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The Importance of Education for Fertility in Sub-Saharan Africa is Substantially Underestimated When Community Effects are Ignored

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List of the last 10 Memoranda:

No 02	By Geir B. Asheim and Martin L. Weitzman: DOES NNP GROWTH INDICATE WELFARE IMPROVEMENT? 8 p.
No 01	By Tore Schweder and Nils Lid Hjort: Confidence and Likelihood. 35 p.
No 43	By Mads Greaker: Strategic Environmental Policy when the Governments are Threatened by Relocation. 22 p.
No 42	By Øystein Kravdal: The Impact of Individual and Aggregate Unemployment on Fertility in Norway. 36 p.
No 41	By Michael Hoel and Erik Magnus Sæther: Private health care as a supplement to a public health system with waiting time for treatment: 47 p.
No 40	By Geir B. Asheim, Anne Wenche Emblem and Tore Nilssen: Health Insurance: Treatment vs. Compensation. 15 p.
No 39	By Diderik Lund and Tore Nilssen: Cream Skimming, Dregs Skimming, and Pooling: On the Dynamics of Competitive Screening. 21 p.
No 38	By Geir B. Asheim and Andrés Perea: LEXICOGRAPHIC PROBABILITIES AND RATIONALIZABILITY IN EXTENSIVE GAMES. 30 p.
No 37	By Geir B. Asheim and Wolfgang Buchholz: THE MALLEABILITY OF UNDISCOUNTED UTILITARIANISM AS A CRITERION OF INTERGENERATIONAL JUSTICE. 22 p.
No 36	By Olav Bjerkholt: A turning point in the development of Norwegian economics - the establishment of the University Institute of Economics in 1932. 60 p.

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The Importance of Education for Fertility in Sub-Saharan Africa is Substantially Underestimated When Community Effects are Ignored

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The Importance of Education for Fertility in Sub-Saharan Africa is Substantially Underestimated When Community Effects are Ignored

Short abstract (112 words)

Using DHS data for 22 countries in Sub-Saharan Africa, it is found that average educational level in the community (DHS cluster) has a significant depressing effect on a woman's birth rates, net of urbanization and her own education. According to simulations, average fertility for these countries would be 1.00 lower if education were expanded from the current level in the region to the relatively high level in Kenya. Excluding aggregate education from the model leaves a response of only 0.52. A considerable aggregate contribution is estimated even when several potential determinants of education are included. This illustrates the need to consider aggregate education in future assessments of the total impact of education.

Longer abstract (204 words)

Discrete-time hazard models for first- and higher-order births are estimated from DHS data for 22 countries in Sub-Saharan Africa for the 1990s. It is found that, among women with the same number of completed years of schooling, fertility decreases with increasing average educational level in the neighborhood (DHS cluster). Such a significant community effect, net of urbanization, has never been documented before. When the aggregate variable is left out of the model, some of its effect is captured by the individual variable, but only a small part. One may therefore be led to conclude that investments in education are much less powerful in reducing fertility than they really are. For example, a simulation based on a model including only individual education reveals that average fertility for these 22 countries would have been 0.52 lower if education were expanded from the current level in the region to that in Kenya, which is the most advanced country in this respect. However, according to a model where also average education is included, the drop would have been as large as 1.00, of which 0.38 is the purely individual effect. A considerable aggregate contribution is estimated even when several potential determinants of education are entered into the models.

(Main text 7563 words)

Although women's education has been one of the most thoroughly studied determinants of fertility, with the perspective now often extended to include the closely related 'women's position', important questions still cry for a better answer. Not only do we have quite meager knowledge about the importance of various causal channels that education operates through. Even the assessments of total effects, in different settings and on the whole, are quite inadequate.

One rather trivial reason for this is that many studies have disregarded factors that influence both education and fertility, such as the degree of urbanization (see e.g. reviews by Diamond, Newby and Varle 1999; Eloudou-Enyegue 1999). As a parallel to this, Desai and Alva (1998) reported that the effects of maternal education on child health and mortality, which have long been reckoned as extraordinarily clear, are much weaker when some structural characteristics and individual background factors are taken into account. Besides, variables causally subsequent to education have often been included in regression models, which is no better when the intention is to estimate a total effect.

The other reason for inadequate assessment of the total effect is that community effects usually are ignored. It is possible that the educational level among people in the neighborhood has an effect on a woman's fertility above and beyond that of her own education. Uneducated women who live in societies where a large proportion are literate, or where the average educational level is high, may have a fertility different from that of uneducated women elsewhere. In addition, also the better-educated may be influenced by the educational distribution in the community. If aggregate education has, on the whole, a substantial depressing effect, fertility may decline much steeper in response to an increase in women's education than suggested by a model that only includes individual-level effects.

Caldwell (1980) discussed the possible importance of 'mass education' many years ago, and concluded that near-universal enrollment of children in primary school probably is a key factor behind fertility decline. The mechanisms he addressed can be classified largely as aggregate-level effects. However, in the 20 years that have elapsed, little empirical research has been devoted to aggregate education effects.

Some efforts were made on the basis of community data collected in the World Fertility Surveys in a few countries, but with the focus largely on the number of schools in the vicinity (reviewed in Casterline 1985). In an important recent contribution of a similar type, Axinn and Barber (2001) showed that a woman's use of modern contraception depended on the distance to school both in childhood and adulthood (and partly because of its influence on her own children's schooling).

Also the education that has actually been taken by other people in the community has been considered in some studies. For example, Tienda, Diaz and Smith (1985) found effects of average length of education on cumulated fertility in Peru, net of the woman's own education. In a Kenyan study, Lesthaeghe et al. (1985) showed such net effects of aggregate education both on cumulated fertility and some proximate determinants. Moreover, Hirschman and Guest (1990) estimated a significant fertility-inhibiting effect of the proportion of women with post-primary education in four Southeast Asian countries. Unfortunately, a control for urbanization was not included in any of these studies. A recent analysis from Zimbabwe showed that, when such a variable was entered into the models, the effects of community education disappeared completely (Kravdal 2000). In fact, an effect of the educational level in the neighborhood on actual fertility, net of urbanization and the woman's own education, is still not statistically documented. Thomas (1999) wrote that he had found mean educational level to reduce cumulated fertility among South African women, but did not show the size of this effect. Moreover, the significant effect that appeared in a study from Bangladesh (Amin, Diamond and Steele 1996) was for contraceptive use, not actual fertility.

The objective of this study is to estimate how education has influenced birth rates in Sub-Saharan Africa in the 1990s through both individual- and aggregate-level effects, and to illustrate the consequences of neglecting the latter when assessing the total impact of education. All countries with an easily available Demographic and Health Survey held after 1992 are included. The focus is on births two years before the survey, and models are estimated separately for first and higher-order births, because of the fundamentally different behavioral mechanisms involved. Simulation is used to show how changes in educational distribution affect total fertility.

Theoretical considerations

A brief review of suggested individual-level effects of education

There are several plausible reasons why women with, for example, some secondary education usually display a lower fertility than the uneducated. To summarize very briefly (and without showing any literature references for these standard arguments), fertility desires have been thought to be influenced by the individual woman's education because of: i) the high opportunity costs of childbearing involved in some types of work that may be offered the better-educated women, ii) the cash expenses and children's reduced contribution to domestic and agricultural work as a result of children's schooling, which tends to be encouraged by educated mothers, iii) the reduced need for children as old age security, or to support the woman even as a relatively young widow, when the family's wealth allows other kinds of savings, or when the woman is able to earn a living on her own and even set something of that aside for the future, iv) a stronger desire among the better-educated to spend more time caring for a child and to invest more in each child, not only in terms of education, v) a higher prevalence of nucleated families, which may reduce fertility partly because childbearing costs to a larger extent must be covered by parents, vi) a stronger preference for consumer goods or other sources of satisfaction, and vii) a lower infant and child mortality, influencing desires through replacement and insurance effects. These fertility-inhibiting effects may be set off against viii) a possibly stimulating impact of a higher purchasing power resulting from educated women's own work or their marriage into a relatively rich family.[1]

Mortality has a bearing also on the supply side. Besides supply and regulation are likely to be influenced by education, one way or the other, because of ix) the higher age at marriage among the better-educated, x) their knowledge about and accept for modern contraception, and their ability to use it efficiently, as well as their more efficient use of traditional methods because of better knowledge about their own body, xi) the erosion of traditional norms about post-partum sexual abstinence and breastfeeding that is supposed to go hand in hand with education, and xii) their higher fecundity because of better health or treatment for sexually transmitted diseases. As widely known, the fertility-stimulating effects actually seem to have been dominant at a moderate educational level in many countries, and in particular in Africa during the 1970s and early 1980s.

One reason why education may operate through these channels is that schooling generally (disregarding variations in curriculum, resources and teacher attitudes) makes the women able to read and write, increases their knowledge about the outside world, and provides them with certain practical and theoretical skills that enhance their productivity.[2] In addition, women's position relative to men may be involved. While their 'economic autonomy', 'physical autonomy' and 'decision-making autonomy' (using terms from Jejeebhoy 1995) are likely to depend to a large extent on community norms and rules and institutional structures, there may also be individual variations determined by individual factors, such as education and each family's interpretation of the cultural proscriptions (see e.g. Niraula and Morgan 1996). In other words, her own current position compared to men, and the position she expects for the future and for her daughters, are probably determined both by gender attitudes and structures in society and such individual characteristics as her own education. If she has an education, she may, for example, be allowed by the family to work outside the house and more often be heard in discussions with husband or in-laws.[3] This will add to the effect of her literacy and skills and possibly reduce fertility desires through such factors as opportunity costs, old age security concerns and child mortality.

Women's status may also operate through channels other than those listed above. For example, in situations where the husband wants more children than the wife (which has been indicated in some studies (e.g. Bankole and Sing 1998), but not all), a strengthening of women's decision-making autonomy is likely to reduce fertility (see also Mason and Smith, 2000). This is particularly relevant for Africa, where women are reckoned to be very subordinate in relation to their husband (whereas women in South Asia typically suffer more from a lack of physical and economic autonomy). Besides, when a wife is considered more of an equal, the couple may communicate better about contraception, and the husband may see clearer how childbearing burdens the wife. On the other hand, a closer relationship may stimulate sexual activity. As a final example, women who themselves have a relatively inferior position relative to men (and consider it unlikely that their daughters' life will be very different) may not only consider the childbearing costs generally low and the rewards high, but expect boys to be even more useful than girls. Such boy preferences (which are much less pronounced in Africa than in parts of Asia) will enhance fertility desires in settings where fertility is not extremely high (see e.g. Cain 1993).

The possible importance of others' education

Several of the causally intermediate factors mentioned above may depend not only on the woman's own education, but also that of other women. As pointed out by, for example, Montgomery and Casterline (1996), other women may exert an effect because of social learning, social influence and more indirect mechanisms. The individual woman may learn directly from others by communication and observation. It is not only factual knowledge that is likely to be transmitted, but also attitudes as well as understanding of possible consequences of different actions. Bongaarts and Watkins (1996) have stressed that this learning may include interpretation in light of current local conditions and the individual situation. There may also be a more passive imitation of behavior ('social influence') without any (active digestion of) new knowledge, driven by a desire to attract other people's approval. A more indirect mechanism is that others' ideas, resources or behavior can influence society and social institutions and thereby also behavior more generally.

In principle, these influential 'others' may be close neighbors, other women in the village or city, or even women in other parts of the country, and they may be of the same or a different age. In fact, there may even be spill-over effects from the behavior and characteristics of adolescents and children. In this study, it is the education of other women of reproductive age in the DHS cluster (i.e. the village level; see below) that has been in focus.

To be more specific, uneducated women may have more knowledge of contraception and more modern views about its acceptability if they live in a society where many women have attended school for some years than if they live elsewhere. They may also simply tend to imitate the more widespread use of contraception among the better-educated. Moreover, their preference structure and their practice of breastfeeding and post-partum abstinence may be influenced by aggregate education.

Other people's education may be of importance also to those who themselves have more education, although for slightly different reasons. A diffusion of factual knowledge of contraception is, for example, less relevant, but there may be a more efficient interpretation of the ideas and attitudes the better-educated have been exposed to at school or through reading if there are more women to share these experiences with.

An argument advanced by Caldwell (1980) was that introduction of compulsory education, which will lead to high enrollment rates in the country (‘mass education’), is likely to reduce fertility by increasing parents’ costs of childbearing and undermining the possibilities to make use of children’s work potential. One might add that seeing many children enrolled perhaps will make everyone more conscious about the need to educate their offspring, regardless of legislation (see elaboration by Axinn and Barber 2001). The latter argument would, of course, be relevant also for aggregate education at a lower geographical level than the country. Another particularly important point raised by Caldwell was that a generally high educational level among adults and children alike (in the neighborhood or in a larger region) might strengthen Western middle class values, with more emphasis on individual rights than on the duty to a larger family network. He thought that an increase in the proportion with a few years of schooling (breadth of education), would be the most crucial change, whereas the average length of education within this group (depth of education) would be of less importance.

Moreover, opportunity costs of childbearing may depend on other people’s education. Generally, having a high education will increase a woman’s chance of finding a relatively well-paid job (where she cannot bring her children with her). However, under the assumption of a fixed supply of such jobs, a high proportion of well-educated women in the community will decrease her chance. To elaborate on this, even women with a quite short education may be able to get into this niche in the labor market when few have an education, whereas their situation would be little different from that of the uneducated when the average education is higher.

In addition to its influence through such a competition effect, aggregate education is linked to the supply side. When more women are educated, the attitude towards women’s work in the modern sector is likely to change, and more jobs that are attractive to and suitable for these women may be created. Because of the inertia of these processes, the availability and acceptability of jobs presumably depend more on aggregate education some years before than on the current situation. Better-educated women who are forerunners, in the sense that few had such high education in the immediate past, may find it particularly difficult to make use of their schooling.

In other words, if the temporal dimension is disregarded for simplicity, it can be concluded that a high average education may reduce the opportunity costs because of a competition effect and add to them because of increased supply and acceptance of well-paid jobs. To complicate this further, opportunity costs may be substituted by direct costs by purchasing child care, which is likely to be particularly cheap when only a few women work away from home.

Of course, if a general rise in women's education (with or without an accompanying rise for men) contributes to undermine old ideas about women's rights and obligations compared to men, it is not only the opportunity costs of childbearing that will be enhanced. An improvement of women's status as a contextual phenomenon, and the concomitant changes in women's individual position, may influence fertility for many other reasons, a few of which were reviewed above. This may influence also the fertility of women who themselves have little education.

Besides, broader economic transformations are likely to take place as a result of a better-educated work force, in the long run. In addition to the increase in the number of well-paid jobs in the modern sector, as referred to above, it is possible, for example, that the agriculture will be generally modernized, including that among uneducated farmers. This will reduce children's relative importance in the fields, and thus the incentive for childbearing. Moreover, higher productivity in agriculture, combined with a general knowledge level that may facilitate the establishing of manufacturing industries that benefit particularly strongly from economies of scale, may lead to an increased concentration of people in urban areas. In other words, it can be argued that investments in education in an area may contribute to stimulate the urbanization of that area, although slowly. Also the generally higher wealth that is likely to be a part of these transformations may have an effect on fertility.

Macro- micro interactions

There may well be interactions between the individual and aggregate level. Some of the effects of aggregate education that are suggested above are most likely to be felt among women who themselves have little education, whereas others may be just as strong, or even stronger, among those who have some education.

As yet, there is no clear empirical evidence about such interactions. Jejeebhoy (1995) concluded that, in countries where women's literacy is high, primary education is more likely to push fertility down, and the negative effect of secondary education is particularly sharp. This is, of course, the same as claiming that the literacy rate has the clearest negative effect among the better-educated. Her conclusion was based on a review of a number of studies with different, and more or less relevant, control variables included, and did therefore not have a very solid basis. She found, for example, that fertility *desires* responded most sharply to secondary education in the countries with a generally *low* educational level, and that education was least powerful in weakening the breastfeeding norm, which would contribute to a particularly strong *negative* effect on fertility, in these settings. In the recent Zimbabwean study, effects of aggregate education on birth rates were generally weak, regardless of individual education (Kravdal 2000). The few other original multilevel studies addressing such interactions have not left a clear picture (Lesthaeghe et al. 1985; Tienda et al.1985).

Data and methods

Data

DHS data for the following countries and years are included: Benin 1996, Burkina Faso 1999, Cameroon 1998, Central African Republic 1994, Chad 1996, Cote d'Ivoire 1994, Comoros 1996, Ghana 1999, Kenya 1998, Madagascar 1997, Malawi 1992, Mali 1996, Mozambique 1997, Namibia 1992, Niger 1998, Rwanda 1992, Senegal 1997, Tanzania 1996, Togo 1998, Uganda 1995, Zambia 1996, and Zimbabwe 1994. Only the data for women are used.

These data include information on the woman's educational level at the time of interview, whether her current place of residence has a rural or urban character, her birth history, and various indicators of, for example, her status, wealth and religion.

The surveys have a clustered sample. In each of the 22 countries, 100-521 'enumeration areas' or 'census tracks' (or whatever they are called) have been selected. They cover one or a few villages or settlements, a small town, or part of a larger town or city. On average, 25 women from such an area have been included in the sample, and constitute a cluster. In total, there are 5986 clusters in the 22 countries. Aggregate education is calculated at the cluster level by summarizing over individual observations within this cluster. Some other cluster-level indicators are also constructed.

Hazard regression models

Discrete-time hazard regression models for the two years before the survey are estimated. This limit is not critical. For example, a four-year observation period gave almost exactly the same estimates.

Each woman contributes a series of three-month observation intervals. Tests showed this to be a sufficiently short interval. In the first-birth models, follow-up starts at age 14 or two years before the survey, whichever came latest. After first birth, multi-episode models for the transition into a higher parity level are estimated, with observations running from the time of first birth or from two years before the survey. (Such a 'piecemeal' approach has been criticized by e.g. Heckman and Walker (1990), but a more advanced simultaneous modeling that includes unobservables correlated over parity transitions is left to future studies).

Generally, one should be careful to include indicators of attitudes and characteristics at interview in such models. This is because they may be different from those earlier in the two-year period, and, even more critically, they may partly be a response to births. Fortunately, educational level is not a very problematic variable. In principle, the relatively low fertility that is found during the two preceding years among, for example, women who reported at interview that they had taken some secondary education, does not only reflect a causal effect of such factors as the skills obtained at secondary school. It may also reflect that pregnancy or childbirth among those with less education have inhibited their entry into or continuation of secondary school. However, only estimates from first-birth models suffer from such a simultaneity bias, and only at certain ages and for certain educational levels. For example, the estimated effects of a short secondary education will be biased only for early teenage years, when attending the first part of secondary school is still an option. Primary education takes place too early to be influenced by childbearing, and higher-order birth models are not hampered by such problems, because, at this stage, few women would take further education anyway. It was experimented with models where both enrollment and educational level (lagged one year) were included as time-varying variables, on the basis of an assumption that school attendance is continuous from age 6, with no repetition. This gave slightly weaker effects of secondary education, but otherwise the same estimates.

An account of the weighting procedure and a discussion of the need to include a community-level random term can be found in Appendix 1.

Definition of education

Five categories are defined for women's individual education, according to the number of years completed: i) no education or an incomplete primary education lasting less than 3 years, ii) incomplete primary education of longer length (3-6 years), iii) complete primary education or incomplete secondary education of less than 2 years (i.e. 7-8 years in total), iv) 2-3 years of secondary education (i.e. 9-10 years in total), and v) secondary education of 4 or more years (i.e. 11+ years in total).[4]

The main measure of aggregate education is the average number of years at school among women of reproductive age in the cluster. (When the woman in focus was excluded, the estimates were not perceptibly different).

In addition, some models are estimated for women in clusters where at least one woman had three or more years of education (about 90 percent of the total sample). These models include both the proportion of women with at least three years of education and the average level within this group. (Separation of effects is not difficult, given the size of the data and a correlation of only about 0.6).

These aggregate measures of education are obviously linked with the average age of the women in the cluster, but inclusion of such an age variable turned out to be completely unimportant for the estimates.

The impact of leaving aggregate education out of the model

When models for individual fertility are estimated (from surveys, registers or census data) with the intention of assessing the impact of education, aggregate education is hardly ever considered. This can be a serious misspecification. When only individual education is included in the model, part of the aggregate effect is captured, but not the entire. An empirical example of this will be given below. It is also easy to show mathematically for a simple linear regression model (see Appendix 2), but not for a hazard regression model.

Also the consequences of including aggregate education exclusively are addressed in Appendix 2 and below.

Controls for determinants of education

A number of factors are likely to influence both education and fertility, and should therefore be included as control variables. The urban/rural character of the place of residence is one such variable. The more advanced economy in cities requires an educated work force and allows investments, and educational returns to these investments may be high because of the higher population density. More precisely, having grown up in an urban area may have influenced the woman's educational level, as well as that of other women who lived there. Besides, the degree of urbanization in the community where she lived at interview must have had a bearing on the general educational level there, which may also be of importance for her behavior. The Zimbabwean study referred above clearly showed that it was very important to control for urbanization, and that the results were sensitive to the choice of urban-rural variable (Kravdal 2000). In this study, it is the urban/rural character of place where the woman lived at interview that is used. This is the variable that had the most pronounced impact in the Zimbabwean study.

One cannot completely rule out the possibility of a reverse relationship. As pointed out above, the aggregate level of schooling may fuel urbanization in the long run. Similarly, a woman's own education may make migration to a city more attractive to her (see further discussion below). If these effects are of any quantitative importance, it means that the total effects of investments in education are more strongly negative than indicated by the estimates shown here (given the signs of the urbanization and education effects, and the positive education-urbanization correlation).

Religion is probably quite stable over a person's life and more likely to influence than be influenced by education, although the latter is not completely implausible. However, model experimentation showed that its inclusion was without importance for education effect estimates.

The causal position of other variables available in the data is more diffuse. The woman's own wealth and autonomy, as reported at interview, may be among the consequences of her education, and also be linked with factors that have determined her education, such as e.g. the economic resources of her family of origin and their attitudes to women. Besides, they may have been influenced by fertility during the two previous years. These variables have therefore not been included at the individual level.

Inclusion of corresponding aggregate-level variables is less problematic. The causal position vis-a-vis aggregate education is, of course, just as ambiguous. However, these factors are at least not the result of the woman's own education, and, more importantly, they are not the result of her fertility (disregarding migration, as briefly discussed below).

Two of the aggregate-level variables included in the models are rough indicators of women's status in the community: Proportion of women who report boy preferences (ideal number of sons larger than ideal number of daughters), and proportion of working women who do not participate in decisions about how to spend the money they earn. The following are indicators of wealth and economic modernization: The proportion who have electricity, the average score on a wealth indicator (0-2 depending on possession of some consumer items), and the proportion of husbands who work in the agricultural sector. In addition, there are three religiosity indicators: proportion who are Muslim, proportion with a traditional religion, and proportion who are neither Christian, Muslim nor traditionalists.

Besides, country is included to capture various characteristics at the national level that may have a bearing on both fertility and education.

Migration as a complicating factor

The aggregate variables considered in this study refer to the place where the woman lived at interview. This is particularly problematic if (lack of) migration is partly determined by an expected or actual birth. For example, some people may remain in a rural or poorly developed area if they have a child, perhaps to be in close contact with kin. In principle, this could be handled by a simultaneous modeling of fertility and migration, but the data do not contain sufficient information for this.

Moreover, the effects of aggregate education, net of individual education, are not only confounded by unobserved aggregate characteristics, but also by unobserved individual characteristics, because of selective migration. For example, poorly educated women who have moved to a place where the general educational level is high may be different from the poorly educated who have remained in a place where few are educated.

Simulations

Monte Carlo simulations are performed to see how changes in the educational distribution affect total fertility. Birth histories are generated for 50000 women in a given educational category. This was experimentally proved to be a sufficiently large simulation sample. Starting at age 14, a 3-month birth log odd, easily transformed into a probability, is predicted for each woman every third month on the basis of characteristics at the beginning of the three-month interval and model estimates. A birth is ascribed to the woman within the interval if a random number with a uniform distribution over [0,1] is less than the calculated probability. The average number of births before age 45 in this sample is the simulated education-specific total fertility (for simplicity, also shorter terms for this are used below). When this is done for all five educational categories, an average simulated total fertility can be calculated. (See below for further details)

Results

Main effects of individual and aggregate education

According to a model that includes only age, individual education and country, a woman's education strongly reduces her first-birth rate (Model 1, Panel A, Table 1). This effect is considerably weaker when urbanization is included (Model 2).

Increases in the average educational level are found to push fertility down, net of individual education and urbanization: An additional year reduces first-birth log odds by 0.064 (Model 4). Besides, the inclusion of this variable reduces the effect of individual education. Stated differently, the effect of individual education in a simpler model captures part of the aggregate effect (but, as show below, not the entire).

Without control for urbanization, the aggregate effect is, of course, stronger (Model 3).

(Table 1 about here)

Similar patterns, but generally weaker education effects, are seen for higher-order births (Panel B). The exception is that a few years of education does not reduce fertility when aggregate education is included.

These effects of community education are markedly different from those estimated for Zimbabwe, where inclusion of the same urbanization variable as here completely eliminated the aggregate effects (Kravdal, 2000). One reason for this is that the Zimbabwean study was based on aggregate census data for 70 districts rather than DHS-based aggregate measures for 230 clusters. Effects at that level may be weaker, for example because of longer average distance to the influential 'others'. This idea is supported empirically. When a separate analysis was done with the Zimbabwean data and it was aggregated up to the district level (identified on request by Central Bureau of Statistics, Harare), using DHS data exclusively, the effects of aggregate education reported by Kravdal (2000) were nicely replicated (not shown). When it was aggregated up to the cluster level, however, average education had an almost significant negative effect on first births, whereas there were no indications of an effect for higher-order births (not shown). Unfortunately, it would be very time-consuming to get an identification of the equivalent of the Zimbabwean district for all countries. As a simpler check, a measure of average education in provinces (of which there are nine in each country on average) was instead included in a model for all 22 countries pooled. The effects were about half the size of those estimated for cluster-level education, although clearly significant. This lends further support to the idea that effects are stronger at a lower level.

The differences that remain when the same statistical approach is used are not easily explained. Country-specific analyses revealed a lack of significant effects for both first-and higher–order births in only a few other countries than Zimbabwe, and they have apparently little in common. For Zimbabwe (but not all of the others), one might suspect a relatively weak effect of an additional year of aggregate education because the level is already generally high. However, such a pattern does not appear in the data. Whereas the first-birth log odds decline sharply with increasing aggregate education at very low levels, and display an irregular pattern at high levels, the higher-order birth rates are more negatively influenced by average education at high than at low levels (Panel A, Table 2).[5]

(Table 2 about here)

In light of Caldwell's hypothesis, it is interesting to see significant effects of both breadth and depth of education, for first – as well as higher-order births (Panel B, Table 2).

Macro-micro interactions

Significant macro-micro interaction effects are found (Panel C, Table 2). For first births, a higher general level of education has the sharpest depressing effect among women who themselves have less than three years of schooling. The pattern at higher educational levels is not clear, except that the weakest impact of average education is estimated for those with at least four years of secondary education. However, the effect is significant even at that level (not shown).

The opposite is found for higher-order births: The effect of aggregate education is sharpest for women with 2-3 years of secondary education, and weakest for those with less than three years of primary education.

It can be shown by simulation that the interaction effects for higher-order births dominate. As a conclusion, an additional year of aggregate education reduces total fertility regardless of the woman's own education, but less markedly so for the poorly educated. Conversely, her own education generally exerts a monotonic negative effect, except at the lowest level of aggregate education. For example, when the average is less than one year, the higher-order birth rate is higher for women with 3-6 years of education than for the less educated, and this is not fully offset by the lower first-birth rate.

Inclusion of other aggregate variables

When aggregate indicators of wealth, economic modernization, religion and women's status are included, the effect of average education on first-birth rates is reduced to less than half its size in the simpler models (Table 1, Model 6). The effect on higher-order birth rates is reduced by 1/5. As pointed out above, these variables may, to some extent, be considered causally prior to education. The interpretation is then that the existence of many educated women in the neighborhood is the result of community characteristics that would have reduced fertility anyway, and that the true impact of investments in education (through the aggregate-level effect) is weaker than indicated in the simpler model. If additional indicators of these factors, or indicators of other potential sources of spuriousness, had been available, even weaker effects of aggregate education might have been estimated. On the other hand, the opposite causality is also possible, in which case part of the total effect of aggregate education will be tapped out by including such variables.

Implications for total fertility

The impact on total fertility of an educational expansion, according to different models, is assessed by comparing simulated total fertility in one sub-population with that in another where the educational distribution is different. For each sub-population, simulated total fertility is the weighted average of the simulated education-specific total fertility for the five educational categories, with weights equal to the proportions of women in these five categories.

The simulations are based on predicted birth log odds. Such predictions (for any level of the other variables) can be made, for example, for urban areas in a particular country by setting the corresponding country dummy and the urbanization dummy to 1. However, fertility measures that can be considered reasonably representative of the entire region are preferred, so the country dummies are set to the proportions living in the respective countries (according to population statistics), and the urbanization dummy is set to the proportion living in urban areas (according to a summation over the DHS surveys). This is not a critical choice. If other values had been chosen, all log odds would simply have been higher or lower by an additive constant. The patterns of educational differences, which are of interest here, would have been the same.

As a first illustration of the differences between models with and without aggregate education, fertility is simulated as described above for three populations which have the educational distribution observed for i) these 22 countries on average, ii) Kenya, or iii) Chad. These two countries have the highest and lowest average educational level among the 22 countries (6.9 and 0.8 years, respectively, whereas the 22-country average is 3.8).

When aggregate education is left out of the models (Model 2, Table 1), the simulated education-specific total fertility is 6.04, 5.79, 5.23, 4.22 and 3.36, for the five categories, which gives an average of 5.55 when the 22-country distribution is used.[6] Using instead the educational distribution for Kenya reduces fertility to 5.03.

When aggregate education is included (Model 4, Table 1), almost the same fertility (5.53) is, of course, simulated as a 22-country average. However, the levels simulated for the different educational groups (5.85, 5.83, 5.37, 4.50 and 3.69) differ less. If a new average is calculated from these education-specific levels with the Kenyan educational distribution as weights, total fertility becomes only 0.38 lower. However, when it is taken into account that the average length of education is higher in Kenya, fertility in all educational categories is reduced (to 5.21, 5.18, 4.75, 3.90, and 3.15), and average fertility thus becomes 1.00 lower.

To summarize, an expansion of overall education in the 22 countries up to the current level in Kenya would reduce average total fertility in the region by 0.52 according to a model where only individual education is included (along with some obvious control variables). According to a model where also the community average is included, the drop in total fertility would be 1.00, of which 0.38 is a purely individual effect.

This also illustrates that a relatively small part of the aggregate effect is picked up by the individual-level variable in the simplest model.

Similarly, in a hypothetical situation where education in the 22 countries is reduced to the level in Chad, fertility would increase by 0.42 according to the simplest model, and 0.91 when aggregate education is included, of which 0.28 is the individual contribution.

A model including only the aggregate education, and not the individual, captures the entire impact of education, but of course without providing any information about the individual and aggregate contributions (Model 5, Table 1). According to simulations based on such a model, expansion to the level in Kenya would reduce fertility by 1.05, and contraction to the level in Chad would increase it by 0.93.

A more conservative assessment can be obtained by using estimates from a model where also various other structural variables are included (Model 6, Table 1). The result of this simulation is that expansion of education up to the Kenyan level would lead to a drop of 0.75 in total fertility, whereas a contraction to the level in Chad would give an increase of 0.69.

As a second illustration of the differences between the models, fertility is simulated for nine different educational distributions that correspond to average education of approximately 0, 1, 2, 3, 4, 5, 6, 7, and 8 years (see detailed account in notes to Figure 1). The simulations are done as described above, except that aggregate education (when included) is entered as a 10-category variable along with a macro-micro interaction (specified as in Table 2). The reason for this complexity is that the main effects of aggregate education were shown above to deviate somewhat from linearity, and that macro-micro interactions were found to be significant (although with patterns for first and higher-order births that to some extent are opposites).

(Figure 1 about here)

Total fertility simulated from a purely individual model declines monotonically from 6.02 to 4.93 across the nine settings, with a change that is most pronounced at the highest educational levels (see Figure 1). For example, an increase from 1 to 4 years of average education has a smaller impact (0.38) than an increase from 4 to 7 (0.62).

Almost the same pattern is seen when aggregate education and the macro-micro interaction are included, except that differences are generally more pronounced. There is no difference between 0 and 1 year of average education, but an increase from 1 to 4 years reduces fertility by 0.77, and an increase from 4 to 7 reduces it by 1.26. (If the interaction had been taken out and the aggregate effect specified as linear, total fertility would have declined also at very low levels of education, but the pattern would otherwise differ very little).

If total fertility is plotted by the proportion with at least three years of schooling, rather than the average length of education (as in Figure 1), the increasing steepness of the education-fertility curve appears somewhat clearer. There is no marked turning-point, tough. This sheds some doubt on the idea suggested by Caldwell, and recently acclaimed by Lloyd, Kaufman and Hewett (2000) on the basis of African country-level data, that there is almost a threshold, at a very high level of primary schooling, for the onset of fertility decline. Admittedly, a cross-sectional study such as this is not the perfect background for discussing possible triggers of fertility transition. However, when fertility is markedly lower in populations where, say, 60% have more than three years of education, than in populations where the corresponding proportion is 10%, it is not unlikely that the former have experienced a decline, which may have started at levels already below 60%.[7]

Summary and conclusions

Univariate tabulations of total fertility rate by the individual woman's educational level, such as those routinely produced in DHS country reports, give a poor impression of the impact that investments in education would have on fertility. One reason is that the urban background of the better-educated is not taken into account. It is shown in this study that effects of a woman's education on her first- and higher-order birth rates are considerably reduced when urbanization is included (in addition to education, age, parity, duration since last birth, and country).

On the other hand, there is good news for those who hope to see demographic effects of education: In this analysis of 22 countries in Sub-Saharan Africa, the average educational level in the community (DHS cluster) has a significant depressing effect on a woman's birth rates, above and beyond that of her own education. Such theoretically plausible spill-over effects from other people's education, which have not been seen in previous studies, more than compensate for the attenuation of effects that results from a control for urbanization.

Community education exerts an effect for the uneducated and the better-educated alike, although slightly sharper effects are seen for the latter. It is also found that both the proportion with at least three years of education and the average level within this group are of importance. The effects of individual and aggregate education may, of course, differ across this vast region, because of political, cultural, economic or other variations. However, a check of such interactions is beyond the scope of this analysis.

A simulation based on a model where aggregate education is included reveals that average fertility for the 22 countries would have been 1.00 lower if education had been expanded from the level currently observed in the region to that in Kenya. Only 0.38 of this is an individual effect. If only individual education is included in the model, some of the aggregate effect is captured, but only a quite small part. Simulations show a drop in fertility of no more than 0.52.

Inclusion of aggregate education exclusively would have given the same estimates of the total impact of expansion. This does not mean, of course, that it would be wise to aggregate up available individual data with the intention of performing a purely ecological analysis. It merely illustrates that a researcher with access only to aggregate data, for example from censuses, might be quite well equipped to trace such total effects, had it not been for the usually poorer fertility measures in such data, and often more limited number of potential control variables.

According to the most complex model, which includes both individual and aggregate education quite finely categorized, as well as an interaction (of modest importance) between them, fertility will decline monotonically as more people are offered an education. The decline is steeper at high than at low levels, but no threshold can be discerned.

An important question is whether structural factors other than urbanization can be responsible for the aggregate effects. As an attempt to check this, some indicators of economic modernization, religion and women’s general status in the community were included in the models. This reduced the aggregate effects appreciably, down to about the size of the individual effects. Because some of these indicators (and in fact also urbanization) to some extent may be consequences rather than determinants of education, one may argue that this is a conservative estimate of the total effect of education. On the other hand, there may be variations in modernization and women’s status that are not captured by the included variables. Besides, factors not considered at all (for lack of data) may be a source of spuriousness. Such factors could be the political attitudes in the area, the competence of the local government (e.g. in building schools and providing good outlets for contraception), or even certain individual characteristics (see discussion of selective migration above). In that case, the aggregate effects may just as well be smaller than suggested above.

Also individual-level effects of education may, of course, be biased because of unobserved factors (at aggregate or individual level). Therefore, even though the true effects of aggregate education may be weaker than indicated here, their importance relative to the individual effects is not necessarily less. The fact that the controls in this study are not perfect should not be taken to undermine the conclusion that community education deserves attention in future assessments of the importance of schooling for fertility decline.

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Appendix 1

Weighting

The clusters in the DHS data are assumed to be representative of the population at a higher level (e.g. province or a combination of province and rural/urban), but the distribution over these higher-level units is not as in the actual population. Weights are therefore defined in the data.

To obtain estimates that are representative of the situation in the 22 countries on the whole, the province-specific weights referred to above are in this study multiplied by country-specific weights that reflect the relative size of the country populations compared to the relative size of the country samples. However, a purely province-specific weighting gave almost the same results.

Multilevel models

Individuals in the same cluster may share some unobserved characteristics, which means that standard assumptions in regression analysis about independent observations are not reasonable. So-called multilevel models have been developed to handle these problems, and have been applied in many demographic research projects the last few years. In this study, random terms at the cluster-level were added to the constant term in a first-birth model to check the robustness of the most important estimates. More precisely, the probability p_{ij} of having a first child for individual i in cluster j is given by

$$\log (p_{ij} / (1-p_{ij})) = \boldsymbol{\beta_1} \mathbf{x_{ij}} + \boldsymbol{\beta_2} \mathbf{y_j} + u_j ,$$

where $\boldsymbol{\beta_1}$ is the effect of a vector of individual characteristics $\mathbf{x_{ij}}$, and $\boldsymbol{\beta_2}$ is the effect of cluster characteristics $\mathbf{y_j}$. The unobserved factors are represented by the random term u_j, which is assumed to be normally distributed with mean 0. The estimation was done in MLwiN (Goldstein et al 1998).

As shown in Appendix Table 1, estimates differed very little between the MLwiN model and the corresponding ordinary logistic model. The latter is therefore preferred, for practical reasons. Unfortunately, a higher-order birth model could not be estimated in MLwiN due to size constraints.

(Appendix table A1 about here)

Appendix 2

It is shown here that, when the number of births is given by a very simple linear model, the exclusion of the aggregate variable will produce an individual effect estimate that is the sum of the true individual and part of the true aggregate effect.

Assume that the number of births F_{ij} to a woman i in a district j (e.g. village or province) is given by

(1) $F_{ij} = a_0 + a_1 U_{ij} + a_2 P_j^* + e_{ij}$,

where U_{ij} is a 0/1 variable for education (e.g. less than three years of schooling vs. three or more years) and P_j^* is the proportion of women with $U_{ij} = 1$ in district j. e_{ij} is an independent normally distributed error term. According to this model, an increase in the proportion with $U_{ij} = 1$ in a district from p_1 to p_2 will increase fertility by $a_1 (p_2 - p_1) + a_2 (p_2 - p_1) = (a_1 + a_2)(p_2 - p_1)$.

Assume that a sample of size N_j is taken from each district j, and that the following model is estimated from this sample (N is the sum of all N_j) :

(2) $F_{ij} = b_0 + b_1 U_{ij} + e_{ij}$.

The least-squares estimator b_1^ for b_1 is

(3) $b_1\wedge = (\Sigma_{ij} F_{ij} \Sigma_{ij} U_{ij} - N \Sigma_{ij} (F_{ij}U_{ij}))/((\Sigma_{ij} U_{ij}) (\Sigma_{ij} U_{ij}) - N \Sigma_{ij} (U_{ij} U_{ij}))$

Assume now that, as usual, the expectation values $E\, \Sigma_{ij} e_{ij} = 0$, $E\, \Sigma_{ij} e_{ij}U_{ij} = 0$ and $E\, \Sigma_{ij} e_{ij}P_j = 0$, and that $P_j = \Sigma_i U_{ij} / N_j$ for the sample is equal to the P_j^* for the district. Using equation (1) for F, with Pj*=Pj, in the expression (3) yields

$E\, b_1\wedge = a_1 + a_2 c$,

where

$c = (\Sigma_{ij} P_j \Sigma_{ij} U_{ij} - N \Sigma_{ij} P_j U_{ij}) / (\Sigma_{ij} U_{ij} \Sigma_{ij} U_{ij} - N \Sigma_{ij} U_{ij} U_{ij}) = (\underline{P}\,\underline{P} - \underline{P}\ \underline{P}) / (\underline{P}(1-\underline{P}))$,

which means that $0 < c < 1$, unless all P_j are equal. ($\underline{P}$ and $\underline{PP}$ are the mean values, defined by $\underline{P} = \Sigma_j P_j N_j / N$ and $\underline{PP} = \Sigma_j P_j P_j N_j / N$.)

In these calculations, the following relationships have been used:

$$\Sigma_{ij} U_{ij} = \Sigma_{ij} U_{ij} U_{ij} = \Sigma_{ij} P_j = \Sigma_j N_j P_j$$
$$\Sigma_{ij} U_{ij} P_j = \Sigma_{ij} P_j P_j = \Sigma_j N_j P_j P_j$$

To conclude, the predicted response to an increase in the proportion with $U_{ij} = 1$ from p_1 to p_2, according to this purely individual model, is $(a_1 + a_2 c)(p_2 - p_1)$, which is less than the true response.

If, instead, the individual variable U is left out, the model to estimate becomes:

(4) $\quad F_{ij} = b_0 + b_2 P_j + e_{ij}$.

Calculations corresponding to those shown above, and with the same assumptions, give the result that

$$E\ b_2\text{^} = a_1 + a_2.$$

Thus, by estimating a model including aggregate education exclusively, one captures the entire response to an increase in the proportion with $U_{ij} = 1$.

If the error term had been separated into an individual-level and a district-level contribution, the conclusions would have been the same.

(To the publisher: If possible, the b_1^ and b_2^ should be printed with the ^ above b, and $\underline{P}$ and $\underline{PP}$ should be printed with the _ above P and PP).

Notes

[1] Theoretically, this income effect is relevant also in settings where children are net economic contributors in the long run, because costs at a young age must be covered (in the absence of well-functioning capital markets or fostering arrangements). However, a positive effect often fails to appear in empirical studies of any society. While a higher income may stimulate the demand for children, given quality requirements, the latter may also be sensitive to income.

[2] There may also be an effect of enrollment itself, because it signals educational goals. For example, women in secondary school may prefer not to have a child yet, because a birth would make it more difficult to complete the education, with implications not least for life-time income.

[3] However, education will not necessarily contribute to *improve* women's status. For example, it has been shown in some Asian countries that the uneducated actually may have more freedom of movement than the better-educated (e.g. Balk 1994).

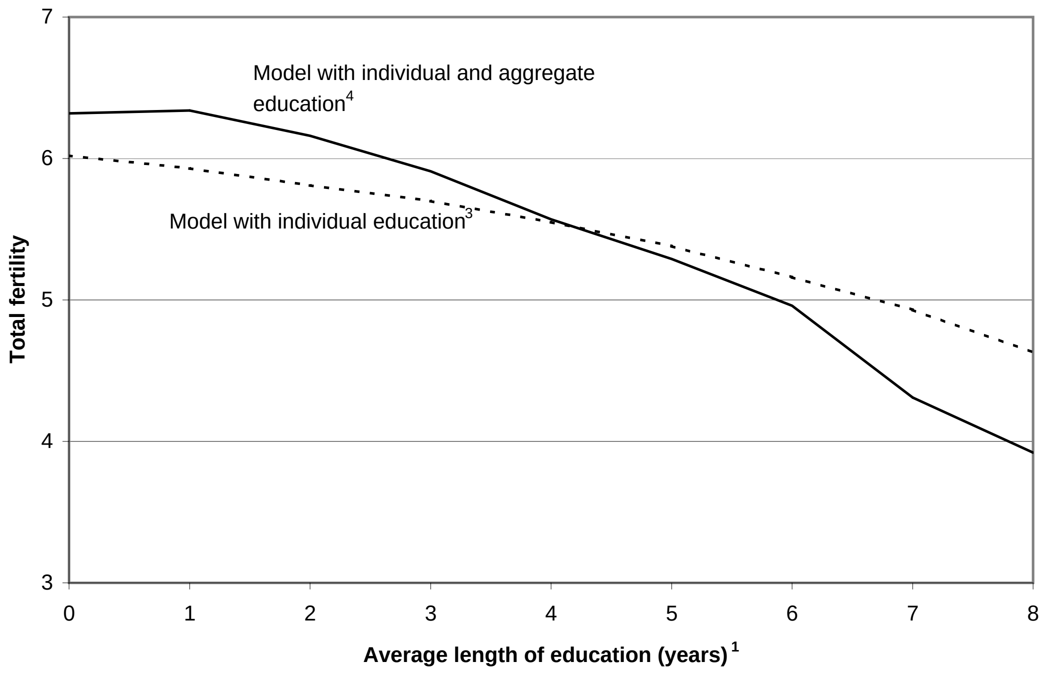
4 The three-year limit is chosen because a majority of the students are literate by then.

[5] There is a striking resemblance with the pattern in the individual effects. Perhaps a woman's higher-order birth rate is particularly high not only if she herself has a few years of primary education, but also if she lives in areas where many others have such a level of schooling, which is particularly likely to be the case if the average is quite low.

[6] This figure is, of course, not exactly equal to the average over the period total fertility rates reported in DHS country publications. The latter are based on a summation over age-specific birth rates, whereas the figure calculated here is from a more complex model.

[7] Lloyd et al. focused on teenage education, and found in a univariate analysis that increases in the proportion with four or more years of schooling had a much more inhibiting effect on fertility when a level of about 75 percent was already reached, than at lower levels (although the latter effect was not negligible). In the present study, such a marked turning point fails to appear also when the nine settings are defined according to the proportion teenagers with more than four years of education, with category limits in steps of 0.1. Moreover, when teenage aggregate education is included in the models instead of the education among women in all reproductive ages, effects are generally weaker and not particularly sharp at high levels. Thus, it does not seem that the use of adult rather than teenage education has masked a threshold effect.

Figure 1. Simulated total fertility[2], according to two different models



Notes to Figure 1

[1] The value 0 corresponds to an average education in the range [0,1), 1 corresponds to [1,2), and so forth. The educational distribution among all women in DHS clusters where the average education is [0,1), the educational distribution among all women in DHS clusters where the average education is the [1,2), and correspondingly for higher averages, up to [8,9), are as follows:

Average length (years)	0	1	2	3	4	5	6	7	8
Proportion of women with education									
0-2 years	0.943	0.748	0.586	0.442	0.319	0.217	0.142	0.084	0.053
3-6 years	0.051	0.205	0.297	0.352	0.368	0.335	0.276	0.224	0.167
7-8 years	0.004	0.031	0.079	0.140	0.207	0.291	0.330	0.332	0.271
9-10 years	0.002	0.014	0.027	0.047	0.072	0.099	0.152	0.200	0.246
11- years	0.000	0.003	0.011	0.020	0.035	0.058	0.099	0.160	0.262

[2] Average number of births during reproductive ages is simulated for 50000 women in each of the 5 educational categories. In the predictions of birth log odds, average education is not set to 0,1, …8, but 0.5, 1.5…, 8.5. To obtain figures representative for the 22 countries, the country dummies are set to the proportions living in the respective countries, and the urbanization dummy is set to the proportion living in urban areas. (See text for further comments on this.) 'Simulated total fertility' is the weighted average of these 5 education-specific averages, with the educational distributions shown in note 1 as weights.
[3] The model includes age, duration since last previous birth (not for first birth), parity (not for first birth), urbanization , country, and individual education, with the same categories as described in Table 1.
[4] The model includes the same variables as described in note 3, plus aggregate education and an interaction between individual and aggregate education as described in Table 2.

Table 1. Estimates (log odds) from discrete-time hazard models for first- and higher-order births based on DHS data for 22 countries in Sub-Saharan Africa for the 1990s.

PANEL A: First births[1]

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
WOMAN'S EDUCATION						
0-2 years[2]	0	0	0	0		0
3-6 years	-0.22***	-0.16***	-0.10***	-0.09***		-0.09***
7-8 years	-0.38***	-0.29***	-0.18***	-0.18***		-0.17***
9-10 years	-0.78***	-0.65***	-0.51***	-0.50***		-0.49***
11- years	-1.14***	-0.96***	-0.81***	-0.79***		-0.77***
URBAN VS. RURAL		-0.32***		-0.18***	-0.21***	-0.01
AVERAGE LENGTH OF EDUCATION (years)			-0.085***	-0.064***	-0.107***	-0.024***
PROPORTION WITH BOY PREFERENCES						-0.04
PROPORTION OF WORKING WOMEN NOT DECIDING OVER MONEY THEY EARN						0.04
AVERAGE SCORE ON WEALTH INDICATOR (0-2)						0.08***
PROPORTION WHO HAVE ELECTRICITY						-0.44***
PROPORTION OF MARRIED WOMEN WITH HUSBAND IN AGRICULTURE						0.23***
PROPORTION MUSLIM						0.10**
PROPORTION OTHER RELIGION OR NO RELIGION						0.34***
PROPORTION TRADITIONAL RELIGION						0.01

PANEL B : Higher-order births[3]

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
WOMAN'S EDUCATION						
0-2 years[2]	0	0	0	0		0
3-6 years	-0.05***	-0.01	0.03*	0.02		0.02
7-8 years	-0.16***	-0.10***	-0.05***	-0.05***		-0.05***
9-10 years	-0.33***	-0.23***	-0.17***	-0.16***		-0.15***
11- years	-0.50***	-0.37***	-0.31***	-0.29***		-0.28***
URBAN VS. RURAL		-0.27***		-0.21***	-0.22***	-0.14***
AVERAGE LENGTH OF EDUCATION (years)			-0.053***	-0.030***	-0.041***	-0.024***
PROPORTION WITH BOY PREFERENCES						0.13***
PROPORTION OF WORKING WOMEN NOT DECIDING OVER MONEY THEY EARN						0.18***
AVERAGE SCORE ON WEALTH INDICATOR (0-2)						0.09***
PROPORTION WHO HAVE ELECTRICITY						-0.21***
PROPORTION OF MARRIED WOMEN WITH HUSBAND IN AGRICULTURE						0.09***
PROPORTION MUSLIM						-0.13***
PROPORTION OTHER RELIGION OR NO RELIGION						0.03
PROPORTION TRADITIONAL RELIGION						-0.08*

---

[1] Also age (7 categories) and country (22 categories) were included in the models. Indicators for missing information were included in Model 6, but without being important for other estimates. There were 12461 first births in 415986 3-month intervals.
[2] Arbitrarily chosen reference category.
[3] Also age (7 categories), duration since last previous birth (6 categories), parity (6 categories), and country (22 categories) were included in the models. Indicators for missing information were included in Model 6, but without being important for other estimates. There were 46398 higher-order births in 935277 3-month intervals.

* significant at the 0.10 level; ** significant at the 0.05 level; *** significant at the 0.01 level

Table 2. Estimates (log odds) from discrete-time hazard models for first- and higher-order births based on DHS data for 22 countries in Sub-Saharan Africa for the 1990s.

PANEL A: Estimates from models where aggregate education is categorized

	First births[1]	Higher-order births[3]
WOMAN'S EDUCATION		
0-2 years[2]	0	0
3-6 years	-0.08***	0.00
7-8 years	-0.19***	-0.06***
9-10 years	-0.52***	-0.17***
11- years	-0.81***	-0.27***
(integer part of) AVERAGE LENGTH OF EDUCATION		
0 year	0.26***	-0.00
1 year	0.16***	0.02
2 years	0.01	0.04*
3 years[2]	0	0
4 years	-0.05	-0.04**
5 years	-0.08**	-0.07***
6 years	-0.08*	-0.11***
7 years	-0.25***	-0.18***
8 years	-0.19***	-0.24***
9 or more years	-0.38***	-0.31***

PANEL B: Estimates from models including measures of both depth and breadth of education (only for women in clusters where at least one woman had 3 or more years of education)

	First births[1]	Higher-order births[3]
WOMAN'S EDUCATION		
0-2 years[2]	0.00	0.00
3-6 years	-0.09***	0.01
7-8 years	-0.16***	-0.06***
9-10 years	-0.49***	-0.17***
11- years	-0.78***	-0.29***
PROPORTION OF WOMEN WITH 3 OR MORE YEARS OF EDUCATION	-0.27***	-0.12***
AVERAGE LENGTH OF EDUCATION AMONG WOMEN WITH 3 OR MORE YEARS OF EDUCATION (years)	-0.065***	-0.025***

PANEL C: Estimates from models including an interaction between individual and aggregate education.

	First births[1]	Higher-order births[3]
WOMAN'S EDUCATION		
0-2 years [2]	0	0
3-6 years	-0.06*	-0.01
7-8 years	-0.15***	-0.06***
9-10 years	-0.48***	-0.12***
11- years	-0.83***	-0.27***
AVERAGE LENGTH OF EDUCATION (years)	-0.082***	-0.013***
INTERACTION: WOMAN'S EDUCATION * AVERAGE LENGTH OF EDUCATION (years) – 4		
0-2 years * (average – 4)	0	0
3-6 years * (average – 4)	0.026**	-0.023***
7-8 years * (average – 4)	0.021	-0.034***
9-10 years * (average – 4)	0.027*	-0.049***
11- years * (average – 4)	0.039**	-0.032***

[1] Also age (7 categories), urbanization, and country (22 categories) were included in the models.
[2] Arbitrarily chosen reference category.
[3] Also age (7 categories), duration since last previous birth (6 categories), parity (6 categories), urbanization, and country (22 categories) were included in the models.

* significant at the 0.10 level; ** significant at the 0.05 level; *** significant at the 0.01 level

Appendix Table 1. Estimates (log odds), with standard errors, from discrete-time hazard models for first births based on DHS data for 22 countries in Sub-Saharan Africa for the 1990s [1]

	2-level model estimated in MLwiN with a 1st order MQL algorithm[3]		Ordinary logistic model estimated in SAS	
	Estimate	Standard error	Estimate	Standard error
WOMAN'S EDUCATION				
0-2 years[2]	0		0	
3-6 years	-0.096	(0.026)	-0.094	(0.026)
7-8 years	-0.181	(0.031)	-0.181	(0.031)
9-10 years	-0.516	(0.043)	-0.504	(0.042)
11- years	-0.795	(0.046)	-0.790	(0.046)
AVERAGE LENGTH OF EDUCATION (years)	-0.067	(0.0065)	-0.064	(0.0060)
URBAN VS. RURAL	-0.175	(0.031)	-0.180	(0.026)
VARIANCE AT THE CLUSTER LEVEL	0.036	(0.006)		

[1] Also age and country were included, as described in Table 1.
[2] Arbitrarily chosen reference category
[3] Very similar results were obtained with 2nd order PQL algorithm.