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WATER AND HEALTH IN EGYPT: AN EMPIRICAL ANALYSIS

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To my mother and father

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Abstract

This thesis is an empirical work dealing with water issues in Egypt where the emphasis is put on the analysis of the relationship: inadequate water quality and health impacts. The first chapter includes a general discussion of water resources in Egypt and other developing countries. This chapter briefly also deals with water tariffs and sustainable water pricing in Cairo.

In the second chapter the impacts of water and sanitation on child mortality in Egypt are assessed. The analysis is conducted using a three-part model specification, comprising discrete choice to model the child prospects of dying during the neonatal period. The remaining parts use transition models, in which unobserved heterogeneity is accounted for, to model infant and childhood risk of death. The results show that access to municipal water decreases the risk, and sanitation is found to have a more pronounced impact on mortality than water. The results suggest that increasing the awareness of the Egyptian population relative to health care and hygiene is an important means to decrease the risk of child mortality. Moreover, gender discrimination is found to have an important effect beyond the neonatal period.

In the third chapter, controlling for the Egyptian households' 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 neonatal mortality is found, but generally the indirect effect is negligible. Furthermore, changes in wealth and educational levels are assessed taking into consideration a priori the choice of health infrastructure. The analysis suggests that wealth and education contribute loosely to the child mortality reduction.

The fourth chapter analyzes the impact of better water quality on health improvements using two stated preference methods: choice experiments and the contingent valuation method. These methods were administered to a random sample of 1500 households in metropolitan Cairo, Egypt. The results show that both methods give quite the same welfare measures. Moreover, households in metropolitan Cairo do have a positive willingness to pay for reducing health risks owing to water quality that amounts to roughly double their current water bills. This finding suggests that the willingness to pay is rather small compared to the likely cost.

Keywords: Child mortality; Choice experiment; Contingent Valuation Method; Discrete choice; Elasticity; Egypt; Health; Household environment; Marginal effects; Transition models; Unobserved heterogeneity; Water and sanitation; Wealth; Willingness to pay.

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Water Resources in Egypt

1. Introduction

Water is a scarce resource. It is critical for certain areas especially in Africa, where two thirds of the countries are developing a serious water scarcity (Falkenmark, 1989). Water quality and quantity for the various uses (agricultural, domestic, industrial as well as to cover environmental needs) require great attention. Expanding populations coupled with the wide spread of droughts and desertification in water-scarce countries do inevitably lead to increased competition for the limited available water. On a national level, competition occurs between urban and rural populations, and among agricultural interests, households and industry (Falkenmark et al., 1998). Furthermore, the problem could become expanded in the future to competition between counties sharing the same basin. However, water scarcity and water conflict could be prevented if water conservation and/or efficiency of water use were increased in all sectors, and especially in agriculture (Rosegrant and Gazmuri, 1994).

In Egypt it was traditionally thought that water was abundant. This is due to the existence of the Nile. The Greek historian Herodotus (484-430 BC) said, “Egypt is the gift of the Nile.” Today, the country is facing many problems with water use because of population growth and industrialization. In agriculture, water is made available free of charge. Nevertheless, with traditional irrigation methods water is not sufficient to irrigate enough land to realize a reasonable food security ratio. According to Rosegrant et al., a lot of gains could be achieved through policy reforms such as “subsidy reduction.” Without such policy reforms, overuse of water will continue to take a heavy toll on the environment. Without proper drainage, excess water results in waterlogged fields and the buildup of salts in the soil. Thus, water induces land degradation causing reductions in crop yields and could lead to farmlands that can no longer be cultivated. In Chile for instance, aggregate irrigation efficiency increased by 22 to 26 percent during the 1975-1992 period through pure policy reform, while an investment of USD400 million would have been required to accomplish such water efficiency gains.

Another technique to promote efficient use of a scarce resource (in our case water) is to properly price it. In Egypt water pricing policies are neither efficient nor sustainable. The state provides many irrigation and domestic water supply systems at subsidized rates in order to insure food supplies, public health, or legitimacy for the government. However, low or non-existing water charges and poor cost recovery lead to declining funds available for investments in water infrastructure, poor maintenance of existing systems, and growing conflicts between those with and without access to water. Inconsequential regulation has also induced over-pumping of ground water in some regions of Egypt. Hence, if no actions are taken, ground water supplies will be threatened since users will pump water faster than aquifers can recharge.

Further, the spread of industries all over the regions and the lack of effective enforcement of water treatment of effluents have resulted in a degradation in the quality of water. Salinity problems in agriculture require different measures than those for household uses. Accordingly, the water scarcity problem has two dimensions: a quantitative and a qualitative one.

On the other hand, Egypt is located in an arid climate and it is supported by large-scale water transport through the Nile. This fact makes Egypt a net importer of water since 88.6 percent of the utilized water comes from upstream countries sharing the Nile River. As noted by Gleick (2000, p. 26): "The theoretical water availability rarely represents the actual water available to any particular person, which depends on economic factors, legal water rights, technical ability to capture, store and move water from place to place, political agreements with neighboring countries, and so on… On paper, the Sudan has a vast amount of water available on average, but it is compelled by a treaty signed with Egypt to pass on much of the water it receives in the Nile from upstream nations. In recent years, internal turmoil and civil war have prevented the Sudan from using even its legal share from the Nile treaty."

In this thesis I will only deal with water problems in the household sector. The rest of this chapter will deal with domestic water supply, hygiene and sanitation, and the Egyptian water situation in general and in Cairo in particular. Section 4 provides an overview of the thesis. The chapter ends with concluding remarks.

2. General outlook of water supply, sanitation, and hygiene

The Earth was home to more than 6 billion people in 2000 (World Development Indicators 2000). Out of this population, 1.1 billion lacked safe water and 2.4 billion lacked adequate sanitation. As a consequence, water and sanitation-related diseases are widespread. Nearly 250 million cases are reported every year, with more than 3 million deaths annually (i.e. about 10,000 a day). Diarrheal diseases impact children most severely, killing more than 2 million young children a year in the developing world. Many more are left underweight, stunted mentally and physically, vulnerable to other deadly diseases, and too debilitated to go to school. In Egypt, the WHO (2002) reports under age five mortality to be 46 per 1000 live births in 2001, and 20 percent of all child deaths every year are due to diarrheal diseases.

Many studies and a great deal of field experience (WHO, 1997) suggest that a minimum quantity of safe water is required for a person to drink, to prepare food, to ensure personal cleanliness and to use a sanitary latrine. Drinking and cooking require 10 to 15 liters per day. Water needs for hygiene and sanitation are less precise and vary from one culture to another. Yet, a person who practices personal hygiene and uses a latrine needs an absolute minimum of 20 liters per day. Further, health benefits accrue when communities move from public taps to house connections. Those with house connections usually use 40 or more liters per person. Consequently, the minimum quantity of domestic water recommended for a human being to sustain survival and hygiene is around 15 m^3 per year. Hence, the total volume of water required to meet basic needs is relatively small compared to agricultural and industrial uses, where (as will be discussed later) for a country to become self-sufficient in food supply on a subsistence level, 1250 cubic meters of water per capita are required annually. Accordingly, the problem of domestic use is not water quantity but rather quality. Nonetheless, experience (see Esrey et al., 1992) has shown that clean water alone leads to only minor health improvements. The essential factor is sound personal hygiene, with adequate public sanitation and clean water as supporting components. Whilst each of the three aspects alone has some health benefit, their combined effect is far greater.

2.1 Access to water and sanitation

When compared to other countries, and particularly to the neighbors in N. Africa, Egypt has very good access to water. Access is virtually universal for the urban areas and very high (96%) even for the rural areas (see Table 1). As for access to sanitation facilities, however, Egypt appeared to lag far behind its North African neighbors in 1990, but appears to have seen dramatic improvements leading to a virtually total coverage in 2000.

Table 1: Access to improved drinking water sources and sanitation facility

	Year	*Region*	*Global level*	*Developing countries*	*North Africa*	*Egypt*
Water	1990	Urban	95	93	93	95
		Rural	64	61	80	86
	2000	Urban	95	93	96	99
		Rural	71	69	84	96
Sanitation	1990	Urban	80	68	95	80
		Rural	29	19	64	26
	2000	Urban	84	78	96	100
		Rural	40	36	81	95

Source: This table is compiled from the WHO-UNICEF (2001).

The dramatic increase found for sanitation may raise some concern over the quality of the data, but the general picture of the rapid improvement is, as we will see, broadly speaking confirmed by various domestic data sources. Concerning the evolution of the access to water supply and sanitation in Egypt, Table 2 shows the percentage of the Egyptian population with access to a presumably safe water supply and adequate sanitation at different points in time between 1989 and 2000. According to the 2000 Demographic and Health Survey (DHS), the proportion of the population served with piped water into the residence in urban and rural areas is 97 and 65 percent, respectively. This implies a big increase over the decade, particularly in the rural areas. The share of the population with modern toilet facilities increased in urban areas by more than 60 percent and also appeared to increase substantially in the rural areas, although the numbers are low and uncertain. Although the type of sanitation facility is quite a good indication of performance, the best indication is sewer connection. The percentage of the population with public sewer connections is around

48 and 10 percent in urban and rural areas, respectively. This indicates that the municipal water supply in urban areas is twice the rate of sewer connections, while the figure for rural areas is around 6.5 times. This extended provision of water supply in the villages is generally undertaken without a paralleling construction of new sewage systems or rehabilitation of the existing ones, which results in wastewater discharge directly into waterways. This occurs often without any form of treatment, leading to pollution of the water bodies and thereby increasing public health hazards.

Table 2: Access to water and sanitation in Egypt

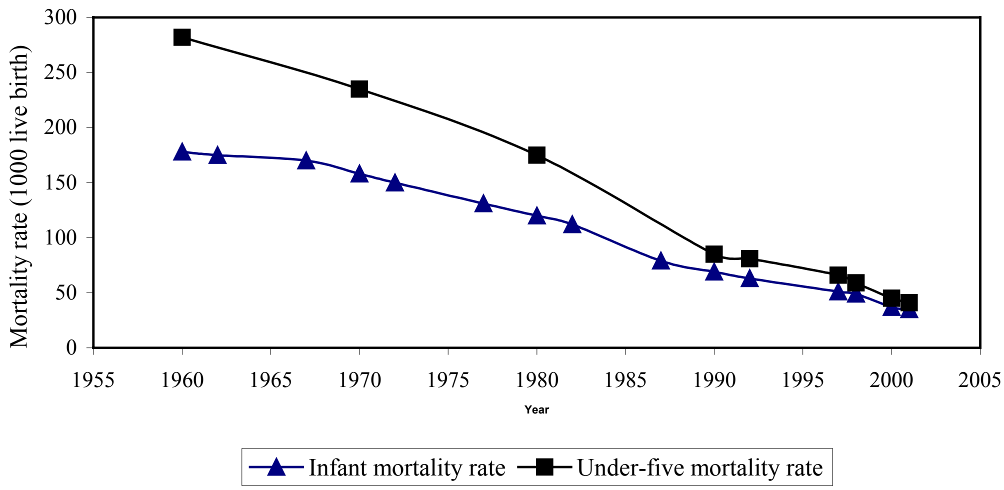
Year and source	*Water*				*Sanitation*			
	Piped water into residence		Public tap		Modern flush toilet		Traditional with tank/bucket flush	
	Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
1989 DHS	92	53.4			36.4	2.1	56.7	60.6
1992 DHS	91.8	44.9	5.1	16.2	46.3	5.7	48.4	51.7
1995 DHS	92.4	53.2	4.1	16.2	50.4	6.2	48.6	64.7
1996 Census	87.8	33.5	5.2	14.2	48.1[a]	10.3[a]	39.2[b]	79[b]
1999 WHO	87.7	39.9	8	30.9	48.1[c]	9.7[c]	39.2[d]	74.2[d]
2000 DHS	97	64.9	2	11	59.2	7.8	40	81.8

Source: This table is compiled from various data sources: the Egyptian Demographic and Health Survey (DHS), the 1996 national census and Global Water Supply and Sanitation Assessment 2000 (WHO).
[a] Households with public sewer connection.
[b] Private sewer connection, septic tank, shared latrine.
[c] Households connected to conventional sewers.
[d] Population without household connection but served with adequate, private or shared on-site system.

2.2 Child mortality

There is a wide spectrum of waterborne diseases such as cholera, hepatitis, trachoma, typhoid and paratyphoid. The most common and pronounced disease is diarrhea, which affects children most severely and can lead to morbidity and in many cases mortality. Figure 1 depicts the child mortality rate for infants and children under-five years of age between the 1960 and 2001. The figure exhibits a declining pattern, where the infant and under five mortality rates reach 35 and 41 deaths per 1000 live births. Although this is roughly an 80 percent decline compared to the 1960s, the figures are still twelve times higher than in a country like Sweden, which has one of the world's lowest mortality rates. Table 3 depicts the infant and under-five mortality rates for Egypt and some selected countries from 1960 to 2001. The WHO (2002) reports that 20 percent of all child deaths every year are due to diarrheal diseases. This is quite a high number for Egypt given the water supply and sanitation discussed above. So what causes this high percentage of deaths? The coming section attempts to explore these causes.

Figure 1: Mortality rate of infant and under five in Egypt



2.3 Water quality and hygiene

As previously mentioned, the availability of so-called safe water and access to sanitation facilities are both good throughout Egypt. It is however not just the supply that matters, but also its quality. To start with, the Egyptian standards for drinking water partly deviate from the WHO guidelines. Second, the surface water that is the main source for drinking water is polluted due to untreated or partially treated discharge of industrial wastewater. Further, the construction of the Aswan High Dam caused the reduction of the sediment load, inducing the agricultural activities to extensively apply agrochemicals that end up reaching surface water causing problems of toxicity and eutrophication. Last but not least, the widespread legal and illegal discharge of untreated or insufficiently treated domestic wastewater is also a contributing problem. The situation is most severe in the Nile Delta as considerable amounts of drainage water are mixed with canal and Nile river water for reuse. In addition to the environmental and health hazards that these discharges may imply, they also make it more costly and difficult to treat drinking water to obtain a viable quality where many people presently have contact with water that is polluted with infected wastewater.

Table 3: Mortality rate of infant and under-five in Egypt and some selected countries (1000 live births)

	Year	*1960*	*1970*	*1980*	*1990*	*1997*	*1998*	*2000*	*2001*
Infant	Egypt	178	158	120	69	51	49	37	35
	Algeria	166	139	98	46	35	35	40	39
	Bangladesh	155	140	132	91	75	73	54	51
	Ethiopia	174	158	155	124	107	107	117	116
	Libya	158	122	70	33	24	23	17	16
	Morocco	161	128	99	64	51	49	41	39
	Sudan	158	118	94	85	71	69	68	65
	Sweden	17	11	7	6	4	4	3	3
	Tunisia	158	121	69	42	29	28	26	21
Under-five	Egypt	282	235	175	85	66	59	45	41
	Algeria	255	192	139	55	39	40	50	49
	Bangladesh	247	238	211	136	104	96	82	77
	Ethiopia	280	239	213	190	175	173	174	172
	Libya	270	160	80	42	30	27	20	19
	Morocco	220	187	152	83	67	61	46	44
	Sudan	210	177	145	125	115	105	108	107
	Sweden	20	15	9	6	5	5	4	3
	Tunisia	254	201	100	52	33	32	29	27

Source: The World Bank Indicators (2002).

On the other hand, the supply of good drinking water alone is insufficient to ensure good health. There are many stages in the collection, storage and handling of food, the disposal of excreta and the care of children at which the drinking water can become contaminated and the community exposed to pathogens. Children, especially those under five are particularly vulnerable to diarrhea. There are many transmission routes for water and sanitation related diseases, and hygiene education could therefore cover a wide range of actions. Examples of behaviors recommended in hygiene education are: i) water should be efficiently used and not wasted while wastewater should be properly drained away; ii) there should be no risk of contamination of water sources from nearby latrines, wastewater drainage, cattle or agricultural chemicals; iii) if necessary water should be filtered to remove any solid material and worms; iv) drinking water should be collected and transported in clean covered containers without coming in contact with hands and other materials; v) household latrines should be sited in such a way that the pit contents cannot enter water sources or the groundwater table, and hand washing facilities and soap or ash should be made available on site; and vi) household wastewater should be disposed of or reused properly. (For a detailed discussion on hygiene education see WHO, 1997).

3. Water quantity and tariffs in Egypt

This section starts with the availability of water in Egypt, then presents a quick overview of water tariffs in Egypt compared with some countries in the Middle East and North Africa (MENA) region. Thereafter, the discussion is restricted to metropolitan Cairo mainly because of data availability and partly due to the focus of one of the thesis chapters on this issue.

3.1 Water availability

In Egypt, the Nile is the main source of water for all uses. Table 4 shows sources and uses of water for 1990/91-1998/99. From a hydrological perspective suggested by Gustafsson (1982), for a country to become self-sufficient in food supply on a subsistence level, 1250 cubic meters of water per capita are required annually. The actual figure for Egypt is only 1025 cubic meters. In 1998/99, the average Egyptian population was around 66 million. This implies a shortfall of 15 billion cubic meters of water to cover the demands of habitats and subsistent crop production, which in turn implies an extra need of around 27 percent of the total annual flow of the Nile.

A quick view of the water profile for the past decade presented in Table 4 reveals the following:

- Evaporation has increased by 10% due to an increased average temperature.
- Navigation water has decreased from 2 billion cubic meters in the early 90s to zero by 1995/96. This could be seen as an indicator of government water rationing.
- Agriculture is the largest consumer of water, responsible for an average of 85 percent of the total water consumption. This indicates the central role of water in assuring an adequate food supply. The effective water used for irrigation has increased by 10.6% from 1991 to 1997, in the face of an increased area of irrigated land by 25%. This could be seen as an indicator of a more efficient water

use. But still, a lot of waste could be saved, since a considerable amount of land is irrigated by traditional mechanisms.

- The amount of water lost to the sea and lakes has been quite static in the past ten years and more than doubled in the 1998-99 period. This was due to the flooding of the Nile that year, and the water flow from upstream doubled. This caused an increase in the water level behind the Aswan Dam to 181 meter, which forced the release of more water in order to relieve the stress on the dam.

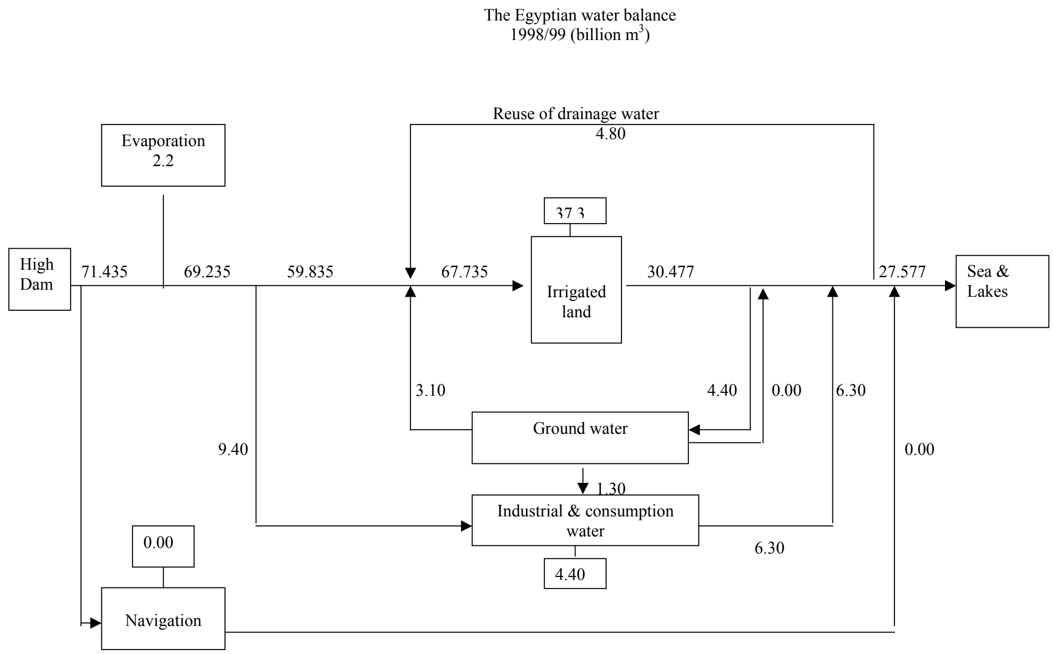
Table 4: The Egyptian water balance (billion m^3)

Year	*Sources of water*			*Utilization of water*				*Volume of water diverted for irrigation*	*Lost to sea and lakes*
	The Nile	Ground water	Drain-age water	Irriga-tion	Cons. & Ind.	Navig-ation	Evapora-tion		
90/91	53.795	2.85	4.1	34.29	3.1	1.84	2	48.91	14.41
91/92	54.245	3.1	4.1	32.34	3.1	1.84	2	49.605	16.808
92/93	55.295	3.3	4.1	35.76	3.2	2.00	2	50.395	14.235
93/94	54.465	3.4	4.2	35.75	3.1	1.16	2	50.105	13.613
94/95	55.5	4.2	4.5	36.13	4.2	.26	2	51.94	13.168
95/96	55.5	4.4	4.6	36.72	4.2	0.00	2	52.2	12.680
96/97	55.97	4.4	4.8	37.13	4.3	0.00	2	52.67	12.540
97/98	55.5	4.4	4.8	35.76	4.3	0.00	2	52.2	13.442
98/99	71.435	4.4	4.8	37.26	4.4	0.00	2.2	67.735	27.577

Source: Unpublished data from the Ministry of Public Works and Water Resources.

Figure 2 illustrates the mechanism and the water flows in Egypt for 1998-99. Out of the 71.435 billion m^3 of Nile water liberated from the Aswan High Dam, 2.2 billion m^3 evaporate along the course to lower Egypt and 9.4 billion m^3 are deviated from the Nile to industry and households, which also receive an additional 1.3 billion m^3 of ground water. However, while only 4.4 billion m^3 of the total quantity of water was utilized for industrial and domestic purposes, there were return flows of 6.3 billion m^3 used for hydrological systems and ecosystem maintenance. However, the benefits from these flows depend critically on water quality and evaporation. Irrigation uses 37.3 billion m^3 of water from the total amount of 67.735 billion m^3 diverted to it, and around 88, 5 and 7 percent of this quantity comes from Nile water, ground water and reuse of drainage water, respectively.

Figure 2: Egyptian water balance



The total distance that the Nile flows from the Aswan High Dam to the Delta Barrage in Cairo is about 950 km. Thereafter the Damietta and Rosetta branches begin, and end 220 km downstream in the Mediterranean. Deterioration in water quality occurs due to the disposal of municipal and industrial effluents and agricultural drainage as well as to decreasing flow. In a number of cases, municipal and rural domestic wastewater is discharged into waterways, often without treatment. The discharges are increasing year after year due to population growth and the expansion of water supply networks. This expansion is not paralleled by the construction of new sewage systems or rehabilitation of the existing ones, and aggravates the pollution and public health hazards. In Egypt most industries are located along the Nile or main canals and use these water bodies as direct sources, while some others are connected to municipal water supply systems. Significant waste loads that can cause considerable water pollution are directly discharged into water bodies. Apart from being the largest consumer of water, agriculture is also a major water polluter. Saline irrigation return flows or drainage, containing agrochemical and pesticide residues, are serious contaminants for downstream water users and groundwater. In spite of all this, the quality of the Nile and irrigation canals is still relatively good, considering the amount of people living within the catchments and the industrial activities that take place.

Organic loads are still mostly within the natural carrying capacity of the river. However, this should not discourage undertaking preventive measures in order to keep the river below that limit. On the other hand, water quality in the coastal lagoons is seriously affected by the discharge of drainage water mixed with domestic and industrial effluents.

Table 5: Water prices for different sectors in selected countries of the MENA region

Country	*Agriculture*		*Domestic*		*Industry*	
	Fixed (US$/ha/yr)	Variable (US$/m^3)	Fixed (US$/ house / yr)	Variable (US$/m^3)	Fixed (US$/ plant / yr)	Variable (US$/m^3)
Algeria	3.79-7.59[a]	0.02-0.022		0.057-0.027[f]		4.66
Egypt	0.00	0.00		0.07-0.09		0.12-0.59
Israel		0.16-0.26		0.36		0.26
Jordan		0.0085-0.049		0.093-1.03		0.12-0.35
Lebanon			8.71[b]			
Pakistan	1.49-5.80[c]		0.25-1.63[g]	0.06-0.10		0.38-0.97
Palestine WB				0.79-1.12[d]		
Palestine Gasa				0.33[d]		
Saudi Arabia	0.00			0.04-1.07	0.00	0.00
Sudan	4.72-11.22[c]		1.67-3.33[h]	0.08-0.10	1.67-3.33[h]	0.08-0.10
Syria	50.00		3.21[b]	0.11-0.53		0.71
Tunisia		0.02-0.08[e]		0.10-0.53[f]		0.58
Yemen		0.02-1.45[d]		0.1-13.79[d]		0.1-13.7[d]

Source: Adapted from Ahmed (2000).
[a] Per liters per second per hectare.
[b] Per month.
[c] Depending on crop and region.
[d] Price in water market.
[e] Depending on location.
[f] Depending on consumption tier.
[g] Depending on monthly rental value per dwelling.
[h] Depending on dwelling or plant size.

3.2 Water tariffs

Countries have different intentions behind their charges for water. Some wish to recover costs; others want to transfer income between sectors through cross subsidization, and some countries use charges to improve water allocation and water conservation. Several interesting patterns emerge from Table 5. Egypt and Saudi Arabia are examples of countries where irrigation water is free of charge and nominal charges are placed on domestic use. In Pakistan, Syria, and Sudan agriculture is charged at fixed rates, whereas in Israel, Jordan, Tunisia and Yemen volumetric tariffs are used. As for the domestic sector, Egypt uses variable charges in the form of very low tariffs, as is the case in some other countries such as Algeria, Pakistan and Sudan.

Prices for industrial water vary more widely across countries, probably because some countries view the industry as an easy source of revenue with a greater willingness to pay and a capability to subsidize consumption in other sectors. Still, these countries follow a low price policy that does not reflect the cost or value of water. Henceforth, these countries do not induce the incentives to the farmers to adopt water saving technologies and they lack the accurate policies that bring consumers and/or producers to save this scarce and depletable resource.

In general and in most countries of the MENA region (if not in all of them), it has traditionally been the responsibility of the public sector to provide water for the population. However, given the rapid growth of water demand over the recent decades, the public sector alone has become incapable of ensuring socially efficient levels of supply and water utilization (Briscoe, 1996).

3.3 Water in Cairo

Cairo has a population of about 15-17 million, representing almost a quarter of the total population of Egypt. Prior to the 1990s applied economic policies were distorted. Prices of goods and services including water were heavily subsidized reflecting the government's desire to hold consumer prices down in the face of urbanization and rapid population growth (Ahmed et al., 2001). Essentially, food rationing began as a temporary measure in Egypt in 1941, designed to help Egyptians cope with the scarcity and inflation due to World War II. This system was set up to provide everyone with necessities such as sugar, kerosene, coarse cotton textile, edible oil and tea (Ali and Adams, 1996). The food subsidy system expanded in the 1960s and 1970s, becoming part of a broader set of consumer welfare programs that also subsidized transportation, housing, energy, water, health, education and some nonfood consumptive products such as soap and cigarettes. The state budget suffered a severe deficit, which reached 17% of the GDP in 1988. In view of the high inflation rates, high external indebtedness and its service burden, and the large balance of payments deficit, the government was forced to follow an Economic Reform and Structural Adjustment Program (ERSAP). The economic principle applied under this program included reducing subsidies, relying on market forces in pricing and investment decisions, and reducing the state budget. This applied to household water pricing policies, for example leading to water rationing since heavy subsidies by the government result in little incentives to save water. Removal of subsidies for urban water use could have substantial effects on the reduction of water use. Evidence of price-induced conservation can be found in Bogor, Indonesia, Goa, India, Sao Paulo and Israel (Dinar et al., 1997).

Table 6: Water tariff in Cairo†

Uses	*Price (L.E. per m³)*	*Sewerage*
Fixed monthly fee		
A one room apartment‡	1.20	
A two room apartment‡	1.50	
A three room apartment‡	1.80	
A more than three room apartment‡	2.40	
Quantity pricing		
Household using less than $60m^3$	.12	
more than $60m^3$	.16	20%
Building price (i.e. when there is no separate metering)	.34	
Parties and syndicates	0.25	60%
Mosques	.08	20%
Embassies	.75	60%
Small factories and cafés	.36	60%
Big factories, petrol stations, second and third degree hotels, private schools	.60	60%
Private hospitals, first class hotels, restaurants, night clubs, tourist centers, companies	1.25	60%
Turbid water	.10	
Non-governmental organizations	.15	20%
Clubs-class B	.10	20%
Public hospitals	.23	60%
Clubs-class A	.50	60%
Parking lots and bakeries	.28	60%
Turbid water for investment companies and free zones	.15	

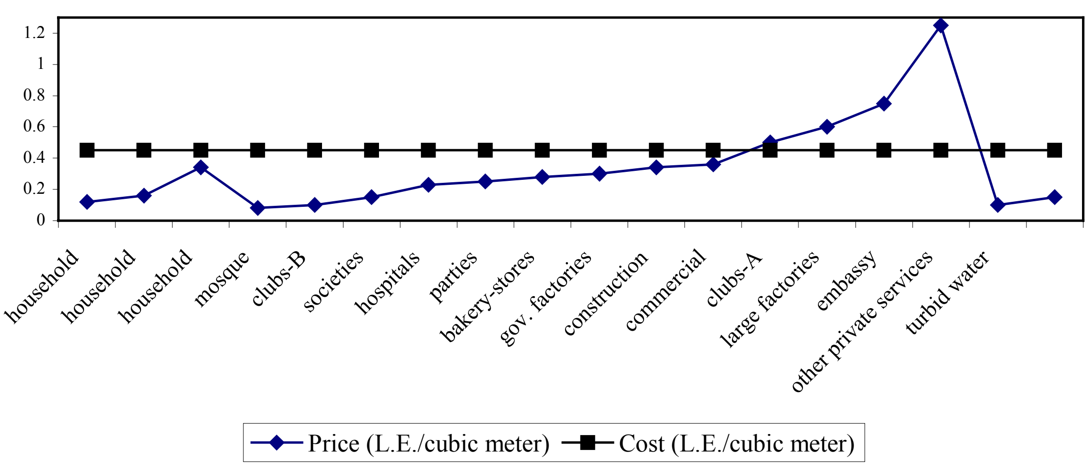
Source: Unpublished data from the Cairo waterworks agency.
† Prices are denominated in Egyptian pounds (L.E.) 1$ ~ 3.4LE.
‡ Prices here are a fixed fee and do not depend on the quantity consumed.

Prices

Table 6 shows the structure of a water tariff in Cairo, where it can be seen that the household sector has three different schemes of billing: (i) an increasing block tariff; (ii) a fixed price per cubic meter for the case where one water meter is used for an entire building; and (iii) a fixed cost regardless of the quantity consumed. A 20 or 60 percent extra fee is added to the water bill, used for wastewater collection and treatment. The waterworks also sells turbid water. This lower quality water is used to irrigate gardens and city parks.

As observed, there are variations in user prices, where some tariffs are set below cost, and others above. A potential reason for this pricing scheme is to meet several societal objectives, such as poverty alleviation. Notice that the cost of producing or supplying a cubic meter of water is 0.45L.E., which is clearly demonstrated in Figure 3. The Figure illustrates the subsidized water rates, which are rooted in the political economy of water as user interests and the government, fearful of losing its legitimacy, often oppose charging the full cost of water (Dinar. 2000). The applied water policy results in a vast gap between the observed water rates and the ideal economic prices based on marginal cost pricing or a reflection of its scarcity value and opportunity cost.

Figure 3: Price and cost of water in Cairo 1997-98



Demand

Table 7 depicts water demand in Cairo 1997/98. Notice however that the biggest consumers are households with metering. They consumed about 802 million cubic meters of water in 1997/1998, followed by commercial shops that consumed around 43 million cubic meters. These two consumers paid a price below the supply cost, while users who paid a price above the supply cost consumed very small amounts of water, i.e. private hospitals, first-class hotels, restaurants, nightclubs, tourist centers, and companies.

Table 7: Water demand in Cairo (1997/1998)

Users	*Number of water-meters*	*Consumption (m^3)*	*Consumption per water meter or subscriber*
Household with metering	581309	801722308	1379
Household without met.	13450	4131121	307
Mosques	1702	2561771	1505
Clubs class B	115	2724869	23695
Societies	777	4127624	5312
Public hospitals	33	1048270	31766
Syndicates and parties	42	357349	8508
Parking lots and bakeries	2582	4170175	1615
Public sector factories	1	458659	458659
Under construction	n.a.	4993714	n.a.
Commercial shops	40974	43075244	1051
Clubs class A	61	1318502	21615
Large factories	1867	33034597	17694
Embassies	197	1015538	5155
Investments & tourism	843	10504065	12460
Watering gardens	521	1090239	2093
Watering invest. Gardens	3	1257720	419240
Total	644477	917591765	1424

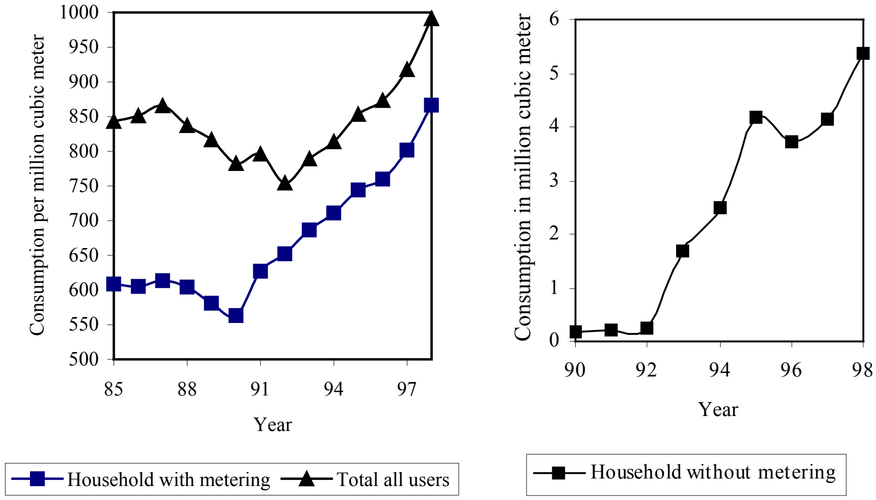
Source: Unpublished data from the Cairo waterworks agency.

The total demand for 1997/98 in Cairo was about 918 million m^3. From the total amount of 4.3 billion m^3 utilized in the industrial and domestic sectors depicted in Table 4 around 21.35% was consumed in Cairo, while Cairo contributes 24.2% of the total population. Since the size of the share of the total industry located in Cairo is unknown, no conclusion may be drawn concerning the fairness or equity of the distribution of water in the industrial and domestic sectors.

The first panel of Figure 4 depicts water consumption per million cubic meters in Cairo from 1985/86 to 1998/99. It can be seen that household consumption constitutes the biggest share among all users. Household use of water was fairly stable around 600 million cubic meters in the first four years. Then consumption exhibited a decrease in 1989/90 and in 1990/91. Nevertheless, this should not be mistaken as a decrease in water consumption; it is rather a result of registration and tariff scheme changes. In 1989/90, there was a redefinition of the networks that belonged to the

Cairo governorate, while in 1990/91 fixed tariffs where launched, depicted in the second panel of the figure.

Figure 4: Water consumption in Cairo from year 1985/86 to 1998/99

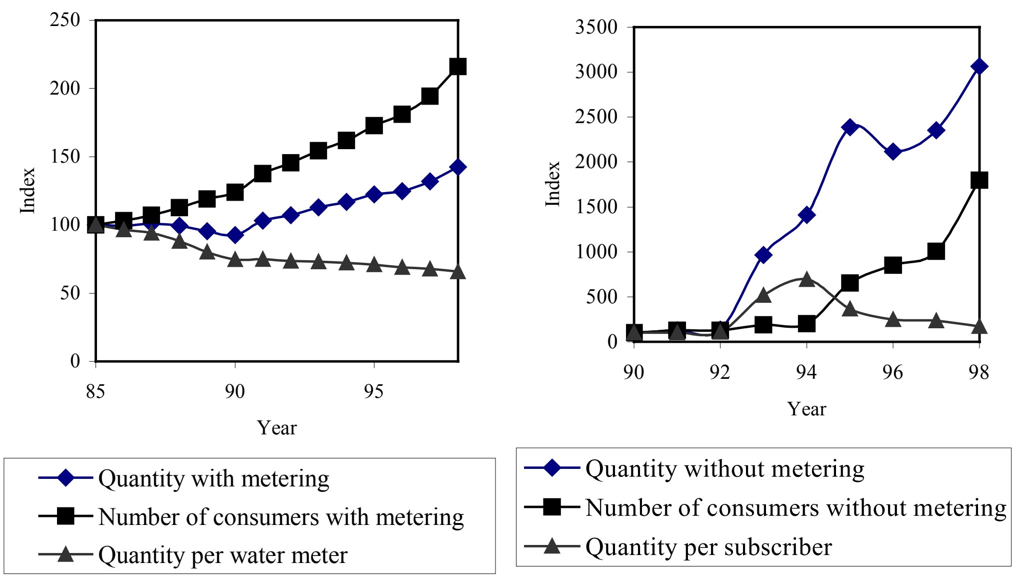


From 1990/91 and on, household water consumption and the number of consumers increased steadily (see Figure 5). In the case of households with metering, the quantity consumed increased by 42 percent, while the number of users in this category more that doubled between 1985/86 and 1998/99. Concerning households without metering, i.e. households paying a fixed fee, the quantity consumed increased between 1985/86 and 1998/99 by around 2940 percent, while the number of users only increased by around 1700 percent. Hence, the related household consumption per water meter decreased by around 35 percent, while the consumption by households without metering increased by 70 percent per subscriber or apartment. This is a good indication that fixed water fees do not induce water conservation, since they do not illicit incentives for water users to conserve water and improve use efficiency. It also sends wrong signals about the scarcity cost of the resource.

Unsustainable water pricing

Water pricing balance in Cairo in 1997/98 could be calculated by differencing the supply cost and the revenues collected by the waterworks. The supply of one cubic meter costs the waterworks 0.45L.E. In Cairo, 918 million cubic meter of water are consumed by all sectors. This results in revenues equal to 145 million L.E. (USD 43 million), while the supply cost is 413 million L.E. (USD 121 million). These figures suggest that in 1997/98 the waterworks had a deficit of around 268 million L.E.[1]

Figure 5: Rate of change in household water consumption and in the number of consumers in Cairo from 1985/86 to 1998/99



This high deficit is due to the mechanism of allocating water administratively. It is created by the use of inefficient water pricing schemes such as flat rates or unrealistically low charges set with no regard for cost. The public allocation is sometimes defended on the grounds that it promotes equity (ensuring water supply to areas of insufficient quantity). It is also said to protect the poor and provide a given level of water to meet minimal needs to the domestic users. However, these badly managed utilities lead to a leaking municipal water supply system that offers bad service and water of poor quality. Further, in poor regions the services are even less maintained and the users experience water outages that lead them to purchase water from water vendors at much higher costs. Therefore, the government should consider a more efficient pricing mechanism that would avoid the tendency to under-pricing, and thereby avoid deficits for the water companies and overuse of water. This will

[1] Using an exchange rate of 1$ ~ 3.4L.E.

inevitably mean that most consumers will have to face a cost that is in some way related to marginal cost pricing. Since this pricing mechanism neglects equity issues, it could be complemented by a cross subsidy that targets the lower income groups and that fulfills reasonable equity considerations. This must however be done quite restrictively and carefully, so as not to distort the underlying efficiency properties of marginal cost pricing. If waterworks are to be subsidized, then even the subsidy mechanism must be designed carefully to achieve its target goals. If we think of clean water as a merit good, then for instance a subsidy per poor family served may be much better than an aggregate lump sum subsidy or a subsidy per cubic meter supplied. For a summary of various principles and examples of water pricing mechanisms see Dinar et al. (1997).

4. Overview of the thesis

The full economic cost of water is the sum of the full supply cost, the opportunity cost and the economic externalities imposed on others. In many LDCs including Egypt, prices paid (if any) by all sectors including households, industries and agriculture are less or equal only to the supply cost leading to a non-sustainable use of water, and to leaking municipal water supply systems that offer bad service and poor water quality.

As mentioned earlier, water supply and sanitation have considerable effects on child mortality in Egypt, as in many other developing countries. According to the World Bank (2002), there is an annual average loss (cost) of 0.8 percent of Egypt's Gross Domestic Product (GDP) due to diarrheal diseases and mortality primarily affecting children, caused by lack of access to safe water and sanitation, and inadequate domestic, personal and food hygiene. Recognizing these facts, the objective of the next chapter is to quantify the improvements in water and sanitation services that would result in a decrease in the mortality risk of children under the age of five. Child mortality is studied by grouping children according to age. With regard to water, it is generally expected that the mortality risk decreases as societies upgrade from less accessible poor quality water to community facilities and finally to household or residential connections. Concerning sanitation, it is expected that mortality is decreased the most with flush toilets, followed by pit latrines, and the least without any facilities. In order to draw some conclusions on these issues, it is important to model mortality taking into account the interrelationship among the affecting factors. Since death is a biological process, the initial health endowment of the child emerges as one of the key factors in determining the outcome. This will be taken into consideration in the form of household frailty. Thus, environmental factors and socio-economic conditions of the household have an indirect impact on mortality to the degree they speed up or slow down the biological process.

The Demographic and Health Survey (DHS) Egypt 1995 and transition rate models are used to estimate a three-part model for child mortality. Neonatal mortality is first modeled by using a discrete dependent variable model and the mortality risk in the infant (up to the first birthday) and childhood (from the first birthday until the fifth) stages is modeled using non-parametric, semi-parametric and parametric duration models. In this particular application, this three-part model predicts mortality better than a duration model for the under-five child mortality in general since it uncovers some interesting differences between the impacts of household environmental and socio-demographic determinants on the neonatal, infant and subsequent mortality risks. The results show that access to municipal water decreases the risk, and sanitation is found to have a more pronounced impact on mortality than water. Moreover, gender discrimination is found to be of an important effect beyond the neonatal period.

These results encourage investigation of the factors determining the household choice of sanitation, and a better understanding of the determinants of sanitation enables drawing some policy conclusions. The third chapter focuses on policies that enable a reduction of child mortality in Egypt. Households are assumed to make the choice of inputs prior to the fertility decision. Once the decision is made, it is assumed to be nonadjustable over the time period of interest, i.e. 1991-1995. The 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 an under- or over-statement of the effect of the intervention related to child mortality. This is done by analyzing the factors that determine household demand for health infrastructure (i.e. sanitation facilities and water accessibility) by means of a discrete choice approach consistent with the random utility model, together with an analysis of the determinants of the household wealth. Combining all available aspects affecting child mortality in order to calculate the elasticity of wealth. Evidence of the indirect effect of the source of drinking water on child mortality is found. The analysis suggests that wealth contribute to the reduction of child mortality. Also, mother's education has shown to be a prerequisite for enhanced health of siblings, implying that more emphasis should be concentrated on female education.

An increasing deterioration in water quality due to industrial, agricultural, and urban waste as well as insufficient investments in domestic water supply and sewage system infrastructures, is becoming a serious problem in developing countries. The availability of safe drinking water, combined with sanitary facilities and improved hygiene standards, could prevent many diseases. In Metropolitan Cairo, it may be of interest to separate the health risks due to drinking water into short and long-term risks. For instance diarrhea is a short-term risk and hepatitis a long-term one. In order to value the benefits of improved water quality two stated preferences (SP) methods are used: the contingent valuation method (CVM) and choice experiments (CE).

The methods were administered to a random sample of 1500 households living in the Cairo, Kalyubia and Giza governorates using a face-to-face survey relative to waterborne illnesses and the value of avoiding them. To define the short run scenario, the household was asked to recall the number of diarrhea illnesses during the past year in the household, and to evaluate their severity. The long run health effects which involved the risk of contracting a dangerous disease in the future, where a bundle of diseases such as hepatitis and cholera were mentioned. The collected data were used in the last chapter to unfold the estimations of the benefits of water quality improvement programs related to health in Metropolitan Cairo. The paper also presents, discusses and exhibits similarities and differences between CVM and CE.

The random utility model is used as the economical model underpinning both methods. The CE is estimated using a conditional logit model while different spike model specifications are used to estimate the CVM. In all models some socio-economic and demographic aspects are included as explanatory variables. The welfare measures are then computed and discussed. No significant difference in magnitude is found between the two SP methods. However, the choice experiment model allows estimation of welfare impacts at different levels of the attributes. As for the CVM, only one change can be examined: the suggested improvement is a decrease in the short run health effect due to poor water quality by 25% and a reduction of the probability of contracting waterborne diseases in the long run to 2%. Thus, in order to compare welfare measures from each model, the choice experiment is restricted to estimate the welfare impact of the same improvement offered in the CVM. As for the magnitude of the willingness to pay, it is between one, and one and a half percent of average household income indicating that the household is willing to pay about 65 percent more on their current water bill.

5. Concluding remarks

The Nile resources are limited and unsecured since it occasionally does not rain enough in the upstream countries together with their potential of economic growth that implies a higher rate of water utilization (Barbier, 2003). This calls for actions inducing water conservation. Efficient and sustainable use should be implemented together with the potential of relying on new sources of water. A possible way to overcome this problem is to increase the awareness of water users in terms of methods to conserve the resource, water law development and enforcement and subsidy reductions. These methods are less costly since the development of new water resources requires new investments encompassing for instance, development of irrigation methods, treatment and reuse of sewage and drainage water, and seawater desalinization.

Another measure that could be applied is water quality conservation. Unfortunately, there is a significant pollutant load related to domestic use. Sanitary wastewater constitutes a significant risk to drinking water production together with other water uses if not treated properly. Improvement measures should be undertaken especially for the public health situation, as at least a considerable part of the population depends on surface water as a source of drinking water and many people get in contact with water that is polluted with infected wastewater. Effective and sustainable programs for the surveillance of water supply and disposal are expected to be undertaken. This requires the active support of local communities by reporting faults, carrying out maintenance and taking remedial actions, together with other supportive actions comprising sanitation and hygiene practices.

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The Effect of Water and Sanitation on Child Mortality in Egypt

Hala Abou-Ali

Abstract

This study assesses the impacts of water and sanitation on child mortality in Egypt. The analysis is conducted using a three-part model specification, comprising discrete choice to model the child prospects of dying during the neonatal period. The remaining parts use transition models, in which unobserved heterogeneity is accounted for, to model infant and childhood risk of death. The results show that access to municipal water decreases the risk, and sanitation is found to have a more pronounced impact on mortality than water. The results suggest that increasing the awareness of the Egyptian population relative to health care and hygiene is an important means to decrease the risk of child mortality. Moreover, gender discrimination is found to have an important effect beyond the neonatal period.

Keywords: Child mortality; Household environment; Transition models; Unobserved heterogeneity; Middle East; Egypt.
JEL classification: C14; C41; I12

1. Introduction

The objective of this study is to quantify the mortality risk decrease for children under the age of five that would result from certain improvements in water and sanitation services, using the Demographic and Health Survey in Egypt from 1995 (DHS, 1995) and transition rate models. Child mortality is studied by grouping children according to age. With regard to water it is generally expected that the mortality risk will decrease as societies upgrade from less accessible poor quality water to community facilities and finally to household or residential connections. Concerning sanitation, it is expected that mortality will be decreased with flush toilets, next best with pit latrines and be at its worst without any facilities. In order to draw some conclusions on these issues, it is important to model mortality taking into account the interrelationship between the affecting factors. Since death is a biological process, the initial health endowment of the child emerges as one of the key factors in determining the outcome. This will be taken into consideration in the form of household frailty. Thus, environmental factors and the socioeconomic conditions of the household have an indirect impact on mortality to the extent that they speed up or slow down the biological process (Ridder and Tunali, 1999).

A duration model is estimated for the entire sample together with a three-part model. Neonatal mortality is first modeled by using a discrete dependent variable model and the mortality risk in the infant (post-neonatal up to the first birthday) and childhood (from the first until the fifth birthday) stages is modeled using non-parametric, semi-parametric and parametric duration models. In this particular application, this three-part model predicts mortality better than a duration model for the under five child mortality in general, since it uncovers some interesting differences between the impacts of household environmental and socio-demographic determinants on the neonatal, infant and subsequent mortality risk.

It has been argued that water supply and sanitation in Egypt have a considerable effect on child mortality. For instance, Ali et al. (1990) find that access to clean water and adequate sanitation decreases child mortality. According to the World Bank (2002), there is an annual average loss (cost) of 0.8 percent of Egypt's Gross Domestic Product (GDP) due to diarrheal diseases and mortality primarily affecting children, caused by a lack of access to safe water and sanitation, and inadequate domestic, personal and food hygiene. Table 1 summarizes some of the features of several studies that are most relevant to this work. In Woldemicael (1998), the central question is whether access to piped water and a flush toilet affects the survival chance of children under age five in urban areas of Eritrea. His finding shows that the effect of a household's environment (water supply and a toilet facility) is large and statistically significant during the post-neonatal and childhood periods while the effect is totally insignificant during the neonatal period. Lee et al. (1997) set out a framework for estimating the effects of interventions that improve health infrastructure on child health, taking into account three responses: firstly, changes in the allocation of nutrition to children; secondly, changes in whom among the children survive; and lastly, changes in the health of the children who survive, net of family resource allocation. They find that estimates based on structural-equations and semi-parametric models applied to data describing households from rural areas of two low-income countries indicate that conventional reduced-form estimates understate the effectiveness of improved sanitation facilities. In Ridder and Tunali (1999), the aim is to assess whether empirical evidence supports the presence of family specific frailty components. Although child mortality differentials, with respect to water supply and sanitation in many developing countries, suggest that access to piped water and a toilet facility may improve the survival chances of children, Ridder and Tunali (1999) could not find any evidence supporting this relation. Lavy et al. (1996) analyze the effects of the quality and accessibility of health services and other public infrastructures on the health of children in Ghana. Incorporating some community characteristics, they constructed an indicator of poor water quality and sanitation. Focusing on child survival, height and weight, their results suggest an important role for public health policy in eliminating the rural-urban disparities, particularly in improving the health status of rural children as well as reducing their mortality rates. Guilkey and Riphahn (1998) estimate a structural discrete time hazard model of the determinants of infant and child mortality in the Philippines in order to evaluate the effect of biological variables on mortality. They find that controlling for biological mechanisms, the birth order, and parity no longer have a direct effect on mortality. However, breastfeeding is found to be one of the most important determinants of child survival. Trussell and Hammerslough (1983) provide a complete self-contained exposition of estimating a life table with covariates through the use of hazard models applied to child mortality in Sri Lanka. Their results show that the type of toilet facility, the mother's and father's education, urban/rural estate residence, ethnicity, birth order, age of mother at birth and gender are factors that are strongly related to child mortality.

Casterline et al. (1989) scrutinize the effects of income on infant and early childhood mortality at the household level in Egypt. They also incorporate socioeconomic and demographic variables in their logistic regression equation, where this type of model does not account for censored data. The main conclusions of Casterline et al. concerning income are: i) household income does not affect survival through infancy but the effects are pronounced during early childhood, ii) the data used suggests that the impact of income is somewhat greater for educated mothers, when the father is of higher socioeconomic status and where the household receives piped water. However, as far as the author knows, the present study is the first study that uses a three-part model setting to comprehensively explain the determinants of child mortality in Egypt. Furthermore, although the issue of gender discrimination is highly ranked on the discussion agenda in the developing world, this is to the author's knowledge the first application that has been able to quantify and measure the effect of gender discrimination on child mortality beyond the neonatal period. Finally, one of the aspects that make this study of interest is that the developing world lacks this type of application to understand and explain the high child mortality levels and undertake the correct measures to deal with this problem.

The aim of this study is to understand and explain the determinants of under-five mortality. The three-part model used allows for the control of censored data together with the accounting of household unobserved characteristic. This study is arranged as follows. Section 2 describes the data. Section 3 details the econometric modeling. In Section 4 the results from the empirical investigation are compiled. Section 5 concludes the paper.

2. The data

2.1 The survey

The data used in this study originates from the DHS conducted in Egypt between November of 1995 and January of 1996. DHS is a large cross-sectional data set that is comparable across countries. It contains information obtained from ever-married women aged 15-49 regardless of whether they had any preschool children. It is a very rich data set that offers more degrees of freedom and additional information on individual attributes. This makes DHS ideal for describing mortality differentials in different regions of the world and for estimating reduced form models of the determinants of infant and child mortality within a country (Guilkey et al., 1998).

Administratively, Egypt is divided into 26 governorates. These in turn consist of 467 districts, forming the primary sampling units of the DHS-95. Each district contains Shiakhas, or villages, giving rise to 934 segments from which the household selection was implemented. The DHS-95 consists of a sample of 16,000 households in order to meet the target of a random sample of 14,000 interviews with ever-married women aged

Table 1: Summary of child mortality studies.

Author(s)	*Dependent variable*	*Method*	*Source of data*	*Water supply or source of drinking water*	*Sanitation (toilet) facility*	*Other covariates*
Trussell and Hammer-slough (1983)	Infant mortality	Hazard model (all main effects vs. no interaction among covariates)	Sri Lanka World Fertility Survey (WFS) 1975	Not significant and has been excluded	Negatively related i.e., better sanitation less mortality (-)	Education of mother and father, age of mother at birth, sex of child, birth order of child, place of mother's current residence and ethnic group.
Casterline et al. (1989)	Infant and child mortality	Logit model	Egypt WFS 1980	Net impact on early childhood mortality	No significant effect	Net household income, region and type of place of residence, sex of child, paternal status, maternal education and demographic status and paternal kin relationship
Aly and Grabowski (1990)	Child death probability	Logit model	Egypt WFS 1980	Significant and negatively related with mortality (-)	Significant (-) and a non-significant (+)	Breastfeeding, blood relation between spouses, number of pregnancies and husband and wife literacy.
Lavy et al. (1996)	Child survival and child anthropometric measures	Hazard regression model (Weibull specification)	Second Ghana Living Standard Survey (GLSS) 1988	Poor sanitation and water is positively related to survival in urban areas and male cases. It shows a negative relation in rural areas and female cases.		Health service quality and availability, food prices, child sex, education of mother and father, height for age and weight for age.
Lee et al. (1997)	Child health	Structural equation semi-parametric model	1981-82 nutrition survey of rural Bangladesh and 84-85 IFPRI Bukidnon – Philippines	No significant effect	Most categories (parts or types) have no significant effect	Wealth, head or female (h/f) education, sex of child, (h/f) age and place of residence.
Guilkey and Riphahn (1998)	Child mortality up to 2 years	Structural discrete time hazard	Longitudinal data from-Metropolitan Cebu-Philippines from 1983 to 1986	Not included	Not included	Biological mechanism (e.g., birth weight and nutritional status), income, sex of child, and place of residence.
Woldemicael (1998)	Neonatal, post-neonatal and childhood mortality	Hazard regression model	Eritrea DHS 1995	Improvement in the provision of water supply and toilet facilities are likely to reduce mortality especially beyond the first month of life.		Mother's education, place of residences, H. economic status and year of childbirth.
Ridder and Tunali (1999)	Child mortality risk	Stratified partial likelihood estimation	Malaysian family life survey 1976-77	Not much impact	Not much impact	Birth interval, child sex, mother's age at birth, birth weight, birth order, childcare and breastfeeding.

15-49 that realize the objectives of the survey. The 934 segments will form the clustering basis in the analysis to come. Furthermore, the DHS data used here are subject to some problems as a source of information on the distribution of duration. In this survey, extended information is only collected for children that are born five years or less before the survey was conducted. This means that information on children born prior to this period is not collected. In this study, the data set was rearranged into spell data in order to ease the estimations. Henceforth, the analysis is limited to children under the age of five. This then leaves us with a sub-sample of 8,017 women who gave birth to 12,104 children who are the interest of this study.

The biomedical perspective distinguishes between the causes of neonatal deaths, or those occurring in the first 28 days after birth, and post-neonatal deaths, or those occurring between the age of 29 days and one year. This age classification is attributed to biomedical research where the causes of child mortality have been divided into endogenous and exogenous categories.[1] According to the DHS Egypt 1995, which is in a monthly format, neonatal is defined here as infants up to one month of age. The infant stage is defined to be post-neonatal, where the age of the infant is between one and 12 months. As for the childhood stage, it is defined to cover the ages between 12 months and 60 months.

The analysis is restricted to the 1991-1995 period, where it is assumed that no investments have been undertaken by the households in order to improve their living conditions. Hence, some covariates are assumed not to vary with time. For example, the water supply and toilet facility variables are constructed based on the state of affairs at the time of the interview. Thus, it may be wise to stick to the recent past that may correspond to the category of the facility listed. The place of residence of the child while exposed to the risk of death is assumed to have been unchanged during the period of concern, which is quite realistic since changing residence is not a very common phenomenon in Egypt.

[1] For an extensive discussion on this matter, see Wolpin (1997) pp. 523-24.

2.2 Variable descriptions and hypotheses

The variables in this study are classified into four groups: environmental, socioeconomic, demographic and behavioral differences. Table 2 presents the definitions and descriptive statistics of the environmental variables.[2] The choice of these variables was guided by the determinants of infant and child mortality literature, such as Trussell and Hammerslough (1983) and Ridder and Tunali (1999). The literature on endogenous fertility (e.g. Olsen et al., 1983, and Wolpin, 1984), poses some difficulties for the proximate determinant approach justifying the inclusion of regressors such as mother's age at birth, birth interval and the total number of children ever born. These, as well as breastfeeding behavior, are to some extent choice variables and are likely to be influenced by parental norms and perceptions. As mentioned earlier, improved water supply and higher quality sanitation facilities are epidemiologically directly related to lower mortality. Therefore, the improvement of water supply is expected to be inversely related to mortality risk. Since the bacterial content of water affects health and since there is no available information about this variable, water supply as a source of drinking water will be used as a proxy variable (see Wolpin, 1997, for more details).

Communities without municipal water range between 23 and 36 percent. Concerning the lack of sanitation, the number falls between 6 and 17 percent. The former communities rely on unimproved water supplies (e.g. wells, rivers, ponds, canals and unprotected springs) and the latter on unimproved sanitation facilities such as holes in the ground, bushes and other places where human waste is not contained to prevent it from contaminating the environment. These categories are treated as baselines in the analysis. Communities with improved water and sanitation do not all have the same services. It should be noted that the functioning or the improvements in sanitation facilities also depends on its connection to a sewer system. However, only some of the urban households have access to sewer systems. The data used here does not contain this type of information and the reader should be aware that this is not controlled for. There is a wide variation in the types of services, but for the purpose of this study, water services were classified into two categories: residential water facilities and public tap. For sanitation, a flush toilet was considered to be a modern type of facility. A traditional facility is defined as a water-based system, a pit latrine or a similar fecal disposal system.

Table 2: Sample statistics and the distribution (%) of environmental variables among children in Egypt

Variable	*Neonatal*	*Infant*	*Childhood*
Sample size (number of children)	12104	11379	8906
Mortality prevalence (number of children)	363	384	106
Mortality prevalence (%)	3	3.4	1.2
Tap water into residence (yes)†	62.9	63.1	63.5
Public tap water (yes)	9.4	9.4	9.4
Modern facility (yes)	18.8	19	19.2
Traditional facility (yes)	70.8	70.6	70.6

† (yes) refers to a dichotomous variable indicating that a value of one 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).

Turning to the socioeconomic variables, income is not available from the data but some proxy variables are used in order to avoid the ambiguity of some related variables (e.g. sanitation facilities and education) that pick up the effect of the omitted income variable and become difficult to interpret. For this purpose, some of the household wealth ingredients in the DHS are used to construct a standard of living index (SLI). The SLI is a simple summation of the number or in one case the type of items present in the household. The items considered are the existence of electricity, a refrigerator, a radio, a TV, an electric fan, a car and/or motorcycle, and type of flooring. Hence, the SLI is a categorical variable indicating the number of possessions of the household ranging from zero to seven. It is expected that this variable will be inversely related to the mortality risk. Although this appears to be a reasonable proxy for income given the data, the reader should be aware of the measurement problems. Furthermore, even though the author has no reason to believe that the likely measurement errors will directly bias the coefficients in any particular direction, a caveat should be made that random measurement error biases may tend to bias coefficients downwards (see e.g. Greene, 2000).

[2] For an extended list of variables together with their definitions and descriptive statistics, see Table A1 in Appendix A.

Differentials by urban/rural residence have commonly been observed, with urban areas having more advantages. Using this partition, the characteristics and the administrative division of Egypt, the place of residence takes the form of six dummies: urban governorates, Lower Egypt urban and rural, Upper Egypt urban and rural and the frontier governorates, with the last category treated as omitted in the estimation.[3] The mother's education is included; it is believed to be inversely related to child mortality. Four dummy variables are constructed to capture different levels of education: mothers with no education, which is treated as the omitted variable; low education, where the mother has some primary schooling; medium education is given for the ones who achieved primary schooling and /or continued through secondary; and high education category encloses the ones who completed secondary school and higher.

Concerning the demographic variables, the patterns of mortality by maternal age and birth order are typically U-shaped; children born to relatively old or young women have higher mortality rates than others. The interpretation of the effect of maternal age at birth on infant mortality must be biological, i.e. it depends on reproductive maturity.[4] Moreover, first and higher order births also have higher mortality rates, since the birth order reflects the components of the child's biological endowments. As for the child's gender, it is widely believed that male mortality is higher due to biological disadvantages. However, the subsequent results clearly show higher female mortality indicating gender discrimination, i.e. girls have a higher risk of dying in Egypt. This could be a cultural reflection of a preference for male offspring, as preferences for having sons have a powerful significant influence on fertility in some selected Arab countries (Al-Qudsi, 1998).

Finally, of the behavioral variables, breastfeeding is one of the most important and is associated with the exposure level of pathogens (organism or substance that causes disease). Breast milk is the most appropriate food for young infants because it is nutritious and sterile, it may reduce the ingestion of other, often contaminated foods, and

[3] The definition of the administrative division of Egypt together with the urban rural partitioning used here evolves from CAPMAS (1996).

it confers immunity. Around 65 percent of the literature on child mortality make use of the birth weight variable and find that infant mortality steeply declines with its increase (see Buehler et al., 1987). Failing to control for birth weight as a determining factor of health condition is due to a lack of information in the data. It could be argued that this omission does not pose serious problems.[5] Although rural clinics are widespread throughout Egypt, their impact is limited by the poor quality of care provided and the extent to which people can effectively make use of the services. This could lead to an ambiguous effect of the maternity care variable.

3. Econometric modeling

The effect of water and sanitation on child mortality is analyzed by classifying children under age five into three age groups. According to Pebley and Stupp (1987), such classification in the analyses of the determinants of child mortality poses two technical problems. The first relates to censored observations. That is, not all live births have the chance to survive to the oldest age under investigation. The second concerns the rapid changing behavior of mortality from one age to the next during a child's life span. The use of a hazard regression model permits inclusion of all births and reflects the changing rates of mortality. Many researchers such as Trussell and Hammerslough (1983), Woldemicael (1998), and Ridder and Tunali (1999) have used this type of model. When comparing standard regression procedures and transition models, two main differences may be noted.[6] Firstly, in regression models, it is assumed that mortality occurs at the rate of exactly one per period. The transition model used in this study assumes that mortality occurs randomly. Thus, the transition model is intrinsically stochastic. The second difference is that a distinguishing feature of duration data is the possibility that some of the durations observed will be censored. Censoring is an event that occurs at some point, so the data consist of a measured spell length together with the information on whether or not the spell was censored. Standard regression methods are not efficient because they do not use all the information in the sample. In general, estimation procedures that do not

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[4] Wolpin (1997) p. 542

[5] For an extensive discussion on this matter see Wolpin (1997).

account for the censored nature of the data will produce biased and inconsistent estimates.

To study child mortality in Egypt, a three-part model is estimated including discrete choice, which is used to model the child prospects of dying during the neonatal period. The remaining parts use a transition model to model the child risk of death beyond that period. The chances of dying in the first month of life are modeled using a probit model (see Maddala, 1983, pp. 22-27). Proceeding with the duration analysis, the non-parametric Kaplan-Meier survival functions are investigated as a first step. As discussed in Kiefer (1988), graphical methods are useful for displaying data on durations and for preliminary analyses**.** This could allow for identifying functional forms having homogeneity being achieved roughly by grouping on explanatory variables. Here the product limit or the Kaplan-Meier estimator of the survival function is used. The survival probability *S(t)* is the contribution of a censored child in duration *t* to the likelihood. He/she being alive during the observation period defines a censored child. On the other hand, the hazard *λ(t)* (which is the risk of completing a spell at duration *t* conditional upon the spell's reaching duration *t*) is $\hat{\lambda}_i = d_i / N_i$, where d_i denotes the number of deaths at duration t_i and N_i denotes the number of children at risk just before t_i. In particular, the plot of the logarithm of the integrated hazard (which can be estimated as minus the logarithm of the Kaplan-Meier survival estimator) against duration provides a starting point for the parametric analysis.

Since the primary interest of this study is to investigate the effect of the household environmental characteristics –i.e. water and sanitation- on the probability of child mortality, a multivariate model of the child life duration is implemented. Two popular methods of analyzing the effect of explanatory variables on the hazard rate are the proportional hazard model and the accelerated failure time. The former is based on a *semi-parametric model* which is a very flexible method of estimation since the baseline hazard is estimated nonparametricly and eliminates the risk of corrupting the estimated

[6] For an extensive discussion on the relative merits of regression vs. hazard model approaches, see Flinn and Heckman (1982).

hazard parameters while the effect of the covariates takes a particular functional form. Cox's proportional hazard framework is used. It is based on the following hazard function for the distribution of living duration that is the transition rate. The probability of leaving life at any moment given that the child is still alive up to that moment is $\lambda(t) = \lambda_0(t)\, e^{\beta' x}$, where $\lambda_0(t)$ is the baseline hazard and $e^{\beta' x}$ is the relative risk associated with the regressors *x*. In the proportional hazard specification, the effect of the regressors is to multiply the hazard function itself by a scale factor. The vector of parameters β in this setting will be estimated without specifying the baseline hazard function, i.e. $\lambda_0(t)$ is treated non-parametrically. Therefore a partial likelihood approach will be used to estimate the parameters (see Cox, 1972). One of the problems here is the possible existence of unobserved heterogeneity between children from different families since they potentially have a different duration distribution, and the control for the effect of the related explanatory variables is incomplete. The result that generally holds about heterogeneity is that it leads to a downward biased estimate of duration dependence. Therefore, a further step is taken by incorporating unobserved heterogeneity into the model, and the hazard function will thus be of the following form: $\lambda_i(t) = \lambda_0(t)\, \alpha_i e^{\beta' x_i}$, where α_i is the group *i* level frailty. The frailties are unobserved positive quantities with a mean of one and variance θ.

On the other hand, *the parametric hazard models* require a more restrictive hypothesis than those models represented above. Here the baseline hazard needs to be modeled. Parametric models provide hazard rates that are monotonic, constant, non-monotonic, or a mixture of these. A very flexible form of the exponential model $\lambda(t) = \lambda$ (constant over time) is used. The time axis is split into time periods. The transition rates are constant in each of these intervals and may change between them. This model is known to be a piecewise constant exponential model. When variables are included, the baseline hazard is characterized by a period specific constant that can vary across time periods, but the variables have the same proportional effects in each period. The literature contains an abundance of choices for parametric models, with a popular one being the Weibull model. The hazard function is defined as $\lambda(t) = \lambda p(\lambda t)^{p-1}$, where $\lambda = e^{-\beta' x}$ and *p* is a scale parameter with $p<1$ indicating that the hazard falls continuously over time, while $p>1$ indicates the opposite (see Greene, 2000, pp. 939-944). It is determined whether this is a proper model by means of the plot of the logarithm of minus the integrated hazard which should be linear.

As previously mentioned, households and their environments differ in so many respects that no set of measured covariates can possibly capture all the variation among them. It is well known that the estimated hazard from a model that neglects heterogeneity falls more steeply or rises more slowly than the true hazards for homogenous groups. Gail et al. (1984) show that the unobserved heterogeneity tends to attenuate the estimated coefficients toward zero. On the other hand, standard errors and test statistics are not biased. For these reasons a correction for the unobserved heterogeneity based on the gamma distribution of heterogeneity with a mean of one and variance θ is used. Incorporating the heterogeneity into the Weibull distribution results in the following hazard function: $\lambda(t) = \lambda p(\lambda t)^{p-1}(S(t))^{\theta}$, where $S(t) = \left[1 + \theta(\lambda t)^{p}\right]^{-1/\theta}$ is the unconditional survival function, where the further θ deviates from zero, the greater the effect of the heterogeneity.

Different models are used here for the purpose of checking robustness. A plot of cumulative Cox-Snell residuals is used as a further step in specification checking and to assess the general fit. This method is based on examining the estimated values of the integrated hazard, which should look like a sample from the unit exponential distribution, if the model is correctly fitted. That is, the plot of the integrated hazard for generalized residuals should be a straight line with the slope equal to one (for a discussion of Cox-Snell residuals, see Cox and Snell, 1968, and Klein and Moeschberger, 1997, pp. 329-332).

4. Estimation results

The statistical model used in this study depends on the nature of the problem at hand, since the child mortality outcome is characterized by rapid change. This was shown by conducting a non-parametric analysis (see Appendix B for details). Graphical presentation of the hazard rate $\hat{\lambda}$ gives an insight on the distribution of the hazard, enabling the selection of a functional form for the parametric approach. The average hazard dropped by around 92 percent when moving from neonatal to the infant period. The declining pattern continues through the childhood period, where it levels off as duration or the age of the child increases in Egypt. Notice, however, that during one and a half, two, and three years of age, peaks in the hazard are estimated. This result may be due to a heaping effect, where respondents may have had a tendency to round off the duration of their child's survival. Another reason for the choice of this model is that some births have the chance to survive up to the end of five years. These types of observations are called censored. The use of a hazard regression allows the inclusion of censored and uncensored observations. The plot of the log (-log [Kaplan-Meier survival estimates]) against the logarithm of the duration in Figure 1 that is close to a straight line, suggests the Weibull model although further inspection is necessary.

As mentioned earlier, one of the problems facing the analysis of the determinants of child mortality is the rapidly changing behavior of the mortality pattern from one age to the next. The non-parametric analysis supports the fact of partitioning the age interval to neonatal and beyond, where the latter in turn can be split into infant and childhood periods. Starting with the neonatal case a probit model is used for the estimation since during the first month of age there is no variation in duration and thus the dependent variable is binary with the value zero if the infant survives and the value one if he or she dies during the first month of life. The results of this model are depicted in Column I of Table 3. It should also be noted that the model was tested for heteroscedasticity following Greene (2000) where it was found that it does not pose a problem in our case (pp. 829-831). Thereafter, the analysis starts with a Cox type proportional hazard model with and without heterogeneity over sample clusters for the full age interval (from more than one month to under age five), infant, and childhood under the age of five.

In the parametric approach, a piecewise constant exponential model (PCE) is used, where time access, i.e. age, is split into three periods (zero to one month, two to 12 months, and

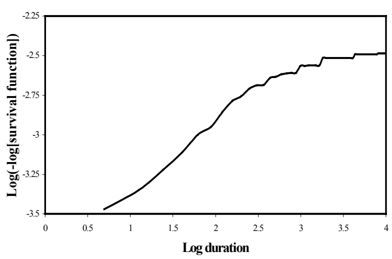
13 to less than 60 months) in order to study neonatal, infant, and childhood mortality. Also, a Weibull specification and a Weibull model with the correction for heterogeneity based on the gamma distribution are estimated.[7] In Tables 3 and 4, the parameter estimates, the standard errors, the marginal effects of the probit model and the relative risk of dying using various duration estimation methods are presented. When heterogeneity is not taken into consideration, the standard errors are estimated including the clustered nature of the sample (see Deaton, 1997). The error term is thus viewed as the sum of a cluster specific component and a child specific component. Nevertheless, although the error may be uncorrelated across children in different places of residence, it is unlikely to be uncorrelated across children in the same place of residence. For the Cox and the Weibull models, the standard errors are typically larger with the cluster option. The relative risk of dying is simply the exponential of the estimated parameter of the hazard model. It should be viewed as a scalar quantity that raises or lowers the underlying baseline hazard proportionally, and this of course depends on the sign of β.

Evidence shows that the estimated value of the shape parameter θ in the Cox and Weibull regression with gamma heterogeneity deviates significantly from zero, suggesting that the data may contain unobserved heterogeneity. Thus, incorporating heterogeneity into the Weibull regression is a more appropriate setting. In the Cox model, the heterogeneity is considered on the cluster level. As for the Weibull, it is found that correlation among families may be ignored in the childhood case but not in the infant case when considering heterogeneity at the household level. So a further step is taken in the childhood period by considering heterogeneity on the cluster level, and a significant frailty effect is detected. This result could be due to the fact that at a certain point in time the child outgrows the family specific frailty, but is still affected by the unobserved characteristic of the place of residence. Checking the estimated integrated hazard for generalized residuals can further assess the goodness of the fit of the models. Although the Cox-Snell residuals are useful for assessing the fit of the parametric models, they are not very informative for Cox models estimated by partial likelihood (on this matter see Allison, 1997, pp. 173-175).

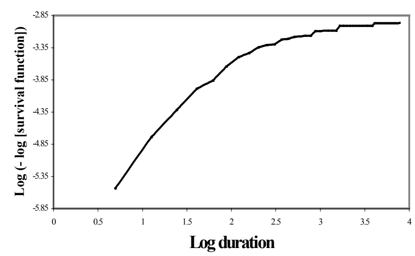
[7] A log-logistic specification was also tried, but the Weibull specification was found to be a better fit for the data.

Figure 2 depicts the cumulative Cox-Snell residuals for the PCE, Weibull, and Weibull with gamma heterogeneity models for various age groupings, where a deviation from the 45º line indicates misspecification. The plots indicate that the Weibull with gamma heterogeneity for the sample from infant to under age five panel (e) of Figure 2 depicts a somewhat better fit than its counterpart using the full sample panel (c). This result further supports the consideration of the neonatal period separately. Panels (f) and (h) show that estimating the infant and the childhood period using a Weibull with gamma heterogeneity is quite a good fit.

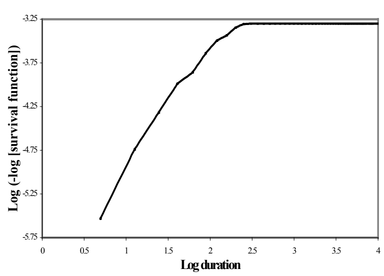
Figure 1: Log (-log [Kaplan-Meier survival estimates])



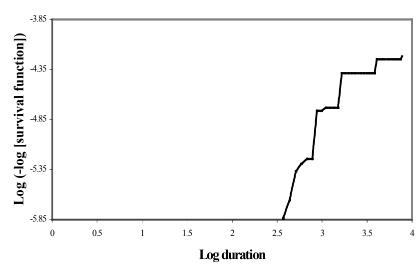
(a) Sample from birth to under five



(b) Sample from infant to under five



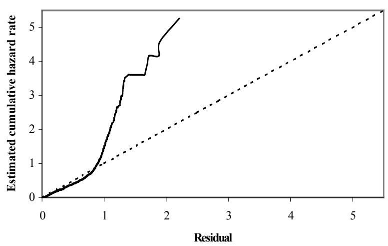
(c) Infant stage



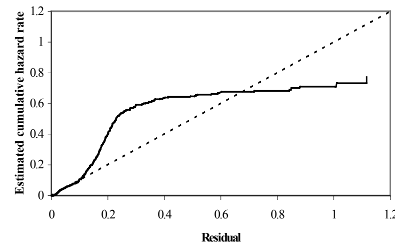
(d) Childhood stage

A further diagnostic checking is called for to make the choice between semi-parametric and parametric models. For this purpose a likelihood ratio test is used. Although models are not nested, this test could still give an indication of the preferred models. The conclusion is that a Weibull with gamma heterogeneity of infant and childhood periods is

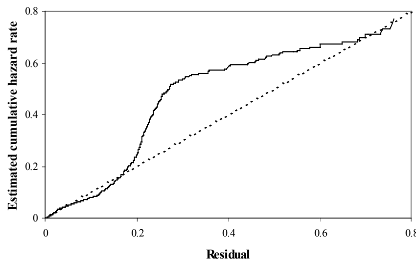
Figure 2: Cumulative Cox-Snell residuals.



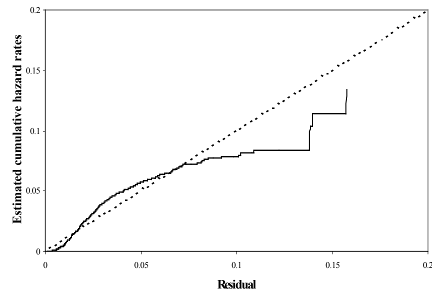
(a) Piecewise constant exponential model, full sample



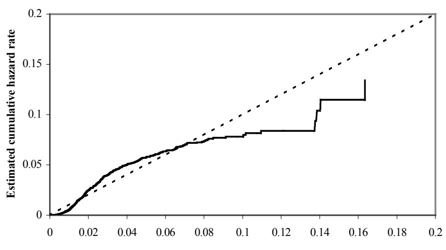
(b) Weibull, full sample



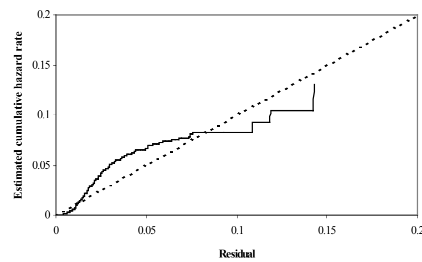
(c) Weibull with gamma heterogeneity, full sample



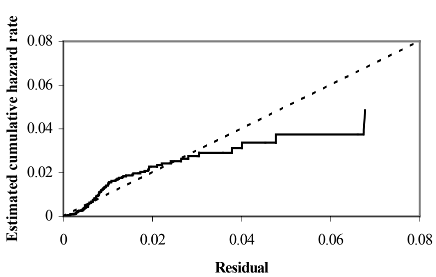
(d) Weibull, sample from infant to under five



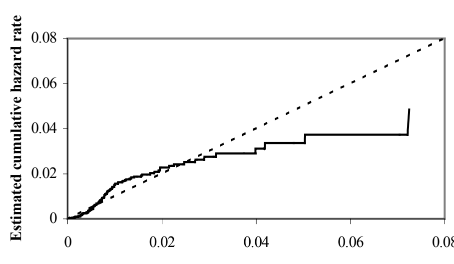
(e) Weibull with gamma heterogeneity, sample from infant to under five



(f) Weibull with gamma heterogeneity, infant stage



(g) Weibull, childhood stage



(h) Weibull with gamma heterogeneity, childhood stage preferred. Since the semi-parametric and the parametric results give qualitatively the same results, it could also be concluded that the restriction imposed by the chosen parametric model does explain the data fairly well, and does not interrupt the results.

A number of potentially confounding variables (Table A1) were measured and controlled for in the analysis by first estimating a full model. Many of the effects are insignificant due to the number of transitions, which are small compared to the number of observations. The indicator for maternal employment activity is omitted since it failed to show an impact in the analysis, possibly because the information available is not specific to the periods immediately preceding or following particular births. The birth order variables are correlated with the total number of children ever born. Another pair of variables that has shown some correlation is the preceding birth interval with the first birth variable. This was expected, since the first order child has no preceding birth interval. Therefore, a subset of covariates was selected following the literature. In this manner a reduced model was estimated. Only the results from the parsimonious model are presented below.[8]

The following discussion on the impacts of explanatory variables will be based on the three-part model composed of the probit estimation for the neonatal case, and the Weibull regression with gamma heterogeneity for the infant and childhood cases which are depicted in Column I in Table 3 and Column II and III in Table 4, respectively. This specification reveals some interesting differences between the impacts on the neonatal,

[8] One of the variations considered for these models is through the construction of an alternative measure of the standard of living indicator (SLI). Dummy variables are specified for each distinct value of the SLI with the lowest value treated as the omitted category. This specification is used to allow the sum of the index item to exert a non-linear influence on mortality. The incorporation of these dummies does not seem to improve the overall results, and the parameter estimates are insignificant. On the other hand, another set of four dummies was constructed by taking into consideration and then varying the type of flooring, access to electricity, possession of a refrigerator and possession of a car/motorcycle: (i) households with finished floor, no electricity, no refrigerator, and no car/motorcycle, (ii) finished floor, electricity, no refrigerator, and no car/motorcycle, (iii) finished floor, electricity, refrigerator, and no car/motorcycle, and (iv) finished floor, electricity, refrigerator, and car/motorcycle. This specification did not give any new insights into how wealth affects mortality. It is therefore chosen to only present models with the aggregated SLI variable. A caveat related to the categories of the mother's age is that those variables have some kind of correlation with each other. This division of the mother's age variable was meant to capture the U-shape pattern exhibited by these categories. The parameter estimates of these categories showed to be insignificant.

infant and subsequent survival amongst certain environmental and socioeconomic determinants. Furthermore, it has shown to be a more robust setting. Notice however that, as expected, it seems that models not accounting for heterogeneity underestimate the effects of the regressors in contrast to the ones with heterogeneity. As shown in Table 4, access to municipal water in the residence decreases infant mortality by around 27 percent. Access to public water decreases the risk of death by 27 percent in general and a decrease of 31 percent is encountered in the infant stage. While this effect is also significant in the neonatal case, it is insignificant in the childhood case. This suggests that the use or the availability of municipal water decreases the risk of mortality as opposed to a non-municipal water source. A counter intuitive result though with an insignificant effect reveals that access to a modern facility increases the changes in the neonatal mortality. This may be due to low hygienic awareness and the misuse of modern sanitation facilities.[9] This finding is supported by the results of Lavy et al. (1996) who found that access to poor water and sanitation in the urban Ghana decreases the risk of mortality. As for the childhood mortality, the modern facility reduces it by 68 percent. Here, sanitation is found to have a more pronounced impact on mortality than water. This is consistent with Esrey (1996) who, in a study of eight countries (Burundi, Bolivia, Ghana, Guatemala, Morocco, Sri Lanka, Togo and Uganda), found that the effects of improved water were less pronounced than those for sanitation. Benefits from improved water occurred only when sanitation was enhanced and only when optimal water was present. Similarly, Esrey et al. (1992) found that sanitation has a larger impact than water in improving health.

Living in urban areas decreases the mortality risk by around 30 percent as opposed to living in rural areas. Taking interactions between water supplies and urbanity into account, it was found that residential water in urban areas has a significant role in mortality risk reduction in different age groups as compared to its role in rural areas. The mortality is reduced in the infant and childhood cases by 61 and 90 percent, respectively.

Therefore, the inclusion of a continuous variable of mother's age was chosen for parsimonious reasons. However, this choice did not change the estimation much.

[9] A thorough examination of the characteristics of our sample shows that 10 percent of the households possessing a modern facility have no access to residential water.

Table 3: Neonatal probit model Cox proportional hazard estimation

Variables	***Probit model Neonatal***	***Cox Proportional Hazard Model***							
		Without heterogeneity				With gamma heterogeneity			
		Infant	Child	All	1-<60	Infant	Child	All	1-<60
	I								
Constant/ θ	-0.51***					0.31***	0.68**	0.34	0.32***
	(0.154)					(0.112)	(0.415)	(0.067)	(0.094)
	-0.024								
I. Environmental condition variables									
Tap water into residence (yes)‡	-0.08	-0.26***	-0.315	-0.265	-0.29***	-0.3**	-0.336	-0.27***	-0.3***
	(0.06)	(0.094)	(0.26)	(0.214)	(0.095)	(0.126)	(0.24)	(0.089)	(0.113)
		0.77			*0.752*	*0.744*		*0.766*	*0.737*
Public tap water (yes)	-0.185**	-0.31***	-0.143	-0.25**	-0.29**	-0.35*	-0.135	-0.29**	-0.29*
	(0.099)	(0.06)	(0.4)	(0.11)	(0.13)	(0.19)	(0.318)	(0.135)	(0.165)
	- 0.0072	*0.732*		*0.776*	*0.749*	*0.708*		*0.748*	*0.749*
Modern facility (yes)	0.114	-0.31***	-1.11*	-0.041	-0.28**	-0.095	-1.14*	-0.085	-0.274
	(0.13)	(0.059)	(0.65)	(0.045)	(0.121)	(0.287)	(0.64)	(0.19)	(0.259)
		0.735	0.33		*0.753*		*0.319*		*0.735*
Traditional facility (yes)	0.217**	0.153	0.008	0.27***	0.117	0.155	-0.05	0.174	0.076
	(0.095)	(0.107)	(0.07)	(0.04)	(0.08)	(0.17)	(0.285)	(0.122)	(0.149)
	0.0091			*1.303*					
II. Socioeconomic variables									
Urban residence (yes)	-0.0023	-0.36***	-0.23**	-0.27***	-0.31***	-0.36**	-0.23	-0.2**	-0.33**
	(0.066)	(0.047)	(0.11)	(0.066)	(0.088)	(0.154)	(0.294)	(0.105)	(0.139)
		0.696	*0.798*	*0.764*	*0.731*	*0.696*		*0.82*	*0.721*
Low education (yes)	-0.163**	-0.011	-0.044	-0.188	0.092	0.123	-0.023	-0.066	0.108
	(0.076)	(0.21)	(0.37)	(0.17)	(0.243)	(0.13)	(0.27)	(0.095)	(0.12)
	-0.007								
Medium education (yes)	0.0018	-0.38***	0.15	-0.181	-0.151	-0.221	0.158	-0.071	-0.133
	(0.09)	(0.112)	(0.62)	(0.203)	(0.227)	(0.197)	(0.365)	(0.128)	(0.174)
		0.686							
High education (yes)	0.076	-0.99***	-0.522	-0.52***	-0.89***	-0.97***	-0.522	-0.48***	-0.87***
	(0.086)	(0.117)	(0.39)	(0.017)	(0.139)	(0.225)	(0.42)	(0.128)	(0.2)
		0.373		*0.592*	*0.409*	*0.377*		*0.616*	*0.42*
Standard of living indicator	-0.05***	-0.05***	-0.2***	-0.06***	-0.04***	-0.012	-0.16**	-0.06***	-0.04
	(0.018)	(0.013)	(0.006)	(0.011)	(0.005)	(0.035)	(0.066)	(0.024)	(0.031)
	-0.0023	*0.952*	*0.856*	*0.943*	*0.959*		*0.853*	*0.937*	
III. Demographic variables									
Mother's age at birth	0.0013	-0.02***	-0.005	-0.0009	-0.0043	-0.002	-0.005	-0.0001	-0.004
	(0.004)	(0.008)	(0.02)	(0.008)	(0.006)	(0.008)	(0.016)	(0.006)	(0.007)
		0.977							
Gender (male=yes)	0.115**	-0.35*	-0.4***	-0.129	-0.34***	-0.32***	-0.41**	-0.127*	-0.35***
	(0.052)	(0.2)	(0.14)	(0.12)	(0.12)	(0.103)	(0.2)	(0.07)	(0.09)
	0.005	*0.705*	*0.669*		*0.709*	*0.724*	*0.666*	*0.881*	*0.703*
IV. Behavioral variables									
Breastfeeding (yes)	-1.61***	-1.37***	-1.1***	-2.83***	-0.82***	-0.95***	-1.14***	-2.15***	-0.86***
	(0.062)	(0.008)	(0.1)	(0.054)	(0.183)	(0.192)	(0.2)	(0.07)	(0.178)
	-0.274	*0.254*	*0.336*	*0.059*	*0.443*	*0.388*	*0.32*	*0.116*	*0.424*
Log likelihood	-1306	-2791.1	-907.4	-7221	-4430.2	-3496.8	-905.13	-7614	-4419.6

† The first number in a cell is the parameter estimate; numbers in parentheses are the standard error and italic number stands for the marginal effects in case of the probit specification and mortality risk elsewhere.

‡ (yes) refers to a dichotomous variable indicating that a value of one 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).

*** Estimate significant at 1 percent.

** Estimate significant at 5 percent.

* Estimate significant at 10 percent.

Table 4: Parametric estimation

Variables	*Weibull without heterogeneity*				*Weibull with gamma heterogeneity*			
	Infant	Child	All	1-<60	Infant	Child	All	1-<60
					II	**III**		
Constant	-3.8***	-7.12***	-1.4***	-3.74***	-3.69***	-7.06***	-0.387	-3.65***
	(0.199)	(0.669)	(0.025)	(0.162)	(0.383)	(0.669)	(0.285)	(0.342)
P	0.553***	1.302	0.487	0.642***	0.588***	1.316	0.522	0.677***
	(0)	(0.046)	(0.052)	(0.003)	(0.029)	(0.116)	(0.0465)	(0.029)
Θ					3.44***	0.81***	6.026***	2.46***
					(0.84)	(0.45)	(0.33)	(0.58)
I. Environmental condition variables								
Tap water into	-0.28***	-0.311	-0.278	-0.28***	-0.32**	-0.336	-0.362	-0.32***
residence	(0.059)	(0.256)	(0.246)	(0.1)	(0.137)	(0.244)	(0.266)	(0.12)
(yes)‡	*0.758*			*0.754*	*0.727*			*0.729*
Public tap	-0.34***	-0.139	-0.26***	-0.29**	-0.374*	-0.126	-0.355*	-0.32*
water (yes)	(0.035)	(0.31)	(0.11)	(0.135)	(0.207)	(0.32)	(0.19)	(0.035)
	0.713		*0.773*	*0.749*	*0.688*		*0.701*	*0.726*
Modern	-0.112	-1.12**	-0.035	-0.29**	-0.192	-1.14*	-0.092	-0.333
facility (yes)	(0.248)	(0.57)	(0.044)	(0.127)	(0.308)	(0.64)	(0.11)	(0.274)
		0.319		*0.748*		*0.319*		
Traditional	0.19**	-0.014	0.291***	0.12	0.182	-0.037	0.328***	0.122
facility (yes)	(0.08)	(0.305)	(0.012)	(0.076)	(0.19)	(0.286)	(0.63)	(0.16)
	1.206		*1.338*				*1.389*	
II. Socioeconomic variables								
Urban	-0.35***	-0.228	-0.28***	-0.31***	-0.36**	-0.233	-0.33***	-0.34**
residence (yes)	(0.084)	(0.289)	(0.074)	(0.093)	(0.158084)	(0.296)	(0.073)	(0.139)
	0.706		*0.758*	*0.731*	*0.697*		*0.719*	*0.712*
Low education	0.12	-0.052	-0.232	0.091	0.14	-0.03	-0.407	0.115
(yes)	(0.21)	(0.27)	(0.178)	(0.24)	(0.147)	(0.27)	(0.251)	(0.13)
Medium	-0.194*	0.175	-0.168	-0.121	-0.207	0.19	-0.252	-0.137
education (yes)	(0.107)	(0.358)	(0.216)	(0.23)	(0.215)	(0.366)	(0.249)	(0.188)
	0.823							
High education	-0.97***	-0.5	-0.53***	-0.87***	-0.99***	-0.5	-0.676***	-0.9***
(yes)	(0.037)	(0.389)	(0.008)	(0.133)	(0.235)	(0.421)	(0.076)	(0.207)
	0.377		*0.587*	*0.418*	*0.372*		*0.509*	*0.408*
Standard of	-0.02***	-0.16**	-0.07***	-0.05***	-0.017	-0.16**	-0.0673***	-0.044
living indicator	(0.004)	(0.073)	(0.013)	(0.003)	(0.039)	(0.066)	(0.003)	(0.034)
	0.981	*0.85*	*0.933*	*0.956*		*0.85*	*0.935*	
III. Demographic variables								
Mother's age	-0.002	-0.005	0.001	-0.004	-0.003	-0.005	0.0009	-0.005
at birth	(0.003)	(0.015)	(0.008)	(0.006)	(0.009)	(0.016)	(0.007)	(0.008)
Gender	-0.321*	-0.41**	-0.114	-0.35***	-0.362***	-0.41**	-0.279***	-0.39***
(male=yes)	(0.103)	(0.187)	(0.123)	(0.118)	(0.11)	(0.199)	(0.106)	(0.098)
	0.725	*0.664*		*0.707*	*0.696*	*0.664*	*0.757*	*0.675*
IV. Behavioral variables								
Breastfeeding	-0.87***	-1.08***	-2.94***	-0.8***	-1.01***	-1.15***	-5.127***	-0.91***
(yes)	(0.222)	(0.2)	(0.063)	(0.183)	(0.224)	(0.2)	(0.335)	(0.203)
	0.408	*0.316*	*0.053*	*0.448*	*0.363*	*0.316*	*0.006*	*0.403*
Log likelihood	-2211.8	-603.46	-3859.8	-2617.5	-2188.99	-600.62	-3703.65	-2596.3

† The first number in a cell is the parameter estimate; numbers in parentheses are the standard error and italic number stands for the marginal effects in case of the probit specification and mortality risk elsewhere.
‡ (yes) refers to a dichotomous variable indicating that a value of one 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).
*** Estimate significant at 1 percent.
** Estimate significant at 5 percent.
* Estimate significant at 10 percent.

These results suggest an important role of policy in eliminating the urban-rural disparities. A mother who has completed secondary school or higher reduces infant mortality by 63 percent as opposed to an illiterate one. In research concerning child mortality, education is thought to be one of the most important factors in reducing the level of child mortality. Cochrane (1979, pp. 93-98) found, from surveying 16 studies on the subject, that female education increases the chances of infant and child survival in two thirds of the studies. The SLI generally marks a significant effect on the neonatal and childhood mortality reduction.

Moreover, it is widely believed that male mortality is higher due to biological disadvantages. This is apparent in the neonatal case where the gender effect is significant and positive marking the male disadvantages. However, on the whole our sample shows higher female mortality indicating gender discrimination together within the infant and childhood cases. When the offspring is a male, he has the advantage of a decreased risk of death compared to a female ranging from 30 to 34 percent. In the absence of social security, males are seen by parents as long-term investments to depend on in their older years (Dasgupta, 2002).

Many of the factors listed in Tables 3 and 4 serve as proxies for health behavior and wealth together with the consideration of the unobserved heterogeneity. Even after controlling for these and other potential confounders, the main results on water and sanitation apply. Thus, it is unlikely that the differences found are due to some inherent characteristic of health or wealth associated with water quality or having a latrine.

5. Discussion and concluding remarks

Using DHS Egypt 1995 and a three-part model while studying child mortality, this study assesses whether improvements in water and sanitation services lead to a decrease in mortality of children under the age of five. The analysis is conducted using a probit model specification for the neonatal case. Non-parametric, semi-parametric and parametric duration model specifications are used for different age intervals including infants and children younger than five year old. One of the problems in studying child mortality is that biological and social entities usually differ in ways that are not fully captured by the model. This unobserved heterogeneity can produce misleading estimates of hazard functions and attenuated estimates of covariate effects. Thus, the transition regression models are estimated with and without heterogeneity. Assessment of model fit by means of Cox-Snell residuals and likelihood ratio tests reveals that a Weibull model with gamma heterogeneity better explains the second and the third part of the model.

The three-part model uncovers some interesting differences amongst the impacts of certain environmental and socioeconomic determinants on the neonatal, infant and subsequent survival. The results show a negative relationship between access to municipal water and mortality. The advantages of having a modern facility prevail in the childhood case with a 68 percent reduction in mortality risk. In a quite similar setting with an application to Eritrea, Woldemicael (1998) shows that the effect of household environment (water supply and toilet facility) is large and statistically significant during the post-neonatal and childhood periods, while the effect totally disappears during the neonatal period. Trussell and Hammerslough (1983) found in a hazard model analysis for child mortality in Sri Lanka, that an improvement in the type of toilet facility reduces mortality while the source of water supply was found insignificant and hence was excluded from their analysis. Ridder and Tunali (1999) found that access to piped water and toilet facilities did not appear to have much of an impact on the child mortality risk in Malaysia.

Moreover, the analysis with the extended dummies of the place of residence shows that living in Upper Egypt implies a relative risk of dying ranging between 88 and 160 percent higher than living in another area. Knowing the characteristics of the region, this is not a surprising result. First of all, there is no rehabilitation of the existing systems, or the services may simply not exist in that area. Using water supply as an example, municipal water is only available to 67 percent of the residents of this area, compared to 99 and 86 percent in urban governorates and for Lower Egypt residents, respectively.

Second, this region also marks the highest rate of illiteracy together with a low standard of living. Last but not least, the recently completed report "Poverty reduction in Egypt - Diagnosis and strategy" indicates that about 17 percent of the Egyptian population were poor in the year 2000. When considered by region, only five percent of the population of Cairo were poor, while poverty rates in several governorates in Upper Egypt exceeded 30 percent (GOE/World Bank, 2002). In general, there is a disparity in rural-urban mortality that largely results from a combination of poor water and sanitation services, a higher illiteracy rate and a lower standard of living. The mother's education showed to be of importance to reduce child mortality. The results also exhibit gender discrimination with preference to male offspring. This finding confirms the ones of Ammar (1954), Ayrout (1963) and of others; Egypt is a strongly patriarchal society in which the male children receive preferential treatment from an early age. Although Casterline et al. (1989) discuss this phenomenon, their sample does not show evidence to confirm it.

In the light of these results, increasing awareness of the Egyptian population relative to health care and hygiene is a prerequisite to decrease child mortality risk. More concern should be given to the region of Upper Egypt. Furthermore, if water infrastructure were extended as much as possible to the whole country, then child mortality would be reduced.

In addition to the direct benefits in terms of increased health and reduced mortality, there are also possible indirect effects, such as a reduced fertility and population growth. Indeed, in line with the theory of the effect of infant and child mortality on fertility as argued by Wolpin (1997), a high child mortality may lead to a high fertility where mothers give birth to many children suspecting that the probability of losing some of them is high. This fact is corroborated with Al-Qudsi's (1998) findings for the Arab countries that infant mortality has a positive influence on fertility.

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Appendix A

Table A1: Distribution (%) of potentially confounding variables among children in Egypt

Variable	*Neonatal*	*Infant*	*Childhood*
Socioeconomic variables			
Urban Residence (yes) †	40.2	41	41.4
Urban governorates (yes)	15.4	15.8	16.3
Lower Egypt urban (yes)	8.9	9.2	9.2
Lower Egypt rural (yes)	22.3	22.1	22.7
Upper Egypt urban (yes)	10.2	10.1	9.9
Upper Egypt rural (yes)	34.0	33.5	32.3
Frontier governorates (yes)	9.2	9.4	9.6
No education	35.1	34.5	34.1
Low education	12.8	12.9	12.7
Medium education	15.4	15.3	14.9
High education	36.7	37.4	38.3
Mother's employment (yes)	17	17.1	17.8
Standard of living indicator	(4.3)‡	(4.3)	(4.3)
Mean persons per room	(1.7)	(1.7)	(1.7)
Demographic variables			
Mother's age at birth	(22.14)	(22.14)	(21.97)
Mother's age ≤ 19*	33.7 (18)	33.5 (18)	34.7 (17.9)
Mother's age 20-34*	65.4 (24.1)	65.6 (24.1)	64.4 (23.9)
Mother's age ≥ 35*	0.9 (37.3)	0.9 (37.3)	0.9 (37.5)
Divorced or widowed (yes)	1.4	1.4	1.5
First birth	65.2	66.1	72
2nd birth	29.5	29.2	25.8
≥ 3rd birth	5.3	4.7	2.1
Gender (male=yes)	51.9	51.9	51.8
Behavioral variables			
Birth interval	(8.6)	(8.3)	(6.3)
Breastfeeding (yes)	94.2	95.5	71
Number of children	(1.8)	(1.8)	(1.8)
Maternity care (yes)	64.6	64.7	64.6

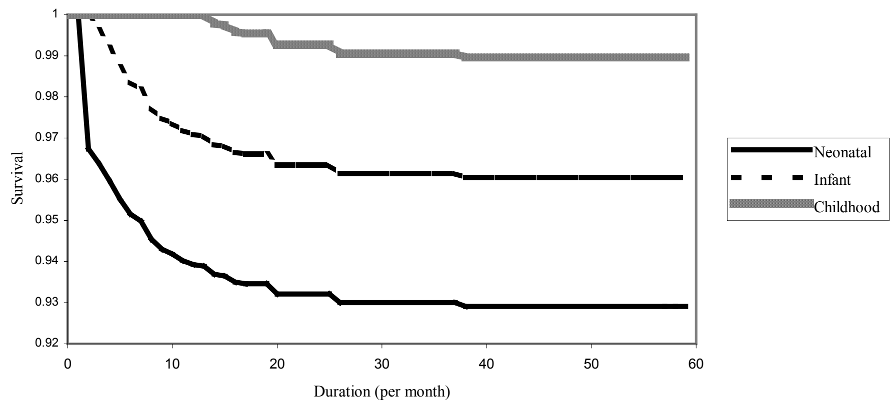
† (yes) refers to a dichotomous variable indicating that a value of one is taken by the variable name (e.g. tap water into residence (yes) = dichotomous variable indicating that the household has municipal water piped into residence).

‡ Numbers in parentheses indicate the mean of the variable, and not the percentage of occurrence.

Appendix B: Kaplan-Meier estimates of the survival rates

Figure B1 illustrates the Kaplan-Meier estimates of the survival rate $\hat{S}(t)$ of the age grouping. The deaths represent the number of completed spells of duration t_i. During the first month, 132 deaths occurred which gave rise to a risk equivalent to 3.32 percent of ending the spell. The survival rate of a spell lasting one month or more is 96.74 percent as seen in Figure B1. In Table B1 the average hazard dropped by 92 percent when moving from the neonatal to the infant period.

Figure B1: The Survival Function of the Age Grouping



In Figure B1, the survival probability during the childhood period is higher than in the infant period, which is in turn higher than the survival probability during the neonatal period. This is an expected result since the hazard risk of dying is decreasing with age. Taking as an example the 20th month, the childhood survival function indicates around 99 percent probability of surviving given that the child survives the infant age. This probability is 96 and 93 percent for the child given that he/she survives the neonatal period and the general chance of survival, respectively.

Table B1: Sample size and average hazard rate.

	Neonatal	***Infant***	***Childhood***
Sample size (No. of children)	4165	3854	2761
Mortality prevalence (No. of children)	132	102	23
Mortality prevalence (%)	3.2	2.7	0.8
Average hazard rate			
Neonatal	3.32	-	-
Infant	-	0.27	-
Childhood	-	-	0.02

Child Mortality, Wealth and Education: Direct versus Indirect Effects.

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Abstract

Controlling for the Egyptian households' 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 neonatal mortality is found, but generally the indirect effect has only a negligible effect. Furthermore, changes in wealth and educational levels are assessed taking into consideration a priori the choice of health infrastructure. The analysis suggests that wealth and education contribute loosely to the child mortality reduction.

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

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

1. Introduction

Previous analyses by Aly and Grabowski (1990), and Abou-Ali (2003)[1] 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 is important from a policy perspective. This paper focuses on policies that enable a reduction of child mortality in Egypt. Households are assumed to make the choice of inputs prior to the fertility decision. Once the decision is made, it is assumed to be nonadjustable over the time period of interest, i.e. 1991-1995. The impact of changes in wealth and education levels is assessed taking into consideration *a priori* the choice of health infrastructure, because ignoring indirect effects could lead to under- or over-statement of the effect of the intervention related to child mortality. This is done by analyzing the factors determining household demand for sanitation and water, using discrete choice models, together with an analysis of the determinants of the household wealth. The data used consists of a sample of 6871 Egyptian households gathered 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 correct estimates of the wealth and education

[1] Chapter 2 in this thesis.

elasticities with respect to child mortality. To our knowledge there is no 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's control.

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

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 and Johansson (1997), and Östberg and Vågerö (1991). Others, such as Mu et al. (1990), Madanat and Humplich (1993), and Persson (2002) focus on studying the demand for water and sanitation by using discrete choice approaches. Moreover, others such as Di Matteo (1997), Taylor and Yúnez-Naude (2000), and Yúnez-Naude and Taylor (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 and Wolpin, 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 the second period 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 and Schultz (1983), let the hazard rate $\lambda(t)$ of dying at age t, corresponding to the mortality production technology be:

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

where $\lambda_0(t)$ is the unknown baseline hazard rate at time t, β is the vector of parameter estimates and x represents a vector of behaviors or covariates which shifts the hazard function proportionally and does 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 model. While no assumptions are made about the functional form of the baseline hazard, the Cox model assumes a proportional relationship between the hazard function and the log-linear function of the covariates, i.e. it is assumed that the ratio of the hazard function for two individuals does not depend on time. 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 in terms of 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) discussed in Thurstone (1927) and McFadden (1973, 1978). Households are assumed to make choices that maximize 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 and 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 equal 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 may potentially participate in multiple activities. Without loss of generality, however, consider a household that allocates its available investment resources to production, in order 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 and Yúnez-Naude (2000) consider a random expected income model in which income is comprised 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 it is taken to influence productivity in the non-market sector by altering the marginal product of the direct inputs in the 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 the 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 under the age of five. Table 1 describes the variables. The sanitation service is divided into three categories: *no facility,* where the households have no toilets in their dwelling or on their premises; t*raditional facility,* including water-based system, pit latrine or a similar fecal disposal system; and a *modern facility,* utilizing flush toilet. The distribution of the categories of sanitation facilities 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 sources and 24 percent have no municipal water. The distance to the source of drinking water is on average of 7.5 minutes. The further the source of water, the more burdens the household endures for consumption.

This paper uses the same construction of a standard of living indicator as in Abou-Ali (2003) 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 female structure in the household needs to be captured since 19 percent of the households contain several eligible women (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 woman with the closest relationship 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 head to be 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 analyses including the mother and the father were conducted but the results were not significantly different.[2]

Table 1: Descriptive statistics for the Egyptian households

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 a value of one is taken by the variable name, e.g. no facility (yes) = dichotomous variable indicating that the household has no sanitation facility in the dwelling.

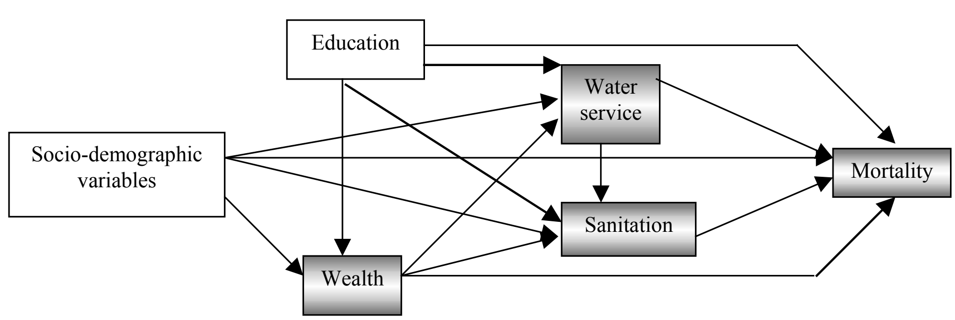
[2] The results related to the mother and the father's characteristics are available from the author.

Since education is believed to impact the choice of services, three levels of education are accounted for: (i) *low education* where the individual had some primary schooling, (ii) *medium education* is achieved by finishing primary schooling and /or continuing through secondary school, and (iii) *high education* includes the ones who completed secondary school or higher. *No education* is treated as the omitted variable. Moreover, education is of special interest to the model, since a verified positive causal link between education and mortality reduction implies that it is possible to decrease child mortality by increasing the level of education. The place of residence is also included since it may affect the lifestyle, together with the choice of services and sanitation. Sanitation programs unveiled that people's aims or desires 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 perspectives: the age perspective (i.e. the neonatal, infant and childhood groups) and woman's age perspective (in the form of child birth order). The latter type of grouping relating to birth order reflects the components of the child's biological endowments. Starting by estimating under age five mortality and by using a Cox proportional hazard model, results are depicted in Table 2.

Figure 1: Model structure



Looking at the environmental condition 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 in the neonatal and in the fourth birth order groups, respectively. The results show that access to municipal water in the fifth and higher birth order group decreases the risk of dying by 33 and 52 percent for tap into residence and public tap, respectively. The effect of water is smaller and non-significant in lower birth order groups. In the infant stage and in the first birth order group, results reveal that access to a modern facility decreases the mortality risk by 17 and 60 percent, respectively, while a traditional facility increases the mortality risk in the childhood stage by 225 percent. Living in urban areas decreases the mortality risk of infants and children 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 indicates gender discrimination in the infant and childhood cases together, with the first and fifth and higher birth order groups. Finally, breastfeeding 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								
Breastfeeding (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

† Numbers in the table are the relative mortality risk.
‡ (yes) refers to a dichotomous variable indicating that a value of one 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.
*** Estimate is significant at 1 percent.
** Estimate is significant at 5 percent.
* 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 a type I extreme-value distribution (see Maddala, 1992 and 1993):

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

where *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 among 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 a 1, 5 or 10 percent significance level. 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. One important property of the multinomial logit model is:

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

for any two responses *i* and *j*. Thus, the log of the odds between any two responses depends solely on Z_k and on the parameters. Thus conditional on either *i* or *j* being chosen, the choice between them is determined by an ordinary logit model with parameter α_k. For instance, the log of the odds between a traditional facility (*i*) and no facility (*j*) is simply 0.52 if the household has residential water. The interpretation of the parameter estimates of continuous variables becomes more problematic and the marginal effects are therefore used. The marginal effects of the odds ratio that can be obtained by taking the exponential of Equation (4) will be presented in the following sub-section. Estimates of the marginal effects 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 effects of the demand for sanitation odds ratio

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:

- *Effect of water*: The ceteris paribus marginal effect of the source of water on the odds of choosing a 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 having no municipal water regarding 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 residential tap water has an effect 1.7 times stronger than having no municipal water favoring the choice of a traditional facility.

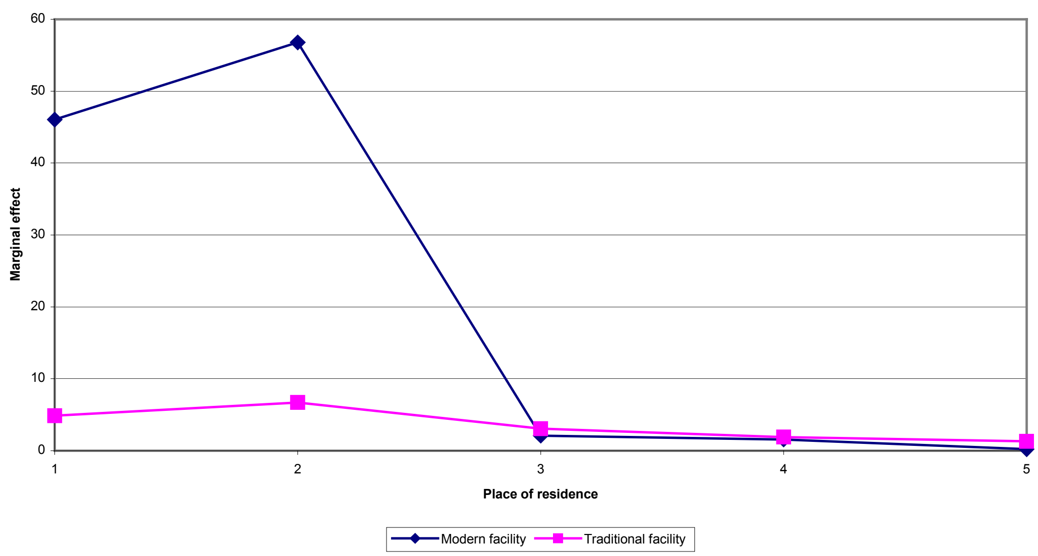
Table 3: Effect of source of drinking water on the odds of sanitation choice.

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

- *Effect of wealth*: 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 choosing a modern facility versus no facility, compared to the odds of choosing a traditional facility.

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

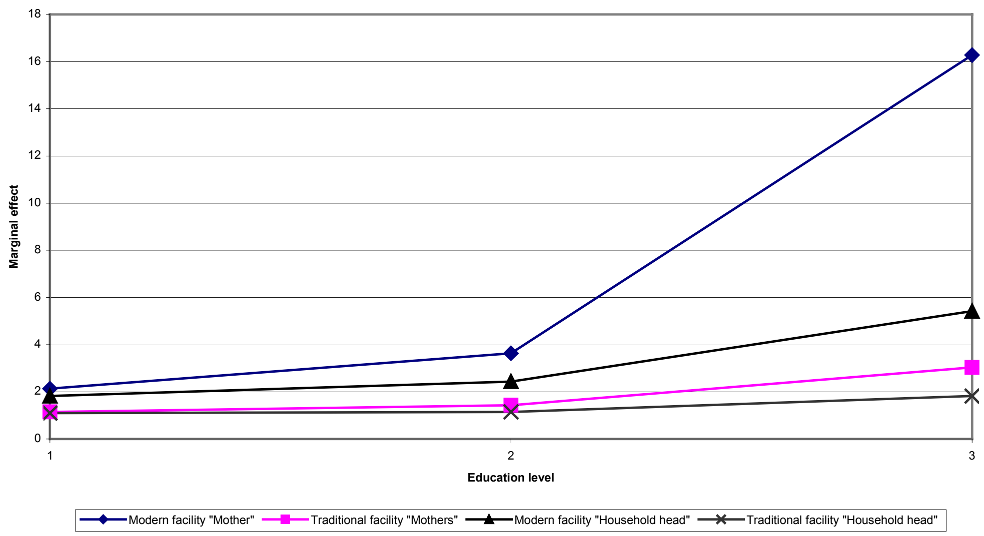
Figure 2: The marginal effects of wealth on the odds ratio of sanitation



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

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

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



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

4.2 Marginal effects 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 sanitation demand:

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

Assuming that 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 educational levels. 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. A household with 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 choosing a modern facility. An investigation of these results emphasizes the role of water as an input in the demand for sanitation. Sanitary services are found in the Cox proportional hazard model to considerably affect mortality while the direct effect of water on mortality was quite negligible, suggesting that water has a considerable indirect effect through the choice of sanitary service.

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 a value of one 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.
*** Estimate is significant at 1 percent level.
** Estimate is significant at 5 percent level.
* 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: 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 a 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 services

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

Table 5 presents the marginal effects for the model of water (Equation 2).[3] 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.

[3] 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.

4.3 Demand for wealth

Following Strauss and Thomas (1995) and Di Matteo (1997) the explanatory variables included in Equation 3 encompass the mother and the household head's education, 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 a value of one is taken by the variable name, e.g. number of women>1 (yes) = dichotomous variable indicating that the household has more than one eligible woman.
*** Estimate is significant at 1 percent level.
** Estimate is significant at 5 percent level.

Despite the fact that wealth is a categorical variable, OLS estimations will be used rather than an ordered approach, such as an ordered probit model. This is for two reasons: First, and most importantly, the interest is in the magnitude of the effects, and not solely in the statistical significance of the parameters. Although one can also calculate marginal effects from an ordered approach, these estimates tend to be much less robust than the parameter estimates from an OLS regression. Second, as noted by

Van Praag and Ferrer-i-Carbonell (2003), an ordered approach contains an implicit cardinalization chosen endogenously in the regressions, even though it is not stated explicitly in advance. Hence, one cannot avoid making some kind of cardinalization of the ordinal wealth variable.

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 on the motivation for saving, see Di Matteo, 1997). A household head at the age of 30 would accumulate total wealth at an annual rate of 0.9 percent (0.015-2*0.0001*30 = 0.009). An average household head would hold a rate of 0.7 percent.

The parameter estimates of education are significant. The estimated return from having a low to high level of education versus no education ranges between 0.6 and 1.4 for the mother and, 0.4 and 1.2 for the household head. Their counterparts in the log-linear specification vary between 16 and 31, and 12 and 30 percent, respectively. Regarding the place of residence it should be noted that living in rural areas negatively affects 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:

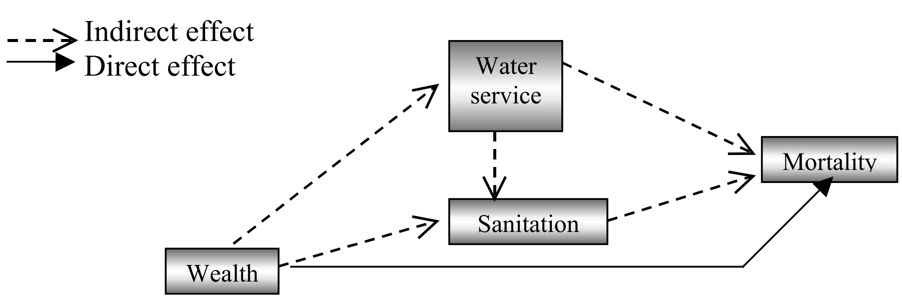
$$\frac{d\lambda}{dY}\frac{Y}{\lambda}=\left[\frac{\partial\lambda}{\partial Y}+\sum_i\frac{\partial\lambda}{\partial S_i}\left(\frac{\partial S_i}{\partial Y}+\sum_j\frac{\partial S_i}{\partial W_j}\frac{\partial W_j}{\partial Y}\right)+\sum_j\frac{\partial\lambda}{\partial W_j}\cdot\frac{\partial W_j}{\partial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

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

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

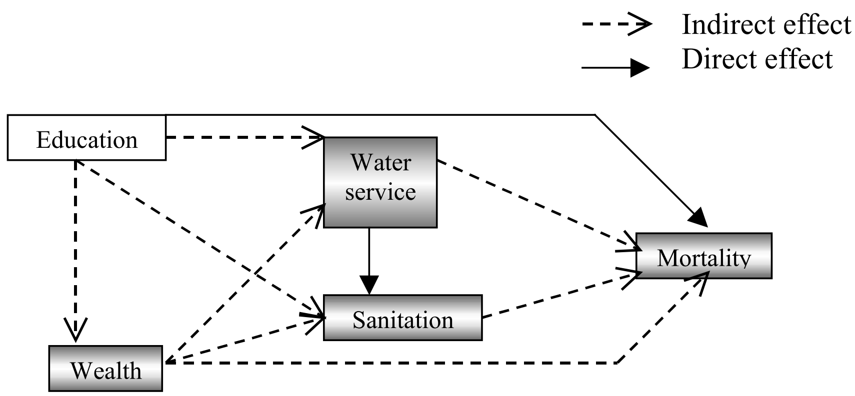
The results are illustrated in Tables 7 to 9 by calculating total effects as well as direct and indirect effects of wealth and education on child mortality. Figures 4 and 5 describe these effects in the case of wealth and education, respectively. The tables display the elasticity of wealth and changes in education calculated as an average of the individual elasticity and education changes. For the sake of comparison the elasticities are also computed at the sample mean and are displayed in Appendix C. There is no *a priori* belief that is better, but it should be noted that the direction of the results are quite similar although they differ in absolute terms; where 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



Inspecting Table 7, the direct effect of wealth is negatively related to mortality indicating that an increase in household 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 most 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 with the third birth where a one percent increase in wealth generates a 0.036 percent increase in mortality. In the neonatal case a one percent increase in wealth generates a 0.63 percent decrease in neonatal mortality.

Figure 5: Education effects



The indirect effect of wealth is calculated for different health infrastructure groups 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 having 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 the fact that they are not connected to residential water. A thorough examination of the characteristics of the sample shows that ten percent of the households possessing a modern facility have no access to residential water.

In summary, of the overall indirect effects are in some cases positive and in some negative. A combination of a modern facility and a public tap as a water source has the worst effect on child mortality, while a combination of a traditional facility and residential water contributes positively to neonatal mortality reduction.

Table 7: Elasticity of child mortality with respect to wealth at the mean of individual elasticity.

	Age Group			*Birth order group*				
	Neonatal	Infant	Child	1	2	3	4	5+
Direct effects	-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 effects				
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 8 displays the effect of the mother's level of education on child mortality. The results for the direct effects are similar both at the sample mean and for the average of individuals, due to the Cox proportional hazard method used in estimating child mortality. The table also suggests that a one percent increase in the high level group of the mother's education decreases infant and child mortality by around 0.74 and 1.16 percent, respectively. The effect of education on mortality reduction is not as clear in the neonatal case since a mother with a low level of education 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 sufficient time to take care of their children. When forced to work, the mother is often obliged to leave the child with insufficient care, which may expose the child to increased danger.

Table 8: Direct, indirect and total percentage change of child mortality with respect to mother education at the mean of individual changes

	Age Group			*Birth order group*				
	Neonatal	Infant	Child	1	2	3	4	5+
				Direct effects				
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				
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				
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

Concerning 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 9, the head's education induces more mortality in the case of neonatal, infant, third and fifth and higher birth order groups. The positive returns of head education on mortality reduction are revealed in the child stage, and first, second and fourth birth order groups.

Table 9: The percentage change in child mortality with respect to the household head education at the mean of individual changes

	Age Group			*Birth order group*				
	Neonatal	Infant	Child	1	2	3	4	5+
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. Concluding remarks

In general, improvements in water and sanitation facilities will likely reduce the spread of diseases, and hence reduce illness and mortality and lead to better health. In this paper wealth and education elasticities are studied in order to show the response of child mortality to wealth and education through different health infrastructures. 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 a better quality of services. This may be also due to the fact that better services are more available or accessible in urban areas. An important role for public health policy is the elimination of rural-urban disparities concerning health status, particularly by 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 put on the enhancement of income levels in the region of Upper Egypt.

The analysis also 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 and rehabilitate water infrastructure accompanied by sewage systems, since the availability of municipal water into residences was found to have a positive impact on child hygiene where the outcome was a decreased mortality rate. A low educational level often implies that the understanding of the health benefits of a sanitary toilet facility is limited or even poor. The results show that the mother's increased level of education is very important for the enhanced health of her children, and it has an amplified effect compared to the household head. This calls for the enhancement of educational programs with a special focus on female education.

One possible extension of the analysis in this paper may build on the fact that the causality may also go in the other direction, so that health may affect wealth. Furthermore, the health status of the parents, in which I have no direct data, may affect child mortality directly. It could also be interesting to find out whether education and child health are correlated with time preferences of the parents, so that people with higher discount rates invest less in education and in the health of their own children.

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Appendix A

Table A1: Multinomial 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 parentheses.

‡ (yes) refers to a dichotomous variable indicating that a value of one 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.

*** Estimate is significant at 1 percent level.

** Estimate is significant at 5 percent level.

* Estimate is significant at 10 percent level.

Table A2: Multinomial 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 parentheses.

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

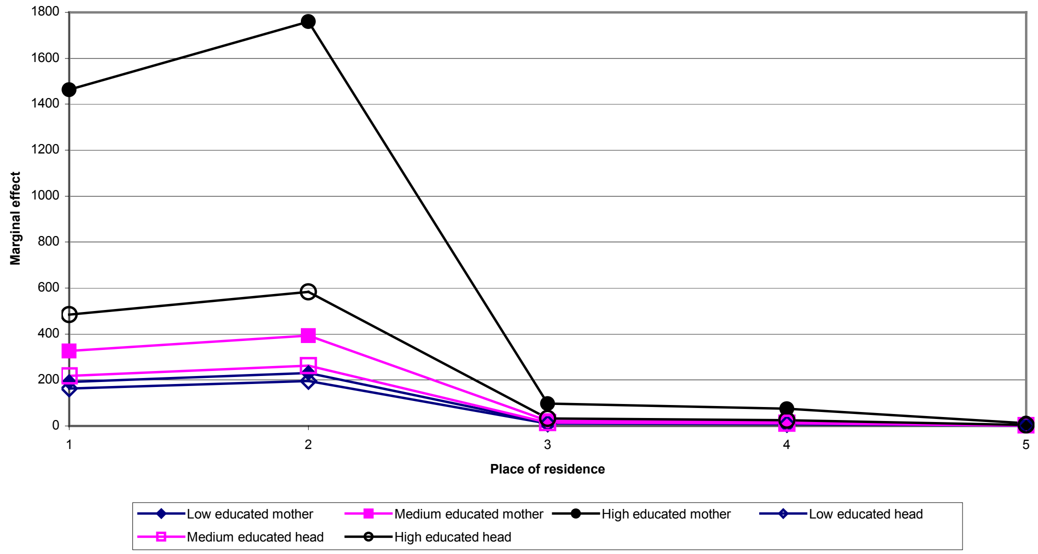
*** Estimate is significant at 1 percent level.

** Estimate is significant at 5 percent level.

* Estimate is significant at 10 percent level.

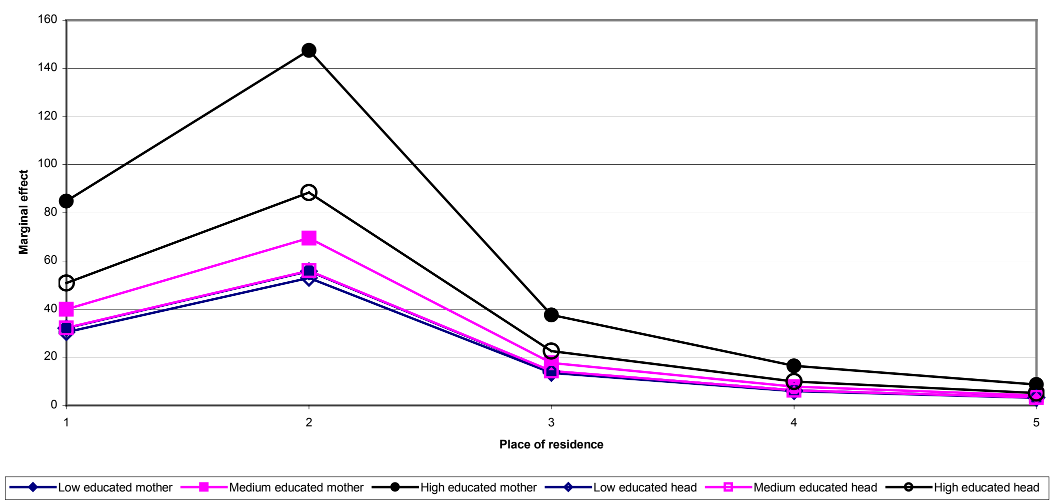
Appendix B

Figure B1: The marginal effects 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 effects 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.

Appendix C: Elasticity at the sample mean

Table C1: Elasticity of child mortality with respect to wealth at the sample mean.

	Age Group			*Birth order group*				
	Neonatal	Infant	Child	1	2	3	4	5+
Direct effects	-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

Table C2: Direct, indirect and total percentage change of child mortality with respect to mother education at the sample mean

	Age Group			*Birth order group*				
	Neonatal	Infant	Child	1	2	3	4	5+
				Direct effects				
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				
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				
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

Table C3: The percentage change of child mortality with respect to the household head education at the sample mean

	Age Group			*Birth order group*				
	Neonatal	Infant	Child	1	2	3	4	5+
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

Using Stated Preference Methods to Evaluate the Impact of Water on Health: the Case of Metropolitan Cairo

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Abstract

This paper analyzes the impact of better water quality on health improvements using two stated preference methods: choice experiments and the contingent valuation method. These methods were administered to a random sample of 1500 households in metropolitan Cairo, Egypt. The results show that both methods give about the same welfare measures. Moreover, households in metropolitan Cairo do have a positive willingness to pay for reducing health risks related to water quality amounting to roughly double their current water bills.

Keywords: Choice experiment; Contingent Valuation Method; Health; Water; Willingness to pay.
JEL classification: C25; I10; Q25

1. Introduction

According to many environmental and resource economists working in developing countries, contingent valuation surveys are straightforward and easy to do (Whittington, 1998). In this study a further step is taken by also applying the choice experiment (CE) technique to estimate the economic value that citizens of a developing country place on improved health by means of a better water quality. To the author's knowledge there is no previous application in the developing world that estimates health improvement through water quality using the CE. The existing applications involve the estimation of household demand for improved water services (e.g. Whittington et. al., 1988, 1990, and 2002) and studies done in the health area such as Alberini et al. (1997) and Whittington et al. (1996, 2002).[1] The contingent valuation scenario and the choice experiment exercise typically require the presentation of information to the respondent about the terms and conditions of the program offered. This is quite a complex task *per se.* In a developing country where illiteracy is quite prevalent, the use of the contingent valuation method (CVM) and/or choice experiments require detailed visuals material and in-person surveys.

[1] For a review of the literature on contingent valuation studies in health care, see Johnson et al. (1997) and Diener et al. (1998). For the application of choice experiments on health, see http://www.rtihealthsolutions.org/services_conjoint.cfm.

Increasing deterioration of water quality due to industrial, agricultural, and urban waste as well as to insufficient investments in domestic water supply infrastructure is becoming a serious problem in developing countries in general and metropolitan Cairo in particular. The availability of safe drinking water, combined with sanitary facilities and improved hygiene standards, could prevent many diseases. In metropolitan Cairo, health risks due to drinking water both in the short and long term, e.g. diarrhea and hepatitis, respectively, are frequently occurring phenomena. The empirical purpose of this study is to estimate the benefits of water quality improvement programs related to health in metropolitan Cairo. This is important in order to compare these benefits to the cost of water management programs and for policy makers to design tariffs. The study focuses on the magnitude and socioeconomic determinants of the willingness to pay (WTP) to improve health through enhanced water quality. A second purpose of the paper is to compare, evaluate and discuss similarities and differences between the two stated preference (SP) methods.

There is a growing number of studies that compare welfare estimates derived from CVM and CE. Overall, the results of the convergence of the CVM and CE are mixed. Nevertheless, the most prevalent result is that the welfare measurements derived from dichotomous choice CVMs are greater than a welfare derivation based on a linear specification of a CE. However, different results may be obtained if different models, e.g. a spike model, and/or a set of bounded CVM questions are applied. The spike models provide a richer set of information, especially when the distribution of the WTP is asymmetric and when a sizeable fraction of the respondents has a zero WTP for the good in question (see e.g. Kriström, 1997). According to Hanemann et al. (1991), the double bounded model gives tighter confidence intervals of the WTP and tends to yield a lower point estimate. This study differs from previous ones in the application and the use of both single- and double- bounded CVM questions.

This paper is organized as follows: Section 2 discusses the SP methods, Section 3 includes a description of the implemented survey and the collected data, Section 4 describes the model and the estimation methodology, Section 5 sketches the socioeconomic determinants of the willingness to pay, Section 6 discusses the welfare estimates and Section 7 concludes the paper.

2. Stated preference methods

In order to value the benefits of improved water quality the CVM and CE are used. Compared to the CVM, the CE includes several advantages and disadvantages such as:

(i) The CE includes different attributes and levels that are varied in an experimental design, which requires respondents to make repeated choices. This set-up focuses on respondents' trade-offs among several different attributes.

(ii) Using only CVM would restrict the respondent's choice to merely one quality where the quality of drinking water may differ from one district to another. One could argue for the use of a repeated CVM approach with many scenarios, but this could be rather costly.

(iii) The National Oceanographic and Atmospheric Administration (NOAA) has issued guidelines on the design of CVM studies in environmental damage suits (Arrow et al., 1993). For instance, they suggest that CVM results should be calibrated against experimental or actual market findings.

(iv) The CE may avoid some of the response difficulties with CVM. For example, dichotomous choice designs in CVM may still be subject to yea-saying despite improvements in design standards (Blamey et al., 1999). On the other hand, CE does not explicitly ask about money values so it is argued that CE is easier for the respondent to understand than CVM.

(v) Carson et al. (1999) argue that, given a consequential survey, a CVM with a binary discrete choice is incentive compatible while any other elicitation format is not.[2]

(vi) The use of CE in the context of environmental and health issues is more recent than that of CVM. Therefore, Bateman et al. (2002) argue that a larger body of literature using CE approaches and further evidence about their results

[2] A consequential survey is defined one that is perceived by the respondents as something that may potentially influence agency action. Furthermore, the respondent is required to care about the outcome of that action.

are required before one should be confident about implementing CE approaches.[3]

There is a growing number of studies that compare welfare estimates derived from CVM and CE (Table 1 provides a summary). Concerning the convergence validity of the methods, the debate is still open giving room for more research. For instance, Boxall et al. (1996) compare the CE and the CVM applied to the effect of environmental quality changes arising from forest management practices on recreational moose hunting. They find significant differences in the welfare measures. The differences between the welfare estimates of the hypothetical environmental quality change at the site were significant. The CVM estimate was higher than the CE estimate by a factor of 20. In order to fully evaluate their results, Boxall et al. emphasize the need for further testing of SP on other goods and services. Further, Hanley et al. (1998) report results from a study of the economic value of the conservation benefits of Environmentally Sensitive Areas in Scotland using CVM and CE. The welfare estimates obtained using both methods were fairly similar, although in their case the welfare estimates obtained from the CE were sensitive to functional form choice.

3. The survey

In January of 2002, an in-person survey concerning waterborne illness and the value of clean water was administered to about 1500 households in metropolitan Cairo. The goal of the questionnaire was to have households evaluate reductions in health risks due to water quality. To define the short run scenario, each household was asked to recall its number of diarrhea illnesses in the past year, and then to evaluate the severity of those illnesses. When investigating the long run health effects, which involved the risk of contracting a dangerous disease in the future, a bundle of diseases such as hepatitis and cholera were mentioned.

[3] For an extensive discussion on the advantages and disadvantages of CE relative to CVM, see Bateman et al. (2002).

Table 1: Summary of Studies comparing stated preference methods, i.e. Contingent valuation (CV) and Choice experiment (CE)

Author(s)	*Application*	*Design*		*Sample*	*Utility specification*	*Estimation method*		*Comparison of welfare estimates*
		CV	CE			CV	CE	
Boxal et al. (1996)	Impact of alternative wildlife management units	Dichotomous choice	2 attributes of 2 levels and 4 attributes of 4 levels	Both methods were administered to the same sample	Linear	Binary logit model	Conditional logit model	CV estimates are around 20 fold higher than CE
Hanley et al. (1998)	Conservation of environmentally sensitive areas	Open-ended and dichotomous choice	5 attributes of 2 levels and 8 price levels	Both methods were administered to different samples	Linear and quadratic	Binary logit model	Conditional logit model	- Linear welfare measures for the CE were greater than CV - Quadratic CE measures were comparable to CV
Hanley et al. (1998a)	Alternative forest landscapes	Open-ended (OE)	5 attributes of 4 levels	Both methods were administered to the same sample	Linear		Conditional logit model	"ideal forest" bid from OE-CV is quite similar to CE
Adamowicz et al. (1998)	Preservation of the Caribou habitat	Dichotomous choice	5 attributes of 4 levels	Both methods were administered to the same sample	Linear and quadratic	Logit model Nested logit model for combined CV and CE	Conditional logit model	- Linear welfare measures for the CE were lower than CV - Quadratic CE measures were higher than CV
Lockwood and Carberry (1998)	Remnant native vegetation conservation	Dichotomous choice	3 attributes of 3 levels and one attribute of 4 levels	Both methods were administered to the same sample	Linear	Binary logit model	Conditional logit model	The CE and CV estimates were not significantly different
Christie and Azevedo (2002)	3 programs to preserve and improve the quality of the lake's water	Dichotomous choice	5 attributes of 4 levels	Both methods were administered to different samples	Linear	Binary logit model	Multinomial logit model	CE measures were higher than CV
Mogas et al. (2002)	Impact of alternative afforestation programs	Dichotomous choice	3 attributes of 2 levels and 3 attributes of 4 levels	Both methods were administered to the same sample	Linear	Binary logit model	Nested logit model	Mixed evidence of equivalence where CE derived estimates where generally greater than CV

Both the CVM and CE questionnaires were administered to a random sample of around 750 households in metropolitan Cairo. Metropolitan Cairo was defined as the urban districts of the Cairo, Giza and Kalyubia governorates lying within the ring-road. In order to meet a target of 1500 households, a random sample of 1680 was drawn to allow for non-responses. The study used a random sample weighted by a population drawn from the sample design of the 2000 Egyptian Demographic and Health Survey (EDHS, 2000), which is based on a three-stage probability sample.[4] The repartition of the sample in the three governorates was 66, 25.45 and 8.55 percent, respectively.

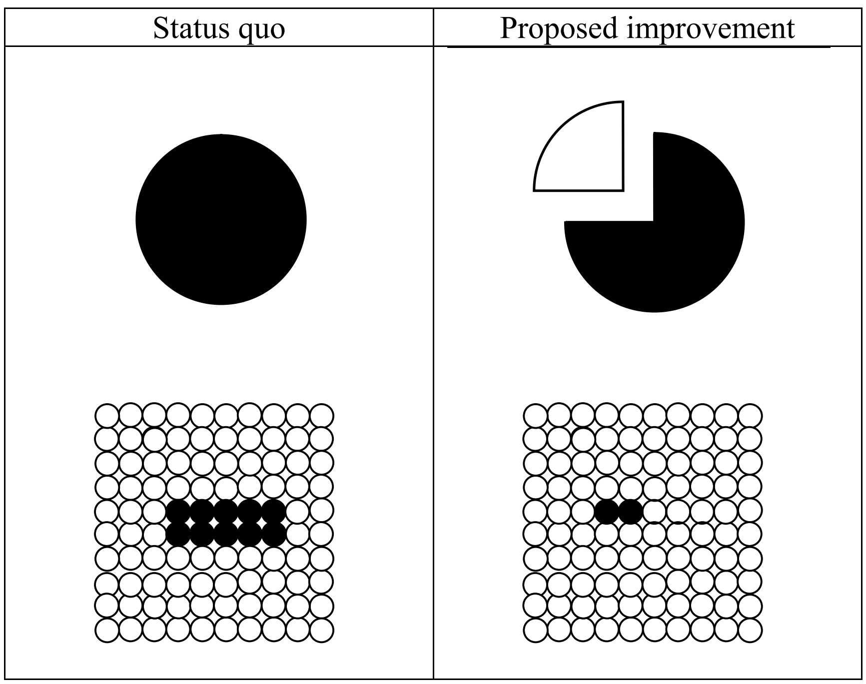
3.1 Design of the CV survey

The contingent valuation study was based on a three stage principle beginning with focus groups, proceeded by a pilot study and finally the implementation of the main study. The format of the valuation question was a referendum question, and the payment vehicle used was a proposed increase in the water bill. The scenario began with a brief text segment describing the proposed health program. The interviewer first read the text aloud and then asked the respondent to describe how the program would affect the household health. After eliciting perceived impacts, the referendum portion of the question detailed the resulting outcomes (services to be obtained) from the program. Respondents were asked for any questions they might have regarding the project. The interviewer then gave a brief list of reasons in order to remind the respondents of the health tradeoffs and the budget constraints involved in a voting decision. Moreover, the respondents were asked whether to go ahead with the program or not. The respondents were also informed about the fact that "some people we had talked to previously" voted for the program and others voted against it. This is done in order to remove the chance of biasing the votes as in Hoehn and Krieger (1998). Then the change in health was presented using visual aids, shown in Figure 1. These illustrate the suggested improvement of a decrease in the short run health effect due to poor quality water by 25%, and a reduction in the probability of contracting waterborne diseases in the long run to 2%. In the CVM format depicted in Figure 2, the respondents were first asked if they would be willing to pay anything, even a small amount, for the health improvement shown to them using Figure 1, i.e. *Q43* of

[4] For details on the 2000 EDHS sample design see El-Zanaty et al. (2001) pp.219-234.

Figure 2. This established three groups of respondents: potential payers, non-payers, and protesters. The proportion of households willing to pay was, in principle, around 50 percent. Non-payers accounted for 43 percent of the respondents, and protesters for 7 percent. The most common motives for protesting were disagreement related to the fact of paying more expenses and that the waterworks are unable to provide the proposed improvement. Then an initial Dichotomous Choice (DC) format of the valuation question was asked (i.e. *Q44* in Figure 2), contingent on the answer to that question, the respondent was offered a second close-ended valuation question (i.e. *Q45* or *Q46* in Figure 2). Finally, an open-ended follow-up question was offered to the respondents (i.e. *Q47* in Figure 2).

Figure 1: Visual aid of health improvement suggested in the contingent valuation



The necessity of using visual aids was imposed by the rate of illiteracy in Egypt. According to the World Bank Indicators, in 2001 the illiteracy rates of Egyptian females and males were 55 and 33 percent, respectively. Hence, the use of visual materiel was applied in order to facilitate the task of the respondents to understand the trade-offs that must be made when making a choice. A number of risk communication tools have been developed in the literature to assist respondents in comprehending the magnitude of risk reduction. For instance, Corso et al. (2001) show not just the importance of visual aids in conveying risk, but also that the type matters as well. They test the effects of visual aids on WTP responses and find that communicating risk using an array of dots enhances the sensitivity of estimated WTP to the magnitude of risk reduction, yielding CV estimates that are more consistent with economic theory. Loomis and duVair (1993) have also tested the effect of different visual aids on WTP. Based on this evidence, together with the use of focus groups and pilot testing, I chose to describe the short run health effect by means of pie charts where the black circles indicate the number of ill days per year. The offered improvement was illustrated by the white part of the pie chart. The long run risk is represented by the aid of an array of dots, where black dots indicate the risk of contracting a disease.

Figure 2: The valuation question

Q43. Supplying an improved health through better water quality is a program that costs money. We are however uncertain about the exact cost. The water agency cannot afford to implement the program unless it collects enough money to cover the costs. Every household in your heta will pay its share of the costs of supplying an improved health through better water quality. The water agency wants to know whether households like yours are willing to pay anything to reduce the number of days you are affected by diarrhea by 25%, and to reduce the probability of contracting a waterborne disease in the long run (such as cholera, typhoid, and hepatitis) to 2%.

YES…………………………………………………1
NO………………………………………………….2 (Skip to 48)

Q44. The water agency wants to know whether households like yours are willing to pay anything additional to the water bill to reduce the number of days you are affected by diarrhea by 25% and to reduce the probability of contracting a waterborne disease in the long run (such as cholera, typhoid, and hepatitis) to 2%.If it costs you LE ☻ increase in the water bill.
If the supply of an improved health through better water quality costs your household an extra ☻ pounds per bill, would your household want this health improvement or not?

YES, WANT IT AT LE ☻/BILL…………………1
NO, DO NOT WANT IT AT LE ☻ /BILL……. 2 (Skip to 46)

Q45. Suppose the actual increase in the water bill is higher and it turned out to be ☺ pounds per bill instead of ☻ pounds per bill. If better health costs your household ☺ pounds per bill, would your household be willing to pay for better health or not?

YES, WANT IT AT LE ☺/BILL…………………1 (Skip to 47)
NO, DO NOT WANT IT AT LE ☺/BILL……..2 (Skip to 47)

Q46. Suppose the actual increase in the water bill is lower and it turned out to be ☼ pounds per bill instead of ☻ pounds per bill. Now suppose better health would cost your household ☼ pounds per bill, would your household be willing to pay for better health or not?

YES, WANT IT AT LE ☼/BILL …………………1
NO, DO NOT WANT IT AT LE ☼/BILL……….2

Q47. The water agency wants to know the maximum willingness to pay per bill for a households like yours to reduce the number of days you contract diarrhea by 25% and to reduce the probability of contracting a waterborne disease in the long run (such as cholera, typhoid, and hepatitis) to 2%?

_________________ AMOUNT PER BILL

Sequential design was used to determine the starting bid (cost) values. The pre-testing on a sample of 60 households was performed and resulted in a median of five Egyptian pounds (L.E.).[5] Following Hanemann and Kanninen (1999), who emphasize that bid values near the center of the WTP distribution are best for obtaining an efficient estimate of median WTP, five starting bids were chosen. The starting bids which were used in the final study were calculated so that they would correspond to two lower values and two upper values arrayed symmetrically around the median. Moreover, each bid was distributed evenly on a sub-sample of 168 households in order to meet a target of 150.[6]

Moving from a single- to a double- bounded valuation format creates some bias despite the gain in efficiency. This is due to the fact that the responses to the follow-up bid are inconsistent with the responses to the starting bid. The bid structure used in this study has separate overlapping sets of bids; for example {starting bid (B)= 5; higher bid (B^u)= 6; lower bid (B^d)= 4} and {B=6; B^u=7; B^d=5}, meaning that the first set of bids starts with 5L.E. and then either goes up to 6L.E. or down to 4L.E., while the second starts with 6L.E. and then goes up to 7L.E. or down to 5L.E.

Households were randomly assigned a set of bids. However, a non-parametric consistency test of the responses suggested by McFadden and Leonard (1993) is implemented in order to check certain relationships between the response probabilities. For instance, two estimates of the probability Pr $\{5 \leq \text{WTP} \leq 6\}$ were compared. One estimate takes the respondents who received the first set of bids and calculates the yes/no proportion. The other calculates the no/yes response's proportion of the second set of bids. This example is given for the sake of illustration, although all possible relationships were tested (see Appendix Table A2). In most cases the consistency test of the responses failed. However, it was decided to continue pooling the responses to the first and second bid despite the inconsistencies. It is believed that the gains in efficiency in the estimation outweigh the inconsistencies (see Alberini, 1995 for more details). A final caveat should be made about the bid distribution

[5] 1 USD = 4.5 L.E. in September 2002.
[6] The heterogeneity in the sample distribution of the bids that resulted was due to two reasons: 1. Non-existence of households since they had either moved, were unavailable at the time of the survey, or simply refused to participate. (For the sample distribution of the bids, see Appendix Table A1.) 2. The willingness to participate in the program, since the bid was only offered to those willing to participate.

applied in this study concerning the high proportion of the sample saying "yes" to the highest bid value. This reflects a problem in the bid design, since no information about the tail of the bid distribution is collected. This accentuates the sensitivity of the WTP estimates with regard to the treatment of the upper tail of the distribution. This problem arose in the estimation of a single bounded model were the welfare estimates were very sensitive to the model specification and the assumptions made about the tail of the distribution.

3.2 Design of the choice experiment

The development of the choice experiment implemented here follows Ryan and Huges (1997), where the procedure starts by determining the attributes and assigning their levels, and then moves on to the construction of the choice sets by combining the attribute levels in each of the alternatives. The next stage consists of first collecting responses and finally proceeding to the econometric analysis of the data. This section concentrates on the first three stages.

Table 2: Attributes and levels of the choice experiment

Attribute	*Level*
Short run health effect	Same as today, 5, 25, and 50 percent decrease
Long run health effect	10% risk of contracting a disease 7% risk of contracting a disease 5% risk of contracting a disease 2% risk of contracting a disease
Price (suggested increase in water bill)	0, 2.5, 10, and 20 Egyptian pounds (L.E.) or 0, 5, 20, and 40 L.E.

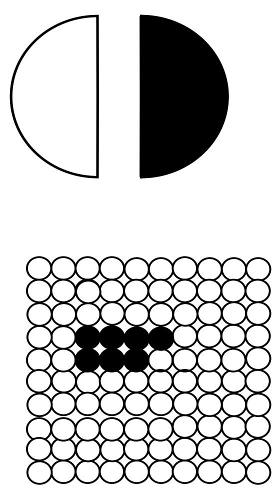
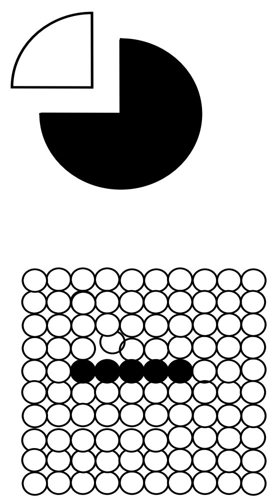
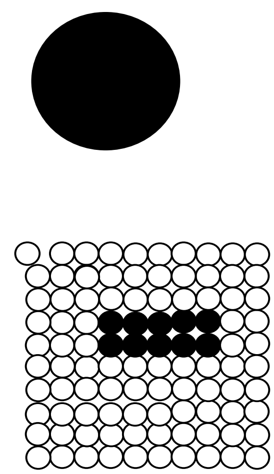
Focus groups and pre-testing with a sample of individuals were used to determine some measurable attributes associated with the effect of the quality of drinking water on health. These attributes were:

1. Short run health effect included the number of ill days caused by waterborne diseases during the year, e.g. diarrhea. The design was constructed as such to allow households to reveal their own level of *status quo* of this attribute. Henceforth, a proposed decrease was offered.

2. Long run health effects involved the risk of catching a dangerous disease in the future. A bundle of diseases such as hepatitis and cholera were mentioned.

3. Prices were formulated such as a proposed increase in the water bill due to the program. Hence, two different sets of prices were prepared and offered according to the current water bill, which is paid every two months by most households. Those with water bills less than 20 L.E. were offered a lower set of prices than households with higher bills. Eight price levels were used, based on the distribution of the open-ended CVM. This is to avoid the drawbacks of the concentration of the bids around the mean previously encountered in the CVM.

Figure 3: Example of one of the four choice sets in the choice experiment task

Option A	Option B	Status quo
 7%	 5%	 10%
2.5 L.E.	20 L.E.	No increase in the bill

The discussion also helped in the specification of the levels of each of these attributes. The attributes, as well as the levels used in the choice experiment, are described in Table 2. Given this set of attributes and levels, a linear D-optimal design method was used to structure paired choice sets. Carlsson and Martinsson (2003) recommend this type of design. The set of attributes and levels presented in Table 2 were used to create choice sets using a ($4^3 \times 4^3$) orthogonal main effects design, which produced 24 choice sets. These in turn were blocked into six versions of four choice sets each, using a D-optimal criterion. Focus group work showed that respondents could cope with up to four choice triplets each. This gave a final sample size of 757 households.

In the survey, each household was randomly assigned to one version.[7] Each household therefore evaluated four triplets of descriptions of different health risk situations, i.e. A, B, and the *status quo*. An example of one of the choice sets is presented in Figure 3. This procedure would imply a trade-off between side effects and an increased water bill. The side effect described to the respondents represented the most frequently occurring waterborne diseases in the short and long run. At this stage, it is worth noting that the wording describing the program to the respondent prior to the choice sets was similar to the wording in the CVM.

Figure 3 depicts an example of a choice set out of four given to the respondent in the CE. It should be noted that the communication of risk offered to the respondent is similar to the CVM with the distinction that the latter only offered the *status quo* and one proposed improvement of a 25 percent reduction in the short run effect and a two percent risk of contracting a disease in the long run. All interviews were carried out face-to-face using the information packs used in the CVM to provide background information. Although no participation question was asked here, a form of protesting or non-participation may still be tractable by the proportion of respondent always choosing the *status quo*. forty percent of the sample chooses the *status quo* in the four offered choice sets.

3.3 Questionnaire development

This phase lasted several weeks, consisting of focus group sessions, open-ended questioning on specific issues and a pilot test of the full questionnaire. Careful attention was also given to the structure and ordering of questions to ensure that concepts which could potentially impact the valuation issue are introduced in a logical sequence to minimize the degree to which respondents may be influenced by the questions posed. The pilot test, involving a sample of 60 households, served to decide the bid vector and the price level for the CVM and the CE, respectively, to check any potential problem areas in the questionnaire, e.g. misunderstanding of the questions, and to include more questions to enhance the survey. The study included two

[7] The six sets were offered in the form of different questionnaires. Each questionnaire was randomly assigned to a sample ranging from 124 to 130 households.

questionnaires: the first one dealt with the CVM approach, and the other with the CE. The questionnaires were made in Arabic to ease respondent understanding.[8]

Each questionnaire consisted of ten parts, or sections. It started with a series of questions on the source of drinking water and its characteristics, and continued with questions about the cost and the reliability of water. The respondents were also asked questions about their household composition and their health status, followed by a section describing the program proposed to reduce health risks from drinking water. In this section, information necessary for the respondents to make a reasoned decision without biasing their responses, was offered, followed by the valuation question or the choice sets for the CVM and CE, respectively. The succeeding section consisted of a set of debriefing questions concerning the health improvement program. The seventh and eighth sections gathered information on the characteristics of the household building and household possessions such as the type of dwelling, availability of electricity and household income. Subsequently, information about the household heads was collected including age, work status, and education. The last section collected information about the respondent's general environmental awareness and concerns.

3.4 Descriptive statistics

Throughout this section, whenever there is a difference in magnitude between CE and CVM variables, the CVM related value appears in parentheses. For the choice experiment (CVM), approximately 757 (732) households responded to each of the corresponding questionnaires as shown in Table 3.[9] Respondents were split as evenly as possible between male and female heads of the households in order to allow for testing of gender related differences in responses, but no significant differences were found. The mean age of the respondent was around 45 (46.6). The mean household size was around 4.3 people with a mean of 1.25 (1.15) persons under 15 years of age. Around 14 (13) percent of the households had a female head, where the mean age of the household head was around 48 (49) years. Nineteen percent had completed preparatory education and around 28 (24) percent had completed a university degree.

[8] Whilst both questionnaires were conducted in Arabic, an English version is presented in Appendix B and C for the CVM and CE, respectively.

[9] For an extended table of descriptive statistics, see Appendix Table A3.

The average household monthly income was around 700 (600) Egyptian pounds for the CE and CVM, respectively. Around 72 percent of the respondents perceived the subjective health of their households as being good or very good. As for the existence of waterborne diseases in the household, the CE and the CVM sample prevalence was 41 (24) percent.

Table 3: Description of the sample and variables used in the analysis

Variables	*Choice experiment*				*Contingent valuation*			
	Mean	Std.	Min	Max	Mean	Std.	Min	Max
Household income (Egyptian pounds / month)	698	832	55	9000	601.8	774.5	38	8000
Good health (subjective health of the household 1= very good and good, 0=fair, poor and very poor)	0.71	0.45	0	1	0.73	0.44	0	1
Diseases in the household (1=diseases, 0=no diseases)	0.41	0.49	0	1	0.24	0.43	0	1
Household Head's characteristics								
High education	0.28	0.45	0	1	0.24	0.43	0	1
Medium education	0.25	0.43	0	1	0.27	0.44	0	1
Low education	0.19	0.39	0	1	0.19	0.39	0	1
No education	0.28	0.45	0	1	0.26	0.43	0	1
Head employment (1=employed, 0=else)	0.73	0.44	0	1	0.72	0.45	0	1
Sample size (*N*)	757				732			

Furthermore, 90.9 (96) percent of the respondents paid a cash amount for water services, where 86 (90) percent of them paid in the form of a bimonthly bill, and the remainder paid a variation of monthly, quarterly, half a year and yearly bill. In addition, 1.2 (1) percent paid for water as part of a rental payment and 7.9 (3) percent did not pay for water. The mean cash payment was 13.15 (15.19) L.E. per household per bill. The mean addition to rent paid for water service was 7.25 (7.66) L.E. per household per month.

Table 4 brings together reasons for the respondents' choices. Around 26 percent of the CE and the CVM participants supported the positive short run effects of better water quality. In the long run, 51 percent of the CE respondents and 69 percent of those willing to participate in the program believed in the reduction of long run ill health effects by enhancing the water quality. Since better water quality may lead to better health, around 26 and 36 percent of the CE and the overall CVM respondents, respectively, were willing to contribute to the program.

Table 4: Reasons for the choices made by the respondents†

Reason	*Method*			
	Choice experiment	Contingent valuation		
		Overall	Yes participation	No participation
Reduce short run problems	25.46	15.71	27.2	
Reduce the probability of diseases in the long run	50.79	39.21	68.5	
Better health worth the cost (instead of going to the doctor)	26.12	35.66	62.5	
No short run problems	4.62	7.24		16.5
Don't believe in long run effects	1.72	5.33		11.43
Can't pay more expenses	40.5	31.56		72.7
Waterworks can't provide the service	1.98	4.23		10

† Values in the table are percentages if not otherwise indicated.

In view of the fact that enhancing water quality is not free of charge, some respondents in both studies revealed their inability to pay more expenses. However, the proportion of the respondents not believing in the relationship between enhanced water quality and better health in both the short and long run, is relatively small.

4. Model and estimation methodology

The Random Utility Model (RUM) is a link between a statistical model of observed data and an economic model of utility maximization. RUM is used in this study since it serves to analyze both the CE and the CVM data (Hanemann, 1984; Mitchell et al., 1989; McFadden, 1974; and Ben-Akiva et al., 1985). The use of the same theoretical foundation permits direct comparison of the welfare estimates from each method.

In this setting each household *h* is assumed to have a utility function associated with each alternative *i* of the choice set *t*:

$$U_{hit} = V_{hit}\left(X_{it}, Z_h, y_h - p_{it}\right) + e_{hit}\,, \qquad (1)$$

where in the choice experiment U_{hit}, $i=1,2\ldots n$ is the utility of each of the *n* alternative health improvement profiles and U_{h0} is the subject's *status quo*. This utility function is composed of a deterministic part $V_{hit}(.)$ and a stochastic part e_{hit}. According to Ben-

Akiva and Lerman (1985), e_{hit} is attributed to unobserved taste variations, unobserved attributes, measurement errors, and the use of instrumental variables rather than the actual variables that appear in the utility function. $V_{hit}(.)$ is the household's indirect utility function that is considered to be a function of the attributes and the socio-economic and demographic characteristics. These are incorporated in order to account for the observed taste variation among the respondents. The indirect utility function is assumed to take the following form:

$$V_{hit} = \alpha_{hi} + \beta X_{it} + \gamma Z_h + \delta_h \left(y_h - p_{it}\right), \tag{2}$$

where α_{hi} captures the household's intrinsic preference for alternative i, β is a vector of attribute parameters, X_{it} is a vector of health risk attribute levels in the profile it, where each decision set is indexed by t. γ is a vector of parameters, Z_h is a vector of socio-demographic characteristics, δ_h is the marginal utility of money, y_h is household income, and p_{it} is the cost attribute.

The probability of a household h choosing an alternative i from the choice set t is:

$$P_h(it) = \Pr\left\{\left(\alpha_{hi} + \beta X_{it} + \gamma Z_h + \delta_h\left(y_h - p_{it}\right) + e_{hit}\right) > \left(\alpha_{hj} + \beta X_{jt} + \gamma Z_h + \delta_h\left(y_h - p_{jt}\right) + e_{hjt}\right)\right\},\ \forall i \neq j\ .$$

Assuming that the random term e_{hit} follows a type one extreme-value with scale parameter μ, the probability of choosing alternative i from the choice set A_t can be estimated using the conditional-logit model (McFadden, 1974, and Maddala, 1983):

$$P_h(it) = \frac{\exp\left(\mu V_{hit}\right)}{\sum_{j \in A_t} \exp\left(\mu V_{hjt}\right)}\ .$$

The analysis of CVM responses can also be based on the RUM, and the responses are analyzed in a similar manner. Hence, the model in (1)-(2) is used but the household is asked three questions starting with if the household would or would not want to contribute to a project offering health improvements. This will be referred to as the participation question. This question is included in order to introduce a spike into the model. The essence of spike models is that they allow for a non-zero probability of zero WTP.[10] Two consecutive bids are offered to the participating household where the level of the second bid is contingent upon the response to the first one.[11] The cost *p* takes the form of a starting bid, a higher bid and a lower bid that will be denoted by B_h, B_h^u and B_h^d, respectively. The household then chooses between two alternatives where the first one is an improved state *1* with three potential costs that derive the utility U_{h1}. The second alternative is the *status quo* case U_{h0} where p_0 equals zero. If the respondent answers "no" to the participation question then his/her WTP is assumed to be zero with a positive nonzero probability *a*. On the other hand, if the answer is "yes," then four possible outcomes arise with different probabilities of occurrence:

(i) both answers are "yes" P_h^{yy},

(ii) a "yes" followed by a "no" P_h^{yn},

(iii) a "no" followed by a "yes" P_h^{ny}, and

(iv) both answers are "no" P_h^{nn}.

If, for instance, a household accepts the bid, it indicates that the utility in the case of an improvement is higher than in the *status quo* case. Further, the participating household, after an acceptance or a rejection of the bids, is offered a follow-up question asking about his/her maximum WTP. The answer to this question is referred to as a result of the open-ended procedure.

This structure of the CVM questions generates various possibilities of models to be estimated. For example, a spike model using the participation question together with the starting bid may be estimated, and a spike model with double bounds may also be estimated using the full structure of the referendum CV question.

Following Kriström (1997), to estimate the spike model, the household is faced with two questions. The first one asks whether or not it would want to contribute to the project. The second suggests a price. For a household *h*, let $S_h=1$ if WTP>0, and zero otherwise. The following formula depicts the sample log-likelihood function:

$$\ln L = \sum_{h=1}^{N} \left[S_h I \ln(1 - G(B_h)) + S_h I \ln(G(B_h)) + (1 - S_h)\ln(1 - G(0)) \right].$$

[10] For an extensive discussion on the spike models see Kriström (1997).
[11] This is the standard double bounded model see Hanemann et al. (1991).

N is the sample size, I is an indicator that equals one when the response to the second question is yes, and zero otherwise. $G(0) = a \in (0,1)$ and the probability of a "yes" response (i.e. that the household accepts the bid [B_h]) is assumed to be logistically distributed:

$$\Pr(yes) = \frac{\exp(V_1 - V_0)}{1 + \exp(V_1 - V_0)} = 1 - G(B_h).$$

This estimation is extended following the method proposed by Reiser et al. (1999), in order to allow for the estimation of a double bounded model with a spike and the incorporation of explanatory variables. Their method suggests breaking up the likelihood function into two separate parts. In the first part the spike is estimated using a logistic regression where the dependent variable c for each household is 1 or 0 according to whether the WTP is greater or equal to zero:

$$\operatorname{logit} c_h = \log(c_h / 1 - c_h) = \alpha + \gamma Z_h .$$

The second part consists of optimizing the cumulative distribution function $F(B_h)$ of the sub-population that is willing to pay anything. In this estimation the following log-likelihood function is estimated:

$$\ln L = \sum_{h=1}^{N} \left[I_{yy} \ln P_h^{yy} + I_{yn} \ln P_h^{yn} + I_{ny} \ln P_h^{ny} + I_{nn} \ln P_h^{nn} \right],$$

where I_{qw} are indicators that equal one when the two responses are qw, and zero otherwise. $P_h^{yy} = 1 - G(B_h^u)$, $P_h^{yn} = G(B_h^u) - G(B_h)$, $P_h^{ny} = G(B_h) - G(B_h^d)$ and $P_h^{nn} = G(B_h^d)$. In addition, the bid distribution is assumed to be log-logistic having the following form:

$$1 - G(B_h) = F(B_h) = \frac{\exp(\eta_h)}{1 + \exp(\eta_h)},$$

where $\eta_h = \alpha_0 + \alpha_1 \log B_h + \gamma Z_h$.

5. Socio-economic determinants of the willingness to pay

5.1 Contingent valuation results

Several explanatory variables were candidates in the preliminary estimations. Variables used in the estimation equation are the ones producing the best fit. Variable choice was based on a likelihood ratio test between various specifications. Table 5 presents the final results where most estimates are in accordance with economic theory and prior expectation. The first column depicts the results of the spike model. The dependent variable in the spike logit, the second column, is simply 1 or 0 according to whether the household's WTP is greater than or equal to zero. It can be seen that household income, the existence of diseases in the household and the household head employment state are the main factors driving the household decision of whether or not to participate in the proposed health program.

Table 5: Estimation results of the CVM†

Variables	*Spike model (logit)*	*Double bounded*	
		The spike (logit)	Participant (logit)
Intercept	0.726**	-0.865**	3.02**
	(0.194)	(0.215)	(0.432)
Price	-0.1**		-0.59**
	(0.01)		(0.046)
Socio-economic and demographic variables			
Household income (1000 Egyptian pounds per month)	0.4**	0.27*	0.86**
	(0.106)	(0.135)	(0.236)
Good health	0.442**	0.268	0.3
	(0.171)	(0.176)	(0.236)
Disease in the household	0.32	0.458*	-0.04
	(0.175)	(0.187)	(0.229)
High education-head	0.61**	0.41	1.24**
	(0.212)	(0.228)	(0.321)
Medium education-head	0.777**	0.639**	0.642**
	(0.195)	(0.207)	(0.258)
Low education-head	0.249	0.131	0.377
	(0.215)	(0.222)	(0.287)
Head employment		0.552**	-0.302
		(0.174)	(0.257)
N	732	732	417
Log-likelihood	-684.66	-476.64	-497.6
Restricted log-likelihood		-500.53	-212.22
Akaike information criteria		1.324	0.93

† Standard errors are in parentheses
** if significant at 99% level
* if significant at 95% level

The last column depicts the results of the double bounded estimation. The negative coefficient of the price variable indicates that giving the respondents a higher price reduces the probability of a respondent saying "yes." The result shows that household income has a statistically significant effect on household willingness to pay (WTP); households with larger incomes are willing to pay more for the improved health service than households with lower incomes. Hence, if monthly household income increases by 1000 L.E., then the household's WTP will increase by about 1.5 L.E. per month. High and medium educated heads had a positive and significant effect on WTP.

While estimating a Heckit model for the open-ended data, the only variable with a significant effect was the starting bid. This indicates that the open-ended data suffer from starting point bias or an anchoring effect (see Mitchell and Carson, 1989, for more details). The presence of an anchoring effect here means that the values of the open-ended WTP are not independent of the bids that were randomly distributed among households, since it is found that increasing the starting bid by one L.E. results in a 0.86 L.E. increase in the open-ended WTP. This result reveals that the estimated coefficient of the starting bid is positive and significantly different from zero. The presence of the anchoring effect suggests that the bids themselves were often important influences on what WTP the respondents stated. This may indicate some uncertainty among households about their true preferences for the proposed health improvement program. For instance, the open-ended data in a study of the benefits of groundwater protection by Press and Söderqvist (1998) also suffered from an anchoring effect. This is similar to Lauria et al. (1999) who, in their study on household demand for improved sanitation services in the Philippines, also found evidence of starting point bias.

5.2 Choice experiment results

The conditional-logit model makes use of 3028 observations. Two different specifications of the attributes are used. First, the attributes are used as continuous variables entailing the assumption that all the attributes are quantitative. As a second specification, the qualitative attributes of the health risk were described using effect codes. These codes were constructed for a four level attribute by coding the first three levels as dummy variables and coding the fourth as "-1." For example, an effect code *Level 2* is created such that if the treatment contains the second level selected, i.e. if a 5 percent reduction in the short run attribute and a 7 percent risk of contracting a disease in the long run attributes, *Level 2 = 1*, if the treatment contains the fourth level, *Level 2 = -1*, otherwise *Level 2 = 0*.The outcome of this procedure is that the coefficient on the fourth level is the negative sum of the coefficients of the other three levels. Notice that *Level 1* represents the *status quo* level of each attribute and *Level 2* to *Level 4* moves from the lowest to the highest reduction offered. These codes are advantageous in experimentally designed research for a number of reasons. For instance, in contrast to dummy variable specification, effect codes are uncorrelated with the intercept in the model. On the other hand, using effect codes is equivalent to calculating the marginal effects of the levels of each attribute. For more details on these issues consult Adamowicz et al. (1994), Louviere (1988) and Louviere et al. (2000).

The models estimated in Table 6 were investigated pair-wise using a likelihood ratio test, which resulted in that the model presented in the last column being the most preferred. Looking at the adjusted R^2, the same result may be concluded since the statistical fit of the latter is better. The variables included in the estimation of the CE (Table 6) are similar to those used in the CVM in order to ease comparison. Many of the covariates operate as expected. The effect of the constant is negative and statistically significant at the 99 percent level, indicating that with everything else held constant, it is more likely that the household will choose the *status quo*. The coefficient of the price attribute is negative and statistically significant, indicating that for each L.E. increase in the water bill, the probability of choosing an option other than the *status quo* decreases by 0.068. The coefficients of the long run health risk variables suggest a rising utility with a reduction in the probability of contracting a bad disease. This suggests that the most preferred long run health risk is 2 percent, i.e. the lowest level of this attribute, and the least preferred risk is the *status quo*. The coefficient of the short run attribute has a positive effect on the utility up to the second level. Consequently, an ambiguous effect is obtained since the coefficient of the higher level is not significant, showing that the health program choice is unaffected by the short run risk. Turning to the socio-economic and demographic covariates, most of them show a significant effect on the WTP. Households with higher income, as well as household heads with higher education are more prompted to choose an alternative that is not the *status quo*.

Table 6: Estimation results of the choice experiment†

Variables and attributes	*Attributes*	*Covariates*	*Effect codes*	*Effect codes & covariates*
Intercept	-0.78**	-2.49**	-1.047**	-2.78**
	(0.082)	(0.142)	(0.119)	(0.168)
Price	-0.064**	-0.068**	-0.064**	-0.068**
	(0.0046)	(0.0048)	(0.0047)	(0.0048)
Short run	-0.002	-0.0013		
	(0.0016)	(0.00165)		
Level 1			-0.156**	-0.18**
			(0.061)	(0.064)
Level 2			0.219**	0.227**
			(0.051)	(0.053)
Level 3			-0.043	-0.039
			(0.053)	(0.055)
Level 4			-0.017	-0.004
			(0.054)	(0.055)
Long run	0.175**	0.184**		
	(0.011)	(0.011)		
Level 1			-0.751**	-0.789**
			(0.066)	(0.068)
Level 2			-0.115*	-0.131*
			(0.054)	(0.056)
Level 3			0.146*	0.166**
			(0.058)	(0.06)
Level 4			0.718**	0.753**
			(0.049)	(0.05)
Socio-economic and demographic variables				
Household income (1000		0.4**		0.4**
Egyptian pounds per month)		(0.0678)		(0.0678)
Good health		0.345**		0.344**
		(0.091)		(0.091)
Disease in the household		0.66**		0.667**
		(0.083)		(0.083)
High education-head		1.24**		1.234**
		(0.12)		(0.12)
Medium education-head		0.929**		0.924**
		(0.11)		(0.11)
Low education-head		0.756**		0.75**
		(0.12)		(0.118)
Head employment		0.316**		0.32**
		(0.093)		(0.0925)
N	3028	3028	3028	3028
Log likelihood (coeff)	-2926.34	-2728.7	-2916	-2718.5
Log likelihood (nocoeff)	-3328.8	-3328.8	-3328.8	-3328.8
AdjustedR^2	0.12	0.178	0.122	0.181

† Standard errors are in parentheses
** if significant at 99% level
* if significant at 95% level

6. Welfare analysis

The objective of the SP task and the associated model estimates was to understand the economic impact of the changing attributes of different health programs. In economic terms this is known as welfare measurement, which refers to the amount individuals (households in this case) are willing to pay for quality or quantity changes. In this study, welfare measures refer to the amounts that households are willing to pay in addition to the bimonthly water bill for health improvements through enhanced water quality. This provides a way to monetize the benefits of health improvements, to measure based on the same scale, and to compare them to other health improvements already measured in monetary terms.

The results of the SP models can be used as a guideline for policy makers on how households trade different health risks while considering various possible health programs with diverse outcomes. The results could also serve as an indication of the benefits of improving water quality, although comparing cost and benefits is beyond the scope of my study.

6.1 Contingent valuation welfare estimates

The welfare measures are evaluated using various models in which the results vary with model specification. Starting with the open-ended approach, the mean and median WTP for health improvement is estimated to be 6.8 and 5 L.E./bill, respectively. In the spike model without covariates, the mean WTP is 9.02 L.E./bill. Concerning the double bounded without a spike, the mean and median willingness to pay are estimated to be around 7 and 5 L.E./bill, respectively. The counterparts of the welfare estimates generated when introducing a spike to the double bounded model are lower, scoring 4.8 and 2.9 L.E./bill, respectively. Table 7 presents the welfare estimates at sample mean, mean of the sample and for a specific household. The 95 percent confidence intervals (CI) are also depicted. As expected, the double bounded give lower point estimates and tidier CI.

Table 7: CVM welfare estimates and their confidence intervals in Egyptian pounds

	Spike	*Double bounded without a spike*	*Double bounded with a spike*
Mean without covariates	9.02	6.96	4.797
	[7.29, 10.75]	[6.58, 7.34]	[4.21, 5.38]
Mean with covariates	7.97	6.2	3.87
	[5.42, 10.52]	[5.08, 6.95]	[3.03, 4.71]
Mean average household with covariates	8.99	6.68	4.4
	[6.28, 11.7]	[5.86, 7.5]	[3.56, 5.24]
Mean specific household with covariates†	10.51	6.51	4.27
	[7.16, 13.87]	[5.56, 7.46]	[3.33, 5.21]

†The mean for the specific household is based on a household with an average income, contaminated with diarrhea, the household head has a medium education and is employed.

6.2 Choice experiment welfare estimates

In order to compare welfare measures from each model, the choice experiment is restricted to estimate the welfare impact of the same improvement offered in the CVM. For the choice experiment, changes of a proposed health improvement through a better water quality is calculated using the following expression (Hanemann, 1999):

$$W = \frac{1}{\delta}\left[\ln \sum_{h \in A} e^{V_{h0}} - \ln \sum_{h \in A} e^{V_{h1}}\right], \tag{3}$$

where W is the compensating variation, d is the marginal utility of income (which is considered to be the coefficient of the price attribute), V_{h0} and V_{h1} represent the utility before and after the change. A is the choice set of the household. Using the CE model, the value of health improvement, similar to the CVM, offered to an average household in the sample, is estimated to be around 6.8LE/bill.

Table 8 depicts the welfare estimates for the CE model with a proposed improvement in the short run of 25 percent and 2 percent risk in the long run. The 95 percent CI for the estimates are also calculated. The mean with covariates of the effect codes estimates is the one to rely on, since this model explains the data better than the others due to a better statistical fit. A final caveat is that the reader should be aware of the fact that the attributes of alternatives can be varied in expression (3), and the impact of changing any one or a combination of attributes can be examined. This provides the decision makers with the information they need to compare the impacts of various alternatives.

Table 8: The CE welfare estimates and their confidence intervals in Egyptian pounds

	Attribute	*Effect codes*
Mean without covariates	8.92	8.35
	[7.32, 10.52]	[6, 10.71]
Mean with covariates	10.28	9.712
	[6.68, 13.89]	[5.73, 13.7]
Mean average household with covariates	6.8	6.18
	[3.55, 10.54]	[2.47, 9.89]
Mean specific household with covariates†	15.45	15
	[11.96, 18.94]	[11.14, 18.81]

†The mean for the specific household is based on a household with an average income, contaminated with diarrhea, the household head has a medium education and is employed.

6.3 Comparing the methods

Welfare effects of changes in health through a change in water quality is estimated and compared. Although two different methods are used, comparison is still feasible due to the common basis of the utility theory, as previously discussed. Note that the choice experiment model allows estimation of welfare impacts for different levels of the attributes. As for the CVM, only one change can be examined where the suggested improvement is a decrease in the short run health effect due to poor water quality by 25% and a reduction in the probability of contracting waterborne diseases in the long run to 2%. Thus, in order to compare welfare measures from each model, the choice experiment is restricted to estimate the welfare impact of the same improvement offered in the CVM. The hypothesis of equivalence between the CVM and CE estimates is tested. The test is conducted for different specifications of CVM estimation models and welfare measures against the corresponding welfare measures estimated from the effect codes specification of the CE. The latter specification is chosen because it provides superior estimation efficiency and a greater explanatory power. In Table 9 the confidence intervals for the difference between the CE and CVM welfare estimates are constructed and depicted. The results indicate that welfare estimates of CVM and CE are in general quite similar.[12]

[12] However, when estimating the CVM using a dichotomous choice response and a binary logit specification, the corresponding welfare measures were significantly greater than those generated by the CE.

Table 9: 95% confidence intervals for the difference between the CE and CVM welfare estimates.

	Spike	*Double bounded without a spike*	*Double bounded with a spike*
Mean without covariates	[-4.76, 3.42]	[-1.34, 4.12]	[0.61, 6.49]
Mean with covariates	[-4.79, 8.27]	[-1.22, 8.62]	[1.02, 10.67]
Mean average household with covariates	[-9.23, 3.61]	[-5.03, 4.03]	[-2.77, 6.32]
Mean specific household with covariates†	[-2.72, 11.65]	[3.69, 13.24]	[5.94, 15.47]

†The mean for the specific household is based on a household with an average income, contaminated with diarrhea and the household head has a medium education and is employed.

The welfare measures estimated for the CVM have exhibited differences in magnitude depending on the econometric specification. Nevertheless, it should still be noted that the welfare values given by the CE are quite similar to the ones calculated for the CVM. The results obtained here are the opposite of Boxall et al. (1996) where the CVM estimate was higher than the CE estimate by a factor of 20. Something that could have driven their result is the method used in estimating the CVM results where the single bounded usually produces higher welfare measures. Those measures are also sensitive to the selected model. Moreover, Boxall et al. asked the respondents who were currently hunting, and few were likely to hunt in the site. The latter group of respondents may never hunt in the site at all and thus the probability of use of the good does not differ between the two choices of their CVM exercise. Hence, any response has the same impact on the respondent's utility, implying a violation of the incentive compatibility constraint. Consequently, this group of respondents may have driven a portion of the results to higher CVM welfare estimates. On the other hand, Hanley et al. (1998) find that the welfare estimates calculated from a quadratic CE are comparable to the CVM estimates, while the CE estimate is greater than either of these. Whilst the results obtained in this paper suggest that the estimates are similar, it is difficult to draw firm conclusions about the relationship between the welfare estimates of the CVM and CE from this limited set of studies, since the direction of the relationship varies from study to study. However, Hanley et al. point out the usefulness of the CE approach as opposed to the CVM in offering greater potential for benefit transfer. Also, the CE seems best suited to value individual characteristics that make up a policy, while the CVM is best at valuing an overall policy package, since in the former the attributes of alternatives can be varied and the impact of changing any one or a combination of them can be examined. Allowing the identification of the trade-offs that each individual makes between attributes (Swait and Adamowicz, 2001).

7. Discussion and conclusion

This paper presents an application of the CE and CVM analysis of health improvements through better water quality. The methods were administered to a sample of 1500 households living in metropolitan Cairo, i.e. the Cairo, Kalyubia and Giza governorates. The study asked the households to value a health risk that they had actually experienced (i.e. the short run effect) and a "synthetic" illness that the interviewers described to them. This provides information that can be used to better understand the structure of the benefits of water quality improvement or other health programs in metropolitan Cairo. The analysis of the social determinants of the willingness to pay can also be used to give insights concerning other issues such as tariff construction. The fact that education is a strong determinant of the willingness to pay also underlines the importance of public awareness concerning sanitation, hygiene and education in general.

One of the purposes of this paper is methodological and in that respect it can be concluded that no significant differences are found between the estimated values of the changes in health risk derived from both methods. The fact that the results are similar is very important; particularly considering the concerns researchers have had about response difficulties in CVM and the NOAA guidelines on the importance of calibrating CVM results against other methods. One of the lessons learned from the literature together with this piece of work is that both methods may lead to equivalent outcomes through the model and welfare specification. Hence, researchers are encouraged to choose the method that seems best suited for their task, i.e. if they want to value attributes or situational changes, while they should bear in mind that CE can do both. However, perhaps focus should instead be put on the many other sources of uncertainty in this area such as design issues, information issues and the relationship between stated willingness to pay on the one hand and total social benefits on the other.

For instance, as pointed out by Whittington (1998), there are ethical issues in developing countries when a referendum elicitation procedure is used; in the sense that asking households to pay different prices for the same good could create confusion or raise fairness debate in the community, since information in a developing country community spreads quickly. I argue that these problems may be reduced using CE since the respondent is offered several choices. The respondent is thus forced to make trade-offs, which may give him/her the feeling that he/she is more involved in the decision making process. This is in contrast to the CVM, which focuses on a specific situation with a "take it or leave it" alternative. Although the CE may work around ethical issues it exposes the respondent to higher levels of complexities.

Turning to the empirical results, the households in metropolitan Cairo have a positive WTP to reduce health risks related to water quality. The WTP concerns a 25% decrease in the short run health effect due to poor water quality, and a reduction in the probability of contracting waterborne diseases in the long run to 2%. This WTP varies between one and one and a half percent of the mean income. Although estimates of costs are beyond the scope of this study, it is worth noting that water infrastructure is typically expensive and the value of benefits found appears to be far from cost recovery. The WTP is rather low in absolute terms, indicating that it is economically not worth implementing this health program. To give some orders of magnitude the WTP is found to be approximately 17 USD per household per year and the cost of rehabilitation and upgrading water connections may be around 120-240 USD per household per year according to the World Bank (1995). However, neither the cost of the improvement discussed here nor the savings on public health expenditure due to such a program are known.

Nevertheless, the author is reluctant to draw such a conclusion since the respondents may not have taken the externalities involved (such as the spread of the diseases) into account. This low WTP could possibly be attributed to limitations in understanding health problems and their sources. Alternatively, it may reflect a psychological defense or misinformation, or the respondents' beliefs that such problems are beyond their control. Furthermore, the size of the large health reductions in the scenarios may have been difficult to comprehend, implying that the respondents might have been valuing a risk change different (and smaller) than the one stated in the survey. This may be seen as a form of scenario rejection (cf. Mitchell and Carson, 1989).

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Appendix A

Table A1: The distribution of the bids on the sub-sample and the number of yes/no saying

Lower, starting and upper bids	*Bid values*	*Number of households asked*[a]	*Yes*	*No*
Lower bid (B_h^d)	2		6	9
Starting bid (B_h)	3	81	66	15
Upper bid(B_h^u)	4		41	25
B_h^d	3		2	11
B_h	4	84	71	13
B_h^u	5		55	16
B_h^d	4		8	11
B_h	5	93	75	19
B_h^u	6		49	26
B_h^d	5		9	9
B_h	6	76	58	18
B_h^u	7		40	18
B_h^d	6		10	11
B_h	7	82	61	21
B_h^u	8		51	10

[a] This is the number of households from the sample that were given a price after they had agreed to participate in the project.

Table A2: Consistency test of the bids

Probability	*Proportions*	
	Yes/no	No/yes
Pr $\{3 \leq WTP \leq 4\}$	2.7	6.5
Pr $\{4 \leq WTP \leq 5\}$	4.4	2.4
Pr $\{5 \leq WTP \leq 6\}$	2.7	2
Pr $\{6 \leq WTP \leq 7\}$	3.2	2.1

Table A3: Description of the sample and variables used in the analysis

Variables	*Choice experiment*				*Contingent valuation*			
	Mean	Std.	Min	Max	Mean	Std.	Min	Max
Household size	4.29	1.77	1	11	4.33	1.84	1	13
Female household head	0.14	0.35	0	1	0.13	0.34	0	1
# people working for money	1.18	0.75	0	5	1.14	0.73	0	4
# children under15	1.25	1.35	0	10	1.15	1.25	0	5
# children between 5 and 15 years	0.87	1.08	0	5	0.81	1.03	0	4
# children under 5	0.42	0.7	0	4	0.34	0.65	0	3
Overall household subjective health	2.11	0.87	1	5	2.15	0.86	1	5
Very good	0.25	0.43	0	1	0.2	0.4	0	1
Good	0.47	0.5	0	1	0.53	0.5	0	1
Not bad	0.22	0.42	0	1	0.203	0.4	0	1
Bad	0.06	0.23	0	1	0.044	0.2	0	1
Household member previously ill due to water	0.06	0.23	0	1	0.045	0.21	0	1
Diseases in the household	*0.41*	*0.49*	*0*	*1*	*0.24*	*0.43*	*0*	*1*
Diarrhea	0.39	0.49	0	1	0.22	0.41	0	1
Cholera	0.005	0.07	0	1	0.001	0.04	0	1
Typhoid	0.011	0.1	0	1	0.014	0.12	0	1
Hepatitis	0.03	0.16	0	1	0.007	0.082	0	1
Visited a Doctor	0.24	0.43	0	1	0.21	0.4	0	1
Expenses of medical support	4.44	17.38	0	250	4.36	25.09	0	600
Household Head characteristics								
Age	48	13	10	95	49.13	12.81	21	95
High education	0.28	0.45	0	1	0.24	0.43	0	1
Medium education	0.25	0.43	0	1	0.27	0.44	0	1
Low education	0.19	0.39	0	1	0.19	0.39	0	1
Employed	0.73	0.44	0	1	0.72	0.45	0	1
Respondent characteristics								
Female	0.59	0.49	0	1	0.58	0.5	0	1
Age	45.06	13.8	10	95	46.62	13.27	20	95
High education	0.24	0.43	0	1	0.212	0.41	0	1
Medium education	0.26	0.44	0	1	0.255	0.44	0	1
Low education	0.19	0.39	0	1	0.184	0.39	0	1
Employed	0.42	0.49	0	1	0.42	0.49	0	1
Water characteristics in the household								
Bad odor	0.25	0.43	0	1	0.21	0.41	0	1
Frequency of bad odor	0.103	0.304	0	1	0.1	0.29	0	1
Dirty	0.42	0.49	0	1	0.34	0.48	0	1
Frequency of dirtiness	0.18	0.39	0	1	0.2	0.4	0	1
N	758				732			

Appendix B: Contingent Valuation Questionnaire

Cairo University
Faculty of Economics and Political Science

Survey on the Health Effect of Drinking Water an Application to Metropolitan Cairo

Contingent valuation

Starting bid	Lower bid	Higher bid
☻	☼	☺

The data collected is confidential and will only be used for research

INTRODUCTION AND SCREENING

Good morning, may I speak to the (male/female) head of the household?

YES………………………… (**CONTINUE**)
NO………………………..…. (**END INTERVIEW)**

Is your apartment connected to the government piped water system?

YES………………………… (**CONTINUE**)
NO………………………..…. (**END INTERVIEW)**
DON'T KNOW…………….. (**END INTERVIEW)**

My name is ______________. I work for Cairo University. We are conducting research about the health effect of drinking water in Cairo. We would appreciate if you would agree to participate in this research. I have some questions that I would like you to answer. The interview will take about 30 minutes. You do not have to participate. If you choose to participate, you do not have to answer all the questions and you may stop the interview at any time. Your answers will be confidential.

I will be asking you a number of questions about your household. When I say your household, I mean the group of people you live with who are related (or not related) to you and with whom you share living expenses. Please answer the questions for your household. Do not think about other people or households who may live with you in this building.

IDENTIFICATION	
GOVERNORATE____________ PSU[†]/ SEGMENT NO.____ KISM/MARQAZ____________ MANTEKA_____________ SHIAKHA____________________________________ HOUSEHOLD NO.________________________________ BUILDING NO. ____________ HOUSING UNIT NO.____ NAME OF HOUSEHOLD HEAD__________________ ADRESS IN DETAIL_____________________________	GOVERNORATE ☐☐ PSU/ SEGMENT NO ☐☐☐☐☐☐ HOUSEHOLD NO. ☐☐☐

† Primary sampling units

INTERVIEWER VISITS			FINAL VISIT
	1	2	DAY ☐☐ MONTH ☐☐ YEAR ☐☐☐☐
DATE	________	________	
TIME	________	________	
TEAM	________	________	TEAM ☐☐
INTERVIEWER	________	________	INTERVIEWER ☐☐
SUPERVISOR	________	________	SUPERVISOR ☐☐
RESULT			RESULT ☐
NEXT VISIT: DATE	________	________	TOTAL VISITS ☐
TIME	________	________	

RESULT CODES: 1 COMPLETED 2 NO HOUSEHOLD MEMBER AT HOME OR NO COMPETENT PERSON AT HOME AT THE TIME OF VISIT 3 ENTIRE HOUSEHOLD ABSENT FOR AN EXTENDED PERIOD 4 POSTPONED 5 REFUSED 6 DWELLING VACANT OR ADDRESS NOT A DWELLING 7 DWELLING DESTROYED 8 OTHER__________________________ (SPECIFY)	TOTAL IN HOUSEHOLD ☐☐ TOTAL MEMBERS UNDER 15 YEARS ☐☐

	FIELD EDITOR	OFFICE EDITOR	CODER	KEYER
NAME	______________	______________	__________	__________
DATE	/ / 200	/ / 200	/ / 200	/ / 200
SIGNATURE	______________	______________	__________	__________

Record the time the interview starts: (FILL IN TIME AND CIRCLE AM OR PM) TIME [ ] AM PM

SECTION 1: SOURCE OF DRINKING WATER

No.	Questions and their determinants	Answer coding	Go to
I would like to talk about the water you drink.			
01	What is the main source of drinking water for the members of your household?	**PIPED WATER** PIPED INTO RESIDENCE…………………….…1 PIPED INTO YARD/PLOT………………………..2 PUBLIC TAP……………………………………3 **WATER FROM OPEN WELL** OPEN WELL IN RESIDENCE…………………4 OPEN WELL IN YARD/PLOT………………....5 OPEN PUBLIC WELL…………………………6 **WATER FROM PROTECTED WELL** PROTECTED WELL IN RESIDENCE…………7 PROTECTED WELL IN YARD/PLOT…………8 PROTECTED PUBLIC WELL…………………9 **SURFACE WATER** NILE/CANALS…………………………………10 **BOTTLED WATER**…………………………11 **OTHER** (SPECIFY)____________________12	 → 8
02	How much do you pay for drinking water?	LE PT Monthly amount ………… [ ][ ] [ ][ ] Free of charge…………………… 99995	
03	Do you boil the water before using it for drinking?	YES……………………………………1 NO………………………………………2	 5
04	Why do you boil the water?	______________________________ ______________________________	
05	Are you aware that bad water quality could be a source of illness to you or one of the members of your family?	YES……………………………………..1 NO……………………………………...2 DON'T KNOW…………………………3	
06	What type of illness could be caused by bad water quality?	(see sub-table below)	
07	Does the water smell?	NEVER…………………………………1 SOME TIMES…………………………2 USUALLY…………………………...3 DON'T KNOW…………………………8	→ 10 → 10
08	How often does this happen?	ALWAYS………………………………1 ONCE A MONTH……………………2 ONCE A WEEK……………………...3 SELDOMLY……………………………4 OTHER________________________6 (SPECIFY)	

Question 06 answer coding:

	YES Spontaneous	YES Asked	No
A. Diarrhea……………	1	2	3
B. Cholera………………	1	2	3
C. Typhoid……………..	1	2	3
D. Kidney failure………	1	2	3
E. Hepatitis……………	1	2	3
F. Other_____________ (SPECIFY)	1	2	3

No.	Questions and their determinants	Answer coding	Go to
09	What do you do in this case?	USE IT AS USUAL……………………….a BUY WATER FOR DRINKING AND COOKING……………………………..b WAIT UNTIL ODOR DISAPPEARS….c OTHER (SPECIFY)________________x	
10	Do you think that the water is dirty?	NEVER……………………………………1 SOME TIMES…………………………….2 USUALLY……………………………….3 DON'T KNOW…………………………..8	→ 14 → 14
11	How often does this happen?	ALWAYS……………………………….1 ONCE A MONTH…………………….…2 ONCE A WEEK……………………….…3 SELDOM………………………………..4 OTHER (SPECIFY)________________6	
12	What do you do in this case?	USE WATER PUMP………………….…a BUY WATER FOR DRINKING AND COOKING……………………………..b USE A FILTER………………………….c USE COTTON AS A FILTER………….d WAIT UNTIL ODOR DISAPPEARS….e OTHER (SPECIFY)________________x	} 14
13	How many bottles of mineral water do you use per week? (IF THE RESPONDENT DOES NOT KNOW PROBE WITH "per day")	(SPECIFY)#____________ PER WEEK (SPECIFY)#____________ PER DAY	
14	Has anyone in your household ever been ill because of water?	YES……………………………………..1 NO…………………………………….2 DON'T KNOW…………………………3	 } 15A

No.	Questions and their determinants	Answer coding	YES	YES Asked	No	Go to
15	What type of illness?	A. Diarrhea…………	1	2	3	} 16
		B. Cholera……………	1	2	3	
		C. Typhoid……………	1	2	3	
		D. Kidney failure……..	1	2	3	
		E. Hepatitis…………..	1	2	3	
		F. Other____________ (SPECIFY)	1	2	3	

No.	Questions and their determinants	Answer coding	YES	NO	Go to
15A	Has anyone in your household got ill with…				
	A. Diarrhea?	A. Diarrhea…………	1	2	
	B. Cholera?	B. Cholera……………	1	2	
	C. Typhoid?	C. Typhoid……………	1	2	
	D. Kidney failure	D. Kidney failure……..	1	2	
	E. Hepatitis	E. Hepatitis…………..	1	2	
	F. Any other diseases?	F. Other____________ (SPECIFY)	1	2	

SECTION 2: COST OF PIPED WATER

No.	Questions and their determinants	Answer coding	Go to
The next questions are about how much it costs you to have piped water in your home.			
16	Who do you pay for the piped water you get in your home?	DON'T PAY…………..……………….1 THE GOVERNMENT COLLECTOR…2 THE LANDLORD……………………...3 A NEIGHBOR………………………….4 OTHER (SPECIFY)________________ 5 DON'T KNOW…………………………6	
17	How often do you pay for the water?	EVERY MONTH………………………1 EVERY TWO MONTHS………………2 # OF MONTHS IF > 2______________ 3 DON'T PAY FOR WATER……………4 DON'T REGURLARLY PAY…………5 OTHER (SPECIFY)________________ 9	
18	The last time you paid for piped water, how much did you pay?	LE PT AMOUNT……………. ☐☐ ☐☐ PAID WITH RENT………………..99995	→ 20
19	How much of your rent each month goes to pay for water?	LE PT AMOUNT………………. ☐☐ ☐☐ DON'T KNOW……………………99996	

SECTION 3: WATER RELIABILITY

No.	Questions and their determinants	Answer coding	Go to
The next few questions are about when you can get water from the taps in your apartment now.			
20	Is your tap connected to…?	Motor for pumping up water………a Water tank…………………………b None……………………………….c Other (SPECIFY)________________ x	
21	During the past four weeks, was your water pressure good at all times or did you sometimes have low water pressure or water cut-offs?	GOOD AT ALL TIMES……………1 MEDIUM PRESSURE……………..2 LOW PRESSURE…………………..3	1 → 25
22	During the past four weeks, about how often was your water cut or your water pressure too low?	LESS THAN ONCE EACH WEEK..1 ABOUT ONCE EACH WEEK……..2 SEVERAL TIMES EACH WEEK…3 EVERY DAY………………………4 DON'T KNOW…………………….5	1 → 25
23	At which time of the day do you usually suffer a cut off of water or your water pressure is low?	Mornings……………………………a Noon………………………………...b Afternoon……………………………c Evenings…………………………….d	
24	Do you know about how many hours that day your water was cut or you could not get enough water for your needs?	# OF HOURS………………… ☐☐ DON'T KNOW……………………99	

SECTION 4: HOUSEHOLD COMPOSITION AND HEALTH STATUS

No.	Questions and their determinants	Answer coding	Go to
I would now like to talk more about your household. Remember, by your household I mean the *group of people you live with who are related to you and with whom your share living expenses.*			
25	Including yourself, how many household members live here?	(FILL IN)________________PEOPLE	
26	(Including yourself) how many of the men in your household are 15 years old or older?	(FILL IN)_________________MEN	
27	(Including yourself) how many of the women in your household are 15 years old or older?	(FILL IN)________________WOMEN	
28	How many members in your household are between five and 15 years old?	(FILL IN)___________# BETWEEN 5-15 YEARS	
29	How many children in your household are less than five years old?	(FILL IN)____________ CHILDREN	
30	Over the last 12 months, how would you say your health has been on the whole?	VERY GOOD………………………1 GOOD………………………………2 FAIR………………………………..3 POOR………………………………4 VERY POOR……………………….5	
31	Has any member in your household had diarrhea in the last 14 days?	YES………………………………...1 NO…………………………………2	 → 36
32	Was the diarrhea caused by water?	YES………………………………...1 NO…………………………………2 DON'T KNOW…………………..…3	
33	How many members in your household have had diarrhea in the past 14 days?	(FILL IN) # OF ADULTS…………………..☐☐ # OF ADOLESENTS (5-14 YEARS)…………………...☐☐ # OF CHILDREN UNDER 5……☐☐	
34	Diarrhea can be severe or mild. In your opinion, how many of the members who had diarrhea in the past 14 days, had severe diarrhea?	(FILL IN) # OF ADULTS…………………..☐☐ # OF ADOLESCENTS (5-14 YEARS)…………………☐☐ # OF CHILDREN UNDER 5……☐☐	
35	Of the members in your household who had diarrhea in the last 14 days, how many of those cases happened in the past 24 hours?	(FILL IN)_________________CASES	
36	In the past 12 months, has anyone in your household received medical treatment for diarrhea?	YES………………………………...1 NO…………………………………2	 → 39
37	The last time someone in your household received treatment for diarrhea, where did they go?	**PUBLIC SECTOR** PUBLIC HOSPITAL………………………..a PUBLIC CLINIC……………………………b CHILD AND MOTHERHOOD CARE CENTER……………………………………c **PRIVATE SECTOR** PRIVATE HOSPITAL /CLINIC…………....d PRIVATE PRACTITIONER………………..e PHARMACY………………………………..f TRADITIONAL PRACTITIONER………...g FRIEND/RELATIVE………………………h **OTHER** (SPECIFY)___________________x	
38	How much did you have to pay for the treatment you received?	_____________LE___________PT	

SECTION 5: PROGRAM TO REDUCE HEALTH RISK FROM DRINKING WATER

<table>
<tr><th>No.</th><th>Questions and their determinants</th><th>Answer coding</th><th>Go to</th></tr>
<tr><td>39</td><td colspan="3">The water agency is seriously planning a project to improve health through the provision of a better water quality in some districts of metropolitan Cairo. I am going to describe the project that is being considered for your region (heta). Please listen carefully while I describe the project.
The number of days per year that you suffer from diarrhea will decrease. And consuming better water quality can reduce the probability of contracting a viscous disease such as cholera, Typhoid and hepatitis, in the long term. The water agency can improve your health through the provision of better water quality in your heta by using a special process of purification. Water service in your heta will not change. You will still have water with the same pressure, taste and clearness. There will be water with lower health risks in the tap. This means you will not need to filter, boil or buy bottled drinking water for your household.</td></tr>
<tr><td>40</td><td>How do you think your household's health will change if you can get a better quality of water from your tap?</td><td>______________________________
____
______________________________</td><td></td></tr>
<tr><td colspan="4">The water agency can supply better water quality where:
• Better water quality allows water plants to use more efficient methods (chemicals) for purifying water.
• Supplying better water quality allows the network to replace small, broken, and leaky pipes. These pipes cause the recontamination of water before water reaches your home.
• Supplying better water quality reduces health risks (the probability of getting waterborne diseases/illness).

If the water agency supplies better water quality implying an improved health where…
• The number of days in a year that any member of your household get short run health diseases e.g., diarrhea will be decreased.
• The probability of you or any member of your household contracting a long-term disease (as cholera, kidney failure) will be decreased.
• You will not have to boil water, use a filter or buy bottled water.
• Every household in your heta will pay its share of the costs of better health through the supply of better water quality. Payments will be in the form of a water bill or an increase in the water bill. You will have to pay a higher bill as long as the network is supplying better water quality.

If the water agency does not supply better water quality and your health conditions will remain as they are today…
• Your household's payments to the water agency will stay as they are now.
• Your water quality will stay like it is now.
• Your current health will stay the same.
• The probability of you or any member of your household contracting a waterborne disease in the future will stay the same as today.</td></tr>
<tr><td>41</td><td>Before I go on, do you have any questions about the water agency's plan to improve your health through the supply of better water quality in your heta?</td><td>YES…………………………………1
NO…………………………………..2</td><td>
→ 42</td></tr>
<tr><td>41A</td><td>What would you like to know?
IF THE RESPONDENT ASKS ABOUT COSTS, CLICK HERE ☐ AND SAY: "I will come to that in a moment."</td><td>______________________________
____
______________________________</td><td></td></tr>
</table>

<table>
<tr><th>No.</th><th>Questions and their determinants</th><th>Answer coding</th><th>Go to</th></tr>
<tr><td>42</td><td colspan="3">When we talk to other households, we find that some people want the water agency to supply water with better quality implying an improvement in short and long term health. We also find others who do not want it.
Those who want an improved health through better water quality say things like:
▪ Having better health is worth the cost.
▪ They are tired of being ill and going to the clinic to get a treatment.
▪ Buying bottled water is costly and time consuming.
▪ They want to minimize the risk of getting a waterborne disease in the future (such as hepatitis and kidney failure).

Those who do not want an improved health through better water quality say things like:
▪ They would rather save their money and spend it on other things.
▪ They are not bothered by the water quality.
▪ They never get sick because of the water.
▪ They cannot afford the cost of improved health through the supply of better quality water.
▪ They do not believe that they will be ill in the future because of bad water.</td></tr>
<tr><td>43</td><td>Supplying an improved health through better water quality is a program that costs money. We are however uncertain about the exact cost. The water agency cannot afford to implement the program unless it collects enough money to cover the costs. Every household in your heta will pay its share of the costs of supplying an improved health through better water quality.

SHOW THE VISUAL AIDS OF THE REDUCTION IN ILL DAYS AND THE RISK OF ILLNESS

The water agency wants to know whether households like yours are willing to pay anything to reduce by 25% the number of days you are affected by diarrhea due to water per year and the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will also be reduced to 2%.</td><td>YES……………………….1
NO………………………..2</td><td>
→ 48</td></tr>
<tr><td>44</td><td>The water agency wants to know whether households like yours are willing to pay to reduce the number of days that you suffer from diarrhea due to water per year by 25% and the probability of contracting a waterborne disease in the long run such as cholera, typhoid, and hepatitis will also be reduced to 2% if it costs you LE ☻ increase in the water bill.
If the supply of an improved health through better water quality costs your household an extra ☻ pounds per bill, would your household want this health improvement or not?</td><td>YES, WANT IT AT LE ☻/BILL…………………1
NO, DO NOT WANT IT AT LE ☻ /BILL…………..2</td><td>

→ 46</td></tr>
<tr><td></td><td colspan="3">IF THE RESPONENT SAYS HE/SHE CANNOT MAKE A DECISION FOR THE HOUSEHOLD BY HIMSELF/HERSELF, CHECK HERE ☐ AND SAY.... “In your opinion, what would your household decide?</td></tr>
<tr><td></td><td colspan="3">IF THE RESPONDENT ASKS ABOUT THE WEEKLY COST OR TRIES TO FIGURE IT OUT CHECK HERE ☐ AND SAY… “☻ pounds per bill is the same as ☻ pounds per week”</td></tr>
<tr><td></td><td colspan="3">IF THE RESPONDENT TALKS ABOUT WHAT THE NEIGHBORS WOULD DECIDE, CHECK HERE ☐ AND SAY… “We are only interested in your family. In your opinion, what would your household decide?”</td></tr>
</table>

No.	Questions and their determinants	Answer coding	Go to
45	Suppose the actual increase in water bill is higher. And it turned out to be ☺ pounds per bill instead of ☻ pounds per bill. If better health costs your household ☺ pounds per bill, would your household be willing to pay for better health or not?	YES, WANT IT AT LE ☺/BILL…………………1 NO, DO NOT WANT IT AT LE ☺/BILL……………..2	47
46	Suppose the actual increase in water bill is lower. And it turned out to be ☼ pounds per bill instead of ☻ pounds per bill. If better health costs your household ☼ pounds per bill, would your household be willing to pay for better health or not?	YES, WANT IT AT LE ☼/BILL …………………1 NO, DO NOT WANT IT AT LE ☼/BILL………………2	
47	The water agency wants to know: What is your household's maximum willingness to pay per bill, for a reduction of the number of days you suffer from diarrhea due to water by 25%, and for a reduction of the probability of contracting a waterborne disease in the long run such as cholera, typhoid, and hepatitis to 2%?	LE PER BILL……[ ][ ][ ]	→ 49

SECTION 6: DEBRIEFING

No.	Questions and their determinants	Answer coding	Go to
48	People have different reasons for whether they want the water agency to supply an improved health through better water quality or not. Can you tell me about the main reason why you decided that your household would not want the water agency to supply an improved health through better water quality? **(PROBE with "Anything else?").**	DON'T HAVE HEALTH PROBLEMS THROUGHOUT THE YEAR ……………...a DON'T BELIEVE THAT WATER CAN CAUSE ANY HEALTH CONTAMINATION IN THE LONG RUN………………………..b CANNOT AFFORD TO PAY ANY EXTRA EXPENSES…………….………………...c THE WATER AGENCY CANNOT PROVIDE THIS SERVICE ………………..d OTHER (SPECIFY)________________ x	50
49	People have different reasons for whether they want the water agency to supply an improved health through better water quality or not. Can you tell me about the main reason why you decided that your household would want the water agency to supply an improved health through better water quality?	REDUCE NUMBER OF ILL DAYS PER YEAR ……………………………………….a REDUCE THE PROBABILITY OF CONTRACTING A WATERBORNE DISEASE IN THE FUTURE ………………b AN IMPROVED HEALTH IS WORTH THE COST………………………………………..c OTHER (SPECIFY)________________ x	
50	In your opinion, do you think that the water agency can provide this type of service?	YES……………………………1 NO…………………………….2	
51	In your opinion, do you think better water quality in your heta will improve your health?	YES……………………………1 NO…………………………….2	
52	Why do you think a supply of better water quality (will / will not) improve your health?	________________________________ ________________________________	

SECTION 7: CHARACTERISTICS OF THE RESPONDENT'S BUILDING

No.	Questions and their determinants	Answer coding	Go to
I would like to talk now about the building where your household lives.			
53	What is the building made of?	RED BRICK / CEMENT…………..1 WOOD……………………………..2 TIN…………………………………3 ADOBE…………………………….4 OTHER (SPECIFY)_____________9	
54	Does your household live in….? (READ RESPONSES AND CIRCLE ONLY ONE)	AN APARTAMENT………………1 A ROOM OR MORE IN AN APARTMENT……………………...2 A SEPARATE HOUSE…………….3 OTHER________________________ 9 (SPECIFIY)	
55	A. How many rooms does your household live in? (EXCLUDING BATHROOMS AND KITCHEN). B. How many do you use as bedrooms? Do you have… C. a kitchen? D. bathrooms?	(FILL IN) _____________# OF ROOMS _____________# OF BEDROOMS _____________#OF KITCHENS _____________#OF BATHROOMS	
56	What is the approximate surface of your apartment in square meters?	(FILL IN)____________AREA IN M^2	
57	What are most of the floors in your apartment/room covered with?	**NATURAL FLOOR** EARTH/SAND…………………………….11 **RUDIMENTARY FLOOR** WOOD……………………………………..21 **FINISHED FLOOR** PARQUET OR POLISHED WOOD……...31 CERAMIC/MARBLE TILES……………..32 CEMENT TILES…………………………33 CEMENT………………………………….34 WALL-TO-WALL CARPET……………..35 LINOLEUM……………………………….36 **OTHER** _________________________ 96	
58	What are most of the walls in your flat/room covered with?	OIL (PAINT)………………………………..1 WOOD………………………….………...2 PLASTER………………………………….3 BARE CONCRETE…………….……….4 WALLPAPER………………………………5 OTHER___________________________ 9 (SPECIFY)	
59	Including the ground floor, how many floors does the building have?	(FILL IN) ______________FLOORS	
60	About how many apartments are there in this building?	(FILL IN)_________APARTMENTS	
61	What floor of the building do you live on?	GOUND FLOOR……………………………a FIRST FLOOR……………………………...b SECOND FLOOR…………………………..c HIGHER THAN SECOND…………………d OTHER___________________________ x (SPECIFY)	
62	About how long does it take to walk from the building you live in to the nearest public transportation (metro, bus, minibus, microbus)?	MINUTES………………… ☐☐	

No.	Questions and their determinants	Answer coding	Go to
63	Does someone in your household own this place where you live or does your household rent this place?	RENT THE HOME……………….1 → OWN THE HOME………………..2 COLLECTIVE OWNERSHIP……3 OTHER (SPECIFY)_____________ 9	65
64	If you could buy a place to live just like this in this heta today, how much would it cost?	(FILL IN)______PER THOUSAND LE DON'T KNOW…………………9999	69
65	Suppose an apartment just like yours was for sale in this heta. In your opinion, how much would it cost?	(FILL IN)__________________LE DON'T KNOW……………..9999999	
66	How much did your household pay for rent last month?	(FILL IN)____________LE/MONTH	
67	If your household could rent a (apartment/ room) just like yours in your heta today, how much would you have to pay up front (kelo rigl)?	(FILL IN)______________LE/MONTH DON'T KNOW……………..9999999	
68	How much would you have to pay each month for rent?	(FILL IN)____________LE/MONTH	

SECTION 8: CHARACTERISTICS OF HOUSEHOLD POSSESSION

No.	Questions and their determinants	Answer coding	Go to
69	What type of fuel does your household use for cooking?	ELECTRICITY …………………………………..a LPG/NATURAL GAS …………………………...b KEROSENE………………………………………..c COAL/IGNITE ……………………………………d CHARCOAL ……………………………………...e FIREWOOD/STRAW ……………………………f DUNG……………………………………………..g OTHER(SPECIFY)________________________x	

No.	Questions and their determinants	Answer coding	YES	NO	Go to
70	Does your household have…		YES	NO	
	ELECTRICITY?	ELECTRICITY ……..…………………….	1	2	
	A RADIO?	RADIO …………………………………….	1	2	
	A TELEVISION?	TELEVISION …………………………….	1	2	
	A VCR?	VCR ……………………………………….	1	2	
	A TELEPHONE?	TELEPHONE …………………………….	1	2	
	A MOBILE PHONE?	MOBILE PHONE………………………….	1	2	
	A COMPUTER?	COMPUTER……………………………….	1	2	
71	Does your household have…		YES	NO	
	AN ELECTRIC FAN?	ELECTRIC FAN …………………………….	1	2	
	A WATER HEATER?	WATER HEATER ………………………….	1	2	
	A REFRIGERATOR?	REFRIGERATOR…………………………..	1	2	
	AN AIR CONDITIONER?	AIR CONDITIONER……………………….	1	2	
	SEWING MACHINE?	SEWING MACHINE……………………….	1	2	
	AN AUTOMATIC WASHING MACHINE?	AUTOMATIC WASHING MACHINE…………………………………	1	2	
	OTHER WASHING MACHINE?	OTHER WASHING MACHINE…………...	1	2	
	A DISHWASHER?	DISHWASHER……………………………	1	2	

No.	Questions and their determinants	Answer coding	YES	NO	#	Go to
72	Do you or any member of your household own a…		YES	NO	#	
		BICYCLE……………………..	1	2	☐	
		MOTORCYCLE/MOTOR SCOOTER…………………...	1	2	☐	
		PRIVATE CAR………………...	1	2	☐	
		VAN/TRUCK…………………..	1	2	☐	
		OTHER_________________ (SPECIFY)			☐	

No.	Questions and their determinants	Answer coding	Go to
73	On the whole, how would you say things are these days? Would you say that you are…?	VERY HAPPY ……………………………………..1 PRETTY HAPPY …………………………………..2 NOT TOO HAPPY ………………………….………..3	
74	What is the average household income per month?	(FILL IN)________________________LE/MONTH	

SECTION 9: CHARACTERISTICS OF HOUSEHOLD HEADS

No	Questions and determinants	Male head of the household	Female head of the household
75	How old is…	(FILL IN)______YEARS OLD DECEASED……………...999 SKIP TO FEMALE HEAD	(FILL IN)______YEARS OLD DECEASED……………...999 SKIP TO 80
76	What is the main occupation of…	WORKER……………………….1 CIVILIAN……………………….2 OWN BUSINESS……………….3 RETIRED…………………..….4 OTHER (SPECIFY)_____________9	WORKER……………………….1 CIVILIAN……………………...2 OWN BUSINESS……………….3 RETIRED……………………….4 HOUSEWIFE…………………..5 OTHER (SPECIFY)____________9
77	How many jobs does the male/female head of this household have?	(FILL IN)__________ # OF JOBS	(FILL IN)_________ # OF JOBS
78	What is the income of the male/female head of this household per month?	(FILL IN)_________ LE/MONTH LESS THAN 200LE…………….1 200-<500 LE…………………….2 500-<1000 LE…………………...3 1000-<1500 LE…………………4 1500-<2500 LE………………….6 MORE THAN 2500 LE…………7	(FILL IN)________ LE/MONTH LESS THAN 200LE……………1 200-<500 LE……………………2 500-<1000 LE…………………..3 1000-<1500 LE…………………4 1500-<2500 LE…………………5 MORE THAN 2500 LE………..6 DON'T HAVE…………………9
79	What level of education has the male/female head of this household finished?	NO EDUCATION……………………...1 ILLITERACY CAMPAIGN……………2 PRIMARY SCHOOL…………………...3 PREPARATORY SCHOOL…………...4 SECONDARY SCHOOL………………5 INSTITUTE…………………………….6 UNIVERSITY………………………….7 GRADUATE DEGREE (MS, PHD, DIPLOMA)……………………………8 **SKIP TO FEMALE HEAD**	NO EDUCATION……………………..1 ILLITERACY CAMPAIGN…………...2 PRIMARY SCHOOL…………………3 PREPARATORY SCHOOL…………...4 SECONDARY SCHOOL……………...5 INSTITUTE…………………………….6 UNIVERSITY………………………….7 GRADUATE DEGREE (MS, PHD, DIPLOMA)…………………………….8 **SKIP TO MALE HEAD**

No	Question	Answer	Go to
80	Including the male and female heads of your household, how many people in your household who are over 15 years old work outside your house for cash?	(FILL IN)_____________ADULTS	

REMARKS AND OBSERVATIONS

81	In your opinion, was the questionnaire too long?	YES…………………………………………...1 NO……………….……………………………2
Record the time the interview was completed: (FILL IN TIME AND CIRCLE AM OR PM) TIME [ ] AM PM		
THANK THE RESPONDENT FOR HIS COOPERATION AND DOUBLE CHECK THE QUESTIONNAIRE COMPLETENESS BEFORE LEAVING.		
OBSERVE THE FOLLOWING ABOUT THE RESPONDENT'S BUILDING AND NEIGHBORHOOD.		
82	Did you interview the male or the female head of the family?	MALE HEAD…………………………………1 FEMALE HEAD………………………………2
83	Degree of cooperation	LOW……………………………….…………..1 ACCEPTABLE………………………………..2 GOOD…………………………………………3 VERY GOOD…………………………………4
84	Did the (male / female) head of the household participate in the interview?	YES……………………………………………1 NO……………………………………………..2
85	Does the building have an elevator?	YES……………………………………………1 NO……………………………………………..2
86	What is the general condition of the street in front of the building? Is the street ……. (CIRCLE ONE OF EACH OF THE FOLLOWING) Is the street	PAVED (ASPHALT)…………………………1 UNPAVED……………………………………2 SMOOTH……………………….………….1 ROUGH……………………………………….2
87	Could a truck drive in the street in front of the building or is the street too narrow, rough, or dirty?	TRUCK COULD DRIVE IN STREET……….1 TRUCK COULD NOT DRIVE IN STREET…2
88	INTERVIEWER'S COMMENTS: _____ _____ _____	
89	SUPERVISOR'S COMMENTS: _____ _____ _____	
90	OFFICE EDITOR'S COMMENTS: _____ _____ _____	

Appendix C: The choice experiment part of the questionnaire

Cairo University
Faculty of Economics and Political Science

<u>Questionnaire 1</u>

Survey on the Health Effect of Drinking Water: an Application to Metropolitan Cairo

The data collected is confidential and will only be used for research

SECTION 5: PROGRAM TO REDUCE HEALTH RISK FROM DRINKING WATER

<table>
<tr><th>No.</th><th>Questions and their determinants</th><th>Answer coding</th><th>Go to</th></tr>
<tr><td>39</td><td colspan="3">The water agency is seriously planning a project to improve health through the provision of a better water quality in some districts of metropolitan Cairo. I am going to describe the project that is being considered for your region (heta). Please listen carefully while I describe the project.
The number of days per year that you suffer from diarrhea will decrease. And consuming better water quality can reduce the probability of contracting a vicious disease such as cholera, typhoid and hepatitis, in the long term. The water agency can improve your health through the provision of better water quality in your heta by using a special process of purification. Water service in your heta will not change. You will still have water with the same pressure, taste and clearness. There will be water with lower health risks in the tap. This means you will not need to filter, boil or buy bottled drinking water for your household.</td></tr>
<tr><td>40</td><td>How do you think your household's health will change if you can get a better quality of water from your tap?</td><td>____________________
____
____________________</td><td></td></tr>
<tr><td colspan="4">The water agency can supply better water quality where:
• Better water quality allows water plants to use more efficient methods (chemicals) for purifying water.
• Supplying better water quality allows the network to replace small, broken, and leaky pipes. These pipes cause the recontamination of water before water reaches your home.
• Supplying better water quality reduces health risk (the probability of getting waterborne diseases/illness).

If the water agency supplies better water quality implying an improved health where…
• The number of days in a year that any member of your household get short run health diseases e.g., diarrhea will be decreased.
• The probability of you or any member of your household contracting in a long-term disease (as cholera, kidney failure) will be decreased.
• You will not have to boil water, use a filter or buy bottled water.
• Every household in your heta will pay its share of the costs of better health through the supply of better water quality. Payments will be in the form of a water bill or an increase in the water bill. You will have to pay a higher bill as long as the network is supplying better water quality.

If the water agency does not supply better water quality and your health conditions will remain as they are today…
• Your household's payments to the water agency will stay as they are now.
• Your water quality will stay like it is now.
• Your current health will stay the same.
• The probability of you or any member of your household contracting a waterborne disease in the future will stay the same as today.</td></tr>
<tr><td>41</td><td>Before I go on, do you have any questions about the water agency's plan to improve your health through the supply of better water quality in your heta?</td><td>YES……………………………………1
NO……………………………………..2</td><td>
→ 42</td></tr>
<tr><td>41A</td><td>What would you like to know?
IF THE RESPONDENT ASKS ABOUT COSTS, CLICK HERE ☐ AND SAY: "I will come to that in a moment."</td><td>____________________
____
____________________</td><td></td></tr>
</table>

No.	Questions and their determinants	Answer coding	Go to
42	When we talk to other households, we find that some people want the water agency to supply water with better quality implying an improvement in short and long term health. We also find others who do not want it. Those who want an improved health through better water quality say things like: ▪ Having better health is worth the cost. ▪ They are tired of being ill and going to the clinic to get a treatment. ▪ Buying bottled water is costly and time consuming. ▪ They want to minimize the risk of getting a waterborne disease in the future (such as hepatitis and kidney failure). Those who do not want an improved health through better water quality say things like: ▪ They would rather save their money and spend it on other things. ▪ They are not bothered by the water quality. ▪ They never get sick because of the water. ▪ They cannot afford the cost of improved health through the supply of better quality water. ▪ They do not believe that they will be ill in the future because of bad water.		
43	In order for the waterworks to be able to supply you with an improved health through better water quality we will offer you different alternatives where you will have to choose among them. When you make your choices you have to keep in mind your household income and expenses and that in the future you may be asked about other environmental projects that cost money.		

144	Attributes	Option 144A	Option 144B	*Status quo*
	The change in the number of days you suffer from diarrhea due to water per year by…	Reduced by 50%	Same as today	Same as today
	The change in the probability of contracting a waterborne disease in the long run such as cholera, typhoid, and hepatitis will be…	7%	5%	10%
	The change in the water bill…	2.5 (5)	20 (40)	Zero
	⇨ SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME TO MAKE A CHOICE THEN CROSS ONE OF THE CHOICES.	☐	☐	☐

145	Attributes	Option 145A	Option 145B	*Status quo*
	The change in the number of days you suffer from diarrhea due to water per year by…	Reduced by 25%	Reduced by 25%	Same as today
	The change in the probability of contracting a waterborne disease in the long run such as cholera, typhoid, and hepatitis will be…	2%	7%	10%
	The change in the water bill…	5 (10)	2.5 (5)	Zero
	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME TO MAKE A CHOICE THEN CROSS ONE OF THE CHOICES.	☐	☐	☐
146	Attributes	Option 146A	Option 146B	*Status quo*
	The change in the number of days you suffer from diarrhea due to water per year by…	Reduced by 5%	Reduced by 25%	Same as today
	The change in the probability of contracting a waterborne disease in the long run such as cholera, typhoid, and hepatitis will be…	10%	10%	10%
	The change in the water bill…	2.5 (5)	10 (20)	Zero
	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME TO MAKE A CHOICE THEN CROSS ONE OF THE CHOICES.	☐	☐	☐
147	Attributes	Option 147A	Option 147B	*Status quo*
	The change in the number of days you suffer from diarrhea due to water per year by…	Same as today	Same as today	Same as today
	The change in the probability of contracting a waterborne disease in the long run such as cholera, typhoid, and hepatitis will be…	5%	7%	10%
	The change in the water bill…	10 (20)	5 (10)	Zero
	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME TO MAKE A CHOICE THEN CROSS ONE OF THE CHOICES.	☐	☐	☐

SECTION 6: DEBRIEFING

No.	Questions and their determinants	Answer coding	Go to
48	People have different reasons for the choices they make. Can you give me the main reasons that made you make these choices? **PROBE with "Anything else?").**	DON'T HAVE HEALTH PROBLEMS THROUGHOUT THE YEAR ……………...a DON'T BELIEVE THAT WATER CAN CAUSE ANY HEALTH PROBLEMS IN THE LONG RUN…………………………...b CANNOT AFFORD TO PAY ANY EXTRA EXPENSES……………..…………………...c THE WATER AGENCY CANNOT PROVIDE THIS SERVICE ………………..d REDUCE NUMBER OF ILL DAYS PER YEAR ……………………………………….e REDUCE THE PROBABILITY OF CONTRACTING A WATERBORNE DISEASE IN THE FUTURE ………………f AN IMPROVED HEALTH IS WORTH THE COST……………………………………...g OTHER (SPECIFY)__________________ x	
49	In your opinion, do you think that the water agency can provide this type of service?	YES……………………………1 NO…………………………….2	
50	In your opinion, do you think better water quality in your heta will improve your health?	YES……………………………1 NO…………………………….2	
51	Why do you think supply of better water quality (will / will not) improve your health?	___________________________________ ___________________________________ ___________________________________ ___________________________________	

Questionnaire 2:

244	Attributes	Option 244A	Option 244B	*Status quo*
	The change in the number of days you suffer from due to water per year by…	Reduced by 50%	Reduced by 25%	Same as today
	The change in the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will be…	5%	2%	10%
	The change in the water bill…	2.5 (5)	2.5 (5)	Zero
⇨	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME TO MAKE A CHOICE THEN CROSS ONE OF THE CHOICES.	☐	☐	☐
245	Attributes	Option 245A	Option 245B	*Status quo*
	The change in the number of days you suffer from due to water per year by…	Reduced by 5%	Reduced by 50%	Same as today
	The change in the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will be…	2%	2%	10%
	The change in the water bill…	20 (40)	10 (20)	Zero
⇨	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME…	☐	☐	☐
246	Attributes	Option 246A	Option 246B	*Status quo*
	The change in the number of days you suffer from due to water per year by…	Same as today	Reduced by 50%	Same as today
	The change in the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will be…	7%	10%	10%
	The change in the water bill…	20 (40)	2.5 (5)	Zero
⇨	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME…	☐	☐	☐
247	Attributes	Option 247A	Option 247B	*Status quo*
	The change in the number of days you suffer from due to water per year by…	Reduced by 25%	Reduced by 5%	Same as today
	The change in the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will be…	10%	5%	10%
	The change in the water bill…	10 (20)	2.5 (5)	Zero
⇨	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME…	☐	☐	☐

Questionnaire 3:

344	Attributes	Option 344A	Option 344B	*Status quo*
	The change in the number of days you suffer from due to water per year by…	Same as today	Reduced by 50%	Same as today
	The change in the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will be…	5%	5%	10%
	The change in the water bill…	5 (10)	10 (20)	Zero
▯▯⇨	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME TO MAKE A CHOICE THEN CROSS ONE OF THE CHOICES.	☐	☐	☐
345	Attributes	Option 345A	Option 345B	*Status quo*
	The change in the number of days you suffer from due to water per year by…	Reduced by 25%	Reduced by 25%	Same as today
	The change in the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will be…	7%	10%	10%
	The change in the water bill…	10 (20)	5 (10)	Zero
▯▯⇨	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME…	☐	☐	☐
346	Attributes	Option 346A	Option 346B	*Status quo*
	The change in the number of days you suffer from due to water per year by…	Reduced by 25%	Reduced by 50%	Same as today
	The change in the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will be…	10%	2%	10%
	The change in the water bill…	2.5 (5)	5 (10)	Zero
▯▯⇨	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME…	☐	☐	☐
347	Attributes	Option 347A	Option 347B	*Status quo*
	The change in the number of days you suffer from due to water per year by…	Reduced by 5%	Reduced by 5%	Same as today
	The change in the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will be…	5%	7%	10%
	The change in the water bill…	20 (40)	2.5 (5)	Zero
▯▯⇨	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME…	☐	☐	☐

Questionnaire 4:

444	Attributes	Option 444A	Option 444B	*Status quo*
	The change in the number of days you suffer from due to water per year by…	Same as today	Reduced by 5%	Same as today
	The change in the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will be…	2%	10%	10%
	The change in the water bill…	2.5 (5)	20 (40)	Zero
⇨	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME TO MAKE A CHOICE THEN CROSS ONE OF THE CHOICES.	☐	☐	☐
445	Attributes	Option 445A	Option 445B	*Status quo*
	The change in the number of days you suffer from due to water per year by…	Reduced by 5%	Same as today	Same as today
	The change in the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will be…	10%	2%	10%
	The change in the water bill…	5 (10)	2.5 (5)	Zero
⇨	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME…	☐	☐	☐
446	Attributes	Option 446A	Option 446B	*Status quo*
	The change in the number of days you suffer from due to water per year by…	Reduced by 25%	Reduced by 5%	Same as today
	The change in the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will be…	5%	2%	10%
	The change in the water bill…	20 (40)	10 (20)	Zero
⇨	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME…	☐	☐	☐
447	Attributes	Option 447A	Option 447B	*Status quo*
	The change in the number of days you suffer from due to water per year by…	Reduced by 5%	Reduced by 25%	Same as today
	The change in the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will be…	2%	5%	10%
	The change in the water bill…	20 (40)	5 (10)	Zero
⇨	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME…	☐	☐	☐

Questionnaire 5:

544	Attributes	Option 544A	Option 544B	*Status quo*
	The change in the number of days you suffer from due to water per year by…	Reduced by 25%	Reduced by 50%	Same as today
	The change in the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will be…	5%	10%	10%
	The change in the water bill…	5 (10)	20 (40)	Zero
⇨	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME TO MAKE A CHOICE THEN CROSS ONE OF THE CHOICES.	☐	☐	☐
545	Attributes	Option 545A	Option 545B	*Status quo*
	The change in the number of days you suffer from due to water per year by…	Same as today	Reduced by 25%	Same as today
	The change in the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will be…	7%	2%	10%
	The change in the water bill…	10 (20)	20 (40)	Zero
⇨	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME…	☐	☐	☐
546	Attributes	Option 546A	Option 546B	*Status quo*
	The change in the number of days you suffer from due to water per year by…	Reduced by 25%	Same as today	Same as today
	The change in the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will be…	2%	2%	10%
	The change in the water bill…	20 (40)	10 (20)	Zero
⇨	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME…	☐	☐	☐
547	Attributes	Option 547A	Option 547B	*Status quo*
	The change in the number of days you suffer from due to water per year by…	Reduced by 50%	Reduced by 5%	Same as today
	The change in the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will be…	10%	7%	10%
	The change in the water bill…	10 (20)	10 (20)	Zero
⇨	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME…	☐	☐	☐

Questionnaire 6:

644	Attributes	Option 644A	Option 644B	*Status quo*
	The change in the number of days you suffer from due to water per year by…	Reduced by 5%	Reduced by 50%	Same as today
	The change in the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will be…	7%	7%	10%
	The change in the water bill…	2.5 (5)	10 (20)	Zero
⇨	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME TO MAKE A CHOICE THEN CROSS ONE OF THE CHOICES.	☐	☐	☐
645	Attributes	Option 645A	Option 645B	*Status quo*
	The change in the number of days you suffer from due to water per year by…	Reduced by 50%	Reduced by 25%	Same as today
	The change in the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will be…	10%	7%	10%
	The change in the water bill…	20 (40)	20 (40)	Zero
⇨	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME…	☐	☐	☐
646	Attributes	Option 646A	Option 646B	*Status quo*
	The change in the number of days you suffer from due to water per year by…	Reduced by 50%	Reduced by 5%	Same as today
	The change in the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will be…	7%	2%	10%
	The change in the water bill…	5 (10)	5 (10)	Zero
⇨	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME…	☐	☐	☐
647	Attributes	Option 647A	Option 647B	*Status quo*
	The change in the number of days you suffer from due to water per year by…	Reduced by 50%	Reduced by 50%	Same as today
	The change in the probability of contracting a waterborne disease in the long run as cholera, typhoid, and hepatitis will be…	2%	10%	10%
	The change in the water bill…	10 (20)	2.5 (5)	Zero
⇨	SHOW THE VISUAL AID FOR THESE OPTIONS AND GIVE THE RESPONDENT ENOUGH TIME…	☐	☐	☐