The Senegalese Experience:
Rethinking Fertility Theory for Highly Religious Societies

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Abstract

Despite improvements, traditional fertility theory still remains unprepared to cope with developing countries, such as Senegal, where deep religious beliefs dictate a passive acceptance of natural fertility. Because of an unwillingness to use modern contraception, factors that can reduce fertility in these societies will be primarily factors that influence natural fertility. Particularly, my study finds that age at first marriage, cultural taboos against sex while breastfeeding, living with extended families, and extended periods of breastfeeding can all reduce family size. Education is found to increase fertility at low levels because it increases fecundity, but reduce fertility at higher levels. It also acts through a multitude of indirect pathways, clearly modeled for the first time in this paper.

I. Introduction

Sub-Saharan Africa has long been the locus of the debate over population policy. The debate has swung back and forth between the question of the best way to control population growth to whether curbing population growth should be a goal at all. At the close of the last century, most theorists had settled on the conclusion that while a decrease in population growth often came with development, reduced population growth was not necessarily a precursor or determinant of development. The recent development and refinement of the "convergence model" of demographic effects on growth shows that excess population may have some effect on the rate of productivity gains (see Kelley and Schmidt 2004), but there is little direct correlation between population growth rate overall and GDP growth. Rather, lower population growth can be seen as one component in a system of "virtuous circles" (Birdsall and Sinding 2001) that reinforce one another. Development leads to better education, which leads to lower fertility, which leads to higher productivity, which strengthens gains in development.

But whether one accepts or rejects the idea that population affects growth, it seems clear that for some families and in some areas, excess fertility constrains resources and has negative effects on welfare. Returning to the macro view, we can see that at the core of the questions over population is really a question about development and well-being. When the policy question of decreasing population growth arises, the real question is, "How can we increase our country's development and the well-being of our people by curbing population growth?" Countries that enact some kind of population policy are implicitly accepting the idea that development and well-being can be increased

by population growth reduction. But if the aim is increased welfare, focusing solely on macro population reduction may not be the most efficient strategy.

To meet its aims of increasing well-being, it seems that the true direction that population research should take is targeted population growth reduction in areas where large family size impedes development or strains resources. Taking this one level further, the true goal is not population reduction, but family-size reduction for families unable to support large numbers of children. If population targets are met because the well-off reduce their family sizes further while the poorest members of society continue to have insupportably large family sizes, a policy can hardly be considered a success. The policies that enact targeted change in family sizes among disadvantaged populations may be very different from the policies that are expected to curb population overall, and will certainly involve a careful reexamining of many of the assumptions about limiting population growth.

Senegal makes an ideal case study to examine these factors because it is a society in which high fertility has been largely unaffected by the family planning programs implemented over the past quarter century. The problem is that the policies currently in place to reduce fertility focus solely on the education about and provision of modern contraception, a program that ignores Senegal's specific religious and cultural factors in favor of a one-size-fits-all solution.

There is already a broad literature on fertility reduction, but when it comes to the developing world, this literature is deficient in a number of ways. Much of the literature relies on the assumption that people in the developing world want fewer children, but are unable to meet these targets due to lack of information about contraception. However, in

many developing countries desired fertility is actually higher than natural fertility, and contraception use is not adopted despite widespread knowledge. This has led researchers such as Richard Easterlin (1978) and Kelley (1982) to conclude that these societies are actually *supply constrained*, and therefore not seeking to limit family size. However, even the literature that acknowledges that families in developing countries are not simply unaware of or unable to access contraception, but are rather consciously declining to use it, subscribes to a narrow explanation of this behavior. As Pritchett (1994) asserts, "To a striking extent the answer to why actual fertility differs across countries is that desired fertility differs. In countries where fertility is high, women want more children." However, this perspective is at odds with the plethora of evidence that in many highly religious developing countries, women express that family size should be left for God to decide. Because so many women in many developing countries do not claim agency over family size, attributing large family sizes to large family aspirations is an incomplete picture of complex cultural realities.

While the modeling techniques appropriate for a supply-constrained framework may function similarly well for women who do not claim agency over family size—in both situations actual fertility is expected to equal natural fertility—the implications will be markedly different. Women who do not use contraception because of large family-size aspirations could be persuaded to lower their family-size targets and adopt modern contraception if their opportunity cost increased, if they better understood the costs of child-rearing, or if they were made aware of alternative sources of satisfaction. On the other hand, women who steadfastly refuse to "tamper" with natural fertility because of religious reasons will not be affected by such initiatives. Rather, for these women what

needs to be examined are the factors that impact natural fertility, such as marriage duration.

A refusal to adopt family planning methods does not mean that family size and indeed population growth cannot be reduced as development progresses. What it means is that researchers must come up with new ideas for how to approach fertility in a framework without consciously demanded family size targets. By focusing on the determinants of natural fertility, such as marriage duration and frequency of intercourse, and in turn their determinants, such as age at first marriage and living situation, it is possibly to identify avenues through which fertility can be impacted without conscious agency over family size ever being expressed.

Thus, this paper fills a gap created by the prevailing notion in the literature that women who bear many children must either be uninformed about contraception or seeking large family sizes. For many women in highly religious countries such as Senegal, neither framework is entirely appropriate. Rather, many women do not express conscious agency over family size and therefore experience actual fertility equal to natural fertility. My research, therefore, looks for factors that can reduce family size without agency and factors that may spur women to develop agency over family size. I use modeling techniques similar to earlier research, but focus on interpreting my results for women who do not claim agency over family size. My analysis has two components. First, I select a set of factors from the literature that may reduce family size in ways that do not require women to exercise conscious agency over family size. I then examine how the policy of increased female education, occasionally proposed as an alternative to

traditional family planning programs, may affect each of these variables and, in turn, overall fertility.

To examine and test these ideas, I break down the determinants of fertility in Senegal, a highly religious, high fertility society. Senegal, a former French territory, is 94% Muslim.[1] Despite widespread knowledge of contraception methods, few residents have adopted its use. Instead, 20% of Senegalese women surveyed by the 1997 Demographic and Health Surveys expressed a nonnumeric preference for family size, for example saying that it should be left "up to God."

Because most women in Senegal do not claim agency over family size, policies that continue to promote the use of contraception will likely have a minimal effect. Moreover, while these programs may lower population overall, in countries where religion is a strong factor, it is unlikely to reduce the family sizes of the households that need it most—poor, rural families who also tend to have the strongest religious beliefs.

Therefore, my study models fertility in Senegal with the specific goal of breaking down inputs into factors that require agency over family size (such as the use of contraception) and those that do not (such as age at first marriage). I also improve on previous literature by paying special attention to how female education affects women who do and do not claim conscious agency over family size. Few researchers have specifically broken down the effects of education into its components that require agency and those that do not. For women who do have specific fertility goals, education can affect actual fertility by altering opportunity cost and awareness of alternative sources of satisfaction, lowering family size goals and potentially spurring family planning. For women who lack his agency, however, education must be thought of in terms of its

[1] All background statistics on Senegal are from the CIA's World Fact Book online, unless otherwise noted.

effects on cultural norms that impact natural fertility. The four main factors that are expected to impact fertility without conscious agency are age at first marriage, duration of breastfeeding, cultural taboos regarding sexual practices, and living arrangements. All four affect exposure to pregnancy, and thus natural fertility. Depending on education's effects on these four variables and other factors that influence natural fertility, education may increase or decrease actual fertility for women who do not express agency. To help sort out the myriad effects of education on women acting within different fertility frameworks, I develop a new model that explicitly sorts the effects of education those whose impacts require women exercising conscious agency over family size and those whose impacts do not.

My findings are that later age at first marriage, longer duration of breastfeeding, abstaining from sex while breastfeeding (a cultural taboo), and living with extended families all decrease fertility. Policies that can affect these variables may, therefore, be able to curb Senegal's high fertility without requiring the use of modern contraception, or even conscious family planning. As for education, the net effect is ambiguous: Primary education appears to *increase* fertility, while secondary and higher education reduces it. This increasing effect of primary education is found to be strongest in rural areas. However, when a measure of natural ability to supply children, or fecundity, is controlled for, the effect largely disappears. This leads me to conclude that the increasing effect of primary education is largely because it increases health, and thus fecundity. Primary education may also increase fertility in rural areas due to its decreasing effect on breastfeeding, which naturally delays pregnancy. Contrary to expectations, however, education does not reduce adherence to cultural taboos against sex while breastfeeding,

and actually increases instances of living with extended families. Moreover, education is found to increase age at first marriage, which in turn leads to lower family sizes.

To summarize, my paper will improve on earlier work by acknowledging that, in certain societies, women may choose not to interfere with natural fertility for religious reasons. However, my case study of Senegal suggests that fertility can still be reduced in these societies by attempting to influence factors that affect natural fertility, such as age at first marriage. Education may be a key policy to enact some of these changes, although it also carries the unintended consequence of increasing fertility due to increased health. On net, however, education appears to be a positive policy alternative to misdirected and ineffective family planning programs.

Section II of my paper will be a brief overview of fertility theory, with special attention to its deficiencies when it comes to highly religious countries. It also explains the evidence that Senegal is operating in a framework where family size decisions are not made consciously, and therefore will not be—and have not been—affected by family planning programs. Section III will review some of the models for fertility that have been developed over the past thirty years, and highlight which features of these models fit the Senegalese framework. It also includes a special focus on the complex ways education is expected to interact with fertility. Section IV reviews the data used in this study, the 1997 Demographic and Health Survey for Senegal, and specifies my dependent and independent variables. Section V reports the results of my analysis in two sections: one that explores the proximate determinants of fertility and one that explores education's effects on these factors. Section VI concludes my paper by offering suggestions for future research and policy implications of my findings.

II. Literature Review

Fertility theory and its limitations

The literature on fertility and family planning is immense, but incomplete. While the literature has done an excellent job of explaining behavior in countries where family planning programs have been implemented successfully and resulted in large reductions in family size (See Bongaarts 1994, Mauldin and Ross 1991, and Bongaarts et al. 1990), it has been drastically less successful in explaining or even approaching the anomalous cases where family planning programs fail, usually in low-income, highly religious countries. By undertaking a brief review of fertility theory, this section will outline why the current paradigm remains unprepared to cope with fertility behavior in highly religious countries.

The two principal schools of fertility theory are the Easterlin and Becker camps. However, as Sanderson (1976) points out, since the mid-seventies the two once opposed sides have moved closer together, both producing a model for fertility that cannot explain behavior in countries such as Senegal. The history of the dueling and then converging economic literature on fertility began in 1960, when Gary Becker proposed a radical idea: Perhaps people chose the number of children they would have in the same way they set other consumption targets, such as pizza consumption. Unlike with pizza, the supply constraint was internal; a woman could only bear so many children in her lifetime. Yet the underlying tenet of the model was that a household would want to consume less children than it could naturally supply, because each additional child took resources away from other goods. Child consumption, therefore, was expected to be a function of income.

It became clear almost immediately that such a model was drastically out of step with actual fertility behavior. Blake (1968) presented one of the first critiques, pointing out that most empirical evidence did not support Becker's theory. In fact, as income rises, fertility tends to decrease. Poor families and families in poor areas "consume" many more children than wealthy families in developed countries. Blake suggested several reasons why the Becker model did not fit, arguing among other things that, unlike with cars, as income rises so does the opportunity cost of consuming children, as they take time away from work, especially for the mother. Several modifications to Becker's initial model have brought it closer to being able to explain fertility behavior in the developing world, but countries in which there are no clear family size aspirations still present a challenge to models based around explicit demand for children.

Richard Easterlin (1966) made the first refinement by suggesting that fertility behavior was dependent not only on household income, but on the ratio of one generation's income to that of the previous generation. In other words, a wealthy couple might not consume more children than a poor couple because in comparison to the previous generation, the wealthy couple was not *relatively wealthy*. This led to the development of the notion in both camps that parents have aspirations not just for the quantity of their children, but for their *quality* as well (i.e., whether the child can attend school). Becker and Lewis (1973) proposed that parents make tradeoffs between child quantity and child quality, and that wealthy parents choose quality in lieu of quantity. For his part, Easterlin (1976) proposed that parents wished to give their children as much wealth as their parents had given them. Through varying avenues, both authors

concluded that the observed income-fertility relationship should not be expected to be positive.[2]

Other authors suggested that people may have children in developing countries for reasons other than consumption, including production value (such as farm labor, as in Espenshade 1977) and investment value (the provision of financial security in old age, as in Nugent 1985). Overall, the literature points to at best a *belief* on the part of poor families that they will be increasing their consumption opportunities now or at some future point by having an additional child. In reality, according to the generalized literature, a child does not usually start being of positive net value until well into his or her teens, and overall additional children decrease parental consumption possibilities (Espenshade 1977).

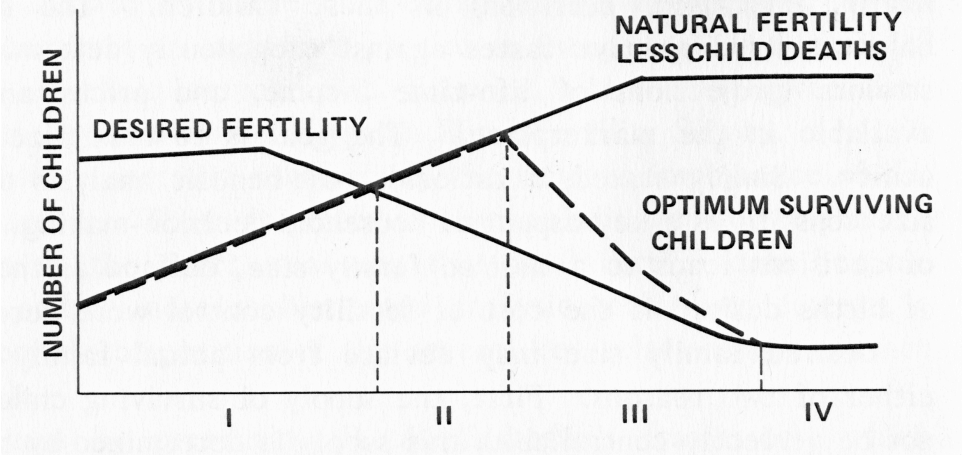
A second strand of fertility literature departs from trying to model *why* households make given consumption decisions regarding family size and begins to develop a model for what factors influence this decision, and then what factors affect the household's ability to meet this target. This is commonly referred to as the "supply-demand" model of fertility, because it is concerned both with natural supply of children and how many are actually desired by a household. While this new model, developed first by Easterlin in 1978, provides some valuable tools for analyzing fertility, it still leaves unquestioned the primary assumption that fertility is a function of explicit demand and natural supply. *Whether* people make specific choices over the size of their family is left largely unexamined by the literature. Nonetheless, a review of Easterlin's model is still instructive for this analysis in several ways.

[2] For a clear treatment of these developments, see Sanderson (1976).

Easterlin's model is useful because it allows for the possibility of dividing fertility into two distinct categories: fertility decisions when natural fertility is below desired fertility, and decisions when fertility is above desired fertility. The Easterlin model breaks down fertility into factors determining demand for children and factors determining supply. As development progresses, family size targets are expected to decrease, creating a gap between natural supply and the now-lower demand, which contraception is used to fill. On the other end of the spectrum are women whose natural fertility is actually lower than their family-size target, resulting in a supply constraint. Under the supply-constrained model, women do not seek to limit family size in any way, and therefore do not use birth control. This new model helps to explain away the fertility behavior in countries where children are tied to social status, have significant production value, and may have investment value—families in these areas seek more children than they can naturally supply, and therefore do not engage in family planning.

The graph below illustrates this model visually, with development progressing along the x-axis. Countries where families are supply-constrained would be operating in section I of the framework below, with modern countries operating in sections III and IV.

Figure 2.1: Easterlin Supply-Demand Framework



Source: Easterlin 1978

In Easterlin's framework, demand for contraception should equal the economic cost of the natural oversupply of children, or the distance between the graph of natural fertility and desired fertility. Stage II demonstrates the lag between when desired fertility crosses below natural fertility and when fertility-reduction measures such as modern contraception are adopted. The key illustration of the above graph is that once the gap between desired and natural fertility becomes large (costly) enough, natural fertility *will* be reduced. The idea is that anyone can access contraception, because if the cost of an additional child is high enough it would be worth the cost of engaging in abstinence, for example. Therefore, the Easterlin model opened up the possibility for the first time that people don't fail to use contraception because it is too expensive or not readily available enough, but rather they deem not to use it because the net benefit of an additional child is still positive, or at least not negative enough to justify the initial cost of family planning.

Several researchers have used this framework to explain the slow adoption of modern contraception, or any form of family planning, in certain sub-Saharan African countries, notably Kelley et al. (1982) in their study of rural Egypt. Kelley et al.'s treatment is particularly instructive because they lay out three frameworks under which observed fertility could remain quite high (too high according to Western standards), even as a country develops along other metrics.

Taken directly from their work, they are:

1) Irrational behavior: family size is determined outside a framework of rational choice; the number of children is "up to God," and the number of surviving children is, thus, the by-product of sexual activity and mortality.
2) Rational behavior with overproduction: family size is determined by rational choice. Parents weigh the benefits and costs (broadly viewed) of children and attempt to attain a family size goal. However, most families exceed that goal due to lack of knowledge or the high cost or the improper use of

contraception. Large families are, therefore, explained by the presence of unplanned children.

3) Rational behavior: family size is determined by rational choice, and, while there may be some overproduction of children, large families are explained to a great extent by the relatively high benefits and low costs of children.

Kelley et al. find the third framework to be the most convincing explanation of Egyptian behavior, although all three elements likely contribute, since families are not homogeneous.

What is most instructive about this work is that Kelley uses a different assumption about the fertility framework of Egyptian women than I do for Senegal, yet models fertility using many of the same variables of interest, including age at first marriage and education. Observed behavior under the supply constrained model (the third framework, above) and the "irrational" behavior model (first framework) is expected to be almost identical—in both frameworks fertility becomes a function of factors like health, duration of marriage, and frequency of intercourse. Therefore, my modeling techniques will be very similar to Kelley's and others (including Bongaarts 1987, Kelley 1988, and Cochrane 1979) who have attempted to model fertility under a different framework. The principal difference between the frameworks, then, and where I will make my main contribution to the literature, is in the interpretation of the results. Women who are supply constrained, but still willing to plan family size, could possibly be persuaded to develop lower targets for family size, and, with sufficient family planning program effort, be persuaded to reduce fertility.[3] But under the "irrationality" framework, family size must be impacted through indirect avenues, because very few women are willing to exert control over their family sizes. Therefore, the proximate determinants of fertility, to

[3] For a discussion of these "demand-focused" family planning programs, such as counseling abut family size, see Bongaarts (1995).

borrow a phrase from Bongaarts (1987), such as age at first marriage, become critical in determining family size.

The next section will review the evidence that demonstrates many Senegalese families to be operating primarily under the "irrationality" framework, which I will henceforth refer to as the innumeracy framework.

Leaving it "up to God": Lack of agency over family size

Evidence from the past thirty years show that while Senegal has invested effort into family planning programs, modern contraception has not been adopted by the broad populace. Nonetheless, Senegal's fertility *has* declined over the same time period, indicating that alternative avenues have the potential to impact family size. The evidence shows that Senegal is not operating primarily under either the rational choice or supply-constrained framework, but rather in an environment where innumeracy over family size leads to high fertility by default.

Cultural research in Senegal reveals a society where childbearing is an ultimate value, not only a sign of social status, but a physical tribute to God. Any tampering with natural fertility, therefore, is seen by many as a rejection of gifts from God. Because of this, the theoretical literature is largely unprepared to explain the determinants of fertility in Senegal or how it might be reduced. The common thread in the theoretical literature is that, as development progresses, women develop a desire to limit family size, and then seek out a method of carrying out this desire. But to even express a desire to limit family size in Senegal is seen as going against God's will. Without a recognition of agency over fertility, there is no fertility decision to target or reduce. Therefore, policy based on the

assumption that households want to have fewer children, or have a specific number of children in mind that can be manipulated somehow, will be ineffective.

A review of the position of women in Senegalese society illustrates how many may come to believe that family size is outside their control. According to research by Kane (1972) and Boye, Hill, Isaacs, and Gordis (1991), women in Senegal experience a high degree of religious constraint and spousal pressure. As a Muslim wife, the woman is expected to both bear children (a symbol of power and wealth) and care for them. The father must provide resources for the family, but it is the wife's responsibility to account for her children's health. Thus, if the children are malnourished, the wife is held accountable. Polygamy is legal, and some sources suggest a husband might threaten a wife with a new marriage if the first wife does not bear a satisfactory number of children or care for them properly. The Senegalese marriage code has measures to protect women, but also solidifies the husband's control over women in many ways. One article allows the husband to oppose his wife's pursuing a profession. Marriages continue to be established by the male suitor offering a dowry to the bride's family, which precludes women having full agency over their choice of partner, since their families stand to benefit. Women can legally marry at age 14, though many marry earlier despite laws. Maternal deaths are common due to the young ages of mothers at first births. There is no law preventing the use of contraception, but it is widely disapproved of.

Such an atmosphere makes Senegal ill-fitted for the types of family planning programs that have had large effects elsewhere. Mauldin and Ross (1991) found that in developing countries as a whole, the availability of contraceptives could account for 72% of the variance in fertility decline from 1975 to 1990. The major weakness of their study,

however, is that it includes countries such as China where family planning is widely accepted alongside those like Senegal, where it has been all but ignored. Although the 1997 Demographic and Health Survey showed that 86% of married women in Senegal knew of some method of contraception and 79% knew of a modern method—reflecting strong programs to spread knowledge of contraception—only 13% reported they were using a method. Careful, country-based analyses reveal that, because sentiments surrounding fertility are so influenced by cultural factors, it is critical to treat countries individually when modeling effects or searching for policies. Lumping countries with drastically different cultural frameworks together results in overly simplified and ill-fitting models.

The limited use of contraception in Senegal despite widespread awareness undermines the long-held tenets of fertility researchers that contraception use is the key (and largely only) determinant of fertility decline. Robey, Rutstein, and Morris epitomize this view in their 1993 article, which holds that "differences in contraception prevalence explain about 90% of the variation in family planning rates." Even researchers such as Pritchett (1994), who have admitted that family planning programs may have limited impact in some countries, subscribe to the narrow over-supply or under-supply model. Pritchett's analysis crystallizes the problem, separating population researchers into the camp that believes a lack of contraception is the main determinant of high fertility and those who attribute it to high family-size targets (Pritchett places himself in the latter group). An examination of cultural values in Senegal, however, reveals that neither framework is appropriate. Many Senegalese women simply do not wish to choose a specific family size.

LeGrand, Koppenhave, Mondain, and Randall (2003) discovered a deep inability and unwillingness to quantify ideal family size in Senegal when they studied whether the "insurance effect" against infant mortality held in Senegal and Zimbabwe. If it held, people would be expected to have more children the higher infant mortality was, to ensure a minimum family size. If infant mortality fell, family size should, too. LeGrand et al. found that families in Senegal were, for the most part, not making fertility decisions based on a (narrowly defined) rational weighing of costs and benefits, in contrast to families in Zimbabwe.

For the insurance effect to act, households must both have specific ambitions for family size and understand and internalize how changes in infant mortality affect the ability to reach that desired family size. LeGrand et al. found the second part of this requirement to hold generally in Senegal, but not the first. The researchers concluded that the high degree of belief that God, not humans, should determine total fertility would render the insurance effect, or any conscious fertility choice, imperceptible in Senegal.

LeGrand et al. highlight that in the 1997 Demographic and Health Surveys (the dataset used for this analysis), 20% of Senegalese women gave non-numeric answers when asked for their ideal family size. These answers would be statements such as, "It's up to God," or "I have no control over that." While 20% is not a majority, it reflects a deep-seated unwillingness to quantify family size, even when asked by an authority figure. Still more women may have responded with very large numbers that were not necessarily sincere, such as 10 or 15 or, in one case, 23, as a way of satisfying the interviewer while not violating religious principles. Zimbabwe, a non-Muslim country, provides contrast, with only 2% of respondents offering non-numeric replies. Urban

Senegalese displayed more willingness to control family size, stating that they desired to leave it up to fate, but recognized that scarce resources required careful planning. Rural Senegalese, however, bristled at the suggestion that births were something to be controlled and planned for. LeGrand et al. reported their findings as follows:

> In contrast, in the Senegalese village there was little reproductive agency in terms of the deliberate control over the number of children born to a woman. There was a consensus that God alone should influence family size, with one woman saying that limiting fertility is akin to stealing lives of children God wants you to bear. The only acceptable justification for a married woman to stop childbearing was when an additional pregnancy would jeopardize her life (Randall 2001)…. To the extent that some women may have sought to limit their fertility, they attempted to do so through longer birth spacing, exaggerated claims of health problems, or terminal abstinence. Villagers were aware of modern contraception and knew that it could be obtained from a nearby dispensary at a moderate price; yet no one admitted to using it or to knowing someone who did.

The same kind of non-numeric replies and unwillingness to quantify family size has been found in other papers, including van de Walle's 1992 study of Mali and Kelley et al.'s Egypt study. However, neither paper fully deals with how family size may be controlled without women expressing agency over it. This question was outside the scope of the LeGrand paper and has not been taken up anywhere else, revealing a large deficiency in the literature.

The Le Grand study provided one additional insight into how people thought about childbearing in Senegal. Polygamy seemed to play a major role in shaping responses, with men often thinking in terms of number of wives rather than number of children. Therefore, it seems reasonable to think of a single wife's fertility as more independent of her husband's fertility aspirations than in some other scenarios. Men who desire more children could take on additional wives, reducing the cost to women of bearing a smaller number of children. Since it is largely the investment of the mother's

time that affects child welfare, a reduction in children per woman even if overall household children remained constant could still provide gains.

Because of this unwillingness to quantify family size, those gains that have been made in fertility levels have been attributed to increases in age at first marriage, rather than family planning programs. The 1997 Report from the Demographic and Health Surveys shows that fertility per woman fell from 6.7 children in 1985 to 5.7 children in the 1997 data, a sharp decline. Cohen (1998) found that while other researchers had dismissed this change as anomalous because of the lack of accompanying contraceptive use there were reasonable explanations for the decline in fertility.

The decrease in fertility could be almost entirely attributed to increases in age at first marriage. In data from 1992-93, the proportion of women age 20-24 who were married by age 20 was 59.7%, whereas 82.5% of women aged 45-49 had been married by age 20. By comparing women who have recently crossed the 20 year-old threshold with women who would have been in the same age group twenty-five years ago, Cohen essentially compared the percentage of women 20-24 who were married before age 20 in 1967 with the percentage who were married before age 20 in the 1992-3 data. While slightly less reliable (since the comparison relies on 25 year-old memories) than if a true comparison were available, Cohen's findings are powerful and show a significant trend toward later marriages. The median age at first marriage, however, remained a very young 16.2 (18.2 urban, 15.7 rural). Cohen also hypothesized that this trend had been obscured for a time because most research treated rural and urban Senegal together. While urban age at first marriage had been increasing, and fertility declining, for some time, both variables in rural areas lagged behind.

Cohen also established that age at first marriage increases with education, with those with no education having a median age of 15.8 at first marriage, those with primary education an age of 19.3, and those with secondary education an age of 23. If it holds that these women had correspondingly later first births, this may provide evidence of education decreasing fertility through later first marriages.

This finding supports the hypothesis that factors impacting natural fertility may be the more effective route to spur family-size reduction in Senegal. While Cohen demonstrated the effect of age at first marriage in a broad, macro framework, my study will examine the effects of this and other natural fertility determinants on a micro level, showing that for Senegalese women the most important determinants of actual fertility are those that affect natural fertility.

One thing is clear: the unique way people think about children in Senegal requires new ideas about fertility control separate from the family planning mindset of Western culture. This broad re-imagining of fertility control will be particularly salient for rural Senegal, where women are most likely to marry young, be illiterate, reject notions of family planning, become engaged in polygamous unions, and suffer from high levels of infant mortality and malnutrition. It is in these areas that women need family planning most, and here that it has been the hardest to implement because conclusions from greater sub-Saharan Africa are incompatible with the Senegalese experience.

In conclusion, fertility theory has evolved from its early beginnings of treating children purely as a consumption good to a more realistic model that better explains high fertility in low-income societies. However, the literature still remains unprepared to cope with societies in which family size is not consciously determined, as LeGrand et al. have

shown to be the case in Senegal. In these societies, it is critical to look to the determinants of natural fertility, such as age at first marriage, because these will largely be the factors that determine actual fertility.

III. Modeling Fertility

Micro and Macro Determinants

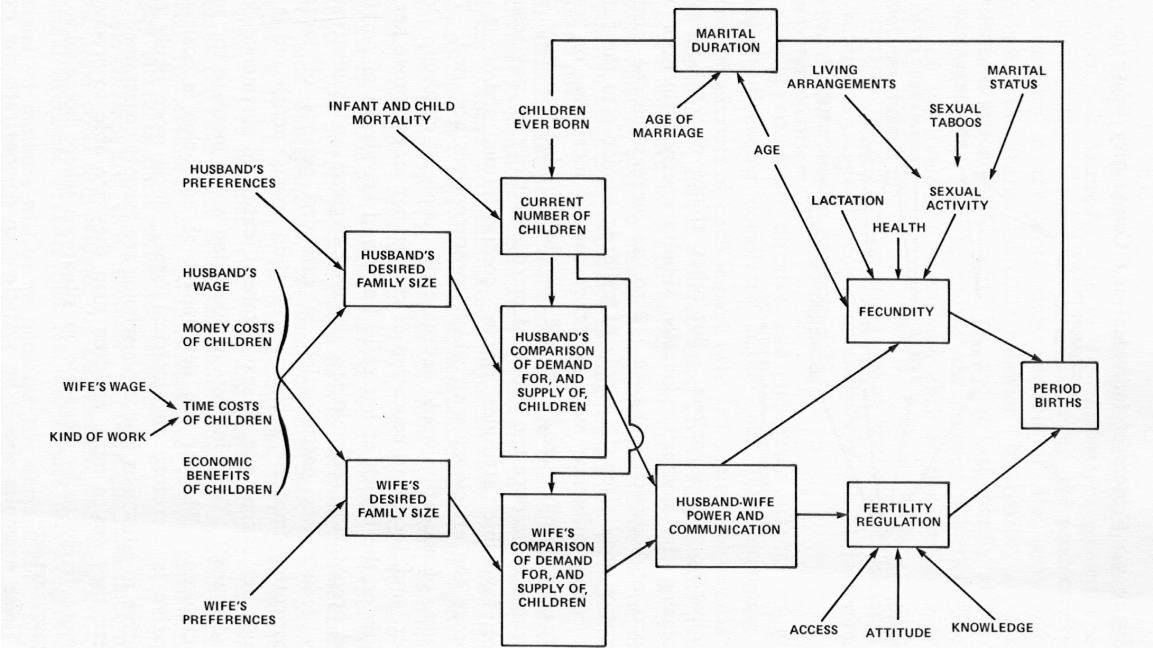
Although the evidence shows Senegalese households to be operating primarily under the innumeracy framework, the inputs we expect to determine actual fertility are largely unchanged. For this reason, earlier work done under different frameworks will inform my choice of modeling techniques.

Perhaps the most notable work in modeling fertility determinants is the 1978 Bongaarts model. Although his examination is of macro fertility, it is still informative. Bongaarts asserted that fertility is first a function of socioeconomic, cultural, and environmental variables, but that these factors do not act directly on fertility. Rather, they act through fertility's direct determinants, which on a macro level are the percentage married in a country, contraception use, induced abortion, infertility during breastfeeding, frequency of intercourse, sterility, miscarriages, and the duration of the fertile period. Bongaarts' model contributes some interesting ideas to the modeling of micro fertility. While we expect factors like education and income to affect fertility, Bongaarts explains that they do not act directly on it. Rather, they either change tastes or change natural supply. However, these variables may still be useful for inclusion in a theoretical model, as many of Bongaarts' direct determinants, such as very early miscarriages, are unobservable. This idea of direct (or proximate, as he calls them) and indirect determinants of fertility largely informs this analysis. The fact that social variables do

not directly impact fertility is critical to keep in mind when interpreting coefficients. For example, education's effect should be thought of in terms of its impact on fertility's direct determinants. An increase in education might, for example, move a woman out of the innumerate framework, encourage her to target a lower family size, and spur the use of contraception (the true direct determinant), or it may actually increase fertility by increasing the woman's health, and therefore decreasing early miscarriages (again, the direct determinant of children born). Therefore, it is important to remember that the more direct determinants of fertility a model includes, the less significant the education effect should be.

As far as what variables should actually be included in a micro model of fertility, both economic literature and socioeconomic literature are informative. Because Kelley et al.'s work on Egypt is most closely related to my own study, it provides a good jumping off point for creating a theoretical model. Kelley estimates the effects of age, age squared, age at first marriage, wife's education, husband's education, personal assets, real assets, electricity, and child deaths on total children ever born. Kelley's regression is, in effect, a pared down version of the sociological model presented by Cochrane (1979). This paper will fully integrate the sociological model into an economic framework, adding other variables that may have an important effect on family size. Cochrane's sociological model expects age at marriage, age, lactation, health, sexual activity, sexual taboos, marital status, living arrangements, current number of children, contraceptive use, wife's occupation, husband's occupation, and husband-wife communication to all affect children ever born, as shown below:

Figure 3.1: Socioeconomic Model of Fertility



Source: Cochrane 1979

Cochrane's model is, in a way, a fancy version of the Easterlin model, as it, too, explicitly deals with factors that go into supply of children (labeled fecundity) and those that go into demand (represented here as fertility control). The supply and demand factors come together to create births. In this analysis, I am most concerned with the factors that influence fecundity, although some factors that influence family size desires will also be included to account for women who are functioning in the conscious-choice framework.

In the above diagram, Cochrane acknowledges the endogeneity of some of these factors with arrows showing how one factor may impact several others, all of which in turn impact family size. While this endogeneity is not accounted for in my model, future research can test the robustness of my results by using some of the estimation strategies suggested by Kelley and Schultz (1988), including finding instrumental variables for those factors thought to be endogenous.

My model is ultimately a more complicated version of Kelley's regression and a simplified version of Cochrane's socioeconomic model. My principal variables of interest are those that can affect family size without a conscious fertility target on the part of the woman, namely age at first marriage, cultural taboos, living arrangements, and breastfeeding. The effects of each of these variables goes back to Bongaarts model of the proximate determinants of fertility. Each variable must be interpreted in terms of how it acts on the *direct* determinants of fertility. For my variables of interest, these effects are: Age at first marriage may decrease fertility by decreasing exposure and therefore shortening the fertile and married time period,[4] cultural taboos against sex while breastfeeding may artificially extend the infertile period following childbirth, alternative living arrangements may reduce frequency of intercourse, and breastfeeding may again extend the infertile period after childbirth. Education is of interest insofar as it affects each of these variables, as an even farther removed determinant of fertility. It may also have effects unrelated to these variables, however, as it can act on women who already express agency over family size by reducing family size targets, and may additionally, at a certain threshold level, remove women from the innumeracy framework and encourage the creation of family size targets.

Because education encompasses so many things, the next section will be devoted to specifically breaking down what its expected effects are and through which avenues it acts.

[4] Kelley et al. (1998) find in their study that age at first marriage exerts strong negative pressure on children ever born, with a statistically significant coefficient of -.21 for each year older. However, this still means age at first marriage would have to increase by five years to see a full-child reduction in children born.

Thinking beyond family planning: the uncertain history of education

The existing literature on family planning has looked to female education as a key variable because it may change demand for children as well as encouraging the modern attitudes that lead to the adoption of family planning methods. Yet by only thinking of female education in terms of its effects on demand for children and contraceptive use, the existing literature glosses over a huge portion of its potential effects. Education doesn't just change the mindset of a woman when it comes to making fertility choices, it changes the entire framework in which she is making those choices. Education occurring early in life affects the entire timeline of a woman's existence. The literature in this area has failed to highlight the effects of education on factors that influence total family size outside of conscious fertility decisions. What is needed is a clear sorting of the effects of education into those that act on fertility *decisions* and require agency (e.g. education increasing opportunity cost, hence decreasing demand for children, hence increasing contraception use, hence decreasing total family size) and those that act on fertility *outcomes* through indirect pathways (e.g. continued education delaying first marriage, leading to less total childbearing time, leading to lower completed family size). This sort of separation is essential because the latter avenues are those more likely to have an effect in highly religious countries such as Senegal.

However, the effect of education on fertility is not unambiguously negative. In areas that are supply-constrained—when people would like to have more children than their natural fertility allows—education may actually increase fertility because it increases health and thereby the ability to have children. It may also subtly alter other

variables in a way that produces an unpredictable net effect on fertility. As T.W. Schultz (1974) put it:

> The education of parents, notably that of the mother, appears to be an omnibus. It affects the choice of mates in marriage. It may affect the parent's preferences for children. It assuredly affects the earnings of women who enter the labor force. It evidently affects the productivity of mothers in the work they perform in the household, including the rearing of their children. It probably affects the incidence of child mortality, and it undoubtedly affects the ability of parents to control the number of births. The task of specifying and identifying each of these attributes of the parents' education in the family context is beset with analytical difficulties.

The most extensive work on education's impacts on fertility, Susan Cochrane's 1979 book, *Fertility and Education*, provides useful background for this study, although she fails to acknowledge that education can act through both demand-based and incidental avenues on fertility.

Cochrane first establishes that the relationship between fertility and education is convoluted. The negative relationship, she finds, is strongest for women in the urban sector, which may be why people are so quick to assume education acts primarily through increased contraception use. However, this result may be because of factors that simultaneously increase fertility in the rural sector when education rises, such as increased health. Where the relationship is negative, Cochrane points to multiple paths, both direct and indirect, through which education acts to reduce fertility. In addition to arguing that education both increases contraception knowledge and willingness to use contraception, Cochrane also points to increases in age at first marriage, decreases in the perceived benefits to children, increased sensitivity to cost of children, increases in awareness of alternative sources of satisfaction, and improved husband-wife communication.

The important caveat of her analysis is that in some areas education's effects that increase fertility may be stronger than those that decrease it. She notes that in some low income areas there may be an initial increase in fertility from small amounts of education, perhaps because it increases the perception of being able to afford children and perhaps because it decreases child mortality, but principally due to decreases in length of breastfeeding, decreases in adherence to sexual taboos, and increases in natural fertility from better health. On balance, she expects female education to decrease fertility, with some possible exceptions.

Kelley et al. (1982) take a more skeptical view of education. Their analysis is useful, however, because it is one of the few sources to sort the effects of education into direct and indirect effects. Kelley et al. assert that low levels of education can be expected to increase age at first marriage and therefore decrease family size indirectly, while high levels may decrease family size directly by decreasing demand for children. The Kelley book is the first to suggest that education may have different effects for different women, depending on whether the schooling is sufficient to create conscious family size goals.

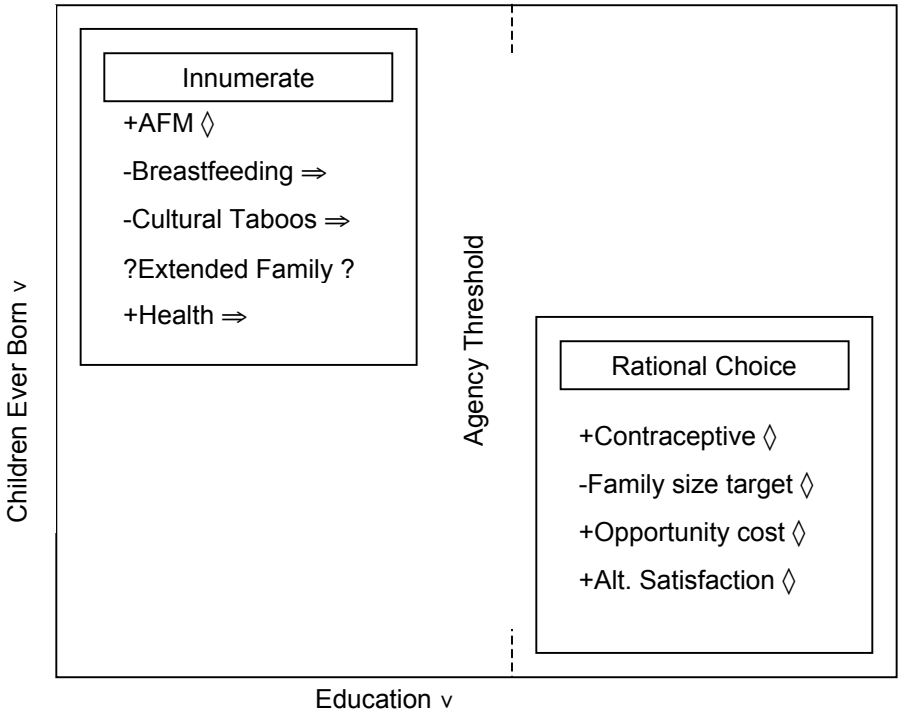
However, they anticipate that other effects such as a reduction in child deaths and fewer incidences of prolonged breastfeeding[5] will increase fertility. Additionally, Kelley et al. suspect that the effect of female education increasing fertility because of health effects is likely to be the strongest, especially for rural areas where the baseline education is low. They postulate that this effect will more than likely outweigh the small reductions.

[5] They note, however, that breastfeeding may increase for those who recognize it as a contraceptive method.

In their empirical study, Kelley et al. find the effect of education to be positive on family size when age at first marriage is controlled for. However, because education is found to have a large effect on age at first marriage, they suggest that the overall effect of education in rural Egypt may be to decrease family size. They also suggest that education may have a more significant decreasing impact on family size if there were more roles for women in the workforce, which would increase women's opportunity cost. Without these roles, some of the expected effect of education may be lost.

While the literature on education and fertility has identified all the variables that will be needed in this analysis and explained their likely effects, nowhere has there been a clear description of how education works through both demand-based avenues (increasing opportunity cost and hence decreasing demand for children, for example) and indirect avenues (such as increasing age at first marriage). Without breaking education down into these separate mechanisms, it is difficult to analyze its effects. For different women, even within the same country, fertility will be determined in different frameworks. To truly understand the effect a policy like education will have on a country, one must understand how it affects each of these frameworks. So while in Senegal, where many women do not express conscious agency over family size, education is expected to act primarily through the unconscious effects, this framework will coexist with a narrowly designed rational framework. I hypothesize that there may be some threshold level of education that increases women's agency over family size, moving them into the conscious decision-making framework. Education, then, would both act on women in the innumerate and rational framework and act to move women from one framework to the other. Below is the conceptualization I propose.

Figure 3.2: Effects of Education on Children Ever Born



The sign to the left of the variable indicates how education is expected to act on each factor, given the literature. Cochrane (1979), Cohen (1998), and Kelley (1982) all expect education to increase age at first marriage, which in turn decreases fertility. This yields the arrow to the right of the variable, indicating that as education increases, children ever born should decrease through this pathway. Cochrane and Kelley expect breastfeeding to decrease with education, and it is widely accepted as a traditional means of fertility reduction, so through this pathway children ever born should increase as education increases. Cochrane expects education to decrease adherence to cultural taboos, which again are expected to reduce fertility, so through this pathway children ever born increases as education increases. There is no literature on whether education should increase or decrease living with extended families, so it is unclear how education will affect fertility through this channel. Education is widely expected to increase health (in Cochrane 1979 and Kelley 1982, among others), which increases fertility resulting in

more children ever born, so this effect yields a positive education-fertility relationship. Therefore, the effect of education in the innumerate framework remains ambiguous, as proposed by previous literature. However, age at first marriage is expected to have accounted for significant fertility declines in Senegal historically (Cohen 1998) and so may outweigh the other effects. My analysis empirically tests each of these effects to determine whether the net effect is expected to be positive or negative on fertility.

After passing the agency threshold, women are willing to aspire to specific family size targets, thereby altering the effects of education. Here, factors effecting demand are expected to have more of an effect than factors affecting supply, because as shown in Easterlin's 1978 graphical representation (Figure 2.1), actual fertility will eventually converge with desired fertility. The marginal cost of fertility control is expected to be much smaller than the initial cost (Easterlin 1978), so once the threshold has been crossed it is not expected to be a high cost proposition to bring realized fertility down to desired fertility. The main effect of interest here, then, is that education is expected to exert a negative influence through all the factors influencing actual fertility. The effect of education on fertility in the rational choice framework is expected to be unambiguously negative, because women form and aspire to specific family size goals.

This analysis updates Cochrane and Kelley's works by using a similar framework under the assumption of innumeracy. By carefully sorting the effects of education into avenues that create and lower family size targets and those which affect the natural supply of children, we can move toward a better understanding of how education affects fertility overall. Under this framework, the demand-side effects of education can only appear in the cases of women who have specific family targets or who

are spurred by their education level to formulate them. We can therefore expect education to act on all four of our indirect variables of interest (age at first marriage, breastfeeding, cultural taboos, and alternative living arrangements) as well as by removing women from the innumerate framework and causing them to target specific family sizes. It will also act on women who are already expressing agency by encouraging lower family size targets, and helping them better meet these targets with contraception use. Because education is expected to have both increasing and decreasing effects on fertility, I pay special attention to which factors carry more weight.

IV. Data

My analysis uses data from the Demographic and Health Surveys (DHS) to examine the determinants of Senegalese fertility. The DHS data is widely established as the best data for this type of analysis (notably, Cochrane 1979). In particular, the Senegal data have been used by Cohen (1998) and Garenne and Joseph (2002). However, few researchers have used the Senegal data for an analysis specific to Senegal. Instead, the Senegal data have been used in concert with the broader sub-Saharan Africa data in order to prove macro theories about greater sub-Saharan Africa. Because part of my thesis is that Senegal differs from other sub-Saharan nations in important cultural factors, I reverse this trend in my paper, and focus solely on the Senegal data.

The Demographic and Health Surveys are a global survey initiative sponsored by the U.S. Agency for International Development. The surveys include a wide range of family and health-related questions. Although the DHS are a worldwide initiative, questions are tailored specifically to each country included, and many questions are country-specific. The questions are then translated into the native language of the

country, and interviews are conducted in person at the subject's residence. Women are the units of analysis, and the survey is administered to a representative sample of women age 15 to 49 in the country.

Volunteers are trained by the DHS to pose the questions, and they may return several times in order to complete the survey. However, despite this vigilance, the Senegal survey still contains many missing values. Values are most frequently missing for sensitive or uncomfortable topics or when the answer would rely on the subject's memory. Because the survey covers the entire childbearing history of the subject, answers that recall greater recollection are more likely to be missing. Additionally, for some questions information is simply unavailable. For example, the weight of a child at birth might be unavailable because no health professional was on hand at the birth to weigh the child, or the level of household income might be unavailable because many people are subsistence farmers or part of the barter economy. For this analysis, variables with large numbers of missing values were not used. This required some creativity in specifying certain variables, but the dataset's many positive features more than made up for the drawbacks.

For my analysis, I use the DHS performed in Senegal in 1997.[6] The dataset includes information in the following areas: background characteristics, reproductive behavior and intentions, contraception exposure and use, prenatal and postpartum care of all children in household, breastfeeding and nutrition of children, children's health, the relative status of the woman in the household, the husband's background, and AIDS and other sexually transmitted infections. My analysis draws variables from all sections of

[6] 1999 data were also available, but had not yet been recoded for use by DHS. A 2005 survey is in progress, and future researchers will be able to compare results from these data with the effects found in this analysis.

the survey except the AIDS section.[7] The dataset contains 8,593 observations, which comprise women from both urban and rural areas. Some of these observations are dropped because of missing values, but every effort is made to preserve the size of the dataset.

My principal dependent variable is "Total Children Ever Born," which I will regress on a large number of demographic inputs, suggested by the theoretical literature as important factors in determining family size. However, I have also added some features to the theoretical model that set my analysis apart. My analysis features a specific variable for rural, since my research shows the rural sector to be different from the urban sector in significant ways. Other researchers have tried to account for the rural effect with income and education proxies or by focusing only on rural areas, as in Kelley et al. (1982). I am adding a specific variable for a non-numeric response to a question asking ideal family size to see if a lack of numeracy over child choice directly impacts total family size.

My analysis explicitly treats women as the unit of analysis, instead of looking at household fertility. This is important because a traditional "household" model assumes a husband and wife, and in Senegal living arrangements frequently do not match this paradigm: many women lived with their extended families, were part of polygamous unions, or had absent husbands. Making the women the units of analysis eliminates any confusion over trying to estimate household factors such as family size or income or total children, and restricts the analysis to factors relating to the specific woman.

From the theory and my own research, it seems the following factors should largely determine a given woman's total family size: age, age at first marriage, household

[7] Information provided by the Demographic and Health Surveys, available: www.measuredhs.com.

income, education, occupation, desired family size, numeracy over family size, sexual taboos, living arrangement, length of breastfeeding, child deaths, contraceptive use, urban/rural sector, frequency of intercourse, and health. Because of data availability, some of these variables have been specified in alternate ways.

Total Children Ever Born: This is my main dependent variable. It refers to the total number of live births, as reported by the woman. Because it does not account for still births, it may not capture a full measure of fertility. However, still births and miscarriages are a supply constraint, and therefore treated in the literature as no different from being unable to conceive. Some researchers have noted that total children may be underreported because women could be reluctant to report live births where the child died soon after childbirth. This omission could bias the variable slightly, but those who do underreport children born are unlikely to be different in significant ways from those that do not. While this paper is focusing on large family sizes, the mean for total children ever born is only 3.19. This may be artificially low because 29.05% of respondents had never had any children. This is largely accounted for by the 25.15% of women in the sample who have never been married. Mean children born for married women is 4.61. For women 40 to 45 who are expected to have completed their childbearing, mean children born is 7.63, giving us a better idea of how many children a Senegalese woman generally bears in her lifetime.

Age: Age is available in the dataset, measured in years, and so is used as a simple continuous variable. There are no missing values for this variable, and responses are expected to be fairly accurate. To account for the non-linear effects of age, an age-squared variable is also included.

Rural/Urban: 64.4% of respondents were from rural areas while 35.6% were from urban areas. While I expect the effect of this variable to be strong as-is, it is important to note that the rural sector may be so different from the urban sector that it needs to be accounted for in other ways. For example 87.83% of the rural population cannot read at all, compared to only 50.83% of the urban population. These sort of huge disparities mean the effects of the two sectors are unlikely to be captured fully by a simple change in intercept. Additionally, Cochrane (1979) found education to impact rural and urban areas differently. For this reason, an interaction term of rural times level of education will be added.

Marital Status: It is obviously expected for unmarried women to have fewer children than married ones, especially because the country is so religious. Women can be married, divorced, widowed, separated, or never married. 74.85% of the sample has been marred at least once. Marital status is first accounted for with a dummy variable for "never married," and later the regression is rerun for only women who have been married, since 87% of never married women have no children.

Education: Education is measured using a survey question for highest level of education attained. I use three dummy variables for "primary," "secondary," and "higher," with no education being the baseline. Overall, 19.84% of women had primary education, 9.25% had secondary, and .85% had higher. The rest had no education. This is interesting because it may be difficult to sort out the effects of education since the sample in each category will be so small. Additionally, even if education is found to have a large effect, it may be difficult to implement because it is currently so uncommon.

Child Deaths: This variable is a measure of total children who were born live and have since died. It includes children who have died at any stage in their lives, so could theoretically include a 25-year-old dying if the mother is within the sampled age range. I initially broke down this measure into sons who have died and daughters who have died, since theoretically families may be more eager to replace sons in pursuit of additional labor, but the effects were found to be near identical. The final model, therefore, treats all child deaths the same.

***Cultural Taboos*:** The only relevant cultural taboo that would affect childbearing in Senegal is a taboo against sex while breastfeeding because it is thought to spoil the mother's milk. This is a zero/one dummy referred to in tables as "No sex." This cultural taboo may provide an unconscious mechanism of birth spacing. 21.46% of women acknowledged they avoid sex while breastfeeding.

***Age at First Marriage (AFM)*:** This variable is self-reported by women who have been married. It is calculated in years. Average age at first marriage is around 17.

Ideal family size: This variable represents the woman's childbearing ambitions. Responses ranged from 0 to 23. Additionally, about 20% of respondents gave a non-numeric answer such as "That's up to God." The effect of ideal family size will be captured in the continuous "family size" variable, with non-numeric response being captured in a zero/one dummy. The mean for people who did give an ideal number was slightly more than five. It is also important to note that some numbers such 10 or 15, which were much more common than, say, nine and 14, displays a lower level of numeracy in regards to family size, and may therefore have a stronger positive effect on total children than just a high ideal number. In rural areas 24.11% of respondents gave

non-numeric responses, in urban areas this was only 14.14%, again displaying the differences between the two sectors.

Labor Force participation: The data does contain a question about the woman's occupation, but it is sorted into many different categories that would be impractical to include. For this reason, I condensed the variable into a "Formal Sector" zero/one dummy. All jobs that involve significant time outside the house were considered formal sector employment, with "no job," "subsistence farming," and "sales" considered to be non formal-sector employment. Subsistence farming was included because this response is indistinguishable from the "not working" response, since both would be applicable to a woman who serves as housekeeper, childrearer, and occasional farmhand. Sales was included because this may include occasional street vending and/or panhandling, and may therefore not entail significant time outside the house.

Contraceptive Use: This is captured in a variable for whether the respondent has ever used any method of contraception, including modern, traditional, and folkloric types. I included all types of contraception because to engage in any type of family planning, even less effective types like folkloric methods, is to cross a barrier from passive family size determination to active reduction. 10.5% of respondents were currently using some contraceptive method. 3.64% were currently using a modern method. There were still stark differences between urban and rural, but neither sector showed high patterns of use.

It is important to note that the rate of contraceptive use does not include extended periods of breastfeeding, which has widely been accepted as a traditional method of birth control. Some women might be using breastfeeding to delay pregnancy (control birth spacing), but might not be comfortable expressing it as a means of

contraception. In this data, the use of "traditional methods" is so low (3.40%) because it only includes those methods consciously undertaken as "birth control," such as withdrawal or periodic abstinence. Because there is a cultural taboo against controlling family size, traditional birth control may be more prevalent than expressed here, but viewed as a method of birth spacing or undertaken for other benefits apart from limiting family size.

Income: This variable cannot be captured directly because so many families do not have conventional incomes to speak of, but rather trade in goods and services. The literature suggests using proxies such as electricity, material possessions, and distance from water source, but none of these were found to be significant. Furthermore, including several measures of material possessions at once decreased rather than increased R-squared, making a joint test of significance meaningless. I therefore constructed a proxy measure of income by dividing number of rooms for sleeping by total household size, creating a ratio of rooms to people. This should proxy for income because a wealthy family would have a bedroom for each person, while very poor families often live as large extended families in single-room structures.

Breastfeeding: Length of breastfeeding is measured by using the length of breastfeeding in months of the second to most recent child. This is because many of the most recent children were still breastfeeding at the time of the survey, which lowers the variable's predictive power. However, there is only data on breastfeeding for women who had a child in the past three to five years, meaning almost 75% of the sample was excluded, leaving 2,284 observations. This information also relies on the woman's memory, resulting in a large number of focal point answers such as 18 or 24 months.

Some Missing Factors: I do not include a variable for relative persuasive power, since this is difficult to quantify, and also because my analysis hopes to remove the assumption that family size is a negotiation where both parties have a desired outcome. Health was left out of this analysis because the Senegal survey contains no data on the health of the woman, including measures of height and weight. While this variable may have considerable predictive power, omitting it should not drastically affect my results, as health in terms of ability to bear children, or fecundity, will be picked up by other variables such as income and education. I also do not include a variable for frequency of intercourse, because the data on this was found to be unreliable. This effect, as well as the effect of health, will be accounted for later in the analysis by the addition of a "birth interval" variable that normalizes fertility by the number of days between marriage and first birth. Summary statistics for my variables are listed below.

Table 4.1: Summary Statistics for Included Variables

Variable	Obs	Mean	Std. Dev.	Min	Max	Expected Effect
Total children ever born	8593	3.194228	3.155993	0	16	
Age	8593	28.18434	9.329213	15	49	+
Age squared	8593	881.3809	567.6174	225	2401	-
Rural	8593	0.644478	0.478699	0	1	+
Never married	8593	0.251484	0.433891	0	1	- strongly
Education Dummies						
Primary	8593	0.198417	0.398831	0	1	+
Secondary	8593	0.092517	0.289772	0	1	-
Higher	8593	0.008495	0.091783	0	1	-
Not wife	8593	0.63319	0.481962	0	1	-
Child deaths	8593	0.583149	1.0864	0	10	+
No sex	8593	0.214593	0.410564	0	1	-
AFMxmarried	6432	17.13169	3.497683	8	42	-
Family size	6814	5.414147	2.357809	0	23	+
Nonnumeric	8593	0.205633	0.404187	0	1	+
Absenthusband	6021	0.282511	0.450258	0	1	-
Formalsector	8507	0.120372	0.325415	0	1	-
Contraceptive	8593	0.104969	0.306532	0	1	?
Rooms to ppl	8176	0.371951	0.1383	0.071429	2	-
Birth interval	5312	27.95105	30.40223	0	378	-
Breastfeeding	2284	16.6979	7.048159	0	36	-

While there are small concerns with certain variables, most of the theoretical variables of interest have readily available counterparts in the DHS dataset. Of these included variables, I am most interested in how education, age at first marriage, cultural taboos, alternative living arrangements, and breastfeeding affect children ever born.

V. Findings

The main goal of my empirical analysis is to show that age at first marriage, length of breastfeeding, cultural taboos, and living arrangements all have large effects on total children ever born. Education is also expected to affect children ever born, both through these pathways and by impacting the fertility decisions of those women who do make conscious choices and by removing some women from the innumerate framework. Through these avenues, family size and infant mortality for low-income women can be reduced without necessarily requiring conscious agency over family size on the part of the woman. This section will be divided into two parts: the first breaks fertility down into its various determinants and highlights factors that have large effects, and the second shows how education may impact each of these important factors.

Modeling Fertility

I regressed "total children ever born" on a number of factors that have been shown to be important determinants in previous literature, with the goal of identifying factors that act without conscious agency over family size. The structure of my model, ordinary least squares, allows me to look for things that *do* reduce family size, rather than factors that make people *want* to reduce family size or make people able to meet their desired family size. My model removes the assumption of conscious choice.

I expect the coefficients on age at first marriage, no sex while breastfeeding (a cultural taboo), not wife of household head, breastfeeding, and education to be large and negative. The following table presents results from my first regression.[8]

Table 5.1 Regress total CEB on independent variables—R^2=.7780

Total children ever born	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
NeverMarried	-2.89963	0.1182	-24.53	0	-3.13134	-2.66793
Current age	0.234148	0.014006	16.72	0	0.206693	0.261602
Age-squared	-0.00084	0.000221	-3.81	0	-0.00127	-0.00041
Rural	0.191281	0.041821	4.57	0	0.1093	0.273261
Education Dummies						
Primary	0.150596	0.048221	3.12	0.002	0.056071	0.245121
Secondary	-0.12344	0.067399	-1.83	0.067	-0.25556	0.008676
Higher	-0.7855	0.188218	-4.17	0	-1.15446	-0.41654
Not wife	-0.5915	0.041598	-14.22	0	-0.67304	-0.50995
Child Deaths	0.841647	0.018726	44.94	0	0.804938	0.878355
No sex	-0.14088	0.041303	-3.41	0.001	-0.22184	-0.05991
AFMXmarried	-0.12608	0.005955	-21.17	0	-0.13775	-0.11441
Family size	0.042528	0.00847	5.02	0	0.025924	0.059131
Nonnumeric	0.171027	0.0643	2.66	0.008	0.044983	0.297071
Formal sector	-0.1536	0.054097	-2.84	0.005	-0.25964	-0.04756
Contraceptive	0.654028	0.057383	11.4	0	0.541541	0.766514
Rooms to ppl	-2.78676	0.122142	-22.82	0	-3.02619	-2.54733
constant	0.230378	0.245953	0.94	0.349	-0.25175	0.71251

To confirm that this regression yields reasonable results, let's first examine the coefficients of some basic control variables. The first two variables account for the major determinants of children born, marital status and age. Both yield statistically significant coefficients. We expect the effect of never being married on total children ever born to be strongly negative, which it is. Women who have never been married have almost three fewer children than women who have. We expect the effect of age to be strongly positive, which it is. The coefficient is not as large as that as marital status because the range of age is so large, from 15 to 49. The coefficient can be loosely interpreted as

[8] Kelley's analysis included only women who were 45 or older, and thus expected to have completed childbearing. Because this limits sample size to such an extent, I chose not to follow his precedent and control for age only with the age and age-squared terms. Limiting the analysis to women older than 45 does not qualitatively change the results, although it affects the significance of some variables.

saying that for each additional year of age a woman will have .23 of an additional child, or about 1 child every five years. The Age-squared term then reduces this, meaning that this effect decreases as age continues to increase.

The next variable is one of our principal variables of interest, education. The baseline here is no education, so in accordance with the theory we expect primary education to have a positive effect, while higher education will have a negative effect. Cochrane (1979) attributes this initial positive effect to education first increasing the ability to have children, through such avenues as better nutrition and better healthcare. She also asserts that small amounts of education may cause women to abandon traditional patterns of breastfeeding and postpartum abstinence. If this is responsible for the increase in fertility, including information on the health benefits of breastfeeding in any planned female education policy might eliminate this unintended effect.

My results for education mirror Cochrane's 1979 results. The coefficient on primary education is positive, and statistically significant. The coefficient for secondary education is negative, as expected, and statistically significant. Women with secondary education tended to have about .12 fewer child births than women without. The coefficient for higher education is extremely large, saying these women tended to have almost one full less child than women without any education.

The effect of abstaining from intercourse during periods of breastfeeding has a statistically significant effect on total children ever born. Literature suggests that women do not abstain from sex while breastfeeding to consciously space their children farther apart, but rather to avoid "spoiling" their milk, according to cultural tradition. While the effect of this taboo is not overwhelming, a reduction of .14 children for women who

abstained during breastfeeding, it is still another avenue through which family size can be reduced without agency. This finding matches a 1973 report by the United Nations, cited in Cochrane (1979), which found that cultural taboos on sex should act negatively on total fertility. The next section will explore how education affects this factor.

The effect of age at first marriage is also statistically significantly negative, although it is not overwhelmingly large. For each additional year before first marriage, women tended to have .13 less children. This finding is in line with the Senegal-specific findings of Cohen (1998), and the Cochrane's 1979 survey of the work of previous scholars, including McGreevy and Birdsall (1968), Kim et al. (1974), Davidson (1973), Yaukey (1972), and Palmore and Ariffin (1969), all of whom found the effect of wife's age at marriage on fertility to be negative. However, the size of this effect means it would require a change in age at first marriage of eight years to get a one-child reduction in family size. Compared to the standard deviation of age at first marriage of 3.5 years, this hardly seems feasible. However, it is impossible to know how the size of this effect breaks down across individuals—for some families the effect from just a single year increase in first marriage might have a significant impact on family size. And, as in Cohen's findings, the effect is expected to have a significant impact on macro fertility levels.

Recall "rooms to people" was constructed as a proxy for income. It is the ratio of the number of rooms for sleeping listed in the survey to the number of household members. While there is little precedent in the literature for this construction, none of the literature-supported income proxies, such as whether a household has electricity, were found to be statistically significant. One reason for the slight effects of such variables

could be because income is thought to act negatively on fertility through channels such as the increased opportunity cost of women. Because other variables such as education and occupation may account for this effect, the income effect may be weakened. However, the "rooms to people" ratio gives us a large, statistically significant, negative effect of about three fewer children for each unit increase in the ratio. However, when compared to the standard deviation of the ratio, .1383, to get this effect would require a change of eight standard deviations. More work should be done to see if this large effect is due to the income effect or other factors.

One interesting feature of this regression is the large negative effect of living in a household headed by someone other than the respondent's husband. Women who were not the wife of the household head had .6 fewer children than those women who were. This is consistent with earlier findings that separate location of spouse (which may be implied by the household head variable), Williams (1976), and joint family living, Williams (1976) and United Nations (1973) both have negative effects on fertility.[9]

The effect of a job in the formal sector is negative, as expected, but not very large. It may also not be as robust as some other factors, as specifying this variable as "working" in general versus no employment does not yield statistically significant results, perhaps because this includes occupations like subsistence agriculture and street vending/panhandling, in which the woman's opportunity cost may not be large. Additionally, this variable loses its statistical significance once unmarried women are excluded.

[9] The dataset contains specific information on whether a given woman's husband lives with her, but only for a limited number of observations. Because of this data constraint, this variable was not tested in the main model. It was, however, found to be negative and statistically significant in a similar regression.

Child deaths have a positive effect on fertility, with a statistically significant coefficient of .84. Schultz (1997) points out that the causality for this variable may run both ways, explaining the large effect. Families may have more children *in response* to child deaths, perhaps acting to replace the child. Families may also have more children *in anticipation* of child deaths, the so-called insurance effect tested by Le Grand et. al (2003). There is also the possibility, however, that the causality runs backward, with rates of infant mortality being higher in large households because resources are more likely to be spread thin.

Contraceptive use is another such mystery. Intuitively, the use of contraception should reduce family size, by helping to bring family size down to desired levels. However, this effect may be confounded by the fact that use of contraceptives is seen as extreme in Senegalese society. Only families severely overburdened with children may consider the use of contraception. This might explain the positive coefficient of contraceptive use in the above results. However, ideally the model would account for all factors influencing natural fertility, and therefore produce a negative coefficient on contraceptive use. The fact that contraceptive use has a positive coefficient because we believe it to be correlated with fertility means that some factors affecting fertility are still unaccounted for. These are the "unobservable" factors in Bongaart's 1978 model. Adding a variable for the interval from marriage to first birth should normalize the results by overall fertility, and help solve this problem (see table 5.3).

This analysis supports my predictions about how three of my variables of interest—age at first marriage, cultural taboos, and living with extended families—affect children ever born. My fourth variable of interest, breastfeeding, will need to be

analyzed separately. The effect of education matches that predicted in the literature, with primary education increasing fertility and secondary and higher education decreasing it, but more analysis needs to be done to sort out how this variable influences other factors. The second stage of my findings section addresses this very question, but first I engage in some sensitivity analysis to test how my variables are affected by a few refinements of the model.

Testing Differences Between Married and Unmarried Women

Because Kelley (1982) chose to look only at married women, it is worth examining whether my findings are robust under this specification. Results for these separate groups are shown below.

Table 5.2: Breakdown by Marital Status

Total children ever born	All	If married	If unmarried
R-squared	.7780	.7043	.3951
NeverMarried	-2.89963	(dropped)	(dropped)
Current age	0.234148	0.423223***	0.022681*
Age-squared	-0.00084	-0.00354***	0.000394
Rural	0.191281	0.277213***	0.042228*
Education Dummies			
Primary	0.150596	0.231241***	0.041562*
Secondary	-0.12344	-0.2102**	-0.03763
Higher	-0.7855	-0.57244*	-0.32106***
Not wife	-0.5915	-0.46452***	0.018255
Child Deaths	0.841647	0.804878***	1.261367***
No sex	-0.14088	-0.23389***	0.061463***
AFMXmarried	-0.12608	-0.13793***	(dropped)
Family size	0.042528	0.056352***	0.000918
Nonnumeric	0.171027	0.237799***	-0.00705
Formal sector	-0.1536	-0.09389	-0.0472*
Contraceptive	0.654028	0.694703***	0.68029***
Rooms to ppl	-2.78676	-3.37466***	-0.22203***
_constant	0.230378	-2.58787***	-0.44235*

***significant at 1% level, **significant at 5% level, *significant at 10%level

Breaking down my results by married and unmarried women, we can see that all findings except the impact of formal sector employment hold up for married women.

However, there is a troubling lack of good explanatory variables for unmarried women. This is probably because women who have children out of wedlock are exceptions to the rule in Senegal, as doing so goes against religious practices. The determinants of having children out of wedlock are unlikely to be the same that explain higher fertility after marriage. For this reason, my next refinement includes only married women in the sample.

Controlling for Birth Interval

The next refinement to the model is normalizing some of the omitted fertility effects by adding a "birth interval" term defined as the interval between marriage and first birth. Logically, this regression was run for only married women.

Table 5.3: Regress total CEB on independent variables—R^2=.7338

Total children ever born	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Current age	0.444787	0.020059	22.17	0	0.405462	0.484112
Age-squared	-0.00343	0.000301	-11.4	0	-0.00402	-0.00284
Rural	0.283041	0.054667	5.18	0	0.17587	0.390212
Education Dummies						
Primary	0.054122	0.068008	0.8	0.426	-0.0792	0.187448
Secondary	-0.30249	0.110396	-2.74	0.006	-0.51891	-0.08606
Higher	-0.54903	0.28959	-1.9	0.058	-1.11675	0.018699
Not wife	-0.36654	0.045523	-8.05	0	-0.45578	-0.27729
Child Deaths	0.618277	0.019849	31.15	0	0.579364	0.657189
No sex	-0.23723	0.054091	-4.39	0	-0.34327	-0.13119
AFMXmarried	-0.22667	0.007907	-28.67	0	-0.24217	-0.21117
Family size	0.043297	0.010264	4.22	0	0.023175	0.063419
Nonnumeric	0.191797	0.080091	2.39	0.017	0.034783	0.34881
Formal sector	-0.05126	0.080049	-0.64	0.522	-0.20819	0.105668
Contraceptive	0.566275	0.067206	8.43	0	0.434523	0.698028
Rooms to ppl	-2.93378	0.161203	-18.2	0	-3.24981	-2.61775
Birth interval	-0.02262	0.000737	-30.68	0	-0.02407	-0.02118
Constant	-1.18935	0.352208	-3.38	0.001	-1.87983	-0.49887

The principal difference in this regression is that the effect of primary education is no longer statistically significant. This is expected, however, as primary education is hypothesized to increase fertility by increasing natural ability to supply children, or

fecundity. Recall that primary education is expected to have positive health effects, due to a better understanding of basic health practices and nutrition. If this is the principal avenue through which primary education increases fertility, controlling for this fecundity effect in birth interval should yield an insignificant coefficient on primary education.

Primary education may also reduce adherence to cultural taboos that delay childbirth as well as decrease length of breastfeeding, but these factors are not accounted for in birth interval since they act after the first birth. Because accounting for birth interval alone is enough to make the coefficient on primary education statistically insignificant, we can infer that these effects of education alone are not strong enough alone to create a statistically significant positive effect.

Therefore, these results suggest that primary education's main impact on fertility occurs through the positive change of increasing health. This lends credence to the idea that while education may initially increase fertility, it does so through effects that are generally considered positive, such as increased health. Since this increased knowledge of health and nutrition can be expected to transfer to the mother's care of her children, this might still create a more supportable family size even if it is actually larger in number, because the woman may be more able to care for her children.

Contraceptive use continues to have a positive correlation with total children ever born, however, indicating that some fertility factors may still be unaccounted for.

Rural/Urban Interactions with Education

To test whether education has different effects in rural versus urban areas, I now add an interaction term for rural combined with education. Recall that Cohen (1998) found that the urban versus rural populations had undergone a demographic transition at

completely different time periods. Cochrane's 1979 work also found differing effects for rural versus urban areas, and she suspected the effect of education might be stronger in urban areas. Additionally, Kelley (1982) looked at only rural women, so this makes the results more comparable. Because here we are interested in the fecundity effects of education, such as how it impacts health in the different sectors, this regression omits birth interval.[10]

Table 5.4: Results with Rural Interactions—R-squared=.7035

Total children Ever Born	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Age	0.421634	0.01866	22.6	0	0.385054	0.458213
Age-squared	-0.00355	0.000287	-12.37	0	-0.00411	-0.00299
Education interactions						
Ruralx1	0.253179	0.115913	2.18	0.029	0.025947	0.480411
Ruralx2	0.460764	0.221792	2.08	0.038	0.025972	0.895557
Ruralx3	0.378338	1.211515	0.31	0.755	-1.99667	2.753343
Education Dummies						
primary	0.038344	0.085097	0.45	0.652	-0.12848	0.205165
secondary	-0.43235	0.113643	-3.8	0	-0.65513	-0.20957
higher	-0.73346	0.306341	-2.39	0.017	-1.33399	-0.13292
Not wife	-0.47415	0.046427	-10.21	0	-0.56516	-0.38314
Child deaths	0.815391	0.020745	39.31	0	0.774724	0.856059
No sex	-0.22871	0.054425	-4.2	0	-0.33541	-0.12202
AFMxmarried	-0.14001	0.006769	-20.68	0	-0.15328	-0.12674
Familysize	0.060975	0.010466	5.83	0	0.040458	0.081491
Nonnumeric	0.27233	0.08086	3.37	0.001	0.113814	0.430845
Formalsector	-0.12311	0.078524	-1.57	0.117	-0.27704	0.030827
Contraceptive	0.671447	0.068658	9.78	0	0.536853	0.80604
Rooms to ppl	-3.31237	0.156567	-21.16	0	-3.6193	-3.00544
Constant	-2.32802	0.314747	-7.4	0	-2.94504	-1.711

This new model is interesting because the coefficients for both primary and secondary education interacted with the rural term are positive, while the general education effect is now insignificant. This means the effect of primary education in urban areas may not be positive at all, while its effect in rural areas is positive, significant, and robust. One possible explanation for this is that health in urban areas

[10] Running the same regression with birth interval does not qualitatively change the results, except to decrease the net positive effect of primary education, as expected.

might already be at a higher level, making the effect on fecundity of better health insignificant. The lower incidence of breastfeeding in urban areas may also play a role, as primary education is also expected to increase fertility through shorter periods of breastfeeding.

Perhaps more surprisingly, the positive interaction term on secondary education is enough to outweigh the overall negative effect of secondary education, indicating that even secondary education may increase fertility in rural areas. This may be because health is so low initially in rural areas that it is a large enough effect to outweigh any of the fertility-reducing effects of education. It may also be because breastfeeding is an important method of fertility control in rural areas, and is lessened with education. It may also be that women in rural areas are more "stuck" in the innumerate framework than in urban areas, and therefore the effects of education will barely include effects from creating or lowering family size targets and adopting contraceptive use. This would be consistent with LeGrand's 2003 finding that people in urban areas were much more willing to express agency over family size and were much more similar to the Zimbabweans surveyed than were rural Senegalese. For this reason, policies aimed at reducing rural fertility in Senegal may need to focus entirely on the innumerate side of the framework, since even at quite high (for Senegales society) levels of education, rural women do not exhibit characteristics consistent with having crossed the "agency threshold."

Overall, these findings are consistent with Cochrane's results that education can be expected to have the largest impact in urban areas. The small and insignificant general primary education term implies that the initial boost in fertility from primary education

occurs mostly in rural areas. It also implies that the fecundity effects of education—or other undiscovered effects increasing fertility—are quite large in rural areas. The fact that Kelley et al. (1982) limited their examination to rural areas might explain why their general conclusions about education are more pessimistic than my own.

Breastfeeding

The next question I try to answer is whether length of breastfeeding after childbirth decreases overall fertility. Because data on this variable only includes women who had a child in the last 3-5 years, the sample size is limited. For this reason, this variable was not included in the main regression.

Table 5.5: Results with breastfeeding—R-squared=.8863

Total children ever born	Coef.	Std. Err.	t	P>|t|	[95% Conf.	Interval]
Current age	0.397822	0.025414	15.65	0	0.34798	0.447665
Age-squared	-0.00091	0.0004	-2.28	0.023	-0.0017	-0.00013
Rural	0.040968	0.056749	0.72	0.47	-0.07033	0.152266
Education Dummies						
Primary	0.088004	0.066537	1.32	0.186	-0.04249	0.218498
Secondary	0.035715	0.131858	0.27	0.787	-0.22289	0.294318
Higher	-0.49692	0.409738	-1.21	0.225	-1.30051	0.306668
Not wife	-0.12546	0.043767	-2.87	0.004	-0.21129	-0.03962
Child Deaths	0.328601	0.021178	15.52	0	0.287065	0.370136
No sex	-0.04861	0.05444	-0.89	0.372	-0.15538	0.058161
AFMXmarried	-0.32569	0.008208	-39.68	0	-0.34178	-0.30959
Family size	0.010719	0.010456	1.03	0.305	-0.00979	0.031225
Nonnumeric	0.061812	0.081805	0.76	0.45	-0.09862	0.222249
Formal sector	0.149608	0.084509	1.77	0.077	-0.01613	0.315348
Contraceptive	0.236448	0.064573	3.66	0	0.109807	0.36309
Rooms to ppl	-1.07032	0.179081	-5.98	0	-1.42154	-0.71911
Breastfeeding	-0.01123	0.003037	-3.7	0	-0.01719	-0.00527
Birth interval	-0.02837	0.000845	-33.59	0	-0.03003	-0.02671
constant	0.364554	0.409967	0.89	0.374	-0.43948	1.168591

From these results we can see that breastfeeding an additional month is expected to decrease fertility by .01 children. Because the maximum length of breastfeeding in the sample was 36 months, ad the standard deviation 7 months, this is not a very economically significant finding. It would take 14 standard deviations, or a change of

100 months in length of breastfeeding, to reduce children born by one child. Alternate specifications of this regression omitting certain variables yielded either insignificant results or a positive coefficient, showing that this finding is not robust. Better data availability would help to explore this effect, but, for now, the effect of breastfeeding is unclear. However, I will defer to the literature and accept the hypothesis that breastfeeding decreases children ever born.

The regression also eliminates the statistical significance of all levels of education. While this is primarily due to sample size, it has an intuitive payoff: the more variables we add that are proximate determinants of fertility the less the indirect determinants should matter. Theoretically, if we could account for every proximate determinant the coefficient of education would be zero.

Thus, the previous sections have yielded expected coefficients on age at first marriage, cultural taboos, and living with extended family, and an expected but not very robust coefficient on breastfeeding. Increased age at first marriage, increased adherence to cultural taboos, increased instances of living with extended families, and increased length of breastfeeding are all expected to decrease total children ever born. The next task will be to see how education impacts each of these effects, as well as effects outside the innumerate framework, to see if it is worth pursuing as a policy for fertility reduction.

Thus far, the results for education have been expected but inconclusive. Primary education was found to increase fertility, while secondary and higher education reduced it. When birth interval was accounted for, the effect of primary education became insignificant, indicating that this effect may be primarily due to increased fecundity from better health. Splitting the effect of education into its general and rural-specific

components yielded positive effects on fertility for both primary and secondary education, indicating that fertility-increasing effects must be strong enough in the rural sector to outweigh many of the fertility-reducing effects of education. However, to see whether education is, on balance, likely to produce a positive or negative effect on fertility, we must examine how it affects the four variables of interest that were controlled for, and thus not entered into the education term, in earlier regressions: namely age at first marriage, adherence to cultural taboos, living with extended families, and length of breastfeeding. We should additionally explore how breastfeeding affects women outside of the innumeracy framework by reducing family size goals and increasing contraceptive use, and also how it may remove people from the innumerate framework demonstrated by a change in nonnumeric answers to the ideal family size question. The next section addresses these issues in detail.

The Effects of Education

This section explores how education affects each of the variables of interest. This will help us examine whether education overall is expected to have a negative or positive effect on fertility. I find that education is expected to increase age at first marriage, decrease length of breastfeeding, have no statistically significant effect on adherence to cultural taboos, increase the chance of living with extended family, and increase contraception use as well as increase numeracy over family size and reduce family size goals. Therefore, education is expected to decrease fertility through multiple indirect avenues that do not require agency while at the same time encouraging women to express agency over family size and lower their family size targets. The only avenue through

which education may increase fertility (besides health, as has already been shown) is by decreasing length of breastfeeding.

I first examine the effects of education on the main determinants of fertility in the innumerate framework, which are the determinants of natural fertility explored earlier. Each dependent variable is regressed on the basic controls of age, age-squared, rural/urban, and formal sector employment, in addition to the three levels of education.

Table 5.6: The Effects of Education on Natural Fertility Determinants

Dependent	AFM	Breastfeeding	No Sex	Not Wife
R-squared	0.1616	0.0246	0.008	0.2714
Education dummies				
Primary	1.442173***	-0.90851**	0.012203	0.090856***
Secondary	3.438614***	-1.21485	-0.01798	0.134741***
Higher	5.885442***	-6.73271**	-0.05536	0.069154
Age	0.348948***	0.658469***	-0.01454***	-0.05576***
Age-squared	-0.00507***	-0.00987***	0.000191***	0.000535***
Rural	-0.95463***	1.156927***	0.018268*	-0.08151***
FormalSector	0.730718***	-1.45834**	-0.02465*	0.088524***
Constant	11.73927***	5.694764**	0.447846***	1.74423***

***significant at 1% level, **significant at 5% level, *significant at 10%level

These tables provide some valuable insights into the various pathways of education that were, in effect, hidden in earlier regressions. Primary education alone results in a 1.44-year increase in age at first marriage. Secondary education yields a 3.43-year increase, and higher education results in a nearly six-year increase. Because age at first marriage decreases fertility, education will also decrease fertility through this avenue. In a sense, then, controlling for age at first marriage in earlier regressions camouflaged some of the fertility-decreasing effects of education. Indeed, rerunning earlier regressions without including age at first marriage as a control results in negative, statistically significant, coefficients for all levels of education, including primary.[11]

[11] The coefficient on primary in this regression is -.13, significant at the 10% level.

As for breastfeeding, this regression shows that all levels of education are expected to decrease duration of breastfeeding, although secondary education is not statistically significant. This is consistent with the conclusions of Cochrane (1979). Because breastfeeding is expected to decrease fertility, this is one avenue through which education will likely increase fertility, and thus an area policymakers should carefully consider when implementing an education program.

Contrary to expectations, and the findings of Cochrane (1979), here education has no statistically significant effect on adherence to the cultural taboo against sex while breastfeeding. Intuitively we expect education to decrease this adherence, as education results in more modern attitudes that are less likely to incorporate folklore into decision-making. While the true coefficient on abstaining from sex while breastfeeding may be negative, we can safely conclude it is not so negative that it is a major concern for policymakers looking to decrease fertility through education. This belief may be so deeply rooted in Senegalese society that it is not affected by education, or it may be tied up in the respondent's understanding of health, which is expected to increase with education.

Additionally, living with extended families in which the woman's husband is not the household head is actually increased by education. Because there was no literature on this variable, we did not have an expected direction for this effect. Again, this coefficient is small so the finding may not have much impact. However, it may be reassuring to policymakers to know that this is another natural check on fertility that will at least not be decreased by broader education.

I now examine how education impacts factors that affect demand for fertility and fertility control, which are expected to function outside the innumerate framework.

Table 5.7: The Effects of Education on Fertility Control and Fertility Demand

Dependent	Contraceptive	Nonnumeric	Ideal family
R-squared	0.0702	0.0366	0.1278
Education dummies			
Primary	0.084978***	-0.11383***	-0.738***
Secondary	0.13353***	-0.16948***	-1.10509***
Higher	0.147538***	-0.17469***	-1.37152***
Age	0.030168***	-0.01436***	0.017462
Age-squared	-0.00042***	0.00025***	0.00014
Rural	-0.05244***	0.039052***	0.942133***
Formal sector	0.021447**	-0.0108	-0.19807**
Constant	-0.37359***	0.406478***	4.548597***

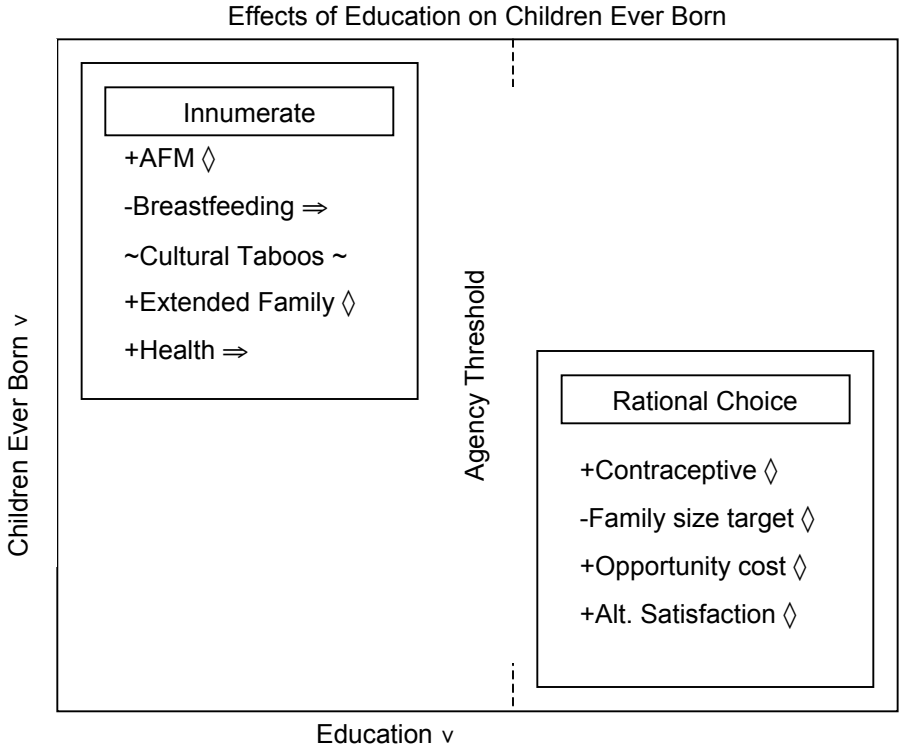
***significant at 1% level, **significant at 5% level, *significant at 10%level

With all levels of education, contraceptive use increases, indicating that more educated women are more willing to engage in family planning, although the overall predictive power of this model indicated by the R-squared is low. There is a significant but economically slight positive effect on contraceptive use for primary education, but a larger effect for secondary and higher education.

All levels of education also decrease the likelihood of offering a nonnumeric response when asked about ideal family size, offering more evidence that education can potentially remove people from the innumerate framework. Because this effect appears at all education levels, it is evident there is not a single agency threshold, but rather that the level of education needed to embrace agency over family size differs for each women. Some women would likely continue to adhere at any education level to religious beliefs dictating family size should be left up to God.

Additionally, for those women who already respond numerically, education lowers ideal family sizes. This indicates that education may be raising the opportunity cost of women or enhancing awareness of alternative sources of satisfaction, as Cochrane (1979) suggests.

These findings lead to the conclusion that while education does not unambiguously reduce family size, it can have powerful effects both on the natural determinants of fertility and on the factors that determine fertility outside the innumerate framework. First and foremost, education is expected to decrease natural fertility by significantly increasing age at first marriage. Education also increases instances of living with extended families and has no effect on adherence to cultural taboos, leaving both of these natural fertility checks in place. At the same time, education removes some women from the innumerate framework, evidenced by lower instances of offering nonnumeric ideal family sizes at higher education levels, and acts on women already making conscious fertility decisions by lowering their family size targets and increasing their use of contraceptives. Therefore, it seems that for these factors, education affects fertility in more ways that decrease family size than that increase it. I have therefore adjusted my theoretical model for education's effects to make it consistent with my findings.



VI. Conclusions

This study aimed to discover whether there are ways to reduce family sizes in rural Senegal within a framework where people are reluctant to admit control over childbearing. By carefully examining both conscious and unconscious ways family size can be impacted, my research improved on earlier literature that did not pay close attention to women who did not admit agency over family size. I first identified factors in the literature expected to impact family size without conscious agency, then tested how these factors affected total children ever born for a representative sample of Senegalese women. I then used a new model for how education acts on fertility in both the innumerate and conscious-agency framework to untangle the myriad impacts of education and try to determine which effects were likely to be strongest.

My research drew largely on Kelley's 1982 framework, and my results are mostly in line with his findings. However, Kelley's conclusions about education were more pessimistic than my own. Interestingly, Kelley et al. were studying rural Egypt in 1976, which was remarkably similar to modern-day Senegal in demographic characteristics. These societies, which lag behind their regions in demographic indicators of development, require new ideas and fresh models to try to improve standard of living on their own cultural terms. It is my hope that my analysis will provide a basis for this sort of new thinking about fertility in Senegal.

The major results of my study are threefold: 1) Age at first marriage is negatively correlated with fertility. By raising age at first marriage, total children ever born can be reduced. This will also result in reductions in infant mortality, since older mothers are shown in the literature to be better able to care for infants, and since smaller family sizes

are less likely to have child mortality. The direct effect on children born is not overwhelmingly large, but this small gain coupled with other gains could make a significant impact. This result is robust for different alternate specifications of the model. 2) Cultural taboos against sex while breastfeeding, living arrangements in which the husband is not the household head, and increased breastfeeding all reduce total children ever born, although my findings on breastfeeding were less robust than other findings. 3) Education acts on fertility in many ways, and it is unclear whether education will increase or decrease fertility in rural areas. Primary education increases fertility, especially in rural areas, when age at first marriage is controlled for. However, this is mainly due to increased health, and thus fecundity, and decreased breastfeeding. Secondary and higher education reduce fertility, but both are rare. Because education is positively correlated with age at first marriage, however, and because increased health increases welfare overall, I am optimistic for the prospects of education increasing welfare in Senegal, even if it does not decrease family size in all cases.

Implications

The implications of these findings are that education may not be the panacea that was hoped for rural women, yet is still worth pursuing because of its multiple positive side effects. Additionally, the effect of education on increasing age at first marriage alone may be enough to make it smart policy. Although small levels of education may increase fertility, it does so only by either increasing the health of the mother or decreasing rates of breastfeeding. The latter could be accounted for by including education on the health benefits of breastfeeding in any education program. Moreover, since education also is expected to increase both the health of the mother and her

children, its increases of fertility through health can hardly be seen as a negative impact. As a result, strengthening the education system for women in Senegal would most likely benefit the country, whether or not it directly impacts fertility.

My other findings provide other possibilities for policies to reduce fertility. The promotion of formal sector jobs for women is expected to decrease fertility and, Kelley (1982) suspects, strengthen the effect of education. Cultural taboos about having sex while breastfeeding, once considered antithetical to a modern society, need to be reconsidered in the wake of evidence that they serve a practical purpose. The government may also want to encourage families to live together as extended units and share resources, since this was shown to reduce family size for each woman. This could be done easily through tax breaks for extended families.

And, perhaps most clearly, later ages at first marriage should be encouraged, first because they reduce total family size, but also because they reduce infant mortality for all children born. This could be done by strongly enforcing, or raising, the legal marriage age of 14 already in place, or pursued through education. Support for later marriages is the strongest conclusion of my analysis. While the impact may be initially small, as the culture changes toward later marriages, the effects on well-being for individual families may be immense.

Limitations and avenues for future research

My study was limited by the data available to me. As such, my first recommendation is that future surveys be DHS be carried out with a mind to the direction of the research the surveys hope to foster. Information on the health of the woman and her children is critical in conducting analyses of well-being in sub-Saharan Africa.

Moreover, it is one of the few things that can be objectively measured by the researcher by calculating height and weight percentiles so that reliable data is more likely. Gathering information on health for mothers and children should be a foremost priority of the DHS.

My study is also limited in that it does not reflect the newest developments in the economic theory of fertility. While this was intentional, because I hoped a simpler model would offer clearer implications, future research may want to re-complicate the model to account for endogeneity of some of the right-hand variables, all the while bearing in mind that the goal of this research should not be an ideal model, but a usable answer. Researchers should look to Kelley and Schmidt (1988) for more robust estimation techniques and ideas for reliable instruments.

Future studies may also want to update the Senegal study with the latest data available, compare Senegal to other highly religious African countries, and incorporate a longitudinal element. Each of these improvements on my work may help to answer the ultimate question of how sub-Saharan African countries can be made better off, specifically by reducing family sizes to levels supportable by individual households.

While making these improvements, however, future research should not lose track of the necessity of tailoring models to specific cultural and religious factors in a given country rather than seeking increasingly complex models that elegantly explain fertility in some situations but fail to capture its mechanisms in others. That an innumerate, or passive, framework for fertility can coexist with more conventional cost-benefit decision-making, and that both must be addressed if fertility theory hopes to remain relevant to developing countries, is the single most important conclusion of my analysis.

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