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SOCIOECONOMIC DETERMINANTS OF FERTILITY AND CHILD MORTALITY IN SUDAN

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Abstract

This paper uses household data from Sudan to examine the determinants of fertility in the context of the microeconomic model of household production, the factors which affect child mortality and the interaction between child mortality and fertility. Thus, the impact of the education of the mother and the father and household income per adult on fertility and child mortality are examined. Also, in examining the interaction between fertility and child mortality the latter is instrumented on the public health programs which are used as identifiers in the two stage least squares estimation of the fertility function. Parental education and income per adult are found to have a significantly negative impact on fertility and child mortality, and mother's education in particular is found to have a larger and more significant effect than that of the father and is robust to the estimation methods. Public health programs are found to produce significant reductions in child mortality and a positive and significant association between fertility and child mortality is revealed by the data.

KEY WORDS : Fertility, Mortality, Education, Mother, Father.

1. Introduction:

This paper examines the effect of parental education on fertility and child survival and the interaction between child survival and fertility in the Sudan. The effect of income is also measured. Studies of other developing countries have found that education reduces fertility and increases child survival (Cochrane, 1979, 1982; Rosenzweig and Schultz, 1982). The relationship between child survival and fertility also plays a crucial role in the mechanism of the demographic transition from a high fertility regime to a lower one and has been investigated empirically for varied environments (Schultz,1981) but only for few African countries (Okojie, 1991; Maglad, forthcoming).

Sudan had a population of 20.6 million in 1983 and a rate of population growth of 2.7% per annum in the period 1955-83 (Population Census Office,1990). Of this total 20.5% was urban, 68.5% rural and 11% nomadic. Completed fertility, measured by children ever born for women in the age group 45-49, increased from 4.8 in 1973 to 5.7 in 1983. However, the average for younger women up to the age group 30-34 were lower in 1983 than in 1973. Child mortality, as in many other African countries, is high but has been declining over the past decades. The proportion of surviving children for women age group 45-49 increased from .73 in 1973 to .81 in 83 (Population Census Office,1990). Women education has been spreading but females' school enrollment still lags behind males' school enrollment. In 1985/86 primary enrollment ratio for males,age 7-12, was 58% while it was 41% for females (Educational Statistics Section,1987).

The rest of this paper proceeds as follows. In section 2 some theoretical background is offered and the empirical model is specified. In section 3 the data on which the analysis is based are discussed and in section 4 the empirical estimates are presented. A conclusion is given in section 5.

2. Theory and Empirical Specification:

The household economic model (Becker,1965) has been used as a basis to study fertility behavior by a number of scholars (Becker(1973); Willis(1973); De Tray (1973); Schultz(1976a,1981); Rozenweig and Evenson (1977)). In this approach, the household is assumed to maximize a utility function of consumption activities Z_i (i=1,....n), which are produced within the household using the resources (of time and market goods) and the technology at the household's disposal, subject to the constraints of full income and the time of its members. This optimizing framework implies that the demand for children is related to the predetermined exogenous variables which the household cannot vary: full income, value of time (given by market wage rate) and prices of market inputs used in production. Thus, if Z_c, Y, ω_f, ω_h,P_{xc} are respectively the number of children, full income, wife's wage rate, husband's wage rate and price of input x in child production, then

(1) $Z_c = f(Y,\ \omega_f,\ \omega_h,\ P_{xc})$

The partial derivatives of Z_c with respect to the argument can be signed under some given assumptions (Schultz, 1976a). Firstly, if it is assumed that the production of children is mother's time intensive, which is not unreasonable, then

$\delta Z_c/\delta\omega_f < 0$ and $\delta Z_c/\delta\omega_f < \delta Z_c/\delta\omega_h$

that is, an increase in the value of wife's time would lead to a reduction in number of children conceived and it will do so to a greater extent than will an increase in the value of her husband's time. Secondly, the assumption of normality in consumption of children implies $\delta Z_c/\delta Y > 0$; that is an increase in income will lead to an increase in number of children. However, if child quality is recognized as an argument in the utility function and it is assumed that the income elasticity of child quality is greater than that of number, then the observed relationship between number of children and income could be negative. Because the rich would tend to demand high quality children, this would raise child costs and therefore a negative relationship between income and the number of children might be observed (Becker and Lewis, 1973).

In the following analysis fertility, defined by the number of children ever born, is hypothesized to be a function of prices, income and some socio-economic variables in the following way:

(2) $F = \beta_0 + \beta_1 E_w + \beta_2 E_h + \beta_3 Y + \beta_4 A_w + \beta_5 R + \beta_6 M + \mu$

where E_w, E_h, Y, A_w, R and M are respectively the education level of wife, education level of husband, household income per adult, wife's age, residence region dummy and child mortality rate. Education level is introduced to capture the effect of the value of time of the individual. Woman's age controls for the wife's biological supply. The income measure which is used in regression is permanent income as measured by annual consumption expenditure of food and non-food items (Deaton and Mauellbauer,1980). One problem with this measure is its endogeneity. In the household, decisions regarding the woman's labour force participation in income-earning activities and number of children to bear are jointly determined. And since the woman's earning and consumption would be difficult to net out of the household, the income measure and the error term in the fertility equation will be correlated resulting in biased estimate of the income effect[1]. Child mortality is included among the explanatory variables since it has been hypothesized that fertility respond positively to child loss as well as the expectation of child loss(Ben-Porath,1984;Schultz,1969). It has been shown that, given an inelastic demand for survivors and unitary elasticity of expected cost per survivor with respect to probability of a child survival to maturity, demand for derived births will increase in response to a decrease in the probability of child survival[2] (Schultz,1976b). It has, also, been argued that child mortality is an endogenous variable and that the use of child mortality in the fertility equation would give rise to simultaneity problems because child mortality itself is hypothesized to depend on the number of births which a woman could bear over the life cycle i.e. a woman with a large number of children would suffer more child loss. Also, fertility and child mortality depend on many unobserved variables (Schultz, 1976a, 1976b). Olsen (1980) however, assumes that the cross sectional child mortality rate, the proportion of children dead to those born, is not correlated with the error term and can be used as an instrument to obtain consistent estimates. In this analysis child mortality, defined as death rate in age one to age five, is assumed to depend on the exogenous variables in (1) plus public program variables related to health and an error υ assumed to be normally distributed, which capture the impact of all other unmeasurable factors on child death

(3) $M = \delta_0 + \delta_1 E_w + \delta_2 E_h + \delta_3 Y + \delta_4 A_w + \delta_5 R + \delta_6 H + \upsilon$

where H is a vector of health program variables. The program variables which are used in the analysis are the availability of hospital beds per capita and services of the Blue Nile Health Project (B.N.H.P). The B.N.H.P. provides services in the areas of sanitation and combats water-borne diseases like malaria and schistosomiasis that are encouraged by irrigated agriculture[3]. The use of health programs in the mortality function only is justified because they are more directly and strongly related to combating and curing diseases than with birth control or the program of family planning services. Finally, the error term μ in the fertility function is taken to reflect the effect of tastes or biological hetrogeneity on fertility and is assumed to be independently normally distributed but potentially correlated with M.

3. **Data:**

This analysis of the determinants of fertility and child survival uses a sample of 2027 Sudanese households resident in rural areas of the Central state and one Western state (Kordofan), and four urban centers. The rural sample included thirty four villages located in four agricultural schemes that extend over most of the Central state and some part of the Eastern state. The households were selected by a multi-stage stratified random sampling where in each area villages are stratified according to the level of development, as indicated by the presence of services, with special emphasis on education and a random village is chosen from each strata. In the second stage a random sample of households was chosen from the list of households in that village (see Appendix A for sample selection description). A total of 1400 units were selected in this way. In the urban areas stratification is based on geographical location according to the different income classes, using residential class as an indicator of the latter(see Appendix A). A total of 627 urban households were thus selected. For each household two questionnaires, one for the household and one or more for all married women in the household were completed. In addition, a community questionnaire registered the available health and education services, total population and number of households, transport facilities and disease problems in each of the sampled villages. For purpose of our analysis only households where both husband and wife are present are analyzed. This working sample includes 1807 households.

4. **Empirical Results:**

The estimation of fertility and child mortality is carried out for women with at least one birth. This restriction on the sample reduced the number of observation further to 1684 households. Table (1) defines each of the variables and Table (2) provide the sample statistics for the variables analyzed below. As Table (2) shows, the mean number of children ever born is 5.64 for all women, while the child mortality rate is 0.10. The number of births for rural and urban areas are 5.84 and 5.15 respectively. The corresponding figures for child morality are .11 and .07. Thus both fertility and child mortality are higher in rural than urban areas. The mean age of wife is 37.8 for all women. The illiteracy rate is higher among women than men, where 57% of all women in the sample are illiterate compared with 44% of the men. Older women are largely illiterate. For example 85% , 62% ,43% and 39% of the age cohorts 50+, 34-49, 25-34 and 15-24 are respectively illiterate.

Table (3) presents estimates of two specification of the fertility equation for all women and by region. In specification (1) the age of wife, the education variables, the logarithm of income per adult and child mortality are included (Appendix Table (B2) gives a specification where child mortality is excluded). Specification (2) adds regional dummies. Wife's age is introduced as a five years interval age dummy, with age cohort 15-19 as the reference category, in order to capture non-linearity in cumulative fertility . Fertility is significantly related to age of wife for the different age-cohorts as shown. An inverse relationship is reported between a woman's education level, husband's education and number of children born. But, it is the women's secondary and above levels of education which have a significant influence, with tertiary level of education having a still larger impact. Since women with these education levels are more likely to be working or seek work opportunities for wages outside the home, the negative impact of education on fertility could be construed as reflecting the effect of the price of time for these women and consequently the cost of children on the number of children born. Moreover, consistent with the microeconomic model of demand for children, it is the wife's education which has the larger and most significant negative impact on depressing fertility compared with husband education's effect. The insignificant effect of primary level of education on children born is explicable in terms of the low value of mother's time as they face few job opportunities. The joint F-test indicates also that the wife's education and husband's education are statistically significant. On average a woman with a secondary level of education has 1.4 fewer children, whereas a woman with higher than secondary education has 1.7 fewer children.

Income is negatively related to fertility and has a statistically significant coefficient. This finding is contrary to the predictions of the most simple microeconomic framework of fertility determination, where income increases the demand for children. The estimated income coefficient might not be measuring a pure income effect if there are regional or household differences in the prices of children which are correlated with measured income. The coefficient on income may thus be reflecting combinations of price and income effects. Since no account is taken of the opportunity cost of children or the opportunity cost of complements to children, a downward bias in the estimate of the impact of income is expected. It is also argued that the woman's decision to enter the labor market and fertility are determined jointly and since household income includes the wife's earnings and consumption the latter cannot be modelled as an exogenous variable. Fertility and income will be jointly determined and the error term and income will be correlated and hence the impact of income on fertility will be biased and inconsistent. The Hausman test of exogeneity (Hausman,1978) is applied to test the exogeneity of log expenditure per adult. Log expenditure per adult is explained by the husband's education, wife's education, husband's age, wife's age, the regional dummies and assets (see Appendix Table (B3). The variables measuring assets are categorical based on ownership and are found to be significantly correlated with income per adult and not correlated with fertility and child mortality[4]. Thus they are used as identifiers of the income function. The t value on the residuals from the predicted expenditure per adult is provided in the bottom of Table (3). The t-value in specification (1) indicates that the null hypothesis that income is exogenous is rejected at 5% significance level. In specification (2), which controls for regions, the exogeneity of log expenditure per adult cannot be rejected at 5% level of significance.

Child mortality is positively and significantly related to fertility in both specifications for all women in Table (3). The coefficient implies that demand for surviving children is inelastic assuming that the expected cost of surviving child is proportional to the probability of child survival. An average replacement coefficient of .20 is derived from the estimated coefficient of child mortality[5] (1.14/(1.14*0.10 + 5.64)). As argued earlier, if child mortality error is correlated with fertility error, then the response coefficient on child mortality may reflect in part the spurious relationship between observed child mortality and fertility. Thus the Hausman test for exogeneity is performed for child mortality where public health programs provide the needed identifying restriction. The t value on the residual child mortality in the bottom of Table (3) is -.97, in the preferred specification (2), implying that the hypothesis that child mortality rate is exogenous can not be rejected at 5% significance level.

The effect of the regions in specification (2) show large geographic differentials in fertility exists even after controlling for differences in household characteristics. Fertility is highest in the rural areas and within the rural areas the highest fertility is observed for the Gezira Extension (Managil) and Eastern Gezira (Rahad). Production in these two areas started lately compared to Gezira, and Rahad land in particular was developed and started production in the early 80's. Agricultural Productivity and income in these areas might thus be higher.The lowest fertility in the rural areas is in Blue Nile (Suki). This is an area which is characterized by the lowest mortality among the rural areas as will appear later (Table (4)). Urban areas do not favor a reduction in fertility. Outside Khartoum fertility is highest in Urban White Nile and lowest in Urban Gezira. Note that Urban White Nile fertility is not different from rural areas of high fertility. This area, as will be shown later (Table (4)), is also characterized by the lowest child mortality among the urban areas. The joint F-test indicates that these regional differences are statistically significant at 5% significance level.

The fertility functions are estimated separately for rural and urban areas in Table (3) and are consistent with the previous findings for all women regarding the effect of the woman's education. However, in the urban areas, husband's education is significant for tertiary level of education while this level of education has no significant influence on fertility in the rural areas but includes only 5 percent of rural men. While secondary level of education of husband has a significant negative effect on number of children ever born in the rural areas, this is not evident in urban areas. However, husband's education is statistically significant in the urban areas when regions are not controlled, as revealed by the F-test. Once again Income has a negative and significant impact in urban areas and in rural areas in specification (2). Child mortality is positively related to fertility in rural and urban areas, but is only significant for the rural areas. The replacement response for rural areas as derived from the estimated coefficient of the child mortality rate and sample mean values is 0.23 (1.35/{1.35*.11 + 5.8.}). The Hausman test shows that in the rural areas the exogeneity of income per adult and child mortality in the preferred specification (2) cannot be rejected at 5% level of significance while in the urban areas the test for the exogeneity of child mortality is rejected.

The preferred specification (2) of the fertility function is estimated for different age cohorts and the results are presented in Appendix Table (B1). The negative effect of both wife's and husband's education and their relative impact on fertility is confirmed for various age cohorts. Primary education is again insignificant in affecting fertility. For the youngest age cohort, 15-24, only secondary education has a significant impact on reducing births. Few women, however, have completed any tertiary education and already had a birth in this age cohort, specifically 1.0 percent (Table (2)). Husband's education is significant only for the secondary level. For age cohort, 25-34, secondary education and tertiary education of wife are both significant in depressing fertility. primary education and secondary education of the husband in this age group is significant in influencing fertility. For age cohort, 35-49, secondary education and tertiary education of the wife has a significantly negative effect on fertility. In this age cohort, husband's education has a significantly negative impact on number of births only for the 10 percent with tertiary level of education. For older women, 50+, completed fertility is negatively and significantly affected by secondary education level of the wife. Husband's education has no significant effect on fertility at all levels and education at primary and tertiary level is observed to have a positive effect on fertility.

Note that the overall effect of wife's education is significant only for the age cohorts 25-34 and 35-49 while husband's education is insignificant in all age cohorts as indicated by the joint F-test.

A negative and significant influence of income is noted for the age cohorts 35-49 and 50+ while a positive effect is observed for the younger age groups 15-24 and 25-34 but significant only for the latter group. The positive income effect in the age cohorts 15-24 and 25-34 might suggest that women in these age cohorts are users of contraceptives, and by controlling for age the effect of children costs (in terms of contraceptives) is isolated from that of income.

Child mortality is positively and significantly related to fertility in young age cohorts 15-24 and 25-34. For the age cohort, 35-49, a positive but insignificant effect of mortality on fertility is observed. Thus the effect of mortality is positively significant in the youngest age cohorts where it is still possible to replace dead children.

Regarding the effect of residence one general pattern seems to emerge. In the oldest age cohort, 50+, fertility is higher in the urban areas than in the rural areas and the difference is statistically significant whereas in age cohort 35-49 the highest fertility is observed in the rural areas and the difference is statistically significant. The differential in fertility between women living in rural and urban areas diminishes as one moves to age cohort 25-34 and for the youngest age cohort fertility is lowest in urban areas but the difference is not statistically significant. The high fertility in the oldest women in urban areas could be explained by the short durations or an abandonment of breast feeding and absence of other methods of birth control among this cohort (Caldwell,1982). An alternative explanation is that these old women may have moved from rural areas to be with children. The observed low fertility in rural Kordofan might be explained by the continuous outmigration and the droughts in the last decade.

The OLS estimates for the reduced form equations of child mortality are presented in Table (4), for all women, and then for rural and urban women separately. Two specifications are presented: one without region controls and the other add regions of residence. First note that child mortality increases with the woman age linearly. An old woman is more likely to fall in the high-order birth group, where the risk of child mortality is high, and hence to suffer more child loss. For all women, and by region, child mortality and parental education are negatively associated. The results for all women in specification (1) show that father's level of education had a larger and significant impact on child survival compared with mother's education at all levels when income is controlled. A primary level of maternal education reduces child death rate by two percents which is not different from the effects of fathers primary education. Secondary and tertiary education of the father produce a larger reduction in child mortality compared with the corresponding education level of the mother. Moreover, mother's education is not significantly different from zero as revealed by the joint F-test while father's education is statistically significant. This could be explained in terms of the differences in the educational levels between the sexes. There are more men with these educational levels compared with women in the sample. Part of the effect of mother's education might also be captured by income since the latter is correlated with mother's education. On the other hand the effect of mother's education may be underestimated if the program variables capture some of the variation in mothers education. Public program services of health and education in a country like Sudan tend to be made available together when they are provided.

A more restricted form of the mortality function is estimated where the program variables are excluded and the results are provided in Appendix Table (B2). In the restricted form estimates the negative effect of mother's education on mortality is more pronounced and is statistically significant.

The large magnitude and significance of the effect of father's education on child mortality may be over-estimated if education is correlated with some omitted variables that are themselves correlated negatively and significantly with mortality. If, for example the educated are located in areas where the mortality rate is low the estimated coefficients attached to husband's education will be biased upward. Farrah and Preston (1982) found that the regional differences in child mortality in Sudan are significant and persists even after controlling for socioeconomic variables. After controlling for regions of residence in specification (2), a reduction in the magnitude and significance of father's education is observed. Moreover, the geographical differences in child mortality are statistically significant and explain 3 percent of the variation in child mortality. In the urban areas mortality is lowest in Urban White Nile while the lowest mortality in rural areas occurs in Blue Nile. The highest mortality in rural areas is observed in rural Kordofan and Gezira Extension. These are areas of low provision in program services and rural Kordofan was subject to desertification and drought in the last decade.

The estimated coefficient on the logarithm of permanent income per adult indicates the favorable effect of a rise in income on child survival, presumably because it can purchase better food and health inputs that reduce mortality. In Sudan in the last decade, because medical services have become increasingly purchased in the private market. The estimated coefficient of the effect of income, however, may be biased and inconsistent if income is measured with error or it is endogenous as we argued before. Based on the Hausman (1978) specification test, the t statistics on the residual from predicted household expenditure variable is 2.0 as shown in the bottom of Table (4). This is statistically significant at 5% level of significance. Household expenditure in the mortality equation therefore appears to be endogenous and other methods of estimation of income effects should be sought.

Public investment on health program, on the other hand, produces a significant effect reducing child mortality. The Blue Nile Health Project (B.N.H.P.) is associated with lower child death rates than the availability of hospital beds per capita. The favorable impact of the Blue Nile Project on child deaths could be explained by its involvement in establishing healthy and sanitary rural health conditions and combating endemic diseases, like malaria and diarrhea. One, however, needs to be cautious regarding the impact of B.N.H.P. shown by these estimates. If the services of the Project are located in particular areas on basis of better transport, the estimated coefficient may be overestimated as it would be capturing in part the favorable impact of these community variables on mortality. Health programs have a lesser significance than when estimates are obtained without regional controls.

The estimates of child mortality for the rural areas confirm the inverse relationship between parental education and child deaths which is revealed for all women. In Table (4), Mother's primary education is shown to produce 2 percent reduction in child death and is equivalent to a father's primary education. Both mother's and father's education are not statistically significant when regions are controlled. However, in the restricted form, when program variables are excluded (Appendix Table (B2)), parental education is statistically significant. Mother's primary education and father's primary education produce equal reductions in child deaths rate of 3 percent. The estimates for the urban areas in Table (4), show that only the woman's age and husband's higher levels of education are statistically significant. Mortality is highest among the oldest women (10%). A negative but insignificant effect of income is observed. The income effect might be underestimated because of the inclusion of husband's education which is correlated with income. The inclusion of household expenditure could explain why wife's education is insignificant in affecting mortality reduction, since an educated woman in the urban area is more likely to be working and thus contributing to household expenditure. Secondly, in rural areas, mother's education has a larger and more significant impact at all levels compared with its effect in urban areas. A similar pattern exists for the effect of father's education in the rural areas for the primary and secondary level. The increased effectiveness of parental education in reducing child mortality in rural than in urban areas may be because education is more effective in circumstances where mortality rates are high and public health care substitutes are not as available.

The B.N.H.P. effect, when the child mortality is estimated separately for rural areas, though negative, is less significant than the hospital service variable. This could be due to the limited coverage of the Blue Nile scheme and to the differential impact which these services might have in the different socio-economic groups. Studies of child mortality have found that the benefits from public health-sanitation services depend on mothers education (Schultz,1984;Rosenzweig and Schultz,1982). If the uneducated women are disproportionately using the hospital services, and since these are the groups which suffer most from child death, the effect of hospital service would be expected to be larger and more significant on child death reduction compared to that of the Blue Nile Health Scheme. Uneducated women are more likely than educated women to use hospitals, which require waiting in long queues and travel time, because the opportunity value of their time is low compared to that of the educated. One test of the interaction between education and program service in rural areas shows that the uneducated benefit more from hospitals in terms of child death reduction compared with the educated (see Appendix Table(B4)). A negative sign on the interaction terms between mother's education and the Blue Nile Project indicates that the services of this program which are largely of sanitary and protective medicine, are complementary to mother's education. Note that in the urban areas estimates of child mortality, in Table (4), hospital services are not statistically significant in influencing mortality, implying that there is no basis for identifying mortality in urban areas.

Hausman (1978) specification test indicated that in the fertility equation when regions are controlled, in Table (3) specification (2), the hypothesis of exogeneity of income is not rejected. The hypothesis of exogeneity of child mortality is also accepted for all and rural sample but not for the urban sample, in which mortality can not be identified through the health programs as noted above. The specification test, however does not support the hypothesis that income is exogenous in the mortality function for total sample and rural sample, Table (4). For this reason Two Stage Least Squares (TSLS) are sought, and the mortality function is estimated for all and rural sample, where income is instrumented on some of the productive assets of the household as shown in the Appendix Table (B3). TSLS are also used to estimate the fertility equation where child mortality is instrumented on the health program variables for all women and the sample of rural women. The results of estimation by TSLS are presented in Table (5).

The TSLS estimates for child mortality in Table (5) are consistent with those obtained previously as far as how parental education affects child survival. This time however, for all women, the effect of husband's primary education is only one fifth the effect of a primary maternal education. The magnitude and the significance of husband's education is reduced considerably in these estimates. Income now has a larger effect on child mortality and highly significant compared with OLS estimates. Note that while the health services have the expected effect on child survival, they are less significant. Husband's education is no longer significant as a determinant of reduction in child mortality. Since husband's education works through income the effect of father's education may be underestimated. The variables which exerts a significant influence on child mortality are the woman's age, areas of residence, income and to some extent the hospital services. The TSLS estimates of fertility confirm the direction and the importance of the wife's education on fertility behavior. A higher estimate of the effect of mortality on fertility is observed this time though with a lower t-value. The effect of income is reduced and seems to work indirectly through its effect on child mortality. The estimates for all women show that although husband's education is negatively related to fertility it is not statistically significant as reported with OLS estimates. The variables which influence fertility significantly are the wife's age, wife's education, income and areas of residence.

5. <u>Summary and Conclusion:</u>

The paper examined the determinants of fertility in the context of the microeconomic model of household production. It also considered the factors affecting child mortality. The evidence indicates that wife's age and education, husband's education and household income are important factors in explaining family size and child mortality. These factors explains more than 40 percent of the total variation in fertility for all women and above 50 percent of urban fertility variation. Also, 8 percent to 10 percent of the variance in child mortality is explained by these factors.

Child mortality is found to be inversely associated with parental education. In regressions where only parental education and income are included, OLS estimates for all women indicate that maternal primary education brings a reduction of 3% in average child mortality. With an average child mortality rate of .10 this implies a reduction of 3 per 1000. A similar effect is observed for father's primary education. Though secondary education and tertiary education of parents also produces a reduction in child mortality it is the father's secondary education and tertiary education which has the large and significant effect. In the rural areas it is the mother's education which is more important in influencing child mortality while in the urban areas the father's education is more important. Thus in the rural areas, a primary education level of the mother brings a reduction of almost 3% in average child mortality. In the urban areas, secondary education and tertiary education of the father brings a reduction in child mortality of 3% and 7% respectively but only tertiary education is highly significant. When program and regional controls are introduced the impact of parental education is reduced, and mother's education becomes statistically insignificant. Government health services is indicated to improve the chances of child survival. Thus the sample average hospital beds per capita (curative medicine) is shown to be associated with a reduction of 4% in average child mortality, which is twice the effect of the provision of Blue Nile Health Project services (largely of preventive medicine). The services of the latter are largely confined to the rural areas and the estimates imply that they tend to benefit those with high income. The computed average income elasticity of child death is

- .1, indicating that doubling income from its sample mean would reduce child mortality by .01. Because of the endogeneity of income in the mortality function TSLS are sought to estimate the effect of income. TSLS overall estimates indicate that income produces a larger and more significant effect on child mortality. Based on TSLS estimates, an income elasticity of child death of - .5 and - .7 is estimated for all women and rural women, respectively. Thus a doubling of income would bring a reduction of .05 on average child mortality. Also, TSLS estimates of father education's effect are statistically insignificant. The factors which significantly influence child mortality in TSLS regressions are wife's age, income, hospital services and areas of residence.

In the fertility function, parental education, which is taken as a proxy for the opportunity cost of time, is found to affect demand for children negatively and significantly. Mother's education at secondary and tertiary level is found to produce the largest and most significant reduction in fertility. A woman with secondary level of eduction would have 25% fewer births (1.4 fewer children) than the average (5.6 children) whereas a woman with tertiary education has 30% fewer children (1.7 children). Primary education of a mother is associated with a 4% reduction in average fertility, but is only weakly significant. Fertility differ significantly by area of residence, and after controlling for education urban residence does not seem to favor reductions in fertility. The income elasticity of demand for children is -.03, implying that doubling the income from its sample mean would reduce fertility by 3%. The income elasticity in rural areas is equal to the overall average of -.03 whereas urban income elasticity is higher, -.04. The negative income effect on fertility may reflect the high cost of children as a consequence of parents desire for high quality of children through investment in schooling. Over all women, using OLS estimates, the child replacement effect is .20 whereas in rural areas a child mortality replacement effect is .23. This implies that for rural areas, where child mortality is 11 percent, a reduction of fifty percent in child death would reduce average fertility from 5.84 to 5.77 children. That is for every 100 families 7 fewer children would be born.

NOTES

1. It was not possible to determine annual current income precisely. Although income from wages and salaries, income transfers and home production are observed, the value of services from durable goods and the imputed rent of an owner-occupant house could not be measured for all units. Imputed rent could be determined only for urban residents. Also for some households, where the head is retired or unemployed, none of the sources of current income are reported. The estimates of current income would probably suffer from sample selection bias (Heckman,1979).

2. If B^d is the number of births parents want, then it can be expressed as

$$B^d = (1/p)^\gamma \; F^s(x,\mu)$$

where p is the expected child survival probability and $F^s(x,\mu)$ is the number of surviving children that parents desire, which depends on a set of socio-economic factors, x, which includes the cost of surviving child, c(p), and tastes distributed at random, μ. Assuming $\gamma = 1$, and differentiating with respect to p,

$$\delta B^d/\delta p = (1/p)\;(\delta F^s/\delta c)(\delta c/\delta p) \; - \; F^s/p^2$$

Thus

$$(\delta B^d/\delta p)(p/B^d) = [(\delta F^s/\delta c)(c/F^s)][(\delta c/\delta p)(p/c)] - 1$$

or $\eta_{bp} = \eta_{sc}\eta_{cp} - 1$. Both η_{sc} and η_{cp} are negative and if their product is less than unity, the elasticity of demand for births with respect to the probability of survival, η_{bp}, will be negative. If the elasticity of the expected cost per survival with respect to the probability of child survival to maturity, η_{cp}, is assumed to be unitary then $|\eta_{sc}| < 1$, that is, demand for surviving children is inelastic.

3. The Blue Nile Health Project (BNHP) is a joint venture between the Sudan Government and the World Health Organization(WHO). The program was launched in

1979 and began its operations in 1980. The B.N.H.P. has been successful in establishing improved sanitation and health education services. Safe water supplies, through the installation of deep bore wells, shallow wells with hand pumps, and construction of Horizontal Flow Roughening/Slow Sand Filters(HFR/SSF) with hand pumps, have been made available in all the villages covered by the project. In addition latrine slabs have been provided for all households in the covered areas (B.N.H.P.,1989). In fact when the source of water for the community in rural areas is statistically controlled, the presence of the Blue Nile scheme becomes insignificant as a determinant of child survival.

4. The assets which are distinguished as identifiers of income are ownership of vehicles used for commercial purposes like pick-up trucks and lorries. Ownership of a shop or grocery and ownership of small scale productive enterprises like bakeries, oil mills or flour mills. The farm machineries are things like tractors and harvesters. All these categories are used for productive purposes and they do not distinguish the household as being engaged in any one particular occupation e.g. farm jobs or commercial and services occupation. More often income from the main occupation is supplemented by engagement in secondary jobs through these activities.

5. If the mortality rate $M = D/F$, defined as the number proportion of dead children, D, over those born, F, then replacement rate is obtained from an OLS $\hat{\beta}$ as follows;

$\delta F/\delta D = \hat{\beta}/[\hat{\beta}\bar{M} + \bar{F}]$,

where $\bar{F}$ and $\bar{M}$ are the average values for the sample.

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Table (1) Description of Variables

Variable	Definition
Endogenous Household	
Children Ever Born	Number of Live Birth
Child Mortality	Proportion of Live Birth Dead
Exogenous Household	
Woman's Age	Age of Wife's in Years
Wife's Education:	
Primary	Dummy = 1 if Wife has Primary Schooling
Secondary	Dummy = 1 if Wife has Secondary Schooling
Tertiary	Dummy = 1 if Wife has above Secondary Schooling
Husband's Education:	
Primary	Dummy = 1 if Husband has Primary Schooling
Secondary	Dummy = 1 if Husband has Secondary Schooling
Tertiary	Dummy = 1 if Husband has above Secondary Schooling
Log(Income/adult)	The value of annual consumption expenditure on food and non food items, including the value of goods used for consumption from own farm production, in thousand pounds, divided by adults, 15 years and over, in household and expressed in natural logarithm. The variable is potentially endogenous.
Exogenous Community	
Programs:	
Hospital Beds	Number of Hospital Beds per Ten Thousand in Area Council
Blue Nile Health Project(B.N.H.P)	Dummy = 1 if village is under Blue Nile Health Project
Regions:	
Rural/Gezira Main	Dummy = 1 if residence is Main Gezira
Rural/Gezira Extension	Dummy = 1 if residence is Managil
Rural/Eastern Gezira	Dummy = 1 if residence is Rahad
Rural/Blue Nile	Dummy = 1 if residence is Elsuki
Rural/Kordofan	Dummy = 1 if residence is Kordofan
Urban/Gezira	Dummy = 1 if residence is Wadmedani
Urban/Blue Nile	Dummy = 1 if residence is Sennar
Urban/White Nile	Dummy = 1 if residence is Eddwame
Khartoum	Dummy = 1 if residence is Khartoum

Table (2) Means and Standard Deviations for all Women Age 15 or more with at least one child and By Region and Age Group

Variable	All	Rural	Urban	15-24	25-34	35-49	50+
Endogenous Household							
Children Ever Born	5.64	5.84	5.15	2.25	4.00	6.87	7.92
	(3.17)	(3.19)	(3.07)	(1.52)	(2.14)	(2.82)	(2.93)
Child Mortality	.102	.113	.073	.033	.086	.106	.160
	(.164)	(.167)	(.153)	(.114)	(.166)	(.156)	(.183)
Exogenous Household							
Woman's Age	37.8	37.2	39.1	21.9	29.0	40.8	56.4
	(11.6)	(11.9)	(10.9)	(1.85)	(2.64)	(4.42)	(6.49)
Wife's Education:							
Primary	.212	.223	.187	.298	.212	.236	.109
	(.409)	(.416)	(.390)	(.458)	(.409)	(.424)	(.313)
Secondary	.184	.109	.362	.303	.286	.131	.046
	(.387)	(.312)	(.481)	(.461)	(.452)	(.338)	(.211)
Tertiary	.037	.011	.098	.016	.081	.024	.000
	(.188)	(.104)	(.294)	(.126)	(.273)	(.153)	(.000)
Husband's Education:							
Primary	.239	.238	.241	.218	.231	.258	.226
	(.427)	(.426)	(.428)	(.414)	(.422)	(.438)	(.419)
Secondary	.218	.169	.336	.409	.287	.167	.089
	(.413)	(.375)	(.473)	(.493)	(.453)	(.374)	(.286)
Tertiary	.104	.047	.241	.053	.148	.108	.049
	(.306)	(.212)	(.428)	(.225)	(.356)	(.311)	(.218)
Log(Income/adult)	5.15	4.96	5.59	5.41	5.51	5.09	4.45
	(1.08)	(1.05)	(1.04)	(.922)	(1.05)	(1.03)	(1.01)
Exogenous Community							
Hospital Beds*10^{-2}	.514	.280	1.07	.406	.526	.525	.536
	(.487)	(.297)	(.387)	(.438)	(.504)	(.482)	(.491)
Blue Nile Health Project	.367	.521		.436	.357	.363	.348
	(.482)	(.499)		(.497)	(.479)	(.481)	(.477)
Regions:							
Rural/Gezira Main	.400	.482		.383	.329	.342	.326
	(.473)	(.500)		(.487)	(.470)	(.475)	(.469)
Rural/Gezira Extension	.049	.069		.074	.056	.042	.033
	(.215)	(.254)		(.263)	(.231)	(.201)	(.179)
Rural/Eastern Gezira	.074	.104		.133	.092	.063	.027
	(.261)	(.306)		(.340)	(.289)	(.244)	(.161)
Rural/Blue Nile	.115	.163		.106	.120	.112	.120
	(.319)	(.370)		(.309)	(.326)	(.315)	(.325)
Rural/Kordofan	.128	.181		.122	.116	.130	.146
	(.333)	(.385)		(.328)	(.321)	(.336)	(.354)
Urban/Gezira	.070		.237	.027	.054	.084	.093
	(.255)		(.426)	(.161)	(.227)	(.278)	(.291)
Urban/Blue Nile	.074		.251	.074	.071	.063	.103
	(.262)		(.434)	(.263)	(.258)	(.244)	(.304)
Urban/White Nile	.051		.173	.021	.043	.063	.056
	(.220)		(.379)	(.144)	(.203)	(.244)	(.231)
Khartoum	.099		.338	.058	.116	.099	.096
	(.299)		(.473)	(.235)	(.321)	(.299)	(.295)
Sample Size	1684	1187	497	188	532	663	301

Table(3) OLS Estimates of Fertility for All Married Women Age 15 or more with at least one child and by Region

	All		Rural		Urban	
Covariate	(1)	(2)	(1)	(2)	(1)	(2)
Woman's Age						
[15-19]						
20-24	1.194(2.10)[a]	1.150(2.00)[a]	1.252(2.00)[a]	1.182(1.89)[b]	0.015(0.01)	0.329(0.21)
25-29	2.457(4.34)[a]	2.410(4.28)[a]	2.524(4.10)[a]	2.461(3.99)[a]	1.181(0.76)	1.412(0.91)
30-34	3.366(5.94)[a]	3.370(5.99)[a]	3.500(5.65)[a]	3.427(5.55)[a]	2.000(1.28)	2.331(1.50)[c]
35-39	4.674(8.27)[a]	4.685(8.32)[a]	5.000(8.10)[a]	4.918(7.96)[a]	2.955(1.89)[b]	3.250(2.10)[a]
40-44	5.678(9.90)[a]	5.654(9.88)[a]	6.183(9.80)[a]	6.000(9.56)[a]	3.595(2.28)[a]	3.920(2.50)[a]
45-49	5.789(10.1)[a]	5.746(10.0)[a]	6.146(9.71)[a]	5.987(9.48)[a]	4.100(2.58)[a]	4.349(2.77)[a]
50+	5.951(10.5)[a]	5.920(10.4)[a]	6.116(9.80)[a]	5.922(9.47)[a]	4.587(2.90)[a]	4.962(3.16)[a]
Wife's Education						
Primary	-0.117(-0.69)	-0.245(-1.44)[c]	-0.107(-0.53)	-0.217(1.10)	-0.277(-0.91)	-0.350(-1.15)
Secondary	-1.440(-6.69)[a]	-1.388(-6.35)[a]	-1.100(-3.67)[a]	-1.187(-3.99)[a]	-1.646(-4.95)[a]	-1.557(-4.71)[a]
Tertiary	-1.980(-5.32)[a]	-1.720(-4.56)[a]	-2.133(-3.00)[a]	-2.210(-3.13)[a]	-1.816(-3.78)[a]	-1.615(-3.37)[a]
Husband's Education						
Primary	-0.176(-1.11)	-0.274(-1.70)[b]	-0.224(-1.17)	-0.332(-1.73)[b]	-0.096(-0.31)	-0.131(-0.42)
Secondary	-0.352(-1.78)[b]	-0.410(-2.00)[a]	-0.389(-1.56)[c]	-0.540(-2.16)[a]	-0.347(-0.98)	-0.249(-0.71)
Tertiary	-0.672(-2.56)[a]	-0.523(-1.94)[b]	-0.076(-0.19)	-0.231(-0.60)	-0.953(-2.37)[a]	-0.641(-1.58)[c]
Log(Income/adult)	-0.148(-2.40)[a]	-0.190(-2.95)[a]	-0.077(-1.00)	-0.155(-1.98)[a]	-0.221(-1.99)[a]	-0.212(-1.83)[b]
Child Mortality	0.963(2.64)[a]	1.136(3.12)[a]	1.144(2.63)[a]	1.355(3.10)[a]	0.433(0.65)	0.442(0.67)
Regions						
Rural/Gezira Main		1.020(4.43)[a]		0.869(4.00)[a]		
Rural/Gezira Ext.		1.085(3.18)[a]		0.968(3.12)[a]		
Rural/East. Gezira		1.087(3.62)[a]		0.939(3.39)[a]		
Rural/Blue Nile		0.600(2.11)[a]		0.489(2.10)[a]		
[Rural/Kordofan]		0.125(0.43)				
Urban/Gezira		0.763(2.61)[a]				0.738(2.54)[a]
Urban/Blue Nile		0.917(3.24)[a]				0.797(2.92)[a]
Urban/White Nile		1.052(3.31)[a]				1.031(3.38)[a]
[Khartoum]						
Intercept	2.700(4.19)[a]	2.179(3.10)[a]	2.079(2.92)[a]	1.990(2.79)[a]	4.648(2.70)[a]	3.593(2.00)[a]
R^2	0.47	0.47	0.45	0.46	0.52	0.53
F	98.3	67.4	64.8	52.9	34.9	30.6
Joint F-test:						
Wife's Age	106.	96.3	79.8	72.8	21.8	22.9
Wife's Education	20.7	15.9	6.79	7.36	9.93	8.37
Husband's Educ.	2.25	1.85	1.02	1.87	2.48	0.98
Regions		5.44		5.00		4.82
Hausman Test:						
Log(income/adults)	-2.64	-1.05	-3.67	-1.29	-1.19	0.10
Child mortality	-1.28	-0.97	-0.86	-0.96	-3.60	3.38
Sample Size	1684	1684	1187	1187	497	497

[ ] Reference category.
Figure in parenthesis are t-statistics.
[a] Coefficient statistically significant at 5% significance level.
[b] Coefficient statistically significant at 10% significance level.
[c] Coefficient statistically significant at 20% significance level.

Table(4) OLS Estimate of Child Mortality for All Married Women Age 15 or more with at least one child and by Region

	All		Rural		Urban	
Covariate	(1)	(2)	(1)	(2)	(1)	(2)
Woman's Age						
[15-24]						
25-29	0.052(3.46)[a]	0.053(3.60)[a]	0.050(2.90)[a]	0.051(2.96)[a]	0.058(1.83)[b]	0.058(1.81)[b]
30-34	0.064(4.27)[a]	0.064(4.27)[a]	0.058(3.27)[a]	0.056(3.18)[a]	0.074(2.43)[a]	0.074(2.40)[a]
35-39	0.057(3.82)[a]	0.057(3.78)[a]	0.050(2.83)[a]	0.048(2.71)[a]	0.066(2.17)[a]	0.064(2.10)[a]
40-44	0.068(4.16)[a]	0.071(4.35)[a]	0.071(3.61)[a]	0.072(3.71)[a]	0.058(1.80)[b]	0.059(1.79)[b]
45-49	0.069(4.16)[a]	0.073(4.34)[a]	0.073(3.62)[a]	0.073(3.64)[a]	0.062(1.91)[b]	0.064(1.95)[b]
50+	0.100(6.34)[a]	0.103(6.46)[a]	0.098(5.15)[a]	0.099(5.19)[a]	0.100(3.37)[a]	0.100(3.38)[a]
Wife's Education						
Primary	-0.019(-1.65)[c]	-0.019(-1.68)[b]	-0.020(-1.46)[c]	-0.024(-1.74)[b]	-0.014(-0.67)	-0.013(-0.64)
Secondary	-0.016(-1.10)	-0.017(-1.13)	-0.033(-1.65)[c]	-0.035(-1.75)[b]	0.001(0.05)	-0.001(-0.02)
Tertiary	-0.027(-1.10)	-0.031(-1.22)	-0.065(-1.37)[c]	-0.067(-1.41)[c]	-0.011(-0.32)	-0.010(-0.33)
Husband's Education						
Primary	-0.025(-2.33)[a]	-0.018(-1.67)[b]	-0.022(-1.73)[b]	-0.016(-1.24)	-0.016(-0.77)	-0.015(-0.71)
Secondary	-0.039(-2.87)[a]	-0.033(-2.46)[a]	-0.037(-2.22)[a]	-0.033(-1.95)[b]	-0.036(-1.50)[c]	-0.036(-1.47)[c]
Tertiary	-0.061(-3.38)[a]	-0.059(-3.28)[a]	-0.043(-1.66)[b]	-0.037(-1.44)[c]	-0.077(-2.76)[a]	-0.077(-2.76)[a]
Log(Income/adult)	-0.009(-2.20)[a]	-0.008(-1.80)[b]	-0.011(-2.12)[a]	-0.009(-1.76)[b]	-0.005(-0.70)	-0.004(-0.47)
Exogenous Community						
Hospital Beds*10^{-2}	-0.028(-2.78)[a]	-0.037(-1.74)[b]	-0.044(-2.18)[a]	-0.034(-1.55)[c]	-0.004(-0.21)	0.009(0.36)
B.N.Health Project	-0.016(-2.20)[a]	-0.037(-1.06)	-0.009(-0.77)	-0.036(-1.03)		
Regions						
Rural/Gezira Main		-0.001(-0.03)		-0.014(-0.35)		
Rural/Gezira Ext.		0.007(0.16)		-0.006(-0.22)		
Rural/East. Gezira		-0.037(-1.12)		-0.050(-2.59)[a]		
Rural/Blue Nile		-0.055(-1.52)[c]		-0.069(-4.40)[a]		
[Rural/Kordofan]		0.014(0.38)				
Urban/Gezira		-0.029(-1.03)				0.019(0.78)
Urban/Blue Nile		-0.018(-0.83)				0.006(0.35)
[Urban/White Nile]		-0.040(-1.48)[c]				
[Khartoum]						
Intercept	0.137(5.69)[a]	0.150(3.34)[a]	0.150(5.14)[a]	0.175(5.88)[a]	0.077(1.53)[c]	0.048(0.75)
R^2	0.10	0.13	0.11	0.13	0.08	0.08
F	14.2	10.5	10.2	9.30	3.17	2.80
Joint F-test:						
Wife's Age	6.841	7.12	4.67	4.80	2.10	2.10
Wife's Education	1.03	1.13	1.39	1.66	0.28	0.25
Husband's Educ.	4.47	3.81	2.10	1.49	2.84	2.87
Programs	5.152	2.10	4.58	1.73		
Regions		3.28		5.32		0.30
Hausman Test:						
Log(income/adults)	2.57	2.00	3.21	2.69	0.75	0.32
Sample Size	1684	1684	1187	1187	497	497

[ ] Reference Category.
Figure in parenthesis are t-statistics.
[a] Coefficient statistically significant at 5% significance level.
[b] Coefficient statistically significant at 10% significance level.
[c] Coefficient statistically significant at 20% significance level.

Table(5) TSLS Estimate of Child Mortality and Fertility for All and Rural Married Women Age 15 or more with at least one child

Covariate	Child mortality All	Child mortality Rural	Fertility All	Fertility Rural
Woman's Age:				
20-24			1.110(1.76)[b]	1.125(1.60)[c]
25-29	0.057(3.70)[a]	0.053(2.83)[a]	2.010(2.68)[a]	2.038(2.47)[a]
30-34	0.065(4.18)[a]	0.051(2.64)[a]	2.900(3.62)[a]	2.966(3.48)[a]
35-39	0.058(3.73)[a]	0.042(2.18)[a]	4.262(5.56)[a]	4.517(5.57)[a]
40-44	0.058(3.15)[a]	0.035(1.36)[c]	5.139(6.11)[a]	5.450(5.77)[a]
45-49	0.047(2.14)[a]	0.016(0.50)	5.225(6.17)[a]	5.415(5.72)[a]
50+	0.068(2.78)[a]	0.034(1.00)	5.190(5.10)[a]	5.155(4.64)[a]
Wife's Education				
Primary	-0.017(-1.39)[c]	-0.023(-1.56)[c]	-0.094(-0.37)	-0.011(-0.03)
Secondary	-0.004(-0.27)	-0.027(-1.22)	-1.250(-4.32)[a]	-0.884(-1.80)[b]
Tertiary	-0.043(-0.44)	-0.027(-0.50)	-1.480(-2.96)[a]	-1.655(-1.61)[c]
Husband's Education				
Primary	-0.005(-0.37)	0.012((0.67)	-0.146(-0.63)	-0.210(-0.81)
Secondary	-0.020(-1.29)[c]	-0.010(-0.49)	-0.171(-0.48)	-0.282(-0.68)
Tertiary	-0.043(-2.11)[a]	-0.004(-0.13)	-0.112(-0.20)	0.045(0.08)
Log(Income/adult)	-0.052*(-2.26)[a]	-0.085*(-2.72)[a]	-0.139(-1.50)[c]	-0.089(-0.75)
Child Mortality			8.020**(1.00)	8.880**(0.98)
Exogenous Community				
Hospital Beds*10^{-2}	-0.034(-1.55)[c]	-0.031(-1.30)[c]		
B.N.Health Project	-0.037(-1.04)	-0.035(-0.93)		
Regions				
Rural/Gezira Main	-0.013(-0.29)	0.033(0.72)	1.010(3.98)[a]	1.349(2.17)[a]
Rural/Gezira Exten.	-0.019(-0.42)	0.016(0.49)	0.828(1.72)[b]	1.195(2.71)[a]
Rural/East. Gezira	-0.051(-1.47)[c]	-0.010(-0.30)	1.030(3.05)[a]	1.386(2.25)[a]
Rural/Blue Nile	-0.089(-2.12)[a]	-0.059(-3.37)[a]	0.610(1.94)[b]	1.019(1.49)[c]
[Rural/Kordofan]	-0.025(-0.58)		-0.352(-0.55)	
Urban/Gezira	-0.054(-1.71)[b]		0.725(2.23)[a]	
Urban/Blue Nile	-0.016(-0.71)		0.910(2.91)[a]	
Urban/White Nile	-0.032(-1.12)		1.127(3.12)[a]	
[Khartoum]				
Intercept	0.395(2.93)[a]	0.528(3.60)[a]	1.566(1.44)[c]	0.723(0.41)
R^2	0.12	0.12	0.43	0.40
F	9.96	8.12	55.1	41.8
Joint F-test:				
Wife's Age	3.85	1.86	30.4	24.3
Wife's Education	0.73	0.92	10.6	2.82
Husband's Educ.	1.73	0.56	0.21	0.45
Programs	1.75	1.28		
Regions	2.76	3.83	3.68	2.76
Sample Size	1684	1187	1684	1187

[ ] Reference Category.
Figures in parentheses are t-statistics.
* Variable treated as endogenous and instrumented as reported in the Appendix, Table(B3).
** This is assumed endogenous . The predicted mortality is estimated by instrumenting on the exogenous program service as reported in Table(4), specification (2).
[a] Coefficient statistically significant at 5% significance level.
[b] Coefficient statistically significant at 10% significance level.
[c] Coefficient statistically significant at 20% significance level.

Appendix A

In the rural areas the selection of households proceeded in a multi-stage sampling process, using the administrative structure in the agricultural schemes as a sampling frame. In Gezira and Managil five groups were chosen (four in Main Gezira and one in Managil Extension). Each group consists of a total population of more than 150 thousand. Then a representative block is selected with probability proportional to population size. The villages in each block were then stratified according to the level of development as indicated by the presence of services with special emphasis on education. Thus three strata are defined according to whether all services are available in the village (primary school, junior school, health centers, midwife, deep bore wells), some of the services available and non are available. In the final stage a representative village is selected from each strata. Thus fifteen village were selected from Gezira. Similar procedure is followed in the other schemes, Rahad and Suki, but because these are relatively small, all groups in these schemes are included. In the final stage a sample of households was selected randomly from each village using household names which are available at rural or district council. In the urban areas two-stage sampling procedure was followed. In the first stage residential areas are grouped into three strata based on the three residential locations: first class area, second class and third class and a representative group is selected. In the second stage household are selected at random from that group. In city planning the residential class is taken to reflect the level of income but this is not necessarily true because some rich residents of the third group are often observed. Some bias, therefore, might arise as a result in selection of households.

Appendix Table (B1) OLS Estimate of Fertility for Married Women with at least one child by Age Group

Covariate	15-24	25-34	35-49	50+
Woman's Age:	0.256(4.28)[a]	0.225(7.53)[a]	0.117(4.85)[a]	-0.001(-0.26)
Wife's Education				
Primary	-0.096(-0.32)	-0.134(-0.57)	-0.023(-0.10)	-0.377(-0.64)
Secondary	-0.446(-1.29)[c]	-1.456(-5.20)[a]	-1.363(-3.21)[a]	-1.383(-1.53)[c]
Tertiary	-0.862(-0.90)	-2.171(-5.35)[a]	-1.110(-1.42)[c]	
Husband's Education				
Primary	-0.174(-0.55)	-0.413(-1.76)[b]	-0.307(-1.11)	-0.217(-0.48)
Secondary	-0.556(-1.70)[b]	-0.468(-1.72)[b]	-0.448(-1.22)	-0.238(-0.36)
Tertiary	-0.600(-1.02)	-0.373(-1.06)	-0.838(-1.80)[b]	0.504(0.53)
Log(Income/adult)	0.062(0.49)	0.244(2.87)[a]	-0.372(-3.05)[a]	-0.595(-3.41)[a]
Child mortality	3.542(3.72)[a]	1.752(3.60)[a]	0.783(1.19)	0.710(0.78)
Regions				
Rural/Gezira Main	-0.118(-0.25)	0.829(2.78)[a]	0.876(2.03)[a]	2.231(3.38)[a]
Rural/Gezira Exten.	-0.031(-0.05)	1.123(2.56)[a]	1.528(2.39)[a]	1.189(1.10)
Rural/East. Gezira	0.125(0.23)	0.782(2.10)[a]	1.718(3.00)[a]	0.394(0.33)
Rural/Blue Nile	-0.156(-0.27)	1.231(3.20)[a]	0.591(1.13)	0.310(0.40)
Rural/Kordofan	-0.283(-0.49)	0.598(1.52)[c]	0.554(1.05)	-0.589(-0.75)
Urban/Gezira	0.643(0.81)	1.073(2.57)[a]	0.410(0.82)	1.572(2.00)[a]
Urban/Blue Nile	-0.255(-0.44)	0.746(1.98)[a]	0.610(1.17)	2.100(2.70)[a]
Urban/White Nile	-0.347(-0.41)	0.818(1.86)[b]	0.720(1.32)[c]	2.868(3.24)[a]
[Khartoum]				
Intercept	-3.231(-1.99)[a]	-3.910(-3.56)[a]	3.644(2.54)[a]	9.755(5.32)[a]
R^2	0.23	0.34	0.23	0.17
F	2.94	15.9	11.4	3.53
Joint F-test:				
Wife's Education	0.79	13.9	4.04	1.19
Husband's Educ.	1.08	1.34	1.14	0.28
Regions	0.33	1.86	1.77	5.47
Sample Size	188	532	663	301

[ ] Reference Category.
Figure in parenthesis are t-statistics.
[a] Coefficient statistically significant at 5% significance level.
[b] Coefficient statistically significant at 10% significance level.
[c] Coefficient statistically significant at 20% significance level.

Appendix Table(B2) OLS Estimates of Fertility and Child Mortality for All Married Women Age 15 or more with at least one child and by Region

	All		Rural		Urban	
Covariate	Fertility	Mortality	Fertility	Mortality	Fertility	Mortality
Woman's Age[1]:						
20-24	1.150(1.99)[a]		1.199(1.90)[b]		0.013(0.01)	
25-29	2.465(4.35)[a]	0.051(3.42)[a]	2.531(4.10)[a]	0.048(2.77)[a]	1.210(0.77)	0.058(1.85)[b]
30-34	3.384(5.97)[a]	0.061(4.10)[a]	3.520(5.66)[a]	0.054(3.03)[a]	2.040(1.31)[c]	0.075(2.44)[a]
35-39	4.685(8.27)[a]	0.053(3.58)[a]	5.000(8.10)[a]	0.044(2.49)[a]	2.982(1.91)[b]	0.067(2.19)[a]
40-44	5.696(9.91)[a]	0.061(3.75)[a]	6.210(9.81)[a]	0.061(3.15)[a]	3.620(2.30)[a]	0.059(1.79)[b]
45-49	5.810(10.1)[a]	0.061(3.71)[a]	6.170(9.73)[a]	0.062(3.13)[a]	4.104(2.60)[a]	0.063(1.91)[b]
50+	6.000(10.6)[a]	0.089(5.81)[a]	6.170(9.86)[a]	0.085(4.59)[a]	4.631(2.94)[a]	0.104(3.36)[a]
Wife's Education						
Primary	-0.141(-0.84)	-0.026(-2.28)[a]	-0.141(-0.70)	-0.031(-2.30)[a]	-0.283(-0.93)	-0.014(-0.67)
Secondary	-1.465(-6.80)[a]	-0.026(-1.81)[b]	-1.134(-3.85)[a]	-0.047(-2.40)[a]	-1.645(-4.95)[a]	0.001(0.04)
Tertiary	-2.020(-5.42)[a]	-0.042(-1.67)[b]	-2.224(-3.14)[a]	-0.080(-1.70)[b]	-1.821(-3.79)[a]	-0.012(-0.35)
Husband's Education						
Primary	-0.205(-1.29)[c]	-0.029(-2.80)[a]	-0.255(-1.34)[c]	-0.026(-2.07)[a]	-0.103(-0.33)	-0.017(-0.77)
Secondary	-0.398(-2.00)[a]	-0.046(-3.51)[a]	-0.440(-1.77)[b]	-0.045(-2.70)[a]	-0.363(-1.03)	-0.037(-1.52)[c]
Tertiary	-0.740(-2.82)[a]	-0.071(-4.01)[a]	-0.130(-0.34)	-0.047(-1.88)[b]	-0.987(-2.48)[a]	-0.078(-2.87)[a]
Log(Income/adult)	-0.160(-2.59)[a]	-0.011(-2.88)[a]	-0.092(-1.21)	-0.013(-2.63)[a]	-0.224(-2.02)[a]	-0.006(-0.74)
Intercept	2.845(4.49)[a]	0.143(5.99)[a]	2.310(3.26)[a]	0.158(5.42)[a]	4.682(2.72)[a]	0.075(1.53)[c]
R^2	.47	.11	.44	.11	.51	.08
F	104.	15.5	68.57	10.9	37.42	3.41
Joint F-test:						
Wife's Age	109.	6.00	82.21	3.72	22.39	2.09
Wife's Education	21.1	2.17	7.279	2.93	9.912	0.27
Husband's Educ.	2.78	6.54	1.262	2.92	2.700	3.12
Sample Size	1684	1684	1187	1187	497	497

1. The age reference category for fertility and mortality is 15-19 and 15-24, respectively.
Figure in parentheses are t-statistics.
[a] Coefficient statistically significant at 5% significance level.
[b] Coefficient statistically significant at 10% significance level.
[c] Coefficient statistically significant at 20% significance level.

Appendix Table(B3) OLS Estimate of Log of Household Expenditure per Adult for Women Age 15 or more with at least One Child

Covariate	All	Rural
Woman's Age:		
25-29	0.130(1.53)[c]	0.077(0.79)
30-34	0.128(1.39)[c]	0.054(0.51)
35-39	0.166(1.66)[b]	0.093(0.80)
40-44	-0.089(-0.80)	-0.257(-1.96)[b]
45-49	-0.338(-2.84)[a]	-0.476(-3.43)[a]
50+	-0.444(-3.75)[a]	-0.464(-3.35)[a]
Wife's Education		
Primary	0.080(1.26)	0.041(0.54)
Secondary	0.251(3.06)[a]	0.126(1.15)
Tertiary	0.381(2.70)[a]	0.484(1.86)[b]
Husband's Age	-0.013(-1.00)	-0.013(-0.94)
Husband's Age Square*10^{-2}	-0.000(-0.00)	-0.001(-0.05)
Husband's Education		
Primary	0.211(3.43)[a]	0.258(3.56)[a]
Secondary	0.210(2.70)[a]	0.190(2.02)[a]
Tertiary	0.263(2.59)[a]	0.300(2.10)[a]
Ownership of Assets		
Commercial Vehicle	0.178(3.29)[a]	0.156(1.87)[b]
Shop	0.200(3.44)[a]	0.210(2.83)[a]
Production Enterprise, Farm Machinery	0.174(1.91)[b]	0.227(1.67)[b]
Regions		
Rural/Gezira Main	-0.305(-3.46)[a]	0.645(8.35)[a]
Rural/Gezira Exten.	-0.636(-4.90)[a]	0.292(2.55)[a]
Rural/East. Gezira	-0.381(-3.32)[a]	0.550(5.45)[a]
Rural/Blue Nile	-0.786(-7.27)[a]	0.140(1.61)[c]
[Rural/Kordofan]	-0.930(-8.54)[a]	
Urban/Gezira	-0.591(-5.38)[a]	
Urban/Blue Nile	0.012(0.11)	
Urban/White Nile	0.131(1.10)	
[Khartoum]		
Intercept	5.950(18.9)[a]	5.133(15.6)[a]
R^2	0.38	0.33
F	40.8	26.9
Joint F-test:		
Wife Age	11.6	8.32
Wife Education	3.88	1.33
Husband Educ.	4.64	4.58
Regions	20.0	22.1
Sample Size	1684	1187

[ ] Reference Category.
Figure in parenthesis are t-statistics.
[a] Coefficient statistically significant at 5% significance level.
[b] Coefficient statistically significant at 10% significance level.
[c] Coefficient statistically significant at 20% significance level.

Appendix Table(B4) Interaction Between Parents Education and Health Programs in Child Mortality Function

Covariate[1]	All	Rural
Wife's Education		
Primary	-0.041(-1.87)[b]	-0.040(-1.67)[b]
Secondary	-0.015(-0.45)	-0.010(-0.21)
Tertiary	-0.064(-0.85)	-0.011(-0.10)
Husband's Education		
Primary	-0.034(-1.88)[b]	-0.031(-1.62)[c]
Secondary	-0.054(-1.96)[b]	-0.041(-1.30)[c]
Tertiary	-0.090(-2.07)[a]	-0.120(-2.07)[a]
Programs		
Hospital Beds	-0.067(-2.56)[a]	-0.078(-2.28)[a]
B.N.Health Project	-0.043(-1.22)	-0.041(-1.12)
Mother's Education*Hospital		
Primary	0.036(1.30)[c]	0.076(1.40)[c]
Secondary	0.025(0.77)	0.079(1.12)
Tertiary	0.057(0.97)	0.057(0.19)
Mother's Education*B.N. Project		
Primary	-0.001(-0.03)	-0.021(-0.61)
Secondary	-0.043(-1.40)[c]	-0.075(-1.41)[c]
Tertiary	-0.043(-0.62)	-0.087(-0.43)
Father's Education*Hospital		
Primary	0.029(1.10)	0.043(0.80)
Secondary	0.028(0.86)	-0.024(-0.37)
Tertiary	0.016(0.40)	-0.023(-0.26)
Father's Education*B.N.Project		
Primary	0.016(0.73)	0.010(0.26)
Secondary	0.017(0.62)	0.031(0.76)
Tertiary	0.072(1.74)[b]	0.122(1.74)[b]
R^2	0.13	0.14
F	7.28	5.94
Joint F-test:		
Wife Education	1.31	0.97
Husband Educ.	2.43	2.10
Programs	3.90	3.40
Sample Size	1684	1187

[1] In addition to the reported variables the regression included the age dummies, the regional dummies and income.
Figure in parenthesis are t-statistics.
[a] Coefficient statistically significant at 5% significance level.
[b] Coefficient statistically significant at 10% significance level.
[c] Coefficient statistically significant at 20% significance level.

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