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Abstract

Notwithstanding the extensive social scientific research, there are still unanswered questions regarding the persistence of high fertility in sub-Saharan Africa. Although fertility behaviour depends on multiplicity of factors, childhood mortality is regarded as an important determinant.However, while the theoretical pathways through which infant and child mortality affect fertility are well understood, the empirical evidence has been inconsistent. Thus, the unsettled nature of the link between childhood mortality and fertility was a major motivation for this study. Methodologically, the paper examines the usefulness of frailty models in exploring the childhood mortality-fertility relationships using DHS data from Ghana and Kenya. Invariably, women with prior infant deaths were found to have more subsequent births than those without mortality experience, suggesting both a physiological and behavioral response. While corroborating this finding, the multivariate results demonstrated that models without unobserved heterogeneity tended to produce biased estimates. Comparing Ghana and Kenya, there were significant differences in the effects of childhood mortality on subsequent births. At all parities, the fertility response to mortality was found to be larger in Ghana, perhaps suggesting a negative relationship between fertility response and the stage of fertility transition.

Introduction

Many developing countries have undergone a remarkable demographic change since the 1950s, experiencing unprecedented declines in childhood mortality and, in most cases, a significant transition to controlled fertility. In sub-Saharan Africa, however, fertility remains high and there is much debate concerning the reasons for the resistance to fertility change. Although fertility behavior depends on a multiplicity of factors, childhood mortality is regarded as one of the most important (Preston, 1978; Montgomery and Cohen, 1998). The effect of declining childhood mortality on fertility thus occupy a central place in demographic research as outlined in the initial formulations of the demographic transition theory.

The relationship between fertility and childhood mortality is complex because of the problem of reverse causation. While child mortality affects fertility through biological and behavioral factors, fertility affects child mortality through inter-birth effects. As Juarez (1993) points out, however, while the latter is well understood, the effect of the former has been consistent. The recent reexamination of theory and empirical evidence on the impact of childhood mortality decline on reproductive change, under the auspices of the U.S. National Research Council's Committee on Population, draws together models and conceptual frameworks within which the relationship could be better examined (Montgomery and Cohen, 1998). As Palloni and Rafalimanana (1999) argue, however, notwithstanding this new body of research, the empirical relationship between childhood mortality and fertility remains unresolved. There is thus a continuing need to study the effects of childhood mortality on fertility.

Methodologically, this paper contributes to examining the usefulness of observational level frailty in exploring the childhood mortality and fertility relationship. Additionally, the argument has been made that the relationship between childhood mortality and fertility changes over the course of transition (see Preston, 1975; Llyod and Ivanov, 1988). Given the different demographic regimes for Ghana and Kenya, this study also explores the conditions under which there might be a strong or weak relationship between childhood mortality and fertility. Substantively, the major research question may be stated as follows; to what extent does couples' reproductive behavior change in response to child loss?

Theoretical issues and hypotheses

The theoretical pathways through which childhood mortality affects fertility are quite clear and have been discussed extensively in the literature (Preston, 1978; Lloyd and Ivanov, 1988; Palloni and Rafalimanana, 1998; Montgomery and Cohen, 1998). Fertility response to infant mortality is a combination of short-term physiological effects and long term behavioral replacement effects. Recently, LeGrand and colleagues (2001) have suggested the possibility of other pathways on the basis of qualitative research in Senegal and Zimbabwe.

The short-term physiological effect operates mainly through the cessation of breast-feeding and earlier return to menses following infant death which consequently expose the mother to pregnancy more quickly than if the child had survived. The physiological is effect is expected to be more pronounced in societies such as those of sub-Saharan Africa with prolong breastfeeding practices and low contraceptive usage. In its usual rendition, the behavioral replacement hypothesis refers to deliberate efforts couples make to bear another child in the hope of replacing the lost one. In most empirical studies, replacement behavior is explored by examining previous infant deaths on contraceptive use, completed fertility and parity progression ratios. These studies attest that the tendency to move to higher parities increases with the number of dead children. Additionally, women with childhood mortality experience tend to have more children ever born than their counterparts without such experience (e.g., Gyimah, 2001; Gyimah and Fernando, forthcoming; Nyarko et al., 1999; Montgomery and Cohen, 1998).

This paper focuses mainly on the physiological effect. To measure the short-term physiological effects in this paper, the approach adopted by Kuate Defo (1998) was slightly modified. I estimated a series of models examining the risk of second, third, and fourth births where the survival status of the index child *i* who opened the interval was treated as a dummy covariate: (0) survived, (1) died in the first year[1]. This categorization was done on the premise that if such an effect is evoked, one would expect women with infant mortality experience to associate with shorter transition from parity *i* to parity *i*+1 than women with no child loss. Given that Ghana is at an incipient stage of fertility transition relative to Kenya, the risk of a subsequent birth following an infant death, reflecting the physiological effect, is expected to be greater in Ghana. This is premised on the hypothesis that the link between childhood mortality and fertility changes over the course of transition (Preston, 1975; Llyod and Ivanov, 1988).

Besides childhood mortality, there are a number of demographic, socio-economic, and socio-cultural factors (see Table 1) that are known to affect both childhood mortality and fertility. To explore childhood mortality-fertility relationship, it is essential that these potential confounders are controlled statistically.

Demographic factors

The social structure of a given society is sustained through its norms, beliefs and values which tend to shape the aspirations and preferences of its individual members. One such area where societal norms are reinforced is the sex composition of surviving children. In societies where the social system accords special privileges to sons, a deficit in sons results in a faster transition to subsequent births. While most sub-Saharan African societies do not show a conscious preference for sons (Trussell et al., 1989) compared with those in Asia, some recent studies in the region allude to son preference (e.g., Kuate Defo, 1998; Nyarko et al., 1999). In this paper, women are classified on the

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[1]The short-term effects of infant deaths are more likely to be higher if the death occurs in the first year of life than thereafter.

basis of the sex composition of surviving children. On the basis of recent findings, women with only surviving daughters are hypothesized to have shorter transition times between births and implicitly, a higher risk of subsequent births than their counterparts whose surviving children are males.

Another demographic factor with significant bearing on reproductive behavior is age cohort which is also indicative of cultural, social-economic and political contexts that shape the life course experiences of individual women. While there are significant differences in the experiences of individual women, the prevailing socio-economic and cultural context may lead them to similar life experiences. In this paper, three age cohorts are identified. The youngest cohort consists of women aged 15-25 years who are at the beginning of their reproductive years. In terms of contextual factors, these women became adolescents in a period of more egalitarian gender roles, more efficient contraceptives, higher enrolments in formal education and labor force participation. The second cohort consists of women aged 26-36 years at the time of the survey, most of whom are in the midst of their reproductive life. The last cohort consists of those over 36 years at the survey, some of whom are nearing the end of their reproductive years. Most women in the last cohort were exposed to well defined gender roles and became adolescents at the time when contraception was less effective, and when there was a much lower female enrollment in formal education. In the light of these, a linear relationship is expected between age cohort and the timing of births with younger women having longer transition times between births than older women.

Age at first marriage and at first birth are other demographic factors of tremendous importance in fertility studies because of their inverse relation to the exposure to the risk of conception (see, e.g., Westoff, 1992). They also shed light on both observable and unobservable characteristics that pre-dispose women to differential timing of births and thus overall fertility. In the light of these, women who marry early and those whose first birth occur early are expected to have shorter transition times and thus a higher risk of subsequent births than their counterparts whose first marriages and first births occur late[2].

Socio-economic factors

There is considerable empirical evidence on the effects of maternal education on fertility and child mortality; these are largely negative. The pathways through which maternal education affects fertility have been explained through late age at marriage, high contraceptive use, and labor force participation (Martin, 1995;Oheneba-Sakyi and Takyi, 1997). All things being equal, we expect

[2]Two other important variables that affect the timing of births are breastfeeding and contraception. Unfortunately, data were not available on the breastfeeding status of all children. In the DHS, the question on breastfeeding was asked only on births that occurred in the three years preceding the survey. Although it is assumed that the effects of breastfeeding, contraception and amenorrhea are ‘captured’ in the frailty models, it was impossible to precisely estimate their net effects.

a lower risk of subsequent births for women with secondary education compared to those with no education.

Further, there are significant differentials in fertility by place of residence which sheds light on the differential influence of environmental, socio-economic and cultural factors on reproduction. Fertility in urban areas of sub-Saharan Africa is substantially lower than what prevails in rural areas, a difference of about 1.8 births per woman (Cohen, 1993). Besides the generally high levels of education of urban women and their active participation in the formal job market, institutional and normative structures that influence fertility are likely to be different in urban and rural settings. Urban residents are thus hypothesized to have longer transition time and thus a lower risk of subsequent birth.

Socio-cultural variables

There are a number of socio-cultural factors that influence reproduction in sub-Saharan Africa (e.g., Trussell et al., 1989; Lesthaeghe, 1989a). The first among these are ethnic-specific practices, norms and values such as sexual taboos that affect demographic behavior across the region. In Ghana, we distinguished the predominantly pro-natalist *Akans* from the *Mole-Dagbanis, Gas, Ewes* and *Others* while in Kenya, the distinction was between the low fertility *Kikuyus* and the *Kisii, Luhya, Kalenjin* and *Others*. Ethnicity is expected to capture both observable and unobservable behavioral and cultural differences that affect demographic behavior. Given the fact that the *Kikuyus* tend to be more educated and urbanized than others in Kenya, we expect to find longer transition times among them compared with the other ethnic groups. In Ghana, the pronatalist *Akans* are hypothesized to have a shorter transition times and thus higher risk of birth than the other groups.

Another significant cultural factor that affects reproduction is polygyny, although understanding its effects at the micro level is quite complex (Ezeh, 1997). While some claim that polygyny reduces the fertility of individual women (e.g, Garenne and van de Walle, 1989; Pison, 1987), there are those who claim it has negligible effects (see, e.g., Pebley and Mbugua, 1989; Sichona, 1993), and others who contend it increases individual fertility of women (Ahmed, 1986; Arowolo, 1981). In this study, we control for the type of marital union and argue that polygyny affects fertility mainly through coital frequency. Thus, after controlling for the residential pattern of the spouse, a proxy for coital frequency, we do not expect any significant differences between women polygynous unions and those in monogamous unions.

Turning to religion, previous research has shown it to be strong correlate of contraceptives use and abortion. While some suggest that religious differences in fertility are converging in the developed countries (e.g., Westoff and Jones, 1979), could the same be said of sub-Saharan Africa? In this study, religious affiliation is measured on a nominal scale and categorized into the following (1) Catholics (2) Other Christian (3) Muslim (4) Traditional and (5) Protestants. In line with previous research, we expect Moslems and Catholics to have shorter times to subsequent births than Protestants.

Again, the length of the preceding interval can be considered a proxy for the combined effects of proximate variables such as length of the voluntary and involuntary abstinence and effective contraceptive use, among others. To capture these differences which might account for differentials in the timing of subsequent births, the length of the preceding interval i is introduced as a dummy covariate in the transition to parity $i+1$. Given the relationship between preceding and succeeding intervals as demonstrated in previous research (Gyimah and Fernando, forthcoming), shorter preceding intervals are hypothesized to associate with shorter transition to subsequent birth and vice-versa.

Data and Estimation

The 1998 Demographic and Health Surveys (DHS) for Ghana and Kenya were used for this study. The surveys were conducted by Macro International in conjunction with host institutions in a number of developing countries based on household and individual interviews of women in the reproductive ages (15-49 years). In addition to country specific modules, there were standard core questionnaires on demographic and health indicators, thus making cross-national comparisons easier. The data include ever married women with at least one birth. Since the number of women of parity i progressing to parities $i+1$, $i+2$, tends to decrease, the analysis is restricted to births of order two to four to ensure the stability and reliability of the estimated coefficients and standard errors.

Data quality is a concern to any study that uses retrospective data to examine the timing of events as this paper does. Although there are non sampling errors on some age-related variables in the DHS, several studies suggest the data compare favorably with other large scale surveys such as the World Fertility Survey (Rustein et al., 1990; Gage, 1995). While a variety of approaches could be used to explore the short term effects of childhood mortality and reproductive behavior, this study mainly focused on one dependent measure, namely duration between successive births measured in months. Following Kuate Defo (1998), the analysis was limited to conceptions that resulted in live births because of the high incidence of misreporting of conceptions resulting in still births and miscarriage in most developing countries. Because of the relatively few number of cases at higher parity births, the analyses were restricted to the fourth births. The intervals between successive live births were decomposed into the first birth interval, the second birth interval, the third birth interval.

Examining the timing of births using retrospective data introduces the problem of selectivity and right censoring (Allison, 2000). Censored cases require special treatment in estimating exposure time and for this reason normal regression procedures cannot be used. The appropriate techniques in the presence of censoring come under the rubric of survival analysis, the oldest being the non-parametric life table technique. To overcome the problem of censoring, survival models make the assumption that censored individuals will eventually experience the event at some future time. Additionally, censoring is assumed to occur randomly over the interval such that censored individuals are assumed to be at risk of experiencing the event at the mid point of the interval.

However, while the life table can be used to estimate survival time, it does not readily allow one to control for theoretically meaningful variables that affect survival time in a multivariate context. The best one could do under such circumstances is to estimate survival probabilities for selected heterogenous groups. There is, however, the risk of getting unreliable parameters as a result of disaggregation of the sample into smaller heterogeneous groups of interest. Hazard models combine aspects of the life table and multiple regression techniques and allow the risk to depend on factors that describe heterogeneity. These models are used when the outcome of interest is a duration until the occurrence of some event, that is the time elapsed for making the qualitative change from an origin state to a destination state.

For this study, a parametric hazard model[3] was used to estimate the effects of infant mortality on the timing of births. As with many event-history models, the AFT takes censoring into consideration in the estimation procedures. A major assumption in parametric hazard models is that the underlying timing function follows some known mathematical distribution and that the specified time-dependent distribution is the right one for the event under study. AFT models thus encompass a variety of sub models that differ in the assumed distribution of the timing function. In this study, a log-normal distribution which assumes that the log of the timing function follows a normal distribution was applied in examining the timing of births. The choice of the log-normal distribution derives from its suitability in substantive theory (see Richards, 1983; Trussell and Richards, 1985) and also from a series of graphical and empirical methods for discriminating between different distributions in exploratory analysis (Gyimah, 2001). Again, when the Akaike Information Criterion[4] was applied, the log normal and log logistic specifications of the hazard provided better fits than other.

[3] In exploratory analysis, parametric and semi-parametric specifications of the hazard were found to yield similar results. However, a parametric distribution was chosen because the statistical package used in this study, namely, STATA, does not allow one to model unobserved heterogeneity using a semi-parametric model.

[4] AIC = -2(log likelihood) +2 (c+p+1)
Where c is the number of covariates in the model and p is the number of model-specific ancillary parameters for the parametric model. The preferred model is the one with the smallest AIC (StataCorp, 2001).

The log-normal hazard $h(t)$, survival $S(t)$, and density $f(t)$ functions are ;

[1]

$$h(t) = \frac{\frac{1}{t\sigma\sqrt{2\pi}} \exp\left[\frac{-1}{2\sigma^2}\left\{\ln(t) - \mu\right\}^2\right]}{1 - \Phi\left\{\frac{\ln(t)-\mu}{\sigma}\right\}}$$

[2]

$$S(t) = 1 - \Phi\left\{\frac{\ln(t) - \mu}{\sigma}\right\}$$

[3]

$$f(t) = \frac{1}{t\sigma\sqrt{2\pi}} \exp\left[\frac{-1}{2\sigma^2}\left\{\ln(t) - \mu\right\}^2\right]$$

where;

$\Phi(z)$ is the standard normal cumulative distribution function;

σ is the standard deviation of the normal distribution, and

μ is the mean.

The model is implemented by setting $\mu = x\beta$, where x is the covariate and β is the coefficient vector. The standard deviation σ is an ancillary parameter to be estimated from the data.

A series of models examining the transition to second, third, and fourth births were estimated on the condition that women at the risk of a third birth, for example, are those with second births. The approach is similar to the piecewise hazard models (Mench,1985; Rodriguez et al., 1984) where a likelihood function is estimated for each parity. The models provide the *time ratios* associated with the characteristics of the women, thus permitting an examination of the variations in the timing of subsequent births among women who experience infant death and those who do not. To avoid the possibility of reverse causation, the modeling strategy was to look at the survival status of the index child *i* who opened the interval before conception leading to a subsequent live birth for each parity.

Unobserved heterogeneity

In hazard models, it is assumed that all heterogeneity is captured by a set of the included covariates (Trussell and Richards, 1985; Trussell and Rodriguez, 1990). Theoretically, however, there is ample reason to believe that there is unmeasured heterogeneity due to a variety of unobserved factors that tend to affect demographic behavior. Increasingly, accounting for unobserved heterogeneity has become a source of concern to many methodologists. Indeed, Heckman and colleagues (1984, 1985) have argued that results from event history models can be misleading unless unobserved heterogeneity has been considered. Similarly, Trussell and Rodriguez (1990) noted that the failure to correct for unobserved heterogeneity can lead to hazards that either decline steeply or rise slowly than the true hazard, resulting in biased parameter estimates.

In the context of the present study, there are substantive arguments for unobserved heterogeneity. First, the absence of some important correlates of the timing of births in the data as well as the problem of recall errors in retrospective surveys necessitate such a model. Additionally, the probability of a mother experiencing a child death may be linked to variations in women's susceptibility to illness during the gestation period that would compromise the health of the fetus and later the infant. With respect to the dependent variable, some women are more fecund than others because they are healthier or because of some genetic predisposition (and some women might be sub-fecund for the same reasons), and as a result tend to have longer or shorter intervals because of such unobserved predispositions. Also, a major problem in repeatable events such as births is dependence among observations which could be thought of as arising from unobserved heterogeneity. Besides the substantive arguments, graphic plots of the estimated hazards controlling for the survival status of the index child showed considerable heterogeneity in the transition to various parities. Invariably, women who experienced index child loss exhibited much more heterogeneity than those who did not.

Thus, on both substantive and methodological grounds, unobserved heterogeneity was explicitly introduced in the statistical models. Statistically, this was done to test the stability of the estimated coefficients through a comparison of models with and without unobserved heterogeneity. Frailty was introduced as an unobservable multiplicative α effect on the hazard function such that

[4]

$$h(t|\alpha) = \alpha h(t)$$

where $h(t)$ is a non-frailty hazard function of the log-normal model described above. The frailty α is a random positive quantity for the purposes of model identifiability assumed to have a mean of one and variance θ (StataCorp, 2001). Given frailty, the survival function becomes

[5]

$$S(t|\alpha) = \exp\left\{-\int_0^t h(u|\alpha)du\right\} = \exp\left\{-\alpha\int_0^t \frac{f(u)}{S(u)}du\right\} = \{S(t)\}^{\alpha}$$

where $S(t)$ is the survival function that corresponds to $h(t)$. Also, the density function given frailty, is

[6]

$$f(t|\alpha) = -S'(t|\alpha) = \alpha f(t)\{S(t)\}^{\alpha-1}$$

where $f(t)$ is the probability density function that corresponds to $h(t)$ and $S(t)$. Since α is unobservable it needs to be integrated out of $f(t|\alpha)$. Let $g(\alpha)$ be the probability density function of α, then

[7]

$$f_\theta(t) = \int_0^\infty f(t|\alpha)g(\alpha)d\alpha = \int_0^\infty \alpha f(t)\{S(t)\}^{\alpha-1}g(\alpha)d\alpha$$

which yields the survival function of frailty model as

[8]

$$S_\theta(t) = 1 - \int_0^t f_\theta(u)du.$$

Assumed distribution for frailty

The choice of the distribution function for unobserved heterogeneity has been the subject of considerable discussion. The literature suggests two main approaches; a parametric approach with well defined distribution (usually the gamma) for the error term (e.g., Guo and Rodriguez, 1992; Sastry, 1997), and a non-parametric approach that only assumes the existence of finite set of values known as 'support points' for the error component (e.g., Heckman and Singer, 1984; Kuate Defo, 1998). For convenience, researchers frequently choose parametric representations of frailty that are mathematically tractable. In this paper, the parametric approach was adopted by assuming that frailty is distributed over individuals as gamma $g(\alpha)$. The advantages of gamma distributed frailty as Sastry (1997) points out, are its flexible shape and mathematical tractability. The gamma distribution with the following probability distribution function was assumed for frailty

[9]

$$g(x) = \frac{x^{a-1}e^{-x/b}}{\Gamma(a)b^a}.$$

To understand the conditions under which the results of the analysis are likely to be sensitive to the assumption of gamma-distributed frailty, the analysis was also performed under inverse-gaussian distributed frailty. The results were, however, found to be less sensitive to the choice of parametric representation of frailty. As a result, the effect of distributional assumption of frailty on parameter estimates is likely to be minor if not negligible.

Findings

Bivariate analyses of the relationship between the survival status of the index child, the covariate of primary interest in this study, and the timing of subsequent births are reported in Table 2. Panel A in the table shows the effects of the two-category measure of mortality while Panel B shows the effects of the three-category measure. Birth intervals are generally longer in Ghana than in Kenya[5] and this is evident in table. Whether considering the two- or three-category measure, the survival status of the index child appears to exert a stronger influence on the timing of subsequent births in both countries. Among Ghanaian women, for example, the median time to the second birth is about 36 months for women whose first child survived compared with 23 months among those whose first child died in the first year of life, a difference of about 13 months. Similarly, the transition to the second birth is about 28 months among Kenyan women whose first child survived compared with 22 months among those who lost their child in the first year of life, a difference of six months. Similar trends are conspicuous in the timing of the third and fourth births.

A parallel pattern emerges with respect to the model using the three-category measure of the survival status of the index child; survived, died in year one, died after year one. There is evidence, however, that the time to the next birth is remarkably reduced if the death occurred in the first year of life than if it occurred after the first year of life. The median time to the third births, for instance, shortens from 35 months among Ghanaian women whose second child survived, to 32 months among those whose child died after the first year of life, to 25 months among those whose child died in the first year of life.

The mean number of subsequent births to women at various attained parities by prior childhood mortality experience are also presented in Table 3. The analysis was separately done for all women and older women (above 37 years). The results demonstrates that women with childhood mortality experience tend to have a larger number of subsequent births than those with no child deaths irrespective of the attained parity. For example, Ghanaian women (all women)with no prior infant death up till the fourth birth had 1.7 additional children while their counterparts with no surviving children had 6 additional children, a difference of about 4.3 children. A parallel pattern is seen among Kenyan women where at the third parity, for instance, those without any infant death proceed to have 2.5 additional children while those with no surviving children go on to have about 4.5

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[5]Contrasting birth intervals in West and East Africa, Lesthaeghe (1989b) attributes the longer intervals in West Africa to certain salient features of its social organization particularly, the gerontocratic control of community and kinship groups .

additional children. This pattern gives some indiction of a deliberate replacement behavior, although the replacement tends to be incomplete.

However, while these bivariate results give a preliminary indication of the relationship between infant mortality and the timing of births, and for that matter the risk of subsequent births, the models do not take the effects of other theoretically meaningful covariates into account and thus provide us with little confidence as to whether the observed differences are real or spurious. Hence, there is a need to adjust for the effects of the other covariates to precisely determine the net effect of each covariate.

Multivariate Models

For each parity, two models are presented. Model 1 includes only the measured covariates while Model 2 includes all the measured covariates and a term for unobserved heterogeneity. The coefficients have been transformed by exponentiation (e^{β}) and can be interpreted as *time ratios*. For each covariate, the time ratio greater than one indicates a later timing (that is, experiences the event later) for the group with the associated characteristic than for the reference group. Conversely, a time ratio less than one works to decelerate the timing of the event (that is, experiences the event sooner) compared with the reference category.

Tables 4a and 4b present the results of the covariates associated with the timing of births in Ghana and Kenya respectively. The respective log likelihoods suggest all models as significant. The results suggest a significant effect of the survival status of the index child and a host of other factors on the timing of births. Model 1suggest that women who experienced child death have shorter transition times to the next than women whose index child survived. For example, the time to the second birth is about a third shorter among Ghanaian women whose first child died in the first year compared with those whose first child survived. A similar conclusion can be made among Kenyan women although the reduction in the time to the second birth occasioned by death of the first child is not as large. It is worth noting that while the sex composition of surviving children does not have a significant effect on the timing of the second birth, the effects are significant at higher parities in both countries. The coefficients for the transition to higher order births suggest a strong sex preference for sons. Controlling for other factors, women whose surviving children are daughters have a significantly shorter transition time compared to those whose surviving children are all sons.

Also, consistent with our hypotheses, there seems to be a linear relationship between age cohort, age at first marriage, age at first birth and the level of education on the timing of birth for all parities in both countries. With respect to age cohort, younger women have longer transition times to the next birth compared with older women and this is reflected in the greater than one. Turning to age at first marriage and first birth, the results suggests that women who marry or have first births at younger ages have shorter transition times to subsequent births. On education, the results suggest that women with secondary education have longer transition times and thus a lower risk of subsequent birth. Current urban residence is also associated with the later timing of births compared with rural place of residence. The effect of rural place of residence as a child also seems to associate with earlier timing of births although the effect is no significant across parities.

Turning to ethnicity, some consistent patterns are discernible across parities. In Ghana, the *Ewes* and *Mole-Dagbanis* tend to have significantly longer transition times than the *Akans*. In Kenya, the *Kikuyus* tend to have longer transition times at all parities while the *Kalenjins* seem to associate with significantly shorter times. On religion, no consistently clear patterns are discernible in either country perhaps confirming the view on convergence in religious differences in reproductive behavior (e.g., Addai, 1998). Again, no consistent significant effect of polygyny is noticeable. It needs mentioning, however, that effect of polygyny seems to operate through the husband's residential pattern. Polygyny is found to have a significant effect in models that exclude the residential pattern of the husband. The effect however dissipates once we control for residential pattern of the spouse which can be thought of as a proxy for coital frequency.

The results of the frailty models are presented in Model 2. For all models, the hypothesis that theta=0 can be rejected, meaning the effects of unobserved heterogeneity is not negligible. Examining Models 1 and 2, the negative log likelihood suggest the latter provides better fits than the former at all parities. Also, while the direction of the covariates remains unchanged in the frailty model, some significant differences are noticeable on the magnitude of the effects reflecting both an under- and over-estimation.

Discussion

The results presented here support the view that indeed, infant deaths have an effect on the timing subsequent births. Invariably, the death of a child in the first year of life significantly reduces the time to the next birth. Although these effects proved robust in the frailty models, some significant changes to the magnitude of effects are noteworthy. In particular, a comparison of the estimated coefficients associated with the death of the index child in the frailty effects models tended to be biased . Among Ghanaian women, for example, the effect of the death of the first child on the timing of the second birth was 0.66 in the gross effects model[6] to 0.58 in the frailty effects model suggesting a change from 34 percent to 42 percent reduction in the inter birth interval. Similar pattern is noticeable among Kenyan women.

Also, the effects of the age cohorts, secondary education and current residence which are quite large in the gross effects models are significantly weakened in the frailty models. For instance, adding a term for unobserved heterogeneity significantly reduces the estimated time ratio associated with secondary education on the fourth birth from 1.65 in the gross effect model to 1.25 in the frailty model in Ghana and from 1.40 to 1.31 in Kenya. Equivalent patterns are apparent at other parities. These significant changes in the estimated coefficients suggest that the gross effect models tend to produce biased estimates. While no consistently clear pattern is visible with respect to the effects

[6] Gross effect is used synonymously with models without a term for unobserved heterogeneity.

of the survival variables across parities, the effects of education, current residence and age cohort tended to be over estimated in the gross effects models. The findings thus substantiate some previous research where the effects of the observed covariates have been found to be significantly weakened after controlling for unobserved heterogeneity (e.g., Sastry, 1997; Trussell and Rodriguez, 1990).

Substantively, the findings confirm previous research on the effects of infant death on subsequent fertility (see, e.g., Preston, 1978; Grummer-Strawn et al., 1998; Kuate Defo, 1998; Rahman, 1998; Nyarko, et al., 1999). While confirming these findings, the present study has also shown that fertility response to childhood mortality is more pronounced in Ghana. The difference between he two countries could partly be due to differential intensity in breastfeeding and contraceptive use in the two countries. While breastfeeding is universal in both countries, evidence from the 1998 DHS suggests the proportion of exclusively breastfed children is significantly higher in Ghana. Among infants 2-3 months, the proportion exclusively breastfed is 33 percent in Ghana compared with only 8 percent in Kenya (GSS and MI, 1999:115; NCPD and MI, 1999:117), perhaps an indication of why the fertility response to childhood mortality is more pronounced in Ghana.

Also, significant in accounting for the observed differences in the effects of the death of the index child on the risk of subsequent births is the differential use of contraceptives. The relative importance of the physiological effect is largely determined by the stage of fertility transition. As Preston (1975) argued, the physiological effect reduces in relative terms as a society adopts parity specific control over reproduction. Situating this argument in the context of this study, the risk of a subsequent birth associated with the infant loss is expected to be less pronounced in Kenya where current contraceptive use and prevalence are higher. The DHS reports indicate the proportion of married women using modern contraception was 32 percent in Kenya compared with only 9 percent in Ghana. Thus, our findings corroborate the hypothesis that the relative importance of mortality on fertility varies over the course of the transition.

The longer transition times among the highly educated and urban women can be explained through socio-economic and cultural perspectives. The socio-economic hypothesis explains the longer transition times through the high use of modern contraception, education and labor force participation in the modern sector while the cultural perspective focuses on beliefs, values and norms regarding reproduction. From the socio-economic perspective, for instance, women with secondary education more likely to be employed in formal occupations that generates mother-worker conflict. The results also suggest that women whose surviving children were all girls had significantly shorter times to the next birth than women whose surviving children were all boys. This finding points to a gender preference and confirms some recent research in sub-Saharan Africa that alludes to son preference (e.g., Kuate Defo, 1998; Nyarko et al., 1999; Mace and Sear, 1997; Rono, 1998).

Also, significant ethnic differences were noticeable in the timing of births. In Ghana, for example, the *Mole-Dagbanis* and *Ewes* were consistently fount to have longer transition times than the *Akans*. In Ghana where the use of modern contraception is generally low, ethnic differences in the timing of births can be explained through socio-cultural factors such as the *badu-gwa*n rites and the lineage systems of the *Akans* and the longer period postpartum abstinence and breastfeeding among the *Ewe* and the *Mole-Dagban*is. Traditionally, *Ewes* and *Mole-Dagbanis* are expected to refrain from sexual intercourse following birth for longer periods than *Akans* (e.g., Gaisie ,1968; Bleek, 1990). The shorter transition times (higher risk of birth) among the *Akans* compared with the *Ewes* and *Mole-Dagbanis* could also be explained in terms of lineage and residential patterns. The matrilocal residence among the *Akans* ensures more flexibility in childbearing and upbringing than the patrilocal residence of the *Ewe* and *Mole-Dagbani.* The greater flexibility in who raises the child of an *Akan* woman means that mothers do not necessarily bear the overall cost of raising their children. As has been found elsewhere, cost-sharing in the up-bringing of children helps sustain high fertility (e.g., Isiugo-Abanihe, 1985; Goody, 1973).

Limitations and future research

This study is not without limitations — mostly, the absence of some important correlates on the risk of births. We could not control for the effects of breastfeeding and amenorrhea because information on them was only available for births that occurred in the three years preceding the survey and thus biased for births among the older cohort. Similarly, because of the difficulty in obtaining specific times of initiation of family planning between successive births, the effect of contraception was not controlled in the multivariate models. While it is assumed that the length of the preceding interval partly controls for these proximate variables, we are not sure how the inclusion of these variables will affect the stability of the coefficients. It is hoped that future work will throw more light on this as data become available.

There are additional research questions spurred by these findings. First, the effect of childhood deaths on reproductive behavior has also been theoretically explained through the insurance effect. This involves having births in excess of one's desired family size with the anticipation that the desired number will survive into adulthood by taking the prevailing mortality conditions into consideration. The higher a couple's perception of possible child loss, the greater will be the excess number of births (Lloyd and Ivanov, 1988). Measuring the insurance effect might require some measure of a couple's perception of prevailing childhood mortality conditions which could be achieved through a qualitative approach. Indeed as Montgomery (1998) has pointed out, there is little understanding of the processes through which childhood mortality perceptions are formed. Are childhood mortality perceptions formed through direct personal experience, observed experience, or through social learning? To further this strand of research, there is a need for multi level studies that explore the relationship among aggregate mortality trends, individual child survival experiences and individual reproductive behaviors.

Further, large scale surveys such as the DHS are less useful in arriving at explanations of the observed patterns. The replacement hypothesis, for example, is fundamentally based on a micro decision model of action. Given the patriarchal context of the family and also the influence of the extended family in much of sub-Saharan Africa, it will be important to know who decides on replacement behavior and when such decisions are made.

Finally, reproductive behavior in sub-Saharan Africa today cannot be adequately examined without reference to the impact of HIV/AIDS. Although a few available empirical studies have suggested a number of theoretical pathways through which HIV/AIDS mortality will impact on reproductive behavior (e.g., Ainsworth et al., 1998), there is not enough empirical evidence to draw firm conclusions. Perhaps in the near future, qualitative and quantitative studies may shed more light on the link between AIDS and fertility and the mechanisms through which AIDS impacts on fertility.

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Table 1: Per cent distribution of the covariates associated with the risk of births in Ghana and Kenya

VARIABLES		GHANA			KENYA		
		2nd birth	3rd birth	4th birth	2nd birth	3rd birth	4th birth
DEMOGRAPHIC FACTORS							
SEX OF SURVIVING CHILDREN							
Males		52.7	42.0	20.0	49.7	19.6	25.0
Females		47.3	15.8	25.0	50.3	38.5	49.0
Mixed		-	33.8	55.0	-	41.8	19.0
AGE COHORT							
Under 26 years		14.0	6.2	2.5	18.4	9.6	4.1
26-36 years		44.0	43.0	38.3	46.0	47.0	44.7
Above 36 years		42.0	50.8	59.0	35.6	43.4	49.0
AGE AT FIRST BIRTH							
Under 21 years		58.0	61.0	63.2	67.3	70.0	72.0
SOCIO-ECONOMIC FACTORS							
LEVEL OF EDUCATION							
Secondary		36.5	32.8	30.0	22.7	20.0	16.6
CURRENT PLACE OF RESIDENCE							
Rural residence		72.7	74.7	77.4	84.5	87.0	90.0
Urban residence		27.3	25.3	22.6	14.5	13.0	10.0
SOCIO-CULTURAL FACTORS							
ETHNICITY							
Ghana	Kenya						
Akan	Kikuyu	45.0	44.0	42.7	15.3	14.0	12.7
Ga	Kisii	6.4	5.9	5.5	7.6	7.7	8.0
Ewe	Kalenjin	12.4	11.4	11.3	17.6	18.4	19.3
Mole-Dagbani	Luhya	36.6	34.6	36.4	15.5	14.9	15.3
Others	Others	3.6	4.0	4.0	45.0	44.7	44.5
MARITAL UNION							
Polygynous		25.0	26.6	27.8	26.4	26.5	27.0
Monogamous		62.0	61.0	60.0	63.5	64.0	64.1
Not married		13.0	12.4	12.2	10.1	9.5	9.0
HUSBAND'S LIVING ARRANGEMENT							
Co-residence with husband		64.0	66.4	67	63.2	65.0	66.0
LENGTH OF PRECEDING INTERVAL							
Under 19 months		8.2	8.3	8.4	17.5	28.0	16.0
19-36 months		48.0	49.0	52.0	53.4	56.6	56.0
Above 36 months		45.0	42.6	39.6	29.0	15.4	28.0
TOTAL		**2798**	**2170**	**1642**	**4618**	**3626**	**2849**

Table 2: Median Survival Time (Months) To Second, Third, and Fourth Births by The Status of the Index Child

	GHANA		KENYA	
	Median	Number	Median	Number
A: SURVIVAL STATUS : TWO CATEGORIES				
SECOND BIRTH				
Index child survived	36***	2500	28	4257
Index child died in year 1	23***	257	22	361
THIRD BIRTH				
Index child survived	35***	1945	28	3367
Index child died in year 1	25***	178	22	259
FOURTH BIRTH				
Index child survived	34***	1477	28*	2655
Index child died in year 1	24***	132	21*	194
B: SURVIVAL STATUS: THREE CATEGORIES				
SECOND BIRTH				
Index child survived	36***	2281	28	4066
Index child died in year 1	23***	257	22	361
Index child died after year 1	32***	219	26	191
THIRD BIRTH				
Index child survived	35***	1776	28	3181
Index child died in year 1	25***	178	22	259
Index child died after year 1	32***	169	27	186
FOURTH BIRTH				
Index child survived	34***	1358	28*	2520
Index child died in year 1	24***	132	21*	194
Index child died after year 1	30***	119	26	135

Notes: Significant level *** = 0.00 or better; **=0.01; *=0.0.5

Table 3: Mean number of subsequent births to women at various attained parities by child mortality experience at that parity.

	ALL WOMEN				WOMEN ABOVE 37 YEARS			
	GHANA		KENYA		GHANA		KENYA	
Number of deaths at each attained parity	No. of subsequent births	No. of women	No. of subsequent births	No. of women	No. of subsequent births	No. of women	No. of subsequent births	No. of women
First parity		3499		5717		1140		1657
0	2.70	3192	3.01	5281	4.62	1029	5.44	1511
1	3.72	307	4.00	430	5.31	111	6.74	146
Difference (0, 1)	1.02		1.26		0.69		1.13	
Second parity		2798		4618		1097		1611
0	2.36	2365	2.71	4029	3.76	928	3.55	1932
1	2.96	399	3.45	519	4.41	150	5.72	188
2	3.74	39	4.41	70	5.11	19	6.00	31
Difference (0,1)	0.60		0.74		0.65		2.17	
(0,2)	1.38		1.70		1.35		2.45	
Third parity		2170		3626		1079		1544
0	2.00	1961	2.47	2978	2.90	811	3.71	1277
1	2.51	398	3.04	524	3.60	181	4.87	218
2	2.85	71	3.56	108	3.80	80	5.26	39
3	4.70	10	4.50	16	5.30	7	5.50	10
Difference (0, 1)	0.51		0.57		0.70		1.16	
(0,2)	0.85		1.09		1.00		1.55	
(0,3)	2.70		2.03		2.40		1.79	
Fourth parity		1642		2849		915		1429
0	1.73	1183	2.14	2201	2.34	673	3.0	1113
1	2.15	361	2.71	483	3.00	187	3.9	244
2	2.50	80	3.17	127	3.51	11	4.6	55
3	3.06	16	3.20	31	3.60	2	4.4	12
4	6.00	2	4.14	7	6.00		8.6	5
Difference (0,1)	0.42		0.57		0.66		0.9	
(0,2)	0.77		1.03		1.17		1.6	
. (0,3)	1.33		1.06		1.26		1.4	
(0,4)	4.27		2.27		3.66		5.6	

Notes: 0= women who have not experienced any child death until that parity; 1= women who have experienced one child death until that parity; 2=women who have experienced two child deaths; 3= women who have experienced three child deaths; 4= women who have experienced four child deaths.

Table 4a: AFT Models of the Survival Status of the Index Child Timing of Births, Ghana

COVARIATES	WITH ONLY COVARIATES			WITH COVARIATES AND UNOBSERVED HETEROGENEITY		
	MODEL 1			MODEL 2		
	Second births	Third birth	Fourth birth	Second births	Third birth	Fourth birth
Survival Status of the index child (ref:survived)	1.00	1.00	1.00	1.00	1.00	1.00
Died in the first year	0.66 (.04)***	0.46 (.04) ***	0.42 (.04)***	0.58 (.02)***	0.56 (.04)***	0.54 (.05)***
DEMOGRAPHIC VARIABLES						
Sex composition of survivng children (ref: sons)	1.00	1.00	1.00	1.00	1.00	1.00
daughters	0.98 (.03)	0.66 (.04)***	0.53 (.04)***	0.95 (.03)*	0.84 (.03)	0.78 (.06)***
sons and daughters	-	0.71 (.04)***	0.55(.04)***	-	0.88 (.03)***	0.78 (.03)***
Age cohort (ref:above 36 years)	1.00	1.00	1.00	1.00	1.00	1.00
under 26 years	3.92 (.20)***	12.4 (1.00)***	28.6 (3.9)***	1.23 (.04)***	1.64 (.12)***	8.24 (.63)***
26-35 years	1.32 (.05)***	2.00 (.10)***	3.08 (.20)***	1.07 (.02)***	1.10 (.03)***	1.27 (.06)***
Age at first birth (ref: above 25 years)	1.00	1.00	1.00	1.00	1.00	1.00
under 25 years	0.66 (.04)***	0.60 (.03)***	0.56 (.04)***	0.82 (.03)***	0.91 (.03)*	0.81 (.03)***
Age at first marriage (ref: above 21 years)	1.00	1.00	1.00	1.00	1.00	1.00
under 21 years	0.84 (.04)***	0.88 (.04) ***	0.74 (.04)***	0.90 (.03)***	0.95 (.03)*	0.92 (.04)***
SOCIO-ECONOMIC VARIABLES						
Level of education (ref: no education)	1.00	1.00	1.00	1.00	1.00	1.00
primary	1.11 (.06)!	1.26 (.09)***	1.09 (.10)	0.98 (.03)	1.07 (.04)	1.03 (.06)
secondary	1.34 (.07)***	1.61 (.11)***	1.65 (.14)***	1.04 (.03)	1.14 (.04)***	1.25 (.06)***
Current place of residence (ref: rural)	1.00	1.00	1.00	1.00	1.00	1.00
urban	1.12 (.05)***	1.25 (.07)***	1.39 (.11)***	1.02 (.03)	1.05 (.07)!	1.13 (.05)*
Childhood place of residence (ref:urban)	1.00	1.00	1.00	1.00	1.00	1.00
rural	0.92 (.03)	0.88 (.03)***	0.85 (.06)***	0.95 (.02)*	0.98 (.03)	0.92 (.06)!
SOCIO-CULTURAL VARIABLES						
Ethncity (ref: Akan)	1.00	1.00	1.00	1.00	1.00	1.00
Ga	1.07 (.08)	1.04 (.11)	0.99 (.14)	1.01 (.05)	0.98 (.06)	0.99 (.08)
Ewe	1.12 (.06)*	1.29 (.10)***	1.11 (.06)*	1.05 (.03)	1.12 (.05)***	1.12 (.11)*
Mole-Dagbani	1.20 (.07)***	1.11 (.05)*	1.08 (.05)*	1.09 (.04)*	1.10 (.04)*	1.10 (.05)!
Others	1.04 (.11)	0.93 (.087)	0.97 (.17)	1.00 (.06)	1.00	1.00 (.10)
Religion (ref: other christian)	1.00	1.00	1.00	1.00	1.00	1.00
Catholic	0.97 (.05)	1.06 (.05)	1.00 (.10)	0.93 (.03)!	1.06 (.05)	0.99 (.06)
Moslem	0.91 (.06)	0.96 (.06)	0.92 (.10)	0.90 (.06)*	0.97 (.04)	0.99 (.07)
Traditional	0.93 (.07)	1.11 (.07)	0.77 (.10)*	0.92 (.05)*	1.09 (.05)!	1.00 (.07)
Others	0.88 (.05)*	0.96 (.08)	0.86 (.09)	0.92 (.05)*	0.98 (.04)	0.93 (.06)
Type of marital union (ref: monogamy)	1.00	1.00	1.00	1.00	1.00	1.00
polygyny	0.98 (.04)	0.94 (.04)	1.01 (.07)	1.00	0.93 (.05)*	1.04 (.04)
not married	1.33 (.08)***	1.26 (.11)***	1.53 (.17)***	0.99 (.03)	1.15 (.06)***	1.08 (.17)
Husband's residency (ref: lives eslewhere)	1.00	1.00	1.00	1.00	1.00	1.00
co-residency	0.80 (.03)***	0.73 (.07)***	0.90 (.08)	0.87 (.02)***	0.88 (.07)***	0.87 (.04)***
Length of preceding interval (ref: 19-36months)	1.00	1.00	1.00	1.00	1.00	1.00
under 19 months	-	0.73 (.07)***	0.64 (.08)***	-	0.88 (.04)***	0.70 (.06)***
above 36 months	-	2.29 (.12)***	3.71 (.26)***	-	1.19 (.04)***	1.61 (.07)***
SIGMA	1.09 (.01)***	1.32 (.02)***	1.55 (.03)***	0.41 (.01)***	0.43 (.02)***	0.61(.02)***
NEGATIVE LOG LIKELIHOOD	4831	4456	3800	3983	4073	3961
THETA	-	-	-	1.92 (.07)***	3.64 (.20)***	3.41 (.20)***
LIKELIHOOD RATIO CHI-SQUARE THETA=0	-	-	-	1695	766	3691
SAMPLE SIZE	2798	2170	1642	2798	2170	1642

Notes: Standard errors are given in parentheses after the coefficients. Significance level ***=0.00 or better; **=.01; *=0.05; !=0.10.

The likelihood ratio that theta=0 and the associated chi-sqaure tests the null hypothesis that unobserved heterogeniety is negligible (see StataCorp, 2001).

Table 4b: AFT Models of the Survival Status of the Index Child on the Timing of Births, Kenya

COVARIATES	WITH ONLY COVARIATES			WITH COVARIATES AND UNOBSERVED HETEROGENEITY		
	MODEL 1			MODEL 2		
	Second births	Third birth	Fourth birth	Second births	Third birth	Fourth birth
Survival Status of the index child (ref:survived)	1.00	1.00	1.00	1.00	1.00	1.00
Died in the first year	0.84***	0.47 (.03)***	0.60 (.05)***	0.72 (.02)***	0.63 (.02)***	0.57 (.05)***
DEMOGRAPHIC VARIABLES						
Sex composition of survivng children (ref: sons)	1.00	1.00	1.00	1.00	1.00	1.00
daughters	0.96 (.02)	0.66 (.02)***	0.23 (.02)***	0.95 (.01)***	0.87 (.02)***	0.27 (.02)***
sons and daughters	-	0.70 (.03)***	0.28 (.01)***	-	0.88 (.02)***	0.31 (.01)***
Age cohort (ref:above 36 years)	1.00	1.00	1.00	1.00	1.00	1.00
under 26 years	3.55(.20)***	9.73 (.55)***	12.2 (1.0)***	1.33 (.03)***	1.63 (.55)***	7.17 (.53)***
26-35 years	1.19 (.04)***	1.67 (.04)***	1.98 (.04)***	1.11 (.02)***	1.11 (.02)***	1.65 (.07)***
Age at first birth (ref: above 25 years)	1.00	1.00	1.00	1.00	1.00	1.00
under 25 years	0.87 (.04)***	0.59 (.03)***	0.58 (.03)***	0.91 (.02)***	0.91 (.00)***	0.69 (.03)***
Age at first marriage (ref: above 21 years)	1.00	1.00	1.00	1.00	1.00	1.00
under 21 years	0.61 (.02)***	0.64 (.03)***	0.63 (.03)***	0.73 (.01)***	0.81 (.02)***	0.73 (.02)***
SOCIO-ECONOMIC VARIABLES						
Level of education (ref: primary)	1.00	1.00	1.00	1.00	1.00	1.00
none	0.94 (.04)	0.98 (.04)	0.90 (.05)	0.96 (.02)	0.94 (.05)	0.90 (.04)*
secondary	1.08 (.04)*	1.30 (.06)**	1.40 (.06)***	1.02 (.04)	1.10 (.2)**	1.31 (.06)**
Current place of residence (ref: rural)	1.00	1.00	1.00	1.00	1.00	1.00
urban	1.11 (.05)***	1.35 (.08)***	1.58 (.05)***	0.96 (.05)	0.99 (.03)	1.00
Childhood place of residence (ref:urban)	1.00	1.00	1.00	1.00	1.00	1.00
rural	0.94 (.04)	0.93 (.06)	0.99 (.06)	1.00	0.99 (.03)	0.97 (.05)
SOCIO-CULTURAL VARIABLES						
Ethncity (ref: others)	1.00	1.00	1.00	1.00	1.00	1.00
Kikuyu	1.08 (.03)*	1.21 (.07)***	1.23 (.08)***	1.07 (.03)*	1.05 (.03)!	1.15 (.06)**
Kisii	0.95 (.05)	0.99 (.07)	0.87 (.07)	1.00 (.05)	1.00 (.04)	0.90 (.06)
Kalenjin	0.88 (.03)***	0.88 (.04)**	0.78 (.04)***	0.91 (.02)***	0.94 (.02)!	0.83 (.04)***
Luhya	0.93 (.04)	0.89 (.04*	0.93 (.05)*	0.93 (.02)***	0.91 (.02)***	0.94 (.05)
Religion (ref: other christian)	1.00	1.00	1.00	1.00	1.00	1.00
Catholic	1.04 (.03)	1.03 (.03)	1.05 (.03)	0.97 (.02)	0.99 (.02)	1.06 (.03)
Moslem	1.01 (.07)	0.99 (.07)	0.98 (.07)	0.95 (.04)	0.99 (.05)	1.09 (.10)
Others	0.93 (.07)	1.20 (.07)*	1.00 (.07)	0.96 (.04)	1.06 (.05)	1.08 (.11)
Type of marital union (ref: monogamy)	1.00	1.00	1.00	1.00	1.00	1.00
polygyny	0.98 (.04)	1.05 (.05)	0.98 (.05)	1.02 (.02)	0.99 (.02)	0.99 (.05)
not married	1.81 (0.08)***	1.78 (.11)***	1.23 (.09)***	1.09 (.03)***	1.18 (.11)***	1.23 (.07)***
Husband's residency (ref: lives eslewhere)	1.00	1.00	1.00	1.00	1.00	1.00
co-residency	0.78 (.02)***	1.02 (.02)	0.88 (.05)***	0.98 (.02)	0.95 (.02)!	0.90 (.05)***
Length of preceding interval (ref: 19-36months)	-	1.00	1.00	-	1.00	1.00
under 19 months	-	0.79 (.04)***	0.83 (.05)***	-	0.87 (.02)***	0.83 (.04)***
above 36 months	-	2.43 (.10)***	3.01 (.15)***	-	1.17 (.03)***	2.43 (.11)***
SIGMA	1.05 (.01)***	1.26 (.01)***	1.37 (.02)***	0.42 (.02)***	0.42 (.01)***	0.95 (.02)***
NEGATIVE LOG LIKELIHOOD	7972	7239	6044	6667	6796	5928
SAMPLE SIZE	4618	3626	2849	4618	3626	2849
LIKELIHOOD RATIO CHI-SQUARE THETA=0	-	-	-	2200	884	232
THETA	-	-	-	1.75 (.20)***	3.39 (.12)***	0.83 (.07)!

Notes: Standard errors are given in parentheses after the coefficients. Significance level ***=0.00 or better; **=.01; *=0.05; !=0.10

The likelihood ratio that theta=0 and the associated chi-sqaure tests the null hypothesis that unobserved heterogeniety is negligible (see StataCorp, 2001).