Child mortality, wealth and education: direct versus indirect effects

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Abstract

Controlling for the Egyptian household choice of health infrastructure (i.e., sanitation facility and water accessibility) is done by means of a discrete choice approach consistent with the random utility model. Evidence of the importance of the indirect effect of the source of drinking water on child mortality is found. Furthermore, changes in wealth and education levels are assessed taking into consideration a priori the choice of health infrastructure. The analysis suggests that wealth and education contribute to the child mortality reduction.

Keywords: Child mortality; Discrete choice; Elasticity; Water and sanitation; Wealth

JEL classification: C25; D12; I12; I21; N35; R22

1. Introduction

Some previous analysis of the author[1] and Aly et al. (1990) emphasize the effect of sanitation on child mortality in Egypt. These results encourage investigation of the factors determining the household choice of sanitation; a better understanding of the determinants of sanitation enables drawing some policy conclusions. This paper focuses on policies that enable reduction of child mortality in Egypt. Households are taken to make the choice of inputs prior to the fertility decision. Once the decision is made it is assumed nonadjustable over the time period of interest i.e., 1991-1995. Impact of changes in wealth and education levels is assessed taking into consideration a priori the choice of health infrastructure. This is because ignoring indirect effects could lead to under/over-statement of the effect of the intervention related to child mortality. This is done by analyzing the factors that determine household demand for sanitation and water using discrete, together with an analysis of the determinants of the household wealth. The data used consists of a sample of 6871 Egyptian households taken from the Demographic and Health Survey (DHS) 1995. The novelty here is the attempt to combine all different aspects affecting child mortality in order to get a correct estimate of the elasticity of wealth. To our knowledge there is no

[1] See Abou-Ali (2002)

previous study that analyzes the elasticity and changes in child mortality with respect to wealth and education taking into consideration both direct and indirect relationships of inputs that are under the household control.

The paper is organized as follows: Section 2 discusses the theoretical framework together with the econometric models used and some background on the topic. The data used and variables are described in Section 3. The results are discussed in Sections 4 and 5. Section 6 concludes.

2. Background, theoretical framework and econometric modeling

The main literature related to the demand for health dating from Grossman (1972) emphasizes the assumption that the households (consumers) are seeking better health rather than the inputs per se. Some of the literature focuses on studying the effect of socio-economic differences or positions on mortality such as Sundquist et al. (1997) and Östberg et al. (1991). Others focus on studying demand for water and sanitation by using discrete choice approaches such as Mu et al. (1990), Madanat et al. (1993) and Persson (2002). Moreover, others such as Di Matteo (1997), Taylor et al. (2000) and Yúnez-Naude et al. (2001) focus on the determinants of income and wealth. Commonly used regression estimates of the determinant of child mortality (e.g. Da Vanzo (1988) and Olsen et al. (1983)) have a potential bias in estimating the relative effect of different factors affecting mortality because they do not take the response of the allocated inputs of health infrastructure into consideration. Lee et al. (1997) suggest a framework to overcome this problem by considering a two-period dynamic model. They assume a linear representation of the health equation in the first period determining survival, of the health production technology for period-2 health, and of the demand equation for the endogenous inputs in the second period.

The analysis in this paper builds on the theoretical models of health production functions, with child mortality as the main outcome variable. Following Rosenzweig et al. (1983), let the hazard rate $\lambda(t)$ of dying at age t, corresponding to the mortality production technology be:

$$\lambda(t) = \lambda_0(t)\exp(\beta' x) \quad (1)$$

where $\lambda_0(t)$ is the baseline hazard, β is the vector of parameter estimates and x represents a vector of behaviors that do not vary over time e.g., gender and age at birth. Adopting the usual production function terminology, specially applied to health by Grossman (1972) x's will be referred to as inputs. $\lambda(t)$ is estimated using a semi-parametric transition models. Some inputs are part of the behavioral decision process while others, like gender, are beyond parental control. In other words, while the mother (household) does not have direct control over child health she (it) controls inputs such as environmental quality (i.e., sanitation facility and water accessibility) where the child is brought up and how the child is fed. This encourages the investigation of the inputs or factors determining the household choice of health infrastructure through sanitation and the source of drinking water.

In these cases the household faces a discrete choice set of inputs implying that consumption of several inputs may be zero. The multinomial logit (MNL) model is a usual way of dealing with discrete choice, which is consistent with the random utility model (RUM) such as Thurstone (1927), McFadden (1973 & 1978). Households are assumed to make a choice that maximizes their perception of well-being since there is imperfect information. Following Dow (1999) utility function U conditional on a choice i is specified as an additively separable, linear function of health H and non-health consumption C. The household h faces a budget constraint such that C and the price P_i of health care choice i equals the period specific income Y. Choice is also constrained by the health production technology, specified as dependent on an alternative specific intercept A_i based on the fact that various inputs have different characteristics affecting the household choice, and a vector of other choice attributes and individual characteristics X_i. Formally the household maximizes,

$$U_{ih} = \omega_1 C_h + \omega_2 H_{ih}$$

s.t. $$C_h = Y_h - P_i$$

and $$H_{ih} = A_i + \gamma_i X_{ih} \qquad i=1,2,3$$

Therefore a household will choose one alternative if and only if,

$$\breve{V}_{ih} > \breve{V}_{jh} \qquad i \neq j$$

$\breve{V}_{ih}$ is the indirect utility function for a specific input choice i and a household h, which can be separated as:

$$\breve{V}_{ih} = V_{ih} + \varepsilon_{ih}$$

V_{ih} is the systematic or deterministic component of the indirect utility function. It is assumed to have an identical form for all households. Therefore the *h* subscript will be suppressed onwards. ε_{ih} is a stochastic or random component reflecting all the unobserved and unmeasured properties of the household and the alternatives. ε_{ih}'s are assumed to be independently, identically distributed (iid). Substituting the constraint into the utility function yields the indirect utility function of the underlying parameters:

$$V_i = \omega_2 A_i + \omega_1 (Y - P_i) + \omega_2 \gamma_i X_i$$

The resulting reduced form of the indirect utility function can be written as:

$$V_i = \theta_{0i} + \theta_{1i} Y + \theta_{2i} P_i + \theta_{3i} X_i \qquad (2)$$

Turning to the wealth equation, households in LDCs potentially may participate in multiple activities. Without loss of generality, however, consider a household that allocates its available investment resources to production, so as to maximize total wealth $\breve{Y}$. The household demand for wealth is modeled as a function of these investments or household resource allocation,

$$\breve{Y} = y(E, D)$$

E is education, and *D* is a set of household socio-economic variables affecting wealth. Taylor et al. (2000) consider a random expected income model in which income is comprgised of a deterministic component *Y* and an unobserved stochastic component ε, which is assumed to be iid. Hence,

$$\breve{Y} = Y + \varepsilon$$

Letting, $$Y = \delta + \xi_1 E + \xi_2 D \qquad (3)$$

and $$\varepsilon \sim N(0,1)$$

the demand for wealth is estimated using an ordinary least squares (OLS) regression.

Consequently, education is thought to change productivity in the market as well as in the household. Since Education is taken to influence productivity in the non-market sector by altering the marginal product of the direct inputs in household health production function. On the other hand, the effects of education are important from a policy perspective. If there is a high correlation between mortality and education an increase of expenditure on education may be a cost-effective technique for decreasing aggregate level of mortality.

3. Data and variables

The data used is a sub-sample of 6871 households from the DHS conducted in Egypt in 1995. The sample selection is based on households having at least one child that is under the age of five years. Table 1 describes the variables.

Table1: Descriptive statistics for the sample of 6871 Egyptian household

VARIABLES	*MEAN*	*STANDARD DEVIATION*	*MIN*	*MAX*
Dependent variables				
Sanitation	1.136	0.54	0	2
Water	1.42	0.85	0	2
Independent variables				
Sanitation				
No facility (yes)†	0.09	0.29	0	1
Traditional facility (yes)	0.68	0.47	0	1
Modern facility (yes)	0.23	0.42	0	1
Source of Drinking water				
Tap water into residence (yes)	0.66	0.47	0	1
Public tap water (yes)	0.1	0.29	0	1
No municipal water (yes)	0.24	0.43	0	1
Household socio-economic and demographic variables				
Wealth	4.08	1.88	0	7
Distance to source of drinking water (minutes)	7.5	18.6	0	720
Mother's age (years)	27.82	6.24	13	48
Mother's age squared	812.91	365.64	179	2304
Household head age (years)	41.93	12.27	15	95
Household head age squared	1908.92	1206.11	225	9025
Number of women>1 (yes)	0.19	0.4	0	1
Household head sex (male=yes)	0.98	0.14	0	1
Mother's education				
Low education (yes)	0.18	0.38	0	1
Medium education (yes)	0.12	0.32	0	1
High education (yes)	0.26	0.44	0	1
Household head education				
Low education (yes)	0.22	0.41	0	1
Medium education (yes)	0.15	0.36	0	1
High education (yes)	0.29	0.46	0	1
Place of residence				
Urban governorates (yes)	0.148	0.36	0	1
Lower Egypt urban (yes)	0.088	0.28	0	1
Lower Egypt rural (yes)	0.21	0.41	0	1
Upper Egypt urban (yes)	0.11	0.31	0	1
Upper Egypt rural (yes)	0.36	0.48	0	1

† (yes) refers to a dichotomous variable indicating that the value 1 is taken by the variable name (e.g.. No facility (yes) = Dichotomous variable indicating that the household has no sanitation facility in the dwelling).

The sanitation service is divided into three categories, *no facility* where the household has no toilets in their dwelling or on the premises. *Traditional facility,* including water-based system, pit latrine or a similar fecal disposal system. The flush toilet is considered to be a *modern facility*. The distribution of the categories of sanitation facility in the sample is 9, 68 and 23 percent, respectively. As for the source of drinking water, 66 percent have residential municipal water, 10 percent have municipal public tap source and 24 percent have no municipal water. The distance to the source of drinking water has an average of 7.5 minutes. The further the source of water the more burdens the household endure for consumption.

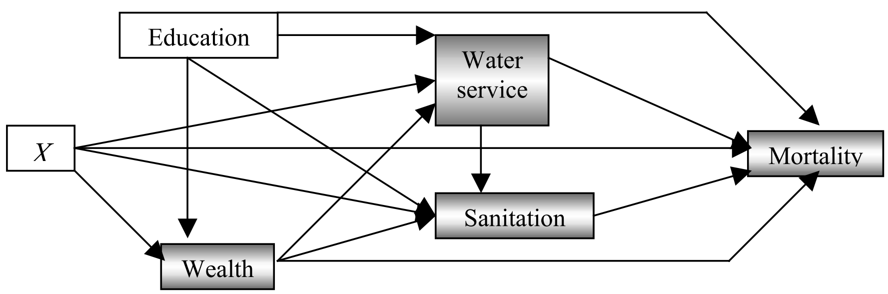
In Abou-Ali (2002) a standard of living indicator was constructed to serve as a proxy of the household wealth. Household structure affects the demand for environmental services since the gains from investments in those services are higher in sizable households. The women structure in the household needs to be captured since 19 percent of the households contain more than one (several) eligible woman -i.e., mothers- for this purpose a dichotomous variable is used where the value one depicts the existence of more than one woman. The mother's information used here is restricted to the closer relation to the household head. It should be noted that only 82 percent of the mothers are wives of the household head. The remaining 12, 4 and 2 percent are daughter-in-law, daughter and other relatives to the household head, respectively. Given the Egyptian social structure it is reasonable to assume the household's head as a part of the decision-making. This is because a household often includes several families but the DHS data does not specify the wealth of each family. However, similar analysis including the mother and the father were conducted but the results were not significantly different. (The results related to the mother and father characteristics are available from the author).

Since education is believed to impact the choice of services, three levels of education are accounted for; (i) *low education* where the individual did some primary schooling (ii) *medium education* is given for the ones who achieved primary schooling and /or continued through secondary (iii) *high education* category encloses the ones who completed secondary school and higher. Moreover, education is of special interest to the model. Since a verified positive causal link from education to mortality reduction imply that it is possible to decrease child mortality by increasing the level of education. The place of residence is also included here since it may affect the life style together with the choice of services and sanitation. Sanitation programs unveiled that people aim or desire are privacy, convenience and status (World Bank (1993)).

4. Econometric findings

The general structure of the model is shown in Figure 1. The model is estimated separately for two major groups, age perspective -i.e. neonatal, infant and childhood group- and woman's age perspective –in the form of children birth order-. This type of grouping that relates to birth order reflects the components of the child's biological endowments. Starting by estimating less than five mortality using a Cox proportional hazard model, results are depicted in Table 2.

Figure 1: Model structure



Looking at the environmental condition's variables in the Table, access to public water decreases the risk of death by 56 percent in the infant stage. Residential water decreases the risk of death by around 28 and 55 percent of the neonatal and in the fourth birth, respectively. The result show that access to municipal water in the fifth and higher birth order decreases the risk of dying by 33 and 52 percent, respectively for tap into residence and public tap. The effect of water is smaller and non significant in lower birth order. In the infant stage and the first birth, results reveal that access to a modern facility decreases mortality risk by 17 and 60 percent, respectively. Whilst a traditional facility increases the mortality risk in the childhood stage by 225 percent. Living in urban areas decreases the mortality risk of infant and child by 31 and 10 percent, respectively as opposed to living in rural areas. The wealth indicator marks a significant effect on the childhood mortality risk reduction by 28 percent. Turning to gender, higher female mortality indicating gender discrimination in the infant and childhood cases together within the first and fifth and higher births. Finally, breast-feeding has shown to have a significant effect on mortality risk reduction.

Table 2: The Cox proportional hazard estimation for the under five mortality†

Variables	***Age group***			***Birth order group***				
	Neonatal	Infant	Child	1	2	3	4	5+
I. Environmental conditions variables								
Tap water into residence (yes)‡	0.721*	0.835	0.875	0.751	0.809	0.871	0.455**	0.667**
Public tap water (yes)	0.723	0.441**	0.6	0.828	1.128	0.428	0.655	0.484**
Modern facility (yes)	1.27	0.829**	1.263	0.396*	0.844	4.068	3.918	0.901
Traditional facility (yes)	1.28	1.084	3.25*	0.62	1.62	2.575	3.893	1.242
II. Socioeconomic variables								
Urban residence (yes)	1.416*	0.688**	0.9*	0.639	0.936	0.425**	1.429	1.025
Low education (yes)	0.844	1.074	1.42	1.684	0.576	0.612	1.341	0.763
Medium education (yes)	1.152	0.642*	0.963	1.192	0.424**	1.162	0.507	0.665
High education (yes)	0.601*	0.4***	0.311	1.893	0.22***	0.52*	0.442	1.361
Wealth	0.954	0.979	0.72***	1.010	1.015	0.96	0.932	0.924*
III. Demographic variables								
Mother age at birth	1.025**	1.014	1,03	0.88***	1.025	0.985	1.007	1.011
Gender (male=yes)	1.064	0.69**	0.669*	0.61*	1.053	0.837	0.638	0.78*
IV. Behavioral variables								
Breast-feeding (yes)		0.32***	0.34***	0.04***	0.03***	0.04***	0.03***	0.05***
Akaike Info. Criteria	1352	2033	437	427	356	462	334	1556

† Number in the table are the relative mortality risk.
‡ (yes) refers to a dichotomous variable indicating that the value 1 is taken by the variable name (e.g.. Tap water into residence (yes) = Dichotomous variable indicating that the household has municipal water piped into residence).
*** Means that the estimate is significant at 1 percent
** Means that the estimate is significant at 5 percent
* Means that the estimate is significant at 10 percent.

Turning to the demand for sanitation and water services, the categories of the dependent variables in the MNL models are truly discrete. Hence, the consumption of one type of input excludes the consumption of the other. For each alternative the probability of a household choosing a certain input i is as follows, given the assumption of type I extreme-value distribution (see Maddala (1992) and (1993)),

$$P(i) = prob(V_i > V_j) = \frac{e^{\sum_{k=1}^{K} \alpha_{ki} Z_k}}{1 + \sum_{i=1}^{I-1} e^{\sum_{k=1}^{K} \alpha_{ki} Z_k}} \qquad i \neq j$$

K is the number of explanatory variables and Z is the set of inputs (i.e., X, Y, P) included in each model. The probability of choosing the last type of sanitation or the source of drinking water between the alternatives is:

$$P(i) = \frac{1}{1 + \sum_{i=1}^{I-1} e^{\sum_{k=1}^{K} \alpha_{ki} Z_k}}$$

Note that the estimation of MNL models relies on the independence of irrelevant alternatives (IIA) property. The validity of this assumption was tested using the Hausman test suggested by Hausman and McFadden (1984). It was found that the IIA assumption couldn't be rejected at 1, 5 and 10 percent significance levels. Tables A1 and A2 in Appendix A display the MNL parameter estimates for the choice of sanitation facility and source of drinking water models, respectively. These parameters can be expressed in log form such as:

$$\ln\left(\frac{P(i)}{P(j)}\right) = \sum_{k=1}^{K} \alpha_{ki} Z_k \qquad i \neq j \qquad (4)$$

For instance, the natural log of odds of a traditional facility (i) versus no facility (j) is affected positively by about 0.52 if the household has residential water. The interpretation of the parameter estimates of continuous variables becomes more problematic. Therefore the marginal effects are used. The marginal effects of the odds ratio that could be obtained by taking the exponential of Equation (4) will be presented in the following sub-section. Estimates of the marginal effect of a change in inputs are presented in Section 4.2 using the following equation:

$$\frac{\partial P(i)}{\partial Z_k} = P(i)\left[\alpha_{ki} - \sum_{i=1}^{I-1} \alpha_{ki} P(i)\right]$$

4.1. Marginal effect of the odds ratio of the demand for sanitation

In order to view expected changes in the odds of alternative sanitation choices as a result of a ceteris paribus unit change in one or some of the inputs, the following is obtained:

- *Water effect*: The ceteris paribus marginal effect of the source of water at the odds of sanitation facility is presented in Table 3, showing that the effect of having residential water on the odds of choosing a modern facility instead of no facility is 2.34 times higher than not having municipal water. The effect of having a public tap as opposed to no municipal water on the choice of a modern facility versus no facility is around zero. This result implies that the source of water affects sanitary choice. On the other hand, when a household chooses between traditional facilities and no facility having a residential tap water has an effect of 1.7 times higher than no municipal water in favoring the choice of a traditional facility.

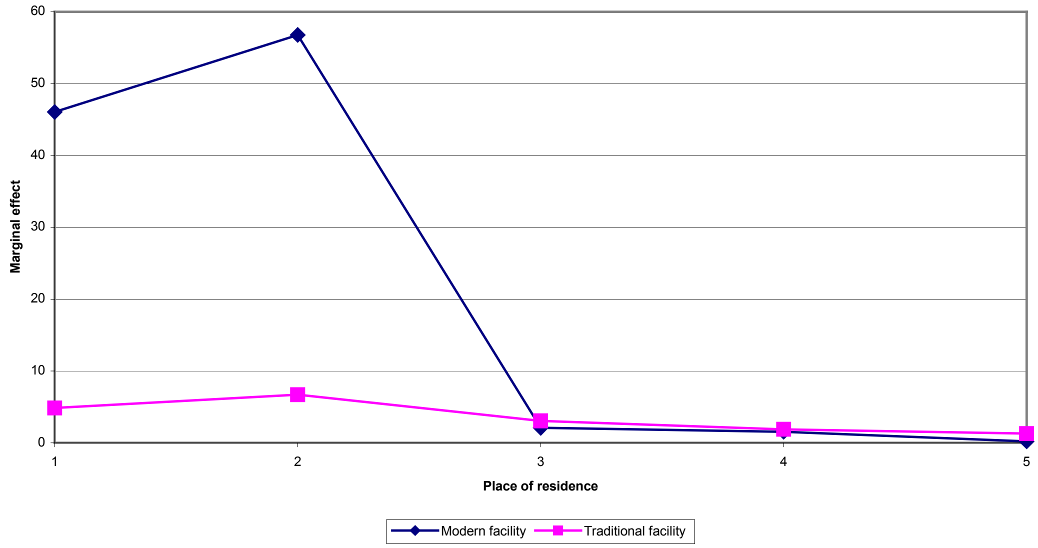
Table 3: Source of drinking water effect on the odds of sanitation choice.

	Modern facility/no facility	*Traditional facility/no facility*
Tap water into residence	2.34	1.68
Public tap water	0.05	0.54

- *Wealth effect*: Figure 2 plots the wealth effect according to the place of residence, other things being equal. It is seen that the wealth effect subject to the place of residence has the highest impact in the Lower Egypt urban region followed by the urban governorates. This exhibits a slightly decreasing pattern between the remaining regions. It should also be noted that the wealth effect for the first two regions is considerably higher for the odds of modern facility versus no facility as compared to the odds of traditional facility.

  Considering the level of education of the mother and household head, a similar pattern is found with a blown magnitude. This result could be seen in Figures B1 and B2 in Appendix B for the odds of modern and traditional facility, respectively. Moreover, the wealth effect of the mother's different education levels is shown to have higher impact than those for the household head. The wealth effect of mothers with high education level is very high compared to the other categories. This fact is consistent with others' finding (see Yúnez-Naude et al. (2001)) where the mother's influence in the household is considerably more important. This encourages the investigation of the education's marginal effect on the odds separately.

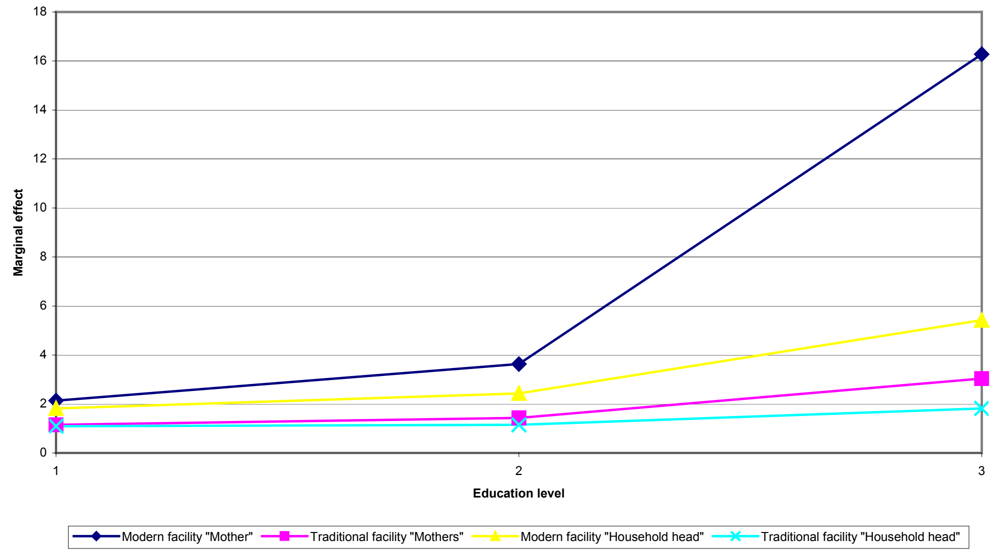
Figure 2: the marginal effect of wealth on the odds ratio of sanitation



Place of residence key: 1=Urban governorates, 2=Lower Egypt urban, 3=Lower Egypt rural, 4=Upper Egypt urban, and 5=Upper Egypt rural

- *Education effect*: the effect of various levels of education on the odds of the sanitation choice evolves in the expected direction. The choice of more educated individuals favors better quality (type) of sanitation services. This result is displayed in Figure 3 and it gives some guidelines to policy makers targeting education. Since mother education has shown to be a prerequisite for enhanced health of their siblings more emphasis should be concentrated on female education.

Figure 3: the marginal effect of education level on the odds ratio of sanitation



Education level key: 1=Low, 2=Medium, and 3=High

4.2. Marginal effect of a change in inputs

4.2.1 Demand for sanitation

Table 4 brings together the marginal effects calculated at the sample mean of the MNL model for the household demand for sanitation:

$$S_i = \alpha_{0i} + \alpha_{1i} T + \alpha_{2i} D$$

Assuming the household's taste T is driven by the accessibility of water and wealth, D is a set of socio-economic and demographic characteristics, such as the place of residence, age, sex of the household head, the household structure and education level which are also accounted for. These characteristics seem to be reasonable to capture the systematic preference of the demand for a specific sanitation input. The table shows that having residential water affects the choice of no facility negatively by 1 percent while the probability of choosing a modern facility is increased by 2 percent. Household-having access to water through a public tap increases the probability of choosing a traditional facility by around 13 percent. The probability is reduced by 14 percent when it comes to the choice of a modern facility. Investigation of this result emphasizes the role of water as an input in the demand for sanitation. Sanitary services are found in the Cox proportional hazard model to be of considerable effect on mortality while the direct effect of water on mortality was quite negligible.

Suggesting that water has a considerable indirect effect through sanitary service choice.

Table 4: Marginal effects for the household choice of sanitation facility

Variables	*No facility*	*Traditional facility*	*Modern facility*
Intercept	0.0166	0.314***	-0.331***
Tap water into residence (yes) †	-0.0102***	-0.01	0.02**
Public tap water (yes)	0.0145***	0.127***	-0.14***
Wealth	-0.0115***	-0.023***	0.034***
Mother's age (years)	0.00062	0.00023	-0.00085
Mother's age squared	-0.0000062	-0.000019	0.000025
Household head age (years)	-0.00025	-0.0003	0.00054
Household head age squared	0.0000014	-0.0000014	0.000000047
Number of women>1 (yes)	-0.0013	0.014*	-0.012
Household head sex (male=yes)	-0.00076	-0.0015	0.0023
Mother's education			
Low education (yes)	-0.0033	-0.034***	0.037***
Medium education (yes)	-0.0079*	-0.048***	0.056***
High education (yes)	-0.023***	-0.078***	0.102***
Household head education			
Low education (yes)	-0.0022	-0.028***	0.031***
Medium education (yes)	-0.0035	-0.04***	0.045***
High education (yes)	-0.0126	-0.053***	0.066***
Place of residence			
Urban governorates (yes)	-0.053***	0.014	0.039***
Lower Egypt urban (yes)	-0.063***	0.045***	0.018*
Lower Egypt rural (yes)	-0.035***	0.11***	-0.075***
Upper Egypt urban (yes)	-0.02***	0.062***	-0.042***
Upper Egypt rural (yes)	-0.0066**	0.12***	-0.114***
Sample Size	6871		
Log Likelihood	-3349.913		
Restricted log likelihood	-5574.312		

† (yes) refers to a dichotomous variable indicating that the value 1 is taken by the variable name (e.g.. Tap water into residence (yes) = Dichotomous variable indicating that the household has municipal water piped into residence).
*** Means that the estimate is significant at 1 percent level.
** Means that the estimate is significant at 5 percent level.
* Means that the estimate is significant at 10 percent level.

The wealth effect negatively relates to the choice of lower quality sanitation services and is positively related to better ones implying that the marginal effect of wealth increases the probability of choosing a modern facility by around 3.5 percent. It may be worth noting that, the education level and the region of residence also affect sanitation choice. Urbanization tends to make people choose better quality of services and this may be also due to the fact that better services are more available or accessible in these areas.

4.2.2 Demand for water service

Table 5: Marginal effects for the household choice of the source of drinking water

Variables	*No municipal water*	*Public tap*	*Water into residence*
Intercept	0.35***	0.11*	-0.46***
Wealth	-0.0446***	-0.0265***	0.07115***
Mother's age (years)	0.0055	-0.0068**	0.0014
Mother's age squared	-0.000085	0.0001*	-0.000013
Household head age (years)	-0.0051**	-0.0011	0.0063**
Household head age squared	0.000044**	0.000002	-0.000047*
Number of women>1 (yes) †	0.03***	0.007	-0.0367***
Household head sex (male=yes)	0.0216	-0.03*	0.0083
Mother's education			
Low education (yes)	-0.0264**	-0.0235***	0.05***
Medium education (yes)	-0.0636***	-0.0397***	0.1***
High education (yes)	-0.0712***	-0.0512***	0.12***
Household head education			
Low education (yes)	-0.0384***	-0.02***	0.059***
Medium education (yes)	-0.0459***	-0.029***	0.074***
High education (yes)	-0.0237	-0.042***	0.065***
Place of residence			
Urban governorates (yes)	-0.647***	0.117***	0.53***
Lower Egypt urban (yes)	-0.431***	0.089***	0.342***
Lower Egypt rural (yes)	-0.258***	0.143***	0.115***
Upper Egypt urban (yes)	-0.34***	0.071***	0.27***
Upper Egypt rural (yes)	-0.17***	0.075***	0.095***
Sample Size	6871		
Log Likelihood	-4398.971		
Restricted log likelihood	-5761.816		

† (yes) refers to a dichotomous variable indicating that the value 1 is taken by the variable name (e.g.. number of women>1 (yes) = Dichotomous variable indicating that the household has more than one eligible women).
*** Means that the estimate is significant at 1 percent level.
** Means that the estimate is significant at 5 percent level.
* Means that the estimate is significant at 10 percent level.

Table 5 presents the marginal effect for the model of water (Equation (2)).[2] The MNL results presented assert that increasing wealth makes the household more inclined to use municipal water as a source of drinking water. The same pattern applies to education.

4.3. Demand for wealth

Following Strauss et al. (1995) and Di Matteo (1997) the explanatory variables included in Equation (3) encompass the mother and the household head's education

[2] The price variable was excluded since its inclusion leads to controversial results. This could be due to the fact that the variable used, i.e. distance to the source of drinking water is an inappropriate (or a bad) proxy of the price. In this variable households with municipal water into residence are assumed to have a zero price, which is unrealistic since residential municipal water is not free of charge.

and the gender of the head. Location dummy variables are included to control for fixed effects of various places of residence. Finally, since years of experience are not available, age and age-squared are used as proxies for experience and experience-squared.

Table 6: Parameter estimates for household wealth

Variable	*Household wealth*	*Log of the household wealth*
Intercept	0.86**	0.76***
Mother's age (years)	0.022	0.0035
Mother's age squared	-0.00034	-0.00006
Household head age (years)	0.065***	0.015***
Household head age squared	-0.00048***	-0.0001***
Number of women>1 (yes)†	0.26***	0.073***
Household head sex (male=yes)	-0.0004	-0.015
Mother's education		
Low education (yes)	0.57***	0.16***
Medium education (yes)	1.11***	0.27***
High education (yes)	1.39***	0.31***
Household head education		
Low education (yes)	0.4***	0.12***
Medium education (yes)	0.77***	0.21***
High education (yes)	1.185***	0.3***
Place of residence		
Urban gover. (yes)	0.65***	0.19***
Lower Egypt urban (yes)	0.26***	0.11***
Lower Egypt rural (yes)	-0.3***	-0.011
Upper Egypt urban (yes)	0.32***	0.11***
Upper Egypt rural (yes)	-0.59***	-0.12***
Sample Size	6871	6871
R-square	0.3860	0.3167

† (yes) refers to a dichotomous variable indicating that the value 1 is taken by the variable name (e.g.. number of women>1 (yes) = Dichotomous variable indicating that the household has more than one eligible women).
*** Means that the estimate is significant at 1 percent level.
** Means that the estimate is significant at 5 percent level.

Although, wealth is a categorical variable it is treated here, as a continuous one by using OLS estimation in spite that some would argue in favor of using an ordered-probit model. As noted by Van Praag and Ferrer-i-Carbonell (2003) the latter contains an implicit cardinalization even though it is not stated explicitly in advance. This cardinalization is of course not without problems and is presented solely to simplify comparisons. Since for example, it implicitly assumes that the difference between moving from one to two possessions is the same as between six to seven possessions, which is not at all obvious. Furthermore, the author also believes that no much will be gained from using and ordered-probit estimator. Table 6 reports estimated effects of education and other explanatory variables on total wealth. These estimates were obtained using OLS for total household wealth (first column) and the log of total wealth (second column). The coefficients of this log-linear model can be interpreted as percentages. The estimated coefficients for age and age-squared provide support for the presence of life cycle savings behavior (for a discussion of the motivation for saving see Di Matteo (1997)). The household head at the age of 30 will be accumulating total wealth at an annual rate of 0.9 percent (0.015-2*0.0001*30 = 0.009). An average household head will hold a rate of 0.7 percent.

The parameter estimates of education are significant. The estimated return from having low to high level of education versus no education ranges between 0.6 and 1.4 for the mother and 0.4 to 1.2 for the household head. Their counterparts in the log-linear specification vary between 16 to 31 and between 12 to 30 percent, respectively. As to the place of residence it should be noted that living in rural areas affects negatively the household wealth while being an urban dweller has a positive and significant influence on the holding of total wealth. These results imply that, the key variables determining wealth are household head age, education and region of residence.

5. Analysis of the results

One of the questions to be investigated is how does child mortality respond to a change in wealth or education level. The observed effect of a change in an input x on the child's mortality λ is obtained by $\frac{d\lambda}{dx} = \frac{\partial \lambda}{\partial x} + \frac{\partial \lambda}{\partial Z_k}\frac{\partial Z_k}{\partial x}$. This indicates that the relationship between x and λ depends not only on the effectiveness of x but also on the response of the allocated inputs Z_k to the change in the health infrastructure. This relationship gives the basis for analyzing the elasticity of mortality with respect to wealth. The elasticity is derived as follows:

$$\frac{d\lambda}{dY}\frac{Y}{\lambda} = \left[\frac{\partial \lambda}{\partial Y} + \sum_i \frac{\partial \lambda}{\partial S_i}\left(\frac{\partial S_i}{\partial Y} + \sum_j \frac{\partial S_i}{\partial W_j}\frac{\partial W_j}{\partial Y}\right) + \sum_j \frac{\partial \lambda}{\partial W_j}\cdot\frac{\partial W_j}{\partial Y}\right]\frac{Y}{\lambda}$$

where S_i, W_j are the probabilities of choosing a sanitation input i and a water input j. The percentage change of mortality with respect to a certain level of education E_k is,

$$\frac{d\ln\lambda}{dE_k}=\frac{\partial\ln\lambda}{\partial E_k}+\sum_i\frac{\partial\ln\lambda}{\partial S_i}\left(\frac{\partial S_i}{\partial E_k}+\frac{\partial S_i}{\partial Y}\frac{\partial Y}{\partial E_k}+\sum_j\frac{\partial S_i}{\partial W_j}\left(\frac{\partial W_j}{\partial E_k}+\frac{\partial W_j}{\partial Y}\frac{\partial Y}{\partial E_k}\right)\right)+\sum_j\frac{\partial\ln\lambda}{\partial W_j}\left(\frac{\partial W_j}{\partial E_k}+\frac{\partial W_j}{\partial Y}\frac{\partial Y}{\partial E_k}\right)$$

The results are illustrated in Tables 7 to 10 by calculating total effects as well as direct and indirect effects of wealth and education on child mortality. Figures 4 and 5 describe these effects in the case of wealth and education, respectively. The tables display the elasticity of wealth and changes in education calculated at the sample mean and computed as an average of the individual elasticity and education changes. They also show that the elasticity calculated as an average of individual elasticity is bigger in magnitude than the ones calculated at the sample mean.

Figure 4: Wealth effects

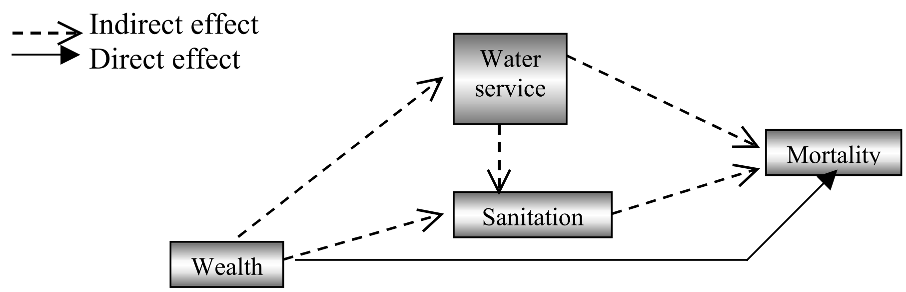


Figure 5: Education effects

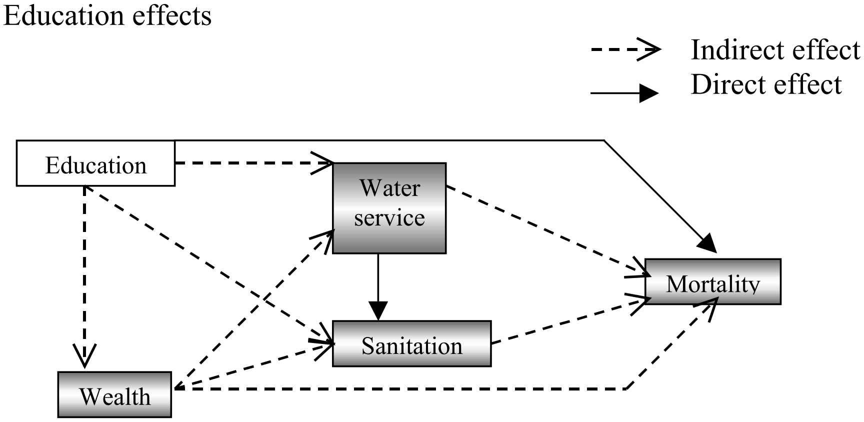


Table 7: Elasticity of child mortality w.r.t. wealth at the sample mean.

	Age Group			*Birth order group*				
	Neonatal	Infant	Child	1	2	3	4	5+
Direct effect	-0.1476	-0.0111	-0.0043	-0.0039	-0.0046	-0.0046	-0.0032	-0.0011
				Indirect effects				
Modern facility								
Residence tap	0.0372	-0.0025	0.0007	0.008	-0.0002	0.0229	-0.00044	0.0046
Public tap water	0.0478	0.0025	-0.0024	0.0082	-0.0005	0.022	0.00002	0.0062
Traditional facility								
Residence tap	-0.0441	-0.0016	-0.0042	-0.0021	0.0003	0.0007	-0.0016	-0.0014
Public tap water	-0.0335	0.0034	-0.0073	-0.0019	-0.0001	-0.0002	-0.0011	0.0002
Total ind. eff.	-0.0007	0.001	-0.007	0.006	-0.0003	0.0232	-0.0017	0.0049
				Total effects				
Modern facility								
Residence tap	-0.1104	-0.0136	-0.0036	0.0041	-0.0047	0.0183	-0.0036	0.0035
Public tap water	-0.0998	-0.0086	-0.0067	0.0043	-0.0051	0.0174	-0.0031	0.0051
Traditional facility								
Residence tap	-0.1917	-0.0127	-0.0085	-0.006	-0.0043	-0.0039	-0.0047	-0.0025
Public tap water	-0.1811	-0.0077	-0.0116	-0.0058	-0.0047	-0.0049	-0.0043	-0.0009
Total	-0.1484	-0.0101	-0.0113	0.0021	-0.0049	0.0185	-0.0049	0.0038

Inspecting Tables 7 and 8, the direct effect of wealth is negatively related to mortality indicating that the increase in household's wealth leads to a reduction in mortality which is quite intuitive since the household may allocate more resources to induce the survival of their children. It should be noted that in around 50% of the cases the direct effect of the wealth dominates the indirect effect therefore most of the signs of the elasticities (total effect) are negative indicating the inverse relationship between wealth and mortality. The elasticities are calculated for different groups of children by age and birth order. The highest elasticity is the one associated to the third birth followed by the first birth mortality where a one percent increase in wealth generates a 0.036 percent increase in the former group and a 0.007 percent in the latter. In the neonatal case one percent increase in wealth generates a 0.63 percent decrease in neonatal mortality.

The indirect effect of wealth is calculated for different health infrastructure groups and this is done in order to emphasize the response of the allocated health infrastructure in the relationship between wealth and child mortality. In some of the cases indirect effects have a dominant impact especially in the modern facility category indicating that the disadvantages of a modern facility outweigh the gains from wealth. This result suggests that the household members may be unaware of how to use modern facilities. Moreover, some households may have modern facilities despite they are not connected to residential water.

Table 8: Elasticity of child mortality w.r.t. wealth at the mean of individual elasticity.

	Age Group			*Birth order group*				
	Neonatal	Infant	Child	1	2	3	4	5+
Direct effect	-0.13	-0.003	-0.0022	-0.0095	-0.006	-0.007	-0.0062	-0.0019
				Indirect effects				
Modern Facility								
Residence tap	0.543	-0.001	-0.0006	0.0302	-0.002	0.045	-0.0012	0.0043
Public tap water	0.684	0.001	0.0008	0.0307	-0.0023	0.044	-0.0002	0.0085
Traditional facility								
Residence tap	-1.179	-0.0002	-0.0002	-0.0142	-0.0008	-0.0005	-0.0067	-0.0036
Public tap water	-1.038	0.002	0.0013	-0.0137	-0.001	-0.0016	-0.0057	0.0006
Total ind. Eff.	-0.495	0.001	0.0006	0.0165	-0.003	0.0433	-0.0069	0.0049
				Total effect				
Modern Facility								
Residence tap	0.412	-0.004	-0.0029	0.021	-0.0081	0.038	-0.0074	0.0024
Public tap water	0.553	-0.002	-0.0015	0.0213	-0.0084	0.037	-0.0064	0.0066
Traditional facility								
Residence tap	-1.31	-0.0032	-0.0024	-0.0236	-0.0069	-0.0077	-0.0129	-0.0055
Public tap water	-1.169	-0.001	-0.001	-0.0232	-0.0072	-0.0088	-0.0118	-0.0013
Total	-0.626	-0.002	-0.0016	0.007	-0.0092	0.036	-0.0131	0.003

Table 9 displays the direct effect of the mother's level of education on child mortality. The results are similar both at the sample mean and for the average of individuals. This is due to the Cox proportional hazard method used in estimating child mortality. The Table also suggests that a one percent increase in the higher level of the mother's education decreases infant mortality by around 1.1 percent. The education effect on mortality reduction is not as clear in the neonatal case since a low educated mother contributes more to the reduction in neonatal mortality. This result may be due to the fact that more educated mothers are employed and they do not have a sufficient time to take care of their children. When forced to work the mother is often obliged to leave the child with insufficient care that may expose him/her to danger.

Table 9: Direct, indirect and total percentage change of child mortality with respect to mother education

	Age Group			*Birth order group*				
	Neonatal	Infant	Child	1	2	3	4	5+
				Direct effect				
Low education	-0.5	0.165	-1.42	-0.211	-0.234	-0.17	0.2	-0.054
Medium education	0.032	-0.478	0.117	-0.256	-0.09	0.245	0.04	-0.158
High education	-0.34	-1.15	-0.242	-0.395	-0.43	-0.594	-0.98	0.87
				Indirect effects at the sample mean				
Low education	0.0179	0.0216	-0.0592	0.026	-0.01	0.093	-0.019	0.015
Medium education	0.0263	0.0376	-0.1155	0.031	-0.013	0.154	-0.038	0.01
High education	0.0349	0.048	-0.1542	0.065	-0.035	0.245	-0.06	0.045
				Total effects at the sample mean				
Low education	-0.482	0.187	-1.479	-0.186	-0.244	-0.077	0.181	-0.039
Medium education	0.058	-0.44	0.0015	-0.225	-0.103	0.399	0.002	-0.148
High education	-0.305	-1.102	-0.396	-0.331	-0.465	-0.349	-1.04	0.915
				Indirect effects at the mean of individual changes				
Low education	-0.014	0.026	-0.143	0.038	-0.079	0.184	-0.069	0.046
Medium education	0.127	0.323	-0.675	0.137	-0.159	0.583	-0.107	0.221
High education	0.143	0.414	-0.92	0.189	-0.247	0.818	-0.176	0.314
				Total effects at the mean of individual changes				
Low education	-0.514	0.191	-1.563	-0.173	-0.313	0.014	0.131	-0.008
Medium education	0.159	-0.155	-0.558	-0.119	-0.249	0.828	-0.067	0.063
High education	-0.197	-0.736	-1.162	-0.206	-0.677	0.223	-1.151	1.184

As concerns the household's head, only indirect effects are calculated since the head's education does not explicitly enter the mortality equation. As shown in Table 10 the head's education induces more mortality in the case of neonatal, infant, third and five and higher births. The positive returns of head education on mortality reduction are revealed in the child stage, first, second and fourth birth.

Table 10: The percentage change of child mortality with respect to the household head education

	Age Group			*Birth order group*				
	Neonatal	Infant	Child	1	2	3	4	5+
				Change at the sample mean				
Low education	0.01	0.016	-0.057	-0.016	-0.009	0.08	-0.022	-0.005
Medium education	0.017	0.027	-0.089	-0.023	-0.013	0.118	-0.032	-0.01
High education	0.022	0.044	-0.126	-0.018	-0.011	0.128	-0.036	-0.014
				Change at the mean of individual changes				
Low education	0.062	0.162	-0.339	0.066	-0.079	0.286	-0.054	0.109
Medium education	0.087	0.23	-0.49	0.099	-0.12	0.426	-0.083	0.161
High education	0.129	0.342	-0.716	0.146	-0.178	0.613	-0.116	0.266

6. Conclusion

Since changes in water and sanitation facilities may potentially affect the spread of diseases, the improvements in such facilities can potentially reduce illness and mortality and lead to better health among survivals. Controlling for the household choice of health infrastructure, and disentangling different cases of wealth elasticity in order to show the response of different health infrastructure on wealth. The results show that the wealth elasticity is negatively related to mortality when having a traditional facility and municipal water. This suggests that Egypt is an old-fashioned society and that there is a low hygienic awareness of how to use modern facilities since disadvantages of a modern facility outweigh the gains from wealth. Furthermore, the results show that urbanization tends to make people choose better quality of services and this may be also due to the fact that better services are more available or accessible in these areas. An important role for public health policy is the elimination of rural-urban disparities concerning health status and particularly in improving water and sanitation infrastructure of rural households leading to the improvement of the health status of their children and consequently a reduction in their mortality rates. Moreover a special emphasis should be given to the enhancement of income levels of the region of Upper Egypt.

The analysis shows that water has an important indirect effect on child mortality through the choice of sanitation facilities. Some of the priorities are the need to extend water infrastructure since the availability of municipal water into residence was found to have a positive impact on the child hygiene and consequently decreasing their mortality rate. Low education level often implies that the understanding of health benefits of sanitary toilet facility is limited or even poor. Since the results show that the mother's levels of education is a prerequisite for enhanced health of their siblings and has an amplified effect as compared to the household head, this calls for the enhancement of education programs with a special focus on female education.

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Appendix A

Table A1: Multinomial1 logit results for the household choice of sanitation facility†

Variables	***Traditional facility***	***Modern facility***
Intercept	-0.52 (1.04)	-6.08 (1.44)***
Tap water into residence (yes)‡	0.52 (0.12)***	0.85 (0.185)***
Public tap water (yes)	-0.62 (0.14)***	-2.98 (0.56)***
Wealth	0.57 (0.034)***	1.14 (0.052)***
Mother's age	-0.032(0.06)	-0.046 (0.08)
Mother's age squared	0.0003 (0.001)	0.0007 (0.0014)
Household head age	0.0124 (0.024)	0.021 (0.036)
Household head age squared	-0.00007 (0.0002)	-0.00007 (0.0004)
Number of women>1 (yes)	0.084 (0.13)	-0.13 (0.19)
Household head sex (male=yes)	0.04 (0.39)	0.075 (0.5)
Mother's education		
Low education	0.14 (0.134)	0.76 (0.19)***
Medium education	0.356 (0.25)	1.29 (0.29)***
High education	1.11 (0.42)***	2.79 (0.44)***
Household head education		
Low education	0.085 (0.12)	0.6 (0.19)***
Medium education	0.14 (0.17)	0.886 (0.22)***
High education	0.6 (0.24)**	1.69 (0.28)***
Place of residence		
Urban governorates (yes)	2.76 (0.54)***	3.36 (0.56)***
Lower Egypt urban (yes)	3.31 (0.74)***	3.54 (0.76)***
Lower Egypt rural (yes)	1.94 (0.22)***	0.65 (0.27)**
Upper Egypt urban (yes)	1.12 (0.265)***	0.39 (0.3)
Upper Egypt rural (yes)	0.47 (0.17)***	-1.46 (0.23)***
Sample Size	6871	
Log Likelihood	-3349.913	
Restricted log likelihood	-5574.312	

† The table presents the parameter estimates. The standard errors are in parenthesis.

‡ (yes) refers to a dichotomous variable indicating that the value 1 is taken by the variable name (e.g.. Tap water into residence (yes) = Dichotomous variable indicating that the household has municipal water piped into residence).

*** Means that the estimate is significant at 1 percent level.

** Means that the estimate is significant at 5 percent level.

* Means that the estimate is significant at 10 percent level.

Table A2: Multinomial1 logit results for the household choice of source of drinking water†

Variables	*Public tap*	*Water into residence*
Intercept	-0.498 (1.1)	-2.85 (0.75)***
Wealth	-0.139 (0.0325)***	0.376 (0.022)***
Mother's age	-0.145 (0.0589)**	-0.0334 (0.042)
Mother's age squared	0.00212 (0.001)**	0.000529 (0.000716)
Household head age	0.0149 (0.026)	0.041 (0.0172)**
Household head age squared	-0.00025 (0.00026)	-0.000343 (0.00017)**
Number of women>1 (yes) ‡	-0.0781 (0.13)	-0.237 (0.088)***
Household head sex (male=yes)	-0.618 (0.325)*	-0.128 (0.264)
Mother's education		
Low education	-0.021 (0.135)	0.0233 (0.09)***
Medium education	-0.229 (0.213)	0.539 (0.13)***
High education	-0.36 (0.226)*	0.612 (0.127)***
Household head education		
Low education	-0.08 (0.124)	0.32 (0.09)***
Medium education	-0.16 (0.165)	0.388 (0.11)***
High education	-0.51 (0.2)**	0.235 (0.12)*
Place of residence		
Urban governorates (yes)	6.01 (0.56)***	4.81 (0.368)***
Lower Egypt urban (yes)	4.18 (0.5)***	3.19 (0.224)***
Lower Egypt rural (yes)	3.94 (0.42)***	1.79 (0.122)***
Upper Egypt urban (yes)	3.3 (0.46)***	2.518 (0.162)***
Upper Egypt rural (yes)	2.29 (0.42)***	1.21 (0.112)***
Sample Size	6871	
Log Likelihood	-4398.971	
Restricted log likelihood	-5761.816	

† The table presents the parameter estimates. The standard errors are in parenthesis.

‡ (yes) refers to a dichotomous variable indicating that the value 1 is taken by the variable name (e.g.. number of women>1 (yes) = Dichotomous variable indicating that the household has more than one eligible women).

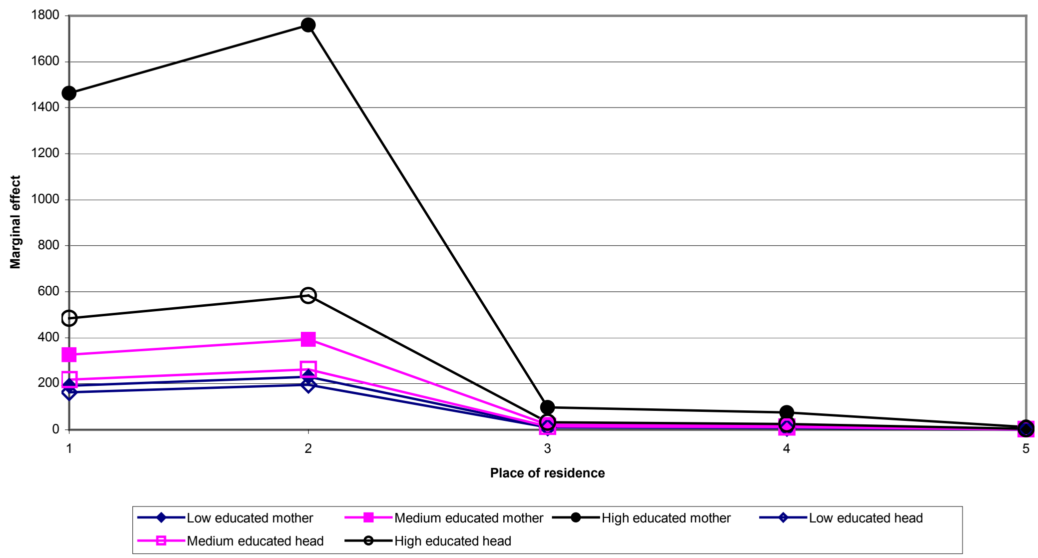
*** Means that the estimate is significant at 1 percent level.

** Means that the estimate is significant at 5 percent level.

* Means that the estimate is significant at 10 percent level.

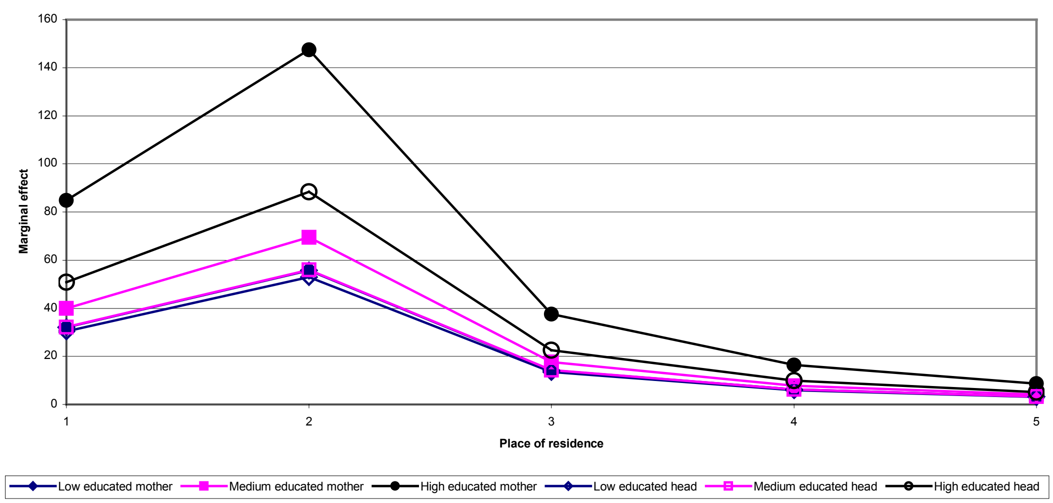
Appendix B

Figure B1: the marginal effect of wealth on the odds ratio of modern facility versus no facility, by place of residence and gender education level



Place of residence key: 1=Urban governorates, 2=Lower Egypt urban, 3=Lower Egypt rural, 4=Upper Egypt urban, and 5=Upper Egypt rural

Figure B2: the marginal effect of wealth on the odds ratio of traditional facility versus no facility, by place of residence and gender education level



Place of residence key: 1=Urban governorates, 2=Lower Egypt urban, 3=Lower Egypt rural, 4=Upper Egypt urban, and 5=Upper Egypt rural