60
145	0.82	0.18	0.50	0.91	3.68
146	0.72	0.33	0.39	0.83	2.89
147	0.77	0.18	0.35	1.29	3.59
148	0.57	0.57	0.57	0.86	4.14
149	0.88	0.12	0.29	1.35	3.59
150	0.52	0.07	0.44	0.63	2.33

Appendix 6D ("Shrunken" Community Means)

Cluster No.	Proportion			Mean Children Born	
	"Married"	Contraceptive Use		in Last	Ever
		Current	Ever	5 Years	
1	0.72	0.08	0.37	0.89	3.17
2	0.76	0.11	0.41	1.04	3.47
3	0.73	0.11	0.24	0.96	3.53
4	0.74	0.09	0.24	0.88	3.36
5	0.65	0.06	0.17	0.91	3.05
6	0.74	0.17	0.32	1.05	3.51
7	0.68	0.15	0.45	0.97	3.57
8	0.81	0.09	0.38	1.04	3.30
9	0.68	0.05	0.16	0.98	3.11
10	0.65	0.09	0.31	0.98	3.10
11	0.63	0.08	0.35	0.87	2.55
12	0.78	0.11	0.39	1.17	3.43
13	0.71	0.14	0.25	0.89	2.61
14	0.73	0.10	0.36	0.90	2.94
15	0.63	0.13	0.23	0.86	3.20
16	0.67	0.10	0.35	0.96	3.66
17	0.68	0.13	0.31	0.86	3.35
18	0.65	0.24	0.50	0.95	2.78
19	0.62	0.12	0.40	0.64	2.60
20	0.75	0.13	0.40	0.87	3.27
21	0.64	0.20	0.41	0.81	2.85
22	0.64	0.13	0.22	0.91	3.09
23	0.66	0.10	0.36	0.93	3.15
24	0.66	0.13	0.30	1.00	3.25
25	0.72	0.10	0.24	1.03	3.10
26	0.71	0.13	0.28	1.00	3.37
27	0.51	0.11	0.32	0.75	2.68
28	0.70	0.11	0.36	0.94	2.98
29	0.74	0.11	0.41	1.00	3.05
30	0.71	0.16	0.40	0.93	3.08
31	0.70	0.19	0.54	1.03	2.93
32	0.59	0.25	0.53	0.65	2.84
33	0.62	0.25	0.54	0.82	3.11
34	0.64	0.24	0.60	0.79	2.79
35	0.66	0.19	0.44	0.77	2.73
36	0.63	0.26	0.50	0.77	2.66
37	0.57	0.13	0.43	0.77	2.58
38	0.62	0.25	0.48	0.65	2.78
39	0.59	0.15	0.52	0.74	2.78
40	0.66	0.15	0.36	0.86	2.74
41	0.55	0.12	0.41	0.58	2.30
42	0.54	0.14	0.40	0.68	2.45
43	0.67	0.23	0.38	0.78	2.67
44	0.69	0.19	0.45	0.85	2.73
45	0.46	0.16	0.46	0.55	2.62
46	0.64	0.16	0.36	0.77	2.73
47	0.54	0.16	0.40	0.85	2.88

48	0.64	0.15	0.42	0.73	2.87
49	0.77	0.14	0.27	0.80	3.05
50	0.72	0.16	0.44	0.78	3.90
51	0.66	0.15	0.43	0.80	3.03
52	0.62	0.14	0.43	0.56	2.39
53	0.76	0.14	0.34	0.87	3.15
54	0.71	0.17	0.31	0.82	3.06
55	0.66	0.16	0.33	0.94	3.03
56	0.63	0.17	0.43	0.69	3.01
57	0.66	0.14	0.36	0.69	2.63
58	0.74	0.10	0.30	0.83	3.09
59	0.73	0.09	0.33	0.90	3.02
60	0.68	0.12	0.25	1.00	2.89
61	0.68	0.15	0.33	0.86	2.95
62	0.74	0.06	0.18	1.04	3.34
63	0.81	0.06	0.23	1.08	3.48
64	0.76	0.08	0.31	1.09	3.52
65	0.84	0.14	0.27	1.06	3.66
66	0.74	0.07	0.28	0.94	3.10
67	0.65	0.13	0.31	0.83	3.73
68	0.67	0.12	0.29	0.99	3.10
69	0.63	0.20	0.46	0.90	3.60
70	0.72	0.12	0.51	0.98	2.66
71	0.73	0.08	0.32	1.33	3.22
72	0.76	0.09	0.28	0.89	3.11
73	0.66	0.20	0.41	0.76	2.66
74	0.78	0.11	0.24	1.05	3.51
75	0.81	0.06	0.21	1.21	4.00
76	0.81	0.09	0.19	1.10	3.02
77	0.69	0.08	0.31	0.87	3.35
78	0.57	0.11	0.29	0.92	3.01
79	0.74	0.06	0.22	1.00	3.28
80	0.76	0.11	0.31	1.08	3.57
81	0.84	0.06	0.18	0.94	3.09
82	0.76	0.15	0.35	1.17	3.75
83	0.83	0.10	0.40	1.04	3.26
84	0.70	0.11	0.30	0.91	3.57
85	0.74	0.07	0.19	1.17	3.61
86	0.65	0.10	0.35	0.90	3.23
87	0.64	0.14	0.38	0.78	2.85
88	0.61	0.10	0.47	0.95	3.40
89	0.63	0.19	0.55	1.00	3.30
90	0.62	0.12	0.33	0.84	3.31
91	0.66	0.09	0.27	0.86	3.52
92	0.61	0.10	0.36	0.94	3.35
93	0.62	0.09	0.28	0.88	3.33
94	0.77	0.14	0.45	0.90	3.56
95	0.81	0.19	0.44	1.07	3.02
96	0.64	0.14	0.41	0.88	2.87
97	0.62	0.11	0.27	0.74	3.13
98	0.66	0.11	0.29	0.72	3.16
99	0.66	0.15	0.33	0.78	3.13
100	0.74	0.15	0.30	0.86	3.40
101	0.63	0.16	0.44	0.92	3.09
102	0.70	0.13	0.48	1.00	2.90
103	0.75	0.13	0.52	0.77	3.11
104	0.69	0.22	0.43	0.85	2.81

105	0.68	0.14	0.36	0.87	3.23
106	0.64	0.17	0.47	0.61	2.57
107	0.68	0.11	0.45	0.68	3.21
108	0.66	0.10	0.27	0.72	2.93
109	0.65	0.12	0.29	0.68	3.10
110	0.48	0.09	0.21	0.64	2.23
111	0.69	0.10	0.20	0.89	2.99
112	0.68	0.09	0.42	0.77	2.56
113	0.70	0.08	0.42	0.91	2.82
114	0.61	0.11	0.39	0.69	2.90
115	0.70	0.13	0.37	0.88	2.99
116	0.66	0.12	0.31	1.00	3.07
117	0.75	0.13	0.34	1.07	3.56
118	0.68	0.15	0.44	0.77	3.05
119	0.75	0.15	0.50	0.96	3.21
120	0.72	0.10	0.43	0.95	3.21
121	0.66	0.05	0.33	0.92	3.03
122	0.55	0.07	0.44	0.74	2.89
123	0.77	0.17	0.42	0.95	3.38
124	0.79	0.15	0.44	1.12	3.49
125	0.78	0.12	0.28	1.18	3.49
126	0.89	0.05	0.07	1.13	3.15
127	0.70	0.10	0.34	1.02	3.05
128	0.77	0.08	0.30	1.13	3.35
129	0.75	0.13	0.36	0.95	3.65
130	0.82	0.11	0.27	1.15	3.87
131	0.84	0.06	0.14	1.08	3.65
132	0.92	0.11	0.26	1.31	3.88
133	0.89	0.06	0.09	1.12	3.40
134	0.82	0.09	0.29	0.86	3.26
135	0.59	0.12	0.29	0.81	2.81
136	0.84	0.09	0.29	0.85	3.10
137	0.75	0.06	0.29	0.95	3.29
138	0.81	0.16	0.33	1.02	3.40
139	0.65	0.08	0.31	0.88	3.47
140	0.78	0.08	0.23	1.09	3.23
141	0.74	0.14	0.42	1.00	3.59
142	0.87	0.14	0.31	1.03	3.89
143	0.63	0.10	0.30	0.83	2.99
144	0.59	0.22	0.48	0.60	2.90
145	0.76	0.15	0.44	0.91	3.35
146	0.71	0.21	0.37	0.87	3.05
147	0.73	0.15	0.35	1.08	3.29
148	0.66	0.22	0.42	0.89	3.31
149	0.79	0.12	0.32	1.11	3.29
150	0.59	0.10	0.41	0.75	2.76

Appendix 6E (Community-level Residuals)

Cluster No.	Proportion			Mean Children Born	
	"Married"	Contraceptive Use		in Last	Ever
		Current	Ever	5 Years	
1	0.04	-0.18	0.18	-0.02	-0.01
2	0.06	0.11	0.81	0.01	0.04
3	-0.10	0.03	-0.19	-0.03	0.01
4	-0.03	-0.16	-0.30	-0.04	-0.04
5	-0.07	-0.32	-0.50	0.00	-0.02
6	0.09	0.51	0.31	0.04	0.03
7	-0.02	0.22	0.34	0.02	0.04
8	0.38	-0.16	0.01	0.04	0.01
9	0.05	-0.43	-0.57	0.05	0.02
10	-0.47	-0.17	-0.18	-0.03	-0.07
11	-0.11	-0.37	-0.28	0.02	-0.01
12	0.03	-0.02	0.15	0.05	0.03
13	0.15	0.26	-0.06	0.01	-0.02
14	-0.02	-0.08	0.18	-0.04	-0.07
15	-0.41	0.20	-0.17	-0.06	-0.04
16	-0.21	-0.16	0.01	0.01	0.02
17	-0.09	0.18	0.09	-0.02	-0.02
18	-0.03	0.72	0.34	0.04	-0.04
19	-0.03	-0.03	0.04	-0.08	-0.05
20	0.12	-0.05	0.09	0.01	-0.04
21	-0.06	0.22	-0.08	0.02	-0.01
22	-0.06	-0.05	-0.41	-0.00	0.00
23	0.04	-0.20	-0.01	0.04	0.03
24	-0.14	-0.16	-0.39	0.04	0.01
25	-0.06	-0.18	-0.25	0.02	-0.00
26	0.07	-0.03	-0.28	0.05	0.03
27	-0.22	-0.23	-0.10	0.02	-0.02
28	0.12	-0.19	-0.01	0.06	0.00
29	0.09	-0.25	0.07	0.04	0.01
30	0.10	0.11	0.13	0.04	0.03
31	0.05	0.05	0.12	0.07	0.01
32	-0.04	0.21	0.01	-0.01	0.02
33	-0.18	0.60	0.46	-0.03	0.02
34	0.06	0.28	0.41	0.01	0.02
35	0.19	0.20	0.16	0.02	0.01
36	-0.01	0.63	0.30	-0.03	-0.03
37	-0.07	-0.06	0.24	0.00	0.01
38	-0.01	0.44	0.10	-0.03	-0.01
39	-0.07	0.03	0.68	-0.02	-0.01
40	0.06	-0.06	-0.22	0.04	0.01
41	-0.04	0.11	-0.31	-0.04	-0.02
42	-0.06	-0.39	-0.17	-0.01	-0.02
43	0.10	-0.12	-0.19	-0.01	-0.03
44	0.02	0.35	0.15	-0.01	-0.02
45	-0.26	0.00	0.14	-0.06	-0.00
46	0.08	-0.07	-0.33	0.02	0.02
47	-0.35	0.09	0.41	-0.01	-0.00

48	-0.22	0.04	0.21	-0.06	-0.04
49	0.14	0.09	-0.17	-0.04	-0.02
50	0.04	0.01	0.07	-0.02	0.01
51	0.04	-0.01	0.14	0.01	0.03
52	-0.01	-0.23	-0.16	-0.07	-0.08
53	0.17	0.01	-0.19	-0.02	0.01
54	-0.07	0.21	-0.13	-0.02	-0.02
55	-0.02	0.15	-0.14	0.04	0.01
56	-0.01	0.13	0.18	-0.04	-0.00
57	0.19	-0.08	-0.18	-0.02	-0.02
58	0.02	-0.25	-0.32	-0.04	-0.02
59	0.21	-0.25	-0.04	0.05	0.03
60	-0.16	0.17	-0.17	-0.00	-0.00
61	-0.09	0.22	0.01	-0.06	-0.03
62	-0.07	-0.32	-0.40	-0.01	0.03
63	0.37	-0.35	-0.29	0.06	0.00
64	-0.01	-0.11	0.10	0.01	0.02
65	0.22	0.20	-0.22	0.00	0.01
66	0.21	-0.31	-0.27	-0.01	0.01
67	-0.11	0.11	-0.19	-0.03	-0.00
68	-0.13	-0.09	-0.52	-0.03	0.01
69	-0.33	0.78	0.58	-0.04	0.02
70	0.26	-0.06	0.32	0.06	0.02
71	0.07	-0.25	-0.10	0.15	0.04
72	0.31	-0.22	-0.31	-0.03	-0.03
73	0.02	0.29	-0.12	-0.03	-0.03
74	0.07	0.13	0.05	0.04	-0.04
75	0.30	-0.34	-0.41	0.10	0.06
76	0.38	-0.14	-0.50	0.04	0.01
77	0.00	-0.23	-0.11	-0.02	0.02
78	-0.38	0.00	-0.11	-0.01	-0.00
79	-0.05	-0.28	-0.17	-0.01	0.00
80	0.06	-0.07	-0.03	0.03	0.04
81	0.44	-0.31	-0.31	0.01	-0.03
82	0.15	0.27	0.03	0.09	0.03
83	0.25	0.02	0.31	-0.03	0.00
84	-0.14	-0.03	-0.11	-0.03	-0.00
85	0.02	-0.22	-0.38	0.06	0.06
86	0.16	-0.15	-0.05	-0.03	0.01
87	-0.04	0.33	0.23	-0.09	-0.06
88	-0.21	-0.04	0.58	0.03	0.02
89	-0.03	0.44	0.57	0.10	0.05
90	-0.26	0.02	0.02	-0.05	-0.02
91	-0.24	-0.11	-0.13	0.05	0.02
92	-0.08	-0.20	-0.17	0.06	0.06
93	-0.08	-0.19	-0.20	-0.02	0.04
94	0.15	0.06	0.28	-0.00	0.01
95	0.27	0.53	0.11	0.01	-0.03
96	-0.08	0.29	0.42	-0.03	-0.00
97	-0.02	-0.21	-0.37	-0.01	0.01
98	-0.10	-0.12	-0.15	-0.03	0.01
99	0.01	0.11	-0.01	-0.01	0.02
100	0.04	0.04	-0.32	-0.02	0.01
101	-0.17	0.06	0.09	0.03	0.03
102	0.10	-0.13	0.17	0.06	0.01
103	0.29	-0.13	0.37	0.00	-0.01
104	-0.05	0.39	0.08	-0.01	-0.02

105	0.00	-0.06	-0.10	0.02	0.01
106	0.07	-0.08	0.03	-0.04	0.00
107	0.19	-0.30	0.13	-0.01	0.06
108	-0.19	-0.23	-0.22	-0.07	-0.04
109	-0.03	0.09	-0.10	-0.04	0.03
110	-0.07	-0.34	-0.62	-0.00	-0.03
111	-0.02	-0.11	-0.33	-0.02	0.01
112	0.26	-0.33	0.17	0.02	-0.04
113	0.06	-0.28	-0.23	-0.00	0.00
114	-0.16	-0.19	0.04	-0.05	-0.02
115	0.09	-0.13	-0.18	0.00	0.00
116	-0.04	-0.08	-0.11	0.07	-0.00
117	0.06	-0.16	-0.30	0.04	0.04
118	0.02	-0.01	0.03	-0.03	-0.01
119	0.16	0.08	0.48	0.01	0.01
120	-0.00	-0.18	-0.08	-0.00	0.01
121	-0.17	-0.50	-0.13	-0.04	0.01
122	-0.34	-0.37	0.37	-0.05	-0.01
123	0.01	0.39	0.25	-0.05	-0.01
124	0.23	0.22	0.27	0.07	0.00
125	0.19	0.09	0.00	0.10	0.02
126	0.19	-0.33	-0.67	-0.01	-0.06
127	-0.02	-0.16	-0.02	0.02	0.00
128	-0.20	-0.14	0.03	-0.01	0.00
129	-0.11	0.20	0.55	-0.04	0.01
130	-0.01	0.03	0.27	0.01	-0.01
131	-0.04	-0.23	-0.39	-0.01	-0.02
132	0.22	0.63	0.29	0.06	0.03
133	0.30	-0.27	-0.53	-0.05	-0.02
134	-0.00	-0.10	-0.07	-0.07	-0.04
135	-0.15	-0.01	-0.03	0.01	0.02
136	-0.02	0.07	0.35	-0.09	-0.05
137	-0.08	-0.26	0.07	0.01	-0.01
138	-0.02	0.51	0.37	-0.02	0.00
139	-0.20	-0.22	-0.15	-0.02	0.02
140	0.08	-0.16	-0.18	0.02	-0.01
141	-0.02	0.19	0.36	-0.01	0.00
142	0.07	0.51	0.46	-0.05	0.02
143	-0.19	-0.15	-0.09	-0.01	0.00
144	0.13	0.30	0.07	-0.06	-0.03
145	0.07	0.04	0.20	-0.00	-0.02
146	0.12	0.44	0.04	0.01	0.01
147	-0.17	0.21	0.24	0.04	0.01
148	-0.05	0.55	0.30	0.02	0.01
149	0.04	0.11	0.26	0.06	0.01
150	-0.17	-0.17	0.38	-0.00	-0.01

Appendix 6F Single-Level Logistic Model of Currently Married

Fixed Parameter	$\hat{\beta}$	S.E. $(\hat{\beta})$	exp $(\hat{\beta})$
Level 1			
Constant	-0.65**	0.24	0.52
20-24	2.19**	0.12	8.94
25-29	3.32**	0.14	27.66
30-34	3.43**	0.16	30.88
35-39	3.49**	0.17	32.79
40-44	3.09**	0.18	21.98
45-49	2.49**	0.16	12.06
Primary	-0.10	0.11	0.90
Secondary	-0.68**	0.18	0.51
Higher	-1.23**	0.36	0.29
Other Christian	-0.17	0.11	0.84
Muslim	0.18	0.20	1.20
Traditional/Other	0.49*	0.22	1.63
No Religion	0.20	0.17	1.22
Ga-Adangbe	-0.07	0.15	0.93
Ewe	-0.08	0.12	0.92
Mole-Dagbani	0.29	0.20	1.34
Other	0.07	0.20	1.07
Level 2			
Rural	0.16	0.10	1.17
Prop. Primary	-1.05**	0.28	0.35
Prop Second/High	-1.45**	0.46	0.23

Random Parameter	$\hat{\sigma}^2$	$\hat{\sigma}$	S.E. $(\hat{\sigma})$
Level 2			
Constant	0.00	0.00	n.a.
Level 1			
Constant	1.00	1.00	n.a.

Model Statistics

Deviance 3930.3

Key

n.a. Not Applicable

* $0.01 < p \le 0.05$

** $p \le 0.01$.

Appendix 6G Single-level Log-Linear Model of Children Born in the Last Five Years (Without Poisson Constraint)

Fixed Parameter	$\hat{\beta}$	S.E.($\hat{\beta}$)	exp($\hat{\beta}$)
Level 1			
Constant	-1.31**	0.09	0.27
20-24	1.53**	0.07	4.62
25-29	1.82**	0.07	6.17
30-34	1.78**	0.07	5.93
35-39	1.65**	0.07	5.21
40-44	1.24**	0.08	3.46
45-49	0.60**	0.10	1.82
Primary	-0.02	0.03	0.99
Secondary	-0.34**	0.07	0.71
Higher	-0.33	0.18	0.72
Other Christian	-0.02	0.04	0.98
Muslim	0.06	0.06	1.06
Traditional/Other	0.10	0.06	1.11
No Religion	0.03	0.05	1.03
Ga-Adangbe	-0.01	0.05	0.99
Ewe	-0.04	0.04	0.96
Mole-Dagbani	0.10	0.06	1.11
Other	0.02	0.06	1.02
Level 2			
Urban	-0.13**	0.04	0.88
Prop. Primary	-0.13	0.09	0.88
Prop Second/High	-0.81**	0.18	0.44

Random Parameter	$\hat{\sigma}^2$	$\hat{\sigma}$	S.E.($\hat{\sigma}$)
Level 2			
Constant	0.00	0.00	n.a.
Level 1			
Constant	0.74	0.86	0.02

Model Statistics

Deviance	7697.6

Key
n.a. Not Applicable
* $0.01 < p \leq 0.05$
** $p \leq 0.01$.

[1]After controlling for the values of the other fixed explanatory variables and the value of the random effect for community.

[2]Conditional on the fixed explanatory variables in the model.

[3]There is some debate about how one should test the significance of the random effect (see Section 2.3.2.1.3). If the change in deviance were compared to the (half-normal(0,1))^2 the 5% critical value is 2.71, if it is compared to a 50:50 mixture of χ_0^2 and χ_1^2 the 5% critical value is 2.79 and if it is compared to χ_1^2 the 5% critical value is 3.84. The change in deviance indicates that the random effect is significant at the 5% level whichever of these tests is employed.

Appendix 6.H

Figure 6.4.1 Histogram of Shrunken Means for Currently Married

Limit	N	
0.450	[illegible]	[illegible]
0.480	[illegible]	[illegible]
0.51[illegible]	[illegible]	[illegible]
0.540	[illegible]	[illegible]
0.570	[illegible]	[illegible]
0.600	[illegible]	[illegible]
[illegible]	22	[illegible]
[illegible]	[illegible]	[illegible]
0.690	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	[illegible]

Figure 6.4.2 Histogram of Shrunken Means for Currently Using Contraception

Lower Limit	N	
[illegible]	[illegible]	
[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]
[illegible]	[illegible]	
[illegible]	[illegible]	[illegible]
0.0900	12	[illegible]
0.1000	15	[illegible]
0.110	12	[illegible]
0.120	15	[illegible]
0.130	8	[illegible]
0.140	15	[illegible]
0.150	13	[illegible]
0.160	6	[illegible]
0.170	2	**
0.180	3	***
0.190	3	[illegible]
0.200	1	*
0.210	2	[illegible]
0.220	4	****
0.230	2	**
0.240	1	*
0.250	3	***
0.260	0	

Figure 6.4.3 Histogram of Shrunken Means for Ever Used Contraception

Lower limit		
0.0400	[illegible]	
0.0800	1	
0.120	1	*
0.160	7	
0.200	7	
0.240	15	
0.280	28	
0.320	22	
0.360	18	
0.400	21	
0.440	[illegible]	
0.480	[illegible]	
0.520	5	
0.560	[illegible]	
0.600	2	**
0.640	[illegible]	

Figure 6.4.4 Histogram of Shrunken Means for Children Born 0-4 Years Before Survey

[illegible]

Figure 6.4.5 Histogram of Shrunken Means for Children Ever Born

Lower limit		
2.200	1	
2.300	2	**
2.400	1	
2.500	4	
2.600	9	
2.700	1	
2.800	13	
2.900	11	
3.000	20	
3.100	17	
3.200	18	
3.300	16	
3.400	9	*********
3.500	12	
3.600	5	*****
3.700	1	*
3.800	3	***
3.900	1	*
4.000	0	

Appendix 6I

Figure 6.5.1 Histogram of Community-level Residuals for Currently Married

```
 -0.500     1 : *
 -0.450     1 : *
 -0.400     2 : **
 -0.350     2 : **
 -0.300     2 : **
 -0.250     5 : *****
 -0.200    13 : *************
 -0.150     8 : ********
-0.1000   [illegible]
-0.0500    27 : ***************************
..39e-017  [illegible]
 0.0500   [illegible]
 0.1000     7 : *******
  0.150   [illegible]
  0.200   [illegible]
  0.250     5 : *****
  0.300     2 : **
  0.350     3 : ***
  0.400     1 : *
  0.450     0 :
```

Lower
Limit

Figure 6.5.2 Histogram of Community-level Residuals for Currently Using Contraception

```
 -0.600     1 : *
 -0.500   [illegible]
 -0.400   [illegible]
 -0.300    20 : ********************
 -0.200    27 : ***************************
 -0.100    23 : ***********************
1.388e-016  19 : *******************
 0.1000    11 : ***********
  0.200    17 : *****************
  0.300     3 : ***
  0.400     5 : *****
  0.500   [illegible]
  0.600     3 : ***
  0.700     1 : *
  0.800     1 : *
  0.900     0 :
```

Figure 6.5.3 Histogram of Community-level Residuals For Ever Used Contraception

```
  -0.700   [illegible]
  -0.600   [illegible]
  -0.500   [illegible]
  -0.400   [illegible]
  -0.300   [illegible]
  -0.200   [illegible]
  -0.100    15 : ***************
-1.388e-016  21 : *********************
  0.1000    16 : ****************
   0.200    11 : ***********
   0.300    13 : *************
   0.400     6 : ******
   0.500     4 : ****
   0.600     0 :
   0.700     1 : *
   0.800     1 : *
   0.900     0 :
```

Figure 6.5.4 Histogram of Community-level Residuals for Children Born 0-4 Years Before Survey

Lower limit	N
[illegible]	[illegible]

Figure 6.5.5 Histogram of Community-level Residuals for Children Ever Born

Lower limit	N
-0.0800	1
-0.0700	2
-0.0600	2
-0.0500	2
-0.0400	10
-0.0300	[illegible]
-0.0200	20
-0.0100	17
6.939e-018	37
0.0100	25
0.0200	13
0.0300	6
0.0400	2
0.0500	3
0.0600	0

7 A COMPARISON OF FERTILITY IN LIBERIA AND GHANA

7.0 Introduction

Liberia and Ghana have geographical and economic similarities in that both countries are located on the coast of West Africa, experience broadly similar climates, are peopled largely by negro tribes, are predominantly Christian and are underdeveloped countries in which the majority of the population is engaged in subsistence agriculture. However, the two have sharply contrasting political histories, Ghana having been a British colony and Liberia an independent republic run for the most part by the descendants of freed slaves from the USA. In Chapter 5 I presented a description of fertility patterns in Liberia and in Chapter 6 I presented a description of fertility patterns in Ghana. In this chapter I briefly compare and contrast fertility patterns in these two West African countries using some of the main findings of the preceding two chapters.

7.1 Socioeconomic and Cultural Characteristics of Liberian and Ghanaian Women

The most striking difference between the women of Liberia and Ghana is the considerably larger proportion of Ghanaian women who have received some education (60.3% as opposed to 37.4%). This is reflected by the higher proportion of Ghanaian women who are literate or semi-literate (48.3% as opposed to 34%). However, although a larger proportion of the Ghanaian women have attended primary school, a larger proportion of the Liberian women have attended secondary school (19% as opposed to 7.5%).

In other important characteristics the two DHS samples are similar. For example, the proportion of women in each country who live in an urban area are similar. Both countries are predominantly Christian and have minorities who are Muslim, traditional or non-religious. It is to be noted that the larger proportion of the Ghanaian sample who were recorded as Christian at least in part reflects the way in which West African Christian or Christian-derived religions (e.g. the Faith Healing Temple of Jesus Christ) were coded in the two surveys.

The two countries are both peopled by negro tribes. However, none of the major ethnic groups is common to both countries.

7.2 Fertility Levels in Liberia and Ghana

Data from the recent Demographic and Health surveys show that the the overall fertility levels (as measured by Total Fertility Rates (TFRs)) for Liberia and Ghana are identical (6.3 in both cases). However, fertility patterns in these two countries differ in that childbearing generally occurs at younger ages in Liberia than in Ghana. The age specific fertility rate (ASFR) is higher in Liberia for the 15-19, 20-24 and 25-29 age groups but is higher in Ghana for the 30-34, 35-39 and 40-44 age groups (Fig. 7.1 shows ASFRs for the two countries).

Numbers of children ever born (CEB) to women aged 40-49 would seem to indicate that in the past levels of fertility were higher in Ghana than in Liberia. However, the TFR for the GFS carried out in 1979-80, (which is identical to that for the GDHS) is not consistent with the evidence of higher levels of past fertility which the numbers of children ever born to women aged 40-49 for the GDHS appear to provide.

7.3 The Proximate Determinants of Fertility in Liberia and Ghana

In both Liberia and Ghana the same broad picture of the determination of fertility emerges, with the high fertility level, in each country, reflecting generally early ages of entry into unions and low levels of contraceptive use and only restrained from being yet higher by the effects of long durations of postpartum amenorrhea and postpartum sexual abstinence. There are, however, some differences between the fertility régimes in the two countries.

7.3.1 Marriage

In both Liberia and Ghana marriage can take a diverse array of traditional forms as well as Christian and Islamic forms. The LDHS and GDHS samples show that when marital status is categorised as "never in union", "currently in union" (i.e. married or living with a man) and "formerly in union" the proportions of women in each category for the two surveys are virtually identical. However, whereas in Ghana virtually all the women who are "currently in a union" are recorded as "married", in Liberia the majority of women who are "currently in a union" are recorded as "living together" rather than as married. In my view it is likely that this difference is of superficial importance and could well merely reflect differing criteria used to translate the various diverse customs of marriage in each country into "married" and "living together" (van de Walle (1985) discusses this problem). It is, for example, possible that a Liberian woman for whom the brideprice has not been paid in entirty would report that she lives with a fiancée (i.e. "living together") whereas a Ghanaian women who has a child from a long-term sexual partner known to her parents with whom she does not live with and for whom no brideprice has been paid would report that she is married (c.f Bleek (1987)). In Ghana the fertility of women who are recorded as "married" is significantly higher than that for women who are recorded as "living together" whereas in Liberia the fertility levels of these two groups are virtually identical.

However, despite the overall proportions never in union, currently in union and formerly in union of the two countries being virtually identical the proportion never married is higher among teenage women but lower among women aged 20 and above in Ghana than in Liberia.

One of the most interesting differences between results of the two surveys is that the fertility levels of single women (i.e. those never having married or lived with a man) in Liberia are far higher than in Ghana. "Pre-marital" childbearing is negligible in Ghana (TFR for single women = 0.6) but is common in Liberia (TFR for single women = 3.5). The high level of childbearing among single women in Liberia, in my view, requires further investigation.

Polygyny is widespread in both countries with around a third of women in each sample who are currently in a union (38% in Liberia and 33% in Ghana) reporting having a co-"wife".

7.3.2 Contraception

In both countries a majority of the women know of contraception

(72% in Liberia, 76% in Ghana), but only a minority have ever used contraception (22% and 34% respectively) and only a small minority are currently using contraception (8% and 12% respectively). The main distinction between patterns of contraceptive use in Liberia and Ghana is the greater extent to which non-modern methods (i.e. periodic abstinence, withdrawal and folk methods) are employed in Ghana. If only modern methods of contraception are analysed the levels of knowledge, ever use and current use of contraception in the two countries are virtually identical.

7.3.3 Postpartum Non-Susceptibility

In both countries durations of postpartum non-susceptibility resulting from amenorrhea, abstinence or both tend to be long. However, durations of postpartum non-susceptibility tend to be substantially longer in Ghana than in Liberia. The longer durations of non-susceptibility in Ghana are largely due to longer durations of postpartum amenorrhea. This longer durations of amerorrhea in Ghana in turn reflect the longer durations of breastfeeding practised by Ghanaian mothers. Postpartum abstinence is more common in Liberia than in Ghana less than a year after a birth. However, the proportion of mothers abstaining more than a year after a birth is greater in Ghana than in Liberia.

7.4 Differentials in Fertility Levels By Background Characteristics

The most notable difference in variations in fertility levels

(i.e. TFR and standardized CEB) between socio-economic and cultural subgroups of the two populations is that whereas in Ghana "inverse" relationships between woman's highest level of education and levels of fertility are found, in Liberia "curvilinear" relationships are observed with women with primary level education only having higher fertility than uneducated women. These inverse and curvilinear relationships between woman's education and fertility in Ghana and Liberia respectively are reflected in inverse and curvilinear relationships between woman's literacy and fertility in Ghana and Liberia respectively.

A second distinction between the patterns of fertility variation is that although fertility in the only large urban area in Liberia, Monrovia, is lower than in rural areas the difference is slight when compared to the difference between the large urban areas in Ghana, Accra and Kumasi, and the rural areas. Moreover, fertility levels in rural areas of Liberia and in rural areas of Ghana are similar to each other. The wider rural- large urban contrast in Ghana reflects that fertility in Accra and Kumasi is considerably lower than in Monrovia.

In both countries differentials between religious groups are similar with Christian women having lower fertility than other religious groups and traditional women having higher fertility than other religious categories. Differentials by ethnic group in the two countries are not comparable and no tribe is numerous in both countries.

In both countries current fertility differs across "communities" (see Sections 5.4 and 6.4). However, this between-community variation in current fertility is greater in Ghana than in

Liberia, a fact that reflects the the markedly low fertility in parts of Accra and Kumasi noted above.

In view of its smaller area and population, it is perhaps surprising to find that the between-community variation in the number of children ever born in Liberia is greater than that for Ghana. This is because, although lowest within-community mean numbers of children ever born are lower in Ghana than in Liberia, the highest within-community mean numbers of children ever born in Liberia are far higher than those the highest within-community mean numbers of children ever born in Ghana.

7.5 Differentials in the Proximate Determinants by Background Characteristics

7.5.1 Marriage

In each country the proportion married declines with increasing levels of woman's education, is less in urban areas than in rural areas and is lower for Christian women than for non-Christian women. In Liberia the proportion of traditional/other women who are married is considerably lower than in Ghana, however, this may at least in part stem from the difference in the way West African forms of Christianity were coded in the two surveys (see Section 7.1). The only other contrast of note between the two countries is the lower proportion of women with primary level education only in Liberia who are married. This is noteworthy because of the high levels of fertility for this section of the Liberian population (see Section 7.3).

The variance in the proportion of women in a community who are currently married is virtually the same for each country.

7.5.2 Contraception

In both Liberia and Ghana both the proportion currently using contraception and the proportion who have ever used contraception increases as woman's highest level of education increases. The main differences are that levels of use of modern methods of contraception are higher among the educated élite (women with secondary or above education) in Liberia than in Ghana whilst women with primary level education or below in Ghana make far greater use of inefficient methods of contraception than their Liberian counterparts.

A study of community-level differentials in contraceptive use shows that in large parts of up-country rural Liberia the proportion of women who are currently using contraception is virtually zero. In Ghana, however, the proportion of communities where this is the case is considerably less. A factor associated with this is that, although in both countries levels of contraceptive use are higher in rural areas than in urban areas, the extent of the difference is far more pronounced in Liberia than in Ghana. The practise of inefficient methods of contraception is far more pronounced in rural areas of Ghana than in Liberia.

The use of modern methods of contraception is far more widespread among Catholics in Liberia than in Ghana. Levels of use of contraception are notably higher for traditional/other women in Ghana than in Liberia a phenomenon which is entirely due to differences in the use of inefficient methods (n.b. there are differences in the coding of this variable in the two surveys).

7.5.3 Postpartum Non-Susceptibility

Within each country durations of postpartum non-susceptibility differ markedly between regions and follow a north-south divide a finding which is largely due to differences in patterns of postpartum abstinence. However, near universal abstinence 18 months after a birth is found in a comparatively far smaller part of Liberia (i.e. Lofa county only) than is the case in Ghana. In both Liberia and Ghana postpartum non-susceptibility declines as woman's level of education increases and is shorter in urban areas than in rural areas.

7.6 A Comparison of the Models of Fertility for Liberia and Ghana

A comparison of Models 5.5.12 and 6.5.11 shows that in each country a woman's age, education and religion are significant predictors of her current fertility. In Liberia, however, the coefficient for the 15-19 age group is far higher than in Ghana. The effects of education in each country are broadly similar with women with secondary-level or above education having significantly lower fertility than that of women with no education or only primary level education. Likewise, in the two countries the effect of religion is similar with Christian women being predicted to have lower fertility than their non-Christian counterparts.

There are three major distinctions, however, between the models of current fertility for the two countries. Firstly, in Liberia ethnicity is a significant predictor of a woman's fertility. Secondly, and of greater interest, the urban-rural status of a community and the proportion of women in a community with secondary-level or above education are significant predictors of a woman's fertility in Ghana but not in Liberia. Partly because of this, in the model of fertility in Liberia there is clearly significant residual community-level variation whereas for that of Ghana the residual community-level variation is only marginally significant. The third difference between these models is that whereas for the Ghanaian model there is underdispersion for the Liberian model the weighted parameter estimates suggest overdispersion.

When the models for children ever born are compared (models 5.5.14 and 6.5.13), we see that in both countries a woman's age, education and ethnic group are significant predictors of her fertility, although the nature of the "effects" of education differ with an "inverse" pattern occurring for Ghana and a "curvilinear" pattern for Liberia. Whether or not a woman is Muslim is a significant predictor of children ever born in Ghana but not so in Liberia. Moreover, the urban-rural status of a community and the proportion of women in a community with at least secondary-level education are significant predictors of the number of children ever born to a woman in Ghana but not in Liberia. For each country the model has significant residual variation at the community level.

7.7 A_Comparison_of_the_Models_of_the_Proximate_Determinants_of Fertility_for_Liberia_and_Ghana

7.7.1 Marriage

The main distinction between the models of "currently married" in the two countries (Models 5.5.1 and 6.5.1) is that, whereas in Liberia the urban-rural variable is significant and the effects of the levels of education in a community not so, in Ghana the urban-rural variable is not important but the proportion of women in a community with primary-level or above education has a significant negative effect. A second difference is that the contrast between women with no education and women with primary-level education is significant in Liberia but not in Ghana.

7.7.2 Contraceptive Use

The striking feature of the models of "currently using contraception" (Models 5.5.4 and 6.5.4) is their similarity. The main differences are that the proportion of women in a community with primary-level education is a significant predictor of the probability that a woman uses contraception in Liberia but not in Ghana and that a woman having "traditional/other" beliefs in predicted to have a lower than average probability of having ever used contraception in Liberia, but a higher than average probability of having ever used contraception in Ghana. There is also considerably more unexplained variation at the community level in Liberia than in Ghana.

The models of "ever used contraception" (Models 5.5.7 and 6.5.7) also have striking similarities, with the main distinctions being for the "effects" for religion and for the levels of education in a community.

8 CONCLUSIONS

In this chapter I summarise the main findings of the thesis and provide suggestions for further research.

8.1 A Summary of the Main Conclusions

8.1.1 Substantive Findings

This thesis is primarily concerned with analysing the high levels of fertility found in Liberia and Ghana. The main findings of this thesis are those in Sections 5.4 and 5.5 for Liberia and Sections 6.4 and 6.5 for Ghana.

In each country there is significant variation in current fertility between communities (see Sections 5.4 and 6.4). Moreover, in each country significant community-level effects on current fertility are found even after controlling for woman's age, highest level of education, religion and ethnicity. In Ghana the urban-rural status of a community and the proportion of women in a community with secondary-level education or above "explain" virtually all the residual community-level variation, but in Liberia neither of these two community-level variables has a significant effect on current fertility.

In both Liberia and Ghana, woman's age, highest level of education and religion are significant predictors of her current fertility with a woman being teenage or aged over 40, having secondary level or above education and being Christian having lower fertility than women aged 20-40, having no education or primary-level education only or being Muslim, traditional/other or no religion respectively. In Liberia ethnicity is also a significant predictor of a woman's fertility with women from the southern Kwa/Kru speaking tribes tending to have lower fertility than their counterparts in other ethnic groups.

A particularly interesting finding is that underdispersion is found for the analysis of current fertility in Ghana (see Table 6.5.2.10). This finding is also found for the unweighted analysis of current fertility in Liberia (see Table 5.5.2.10). I suggest that the effects of birth-spacing practices could produce such underdispersion.

In each country there is significant between-community variation in the number of children ever born. Moreover, such variation persists after woman's age, highest level of education, religion and ethnicity are controlled for. In Ghana the urban-rural status of a community and the proportion of women in a community with secondary-level education are significant predictors of children ever born. In both Liberia and Ghana a woman's age, highest level of education and ethnicity are significant predictors of the number of children ever born she has had. However, whereas in Ghana there is an "inverse" relationship between individual-level female education and children ever born, in Liberia a "curvilinear" relationship is found. In Ghana the contrast between Muslim women and women with other religions is also significant with women who are Muslim being predicted to have higher fertility.

The proportion of women in a community who are married varies considerably with each survey containing some communities in which all or virtually all the women sampled are married and some communities in which only a minority of women are married. In both Liberia and Ghana, sizeable between-community variations in the proportion of women who are currently married are found even after controlling for woman's age, education, religion and ethnicity. In both Liberia and Ghana, woman's age, education and religion are significant predictors of whether she is currently married. In both countries more educated women are predicted to have a lower probability of being married.

The proportion of women currently using contraception varies across communities in each country. In a sizable number of communities in Liberia none of the women sampled is currently using contraception. In both Liberia and Ghana community effects on current use of contraception are still found after woman's age, education, religion and ethnicity are controlled for. In each country the urban-rural status of a community is a significant predictor of current use of contraception. In Liberia the proportion of women in a community with primary-level education only is also a significant predictor of current use of contraception, although it is unclear why this particular measure of community-level education is significant. In each country current contraceptive use increases significantly as woman's education increases. In both countries, Catholic women are predicted to have a high probability of currently using contraception.

Variation in the proportion of women who have ever used contraception is considerable in each country, but in Liberia the between-community variation is particularly pronounced with the proportion of ever-users in sampled communities ranging from 0 to 0.7. Sizeable between-community variation in ever use of contraception is still found after controls for woman's age, education, religion and ethnicity are introduced. In each country levels of ever-use of contraception are higher in urban communities than in rural communities. In Liberia the proportion of women in a community with primary-level education *only* is a significant predictor of ever-use of contraception and in Ghana the proportion of women with primary level education *and above* is a significant predictor of ever-use of contraception. In each country woman's age, education, religion and ethnicity are significant predictors of whether she has ever used contraception with the trend for more educated women to be more likely to have used contraception being common to both countries.

Several of the crosstabulations which appear in Sections 5.3 and 6.3 do not appear in the DHS First Country reports (Chieh-Johnson *et al.* (1987), Ghana Statistical Service (1989)). Of these findings, of particular interest are the high level of childbearing among never married women in Liberia (see Table 5.3.3.1.1), the low levels of current fertility in the major cities in Ghana, Accra and Kumasi (see Table 6.3.3.2.2) and the shorter durations of postpartum non-susceptibility found among ever users of contraception in both Liberia (see Table 5.3.2.3.2) and Ghana (see Table 6.3.2.3.2).

8.1.2 An Appraisal of the Methodology

This thesis serves to demonstrate that multilevel models are needed in the analysis of data on fertility, marriage and contraceptive use. The thesis has found significant community effects on fertility, marriage and contraceptive use even after woman's age, education, religion and ethnicity were controlled for. The possible ways of describing such effects are:

a) to ignore community effects and just fit a model with individual-level variables.

b) to fit fixed effects to community of residence as well as individual-level variables.

c) to fit a random effect for community of residence as well as individual-level variables.

d) to fit community-level variables in addition to individual-level variables.

e) to fit fixed effects for community of residence in addition to community-level variables and individual-level variables.

f) to fit a random effect for community of residence in addition to community-level variables and individual-level variables.

Method f) is the method of analysis used in this thesis. Of the other methods, a) is clearly unacceptable as it ignores structure (i.e. community effects) in the data. Methods b) and e) are to cumbersome in that models containing a fixed effect for each of the 150 or so communities in each survey would be indigestible. Using a random effect for community is more concise than fitting fixed effects for each community because the distribution of community effects is summarized by a single statistic, an estimate of its variance. Moreover, a random effect offers inference to a wider population than a set of fixed effects would.

If community-level variables could be found which completely explain between-community variation, as I argue in Chapter 3, then a model of the form d) would be acceptable and indeed would be superior to a model which fitted a random effect but ignored significant community-level variables. However, if, as is the case in the analyses presented in this thesis, a significant amount of between-community variation is unexplained random effects for community are needed to describe this information. In other words, method f), fitting a multilevel model is necessary. Moreover, given the poverty of community-level information in the various DHS surveys, rendering the use of random effects to be superfluous by finding community-level variables which can explain all the residual community-level variation would seem an unlikely prospect.

In Chapter 3 of this thesis I address the question of how model selection should be approached for multilevel models. I conclude that a "general to simple" approach should be adopted involving firstly removing superfluous random effects and then removing superfluous fixed effects from a model.

8.2 Suggestions for Further Research

8.2.1 Substantive Investigations

Subsequent to the 1986 LDHS Liberia became engulfed in a bitter civil war. It is therefore likely that at least some of the findings of the analyses presented here are no longer applicable. Hence, the greatest priority for further research should be to conduct a follow-up survey (when it is safe to do so). It would be fascinating to compare the analyses presented here to parallel analyses for a post-civil war survey and to investigate the effects of the civil war on fertility.

The multilevel analyses presented in this thesis could be extended by examining whether the coefficients of the individual-level explanatory variables vary across communities and by fitting interaction effects. Restrictions on the number of degrees of freedom used in models fitted using VARCL prohibited investigation of either of these. The development of facilities to allow ML3 to estimate non-linear models means that more general models could now be fitted to the data. A further feature of the data which it would be interesting to investigate is the extent to which residual community effects vary within regions. The method by which this could best be assessed is by fitting a random effect for region (i.e. region as the third level of the model).

One of the most interesting findings of the descriptive analyses conducted in Section 5.3 was the high level of fertility among single women in Liberia. In my view this warrants further investigation both by analysis of differentials in pre-marital fertility between subgroups of the population and by follow-up studies which would investigate the nature of the relationships in which single women with children engage.

A general area in which more work is required is the collection of community-level data. This thesis has found considerable between-community variation in fertility, contraceptive use and nuptiality in both Ghana and Liberia. It remains therefore to find variables which could explain this variation. Therefore, in future surveys information on the nature of the community should be collected. Examples of such information are; what the pattern of male employment is, whether the community is connected to the electricity supply, what the nature of the source of water is and questions on the whether the respondent believes that other people in the community approve of such things as contraception, sex during breastfeeding or the respondent not having another child.

8.2.2 Methodological_Approaches

There are two methodological approaches to the analysis of fertility data which particularly warrant further dissemination.

Firstly, multilevel analogues of survival analysis techniques warrant investigation. This is because the substantive literature points to community-level factors being important determinants of the preservation or otherwise of practises of breastfeeding and postpartum sexual abstinence in sub-Saharan Africa. Macros are currently being developed to enable ML3 to be used to estimate such models (Goldstein (1992) - personal communication).

Secondly, and in my view of even greater importance, is the application of models with multivariate response vectors to fertility data. This is because as well as analysing the variances of proximate determinants of fertility, covariance between measures of the various proximate determinants also is important, particularly if explanations of variation in fertility are to be constructed. For example, it would seem plausible that a woman who is married (i.e. has a positive residual to a model of currently married) is also more likely than not to use contraception and hence it is preferable to analyse one bivariate response consisting of (currently married, currently using contraception) than (the method used in this thesis) to conduct separate analyses of the two univariate responses (and ignoring the covariance between the two). Other examples of analyses where analysing a single multivariate response as opposed to analysing a number of univariate responses response could plausibly offer improvement would be in analyses of breastfeeding, amenorrhea and abstinence (the covariances between these responses are undoubtedly of interest e.g. if breastfeeding determines the practise of abstinence) and analyses of (first, second, third and so on) birth intervals (where one might expect a within-woman correlation of residuals to separate univariate responses). Moreover, analysis of all the (available) proximate determinants should involve modelling a multivariate response. The ML3 software is currently being adapted to enable analysis of multivariate response vectors where the element of the response may have any combination of continuous, binary or Poisson distributions (Goldstein (1992) - personal communication).

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