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A Methodology for Optimal Allocation of Government Budget to Maximize Health Coverage: The Case of Antenatal Care in Egypt

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Mission

The Partnerships for Health Reform (PHR) Project seeks to improve people's health in low- and middle-income countries by supporting health sector reforms that ensure equitable access to efficient, sustainable, quality health care services. In partnership with local stakeholders, PHR promotes an integrated approach to health reform and builds capacity in the following key areas:

- *better informed and more participatory policy processes in health sector reform;*
- *more equitable and sustainable health financing systems;*
- *improved incentives within health systems to encourage agents to use and deliver efficient and quality health services; and*
- *enhanced organization and management of health care systems and institutions to support specific health sector reforms.*

PHR advances knowledge and methodologies to develop, implement, and monitor health reforms and their impact, and promotes the exchange of information on critical health reform issues.

[DATE]

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Abstract

Many developing countries have invested substantial government funds to develop a public sector health care delivery system to provide a set of priority services such as immunization for children or preventive care for pregnant women. The performance of these systems is often disappointing. People seek alternatives to government provision even when it is available to them at little or no direct cost or they do not receive the priority services at all.

Governments often respond to this situation only by trying to do more of what they have done already, increasing the investments in the public sector health care delivery system. This strategy can be found even in countries where government services are clearly underused (i.e., have excess capacity) and where there is also a large and possible growing set of alternative non-government providers that many people may prefer to use.

This paper extends our earlier work that developed an analytical model to analyze government choices to expand coverage with priority services. It develops and tests the operational capability of the model with data for antenatal care in Egypt in 1995, augmented by additional estimations as needed. The objective of this analysis was not, however, to develop policy recommendations for Egypt, but rather to test and demonstrate the approach.

The paper shows that this type of analysis provides interesting results. More resources should be allocated at the margin to subsidizing transportation, educating women, and financing the use of non-government providers rather than expanding the quantity of public provision. Sensitivity analysis with the model highlights the importance of better measurement of some key variables like quality of care and cost of educating the population and operating subsidies.

We conclude that where public services are underused and there are significant non-government alternatives, governments should consider *both* demand- and supply-side factors in designing investment programs. We propose that this approach should be applied in other countries where there is available data and it is possible to collect additional information as needed.

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Acronyms

EDHS	Egyptian Demographic and Health Survey
LE	Egyptian Pound
MOHP	Ministry of Health and Population
QP	Quadratic Programming
SQP	Sequential Quadratic Programming

Currency Conversion:

LE 3.4 = US$ 1.00

Foreword

Part of the mission of the Partnerships in Health Reform Project (PHR) is to advance "knowledge and methodologies to develop, implement, and monitor health reforms and their impact." This goal is addressed not only through PHR's technical assistance work but also through its Applied Research program, designed to complement and support technical assistance activities. The program comprises Major Applied Research studies and Small Applied Research grants.

The Major Applied Research topics that PHR is pursuing are those in which there is substantial interest on the part of policymakers, but only limited hard empirical evidence to guide policymakers and policy implementors. Currently researchers are investigating six main areas:

- Analysis of the process of health financing reform
- The impact of alternative provider payment systems
- Expanded coverage of priority services through the private sector
- Equity of health sector revenue generation and allocation patterns
- Impact of health sector reform on public sector health worker motivation
- Decentralization: local level priority setting and allocation

Each Major Applied Research Area yields working papers and technical papers. Working papers reflect the first phase of the research process. The papers are varied; they include literature reviews, conceptual papers, single country-case studies, and document reviews. None of the papers is a polished final product; rather, they are intended to further the research process—shedding further light on what seemed to be a promising avenue for research or exploring the literature around a particular issue. While they are written primarily to help guide the research team, they are also likely to be of interest to other researchers, or policymakers interested in particular issues or countries.

Ultimately, the working papers will contribute to more final and thorough pieces of research work, such as multi-country studies and reports presenting methodological developments or policy relevant conclusions. These more polished pieces will be published as technical papers.

All reports will be disseminated by the PHR Resource Center and via the PHR website.

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Executive Summary

Many developing countries have invested substantial government funds to develop a public sector health care delivery system. This system is expected to provide much if not all of the population with a set of priority services such as immunization for children, preventive care for pregnant women, and treatment of diseases like acute diarrheas, tuberculosis, and others.

The performance of these systems in many countries is disappointing. There is widespread evidence that people seek alternatives to government provision even when it is available to them at little or no direct cost or that they do not receive the priority services at all.

In many cases, governments respond to this situation only by trying to do more of what they have done already, increasing the investments in the public sector health care delivery system. This strategy can be found even in countries where government services are clearly underused (i.e., have excess capacity) and where there is also a large and possible growing set of alternative non-government providers that many people may prefer to use.

In an earlier paper (Berman and Chawla, 1998), we proposed a framework and an analytical model that could help governments consider a wider set of investment strategies to increase coverage with priority services. The model is essential a programming algorithm that maximizes the cost-effectiveness of alternative expenditure strategies in increasing coverage with a priority health good. We proposed that governments could consider four main alternative uses of additional funds: increasing knowledge of the benefits of the service to create demand among those in need; enhancing the quality of public provision; subsidizing the cost of private provision; and subsidizing travel costs to public providers. This model focused on the provision of a single health good, such as an annual pediatric check-up or efficacious treatment for a dangerous communicable disease. It included both demand- and supply-side behavior.

Economists studying this type of problem have argued that theory alone cannot derive a unique optimal solution for such choices. Plausible objective functions for government, public and private providers, and consumers do not result in clear superiority for either public or private provision on efficiency or even equity grounds. Such questions can be better addressed through empirical analysis of the performance of the different actors, and of the costs and benefits of different strategies under prevailing conditions.

This paper takes the previous analysis one step further and tests the operational capability of the model and policy prescriptions suggested by this framework by employing data from a real country setting. We do this using available data for antenatal care in Egypt in 1995, augmented by additional estimations as needed. The objective of this analysis was not, however, to develop policy recommendations for Egypt, but rather to test and demonstrate the approach. Better data and collaboration with colleagues in Egypt would be need to develop a useful policy analysis.

Antenatal care in Egypt is a good case on which to test our approach. National surveys suggest that about 22 percent of Egyptian women who become pregnant may lack adequate knowledge of the benefits of antenatal care. Of those with such knowledge, 79 percent don't receive care. Of those receiving care, 53 percent use non-government providers, even though the government has established a large rural and urban primary care delivery system which offers such care at little or no

cost. Egypt also has a large private health care provider sector, which is active in both rural and urban areas and provides a significant amount of antenatal care.

The paper demonstrates that this type of analysis is feasible in relatively data-rich countries and does provide interesting results. The findings suggest that more resources should be allocated at the margin to subsidize transportation, educate women, and finance the use of non-government providers rather than to expand the quantity of public provision. Different types of government investment enter into the optimal mix of expenditure strategies according to how much additional budget is available.

Sensitivity analysis with the model highlights the importance of better measurement of some key variables. Differences in perceived quality between public and private providers are an important determinant of where women go for antenatal care. Yet we lack good measures of quality that can be reliably scaled to estimate the impact of quality improvements. Similarly, the cost of some key interventions, such as increasing the knowledge of women about the benefits of antenatal care, is very uncertain.

Overall, the paper demonstrates that this approach can provide valuable insights into government investment strategies to increase coverage with priority services. Where public services are underused and there are significant non-government alternatives, governments should consider *both* demand- and supply-side factors in designing investment programs. We propose that this approach should be applied in other countries where there is some available data and it is possible to collect additional information as needed. This should be done as a collaborative effort with local planners.

1. Introduction

A government wanting to provide a set of health care interventions to all those needing them faces a choice from a range of policy options for finance and provision. These include using government financial resources to pay for and run a public provision system, and using government funds to pay for private provision, either directly through production subsidies or indirectly through consumption financing. With its goal of increased coverage and health impact, it must decide which of these tools to employ incrementally to give the best outcome for a given level of expenditure. Several economists who have looked carefully at such policy questions have argued that theory alone cannot derive a unique optimal solution for such choices. Plausible objective functions for government, public and private providers, and consumers do not result in clear superiority for either public or private provision on efficiency or even equity grounds. Such questions can be better addressed through empirical analysis of the performance of the different actors, and of the costs and benefits of different strategies under prevailing conditions.

In an earlier paper (Berman and Chawla, 1998), we proposed a framework and an analytical model to conduct such an analysis of important health interventions in developing countries. Focusing on the provision of a single health good, such as an annual pediatric check-up or efficacious treatment for a dangerous communicable disease, we modeled public financing and provision separately, highlighting the distinction between the government's decisions regarding financing and public sector providers' decisions regarding production. Government financing decisions were modeled to reflect multiple objectives, such as health coverage, equity, and efficiency goals, while public providers' production decisions were treated as responses to the available budget according to given short-run production relations. To complete the picture on the supply side, the model took cognizance of the extensive network of individual private providers, who set fees for services according to market conditions and provided services similar to the public sector but with extra amenities, such as more convenient locations and hours, nicer physical conditions, and more friendly services. Consumers seeking care in the market were treated as responding to price, perceived quality, and their perception of their need for the intervention of interest, which we called "knowledge." The total demand in the market was posited to be less than the socially desirable demand, since consumers could potentially be constrained by both low income and no knowledge.

Starting from an initial equilibrium situation characterized by a combination of private and public production but less-than-full health coverage, the model presented an empirically estimable algorithm designed to allocate government budget increases to achieve maximum attainment of the specified objectives. Plausible comparative statics results were developed to illustrate the impact on equilibrium solutions of changes in values of exogenous parameters like price of private care, cost of increasing consumer awareness and cost of improving quality in public facilities.

This paper takes the previous analysis one step further and tests the operational capability of the model and policy prescriptions suggested by this framework by employing data from a real country setting. Using data for antenatal care in Egypt in 1995, the results show that the model provides a good approximation of the reality of health care seeking behavior and consumers' choice of public and private provision. We find that, in general, the objective of increasing health coverage is best served by investing in increasing consumer awareness and subsidizing private health care, rather than expanding public production. We also conducted several simulation exercises designed to inform

policy decisions under a variety of scenarios regarding budgetary increments and costs of knowledge and continue to find significant support for increasing education and promoting the private sector.

The rest of the paper is organized as follows. Section 2 presents an empirical version[1] of the model, followed by a description of the estimation methodology in section 3. Section 4 contains a description of the data used in the analysis. Estimation results, analysis and model predictions are presented in section 5. The paper concludes with a discussion in section 6.

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[1] Readers interested in details of the model are referred to the mathematical appendix in Berman and Chawla (1998).

2. Model

There are four players in our model of finance, production, and consumption of the health good: the population in need, public providers, private providers, and the government. The health good is a discrete, well-defined unit such that each person needing the good consumes only one unit for each episode of need and cannot consume more or less than one unit if they consume at all. A unit can be a single complete intervention or an extended intervention, such as complete antenatal care, or complete therapy for a communicable disease such as STD or tuberculosis. The eligible population consists of all individuals who would benefit from use of the health good. For instance, the eligible population for an annual well-baby visit is all children of the prescribed age; similarly, for complete antenatal care the eligible population is all expecting mothers. We consider the market to be an administrative area for which the government makes a budgetary allocation, like a district, a province, or a country.

2.1 Initial Situation

We start by describing the individual consumer's decision-making process. The basic version of the model differentiates individuals according to two income levels: low and high,[2] and according to whether they possess knowledge of the health good. Those who do not have that knowledge do not consume the health good, although clinically they would benefit from it. Potential consumers can obtain the health good from either public or private providers, and we model their choice of provider as a discrete-choice problem. We assume that the utility that each person receives from consuming the health good is dependent on the quality of the health good, the out-of-pocket expenses associated with procuring the good, the individual's income, and an error term. In this view, quality includes two components: an *observable* component, such as cleanliness, waiting-room decor, and politeness of staff, and a *technical* component, such as relevance and appropriateness of treatment, and competence of the provider. Consumers are not readily able to differentiate between the two, and what they perceive is some combination that tends to favor the observable but superficial properties of the good relative to the technical characteristics. The term "perceived quality" refers to consumers' perception of quality of care. Increased perceived quality affects the utility function by making the consumption of the health good more pleasant. Out-of-pocket expenses associated with procurement of the health good include payments made out-of-pocket for the health good as well as expenses incurred in the process of procuring the health good. Thus, costs associated with travel, informal payments, and so forth are all included in out-of-pocket consumption expenses.

In particular, the utility of an individual k belonging to income group i (i = 1, 2) choosing provider j (j = public, private) is expressed as follows:

$$U_{kij} = \gamma \log (Y_{ki} - C_{kij}) + q_j + \varepsilon_{kj} \qquad (1)$$

where i = income groups 1, 2; j = v (private providers), g (public providers); C_{kij} denotes the out-of-pocket expenditure on the health good, q_j denotes the quality of the good, γ is a parameter, and ε_{kj}

[2] This is done only in the interest of tractability and ease of computation. In subsequent extensions, this assumption will be relaxed to accommodate multiple income categories.

is a random variable that captures the noise in the interpretation of quality by individual k, is distributed independently and identically across consumers and providers, and has a logistic or double-exponential distribution.[3] C_j is the sum of components: the price that the consumer pays for the good, P_{kij}, and other expenditure, such as transportation cost, waiting cost, etc., collectively represented by T_{kij}.

(2)

$$D = \sum_{i=1}^{2} [\ N_i \{\text{Prob}(U_{kij} \geq U_k)\}\ ]$$

Total demand for the health good can be computed as the product of the probability of consumption and the eligible population, and can be expressed as follows:

where

N_i = eligible population in income group *i*

U_{kij} = utility from consumption

U_k = utility from non-consumption.

Given the choice of the distribution for the error term, the probability that an individual consumes the health good can be calculated using the standard logit model.

The market shares of public and private providers can be similarly computed:

(3)

$$D_g = \sum_{i=1}^{2} [\ N_i \{\text{Prob}(U_{kig} \geq U_{ivk})\}\ ]$$

(4)

$$D_v = \sum_{i=1}^{2} [\ N_i \{\text{Prob}(U_{kiv} \geq U_{ivg})\}\ ]$$

On the supply side, there are many public and private providers producing and delivering the health good. In the initial formulation, both provider types produce the health good at least at that level of technical quality that provides positive benefit to the consumer, i.e., the model does not allow the intervention to be provided but have no efficacy. However, there is a difference in the perceived

[3] The choice of the logistic distribution for the error term simplifies the computation considerably. For the presentation of the model using alternative distributions, see Berman and Chawla (1998), in which the error terms are assumed to follow a (single) exponential distribution.

quality of the health good produced by public and private providers. In particular, public providers attach less weight than private providers to those attributes of the health good that the consumers are likely to observe and value.

There are other differences between private and public providers in the model. Private providers maximize profits, and thus their objective function is to maximize the difference between revenue and costs. Production decisions by public providers, on the other hand, are not a result of optimization of any clearly defined objective function. There is an extensive economic literature proposing and testing models of firm behavior that are alternatives to the well-developed notion of profit maximization. However, at this time we feel that there is insufficient information to support any one of these models that attribute different types of motivation to public providers. In the present model, public sector providers are generally primary health care facilities with multiple staff on salary. They have an inherited capital stock of land, buildings, vehicles, and equipment. They are funded through an annual recurrent budget allocation, which pays salaries and purchases expendable supplies. The supplies and other inputs they receive are based on a historical system, which typically does not assure an optimal mix of inputs. For many other reasons as well (low salaries, low worker morale, etc.), public providers operate below their production possibility frontier. Nominally, they have excess capacity available to produce services.

In this situation, the market equilibrium is characterized by a vector of prices, costs, and out-of-pocket expenses that maximizes profits for the private providers and does not exceed the budgets of the public providers. Of the total population, those who are not aware of the beneficial aspects of the health good have no demand for the good. Of those who have knowledge of the health good, the probability of consumption depends on the relative utility of consumption and non-consumption. Market shares of the two types of providers depend on the perceived quality of their products and the out-of-pocket expenses associated with consumption. As far as the government is concerned, it allocates its entire budget to the public providers only. We call this the “initial situation.”

2.2 Strategic Response Situation

We then consider the situation in which the government receives a budget increase, but instead of routinely allocating it to the public providers, considers various other ways of allocating the incremental budget so as to meet the objectives of maximizing health coverage. We assume that the initial situation budgetary allocation cannot be changed and that it would be infeasible to close down public facilities even if the production costs in these facilities were very high relative to the private providers. However, the incremental budget may be allocated entirely to any intervention that most effectively increases health coverage. We further assume that the government is indifferent where the good is produced, and does not favor either the private or the public sector for any ideological, political, or non-economic reason.

To increase coverage, the government can take up one or more of the following “interventions”: increase knowledge, subsidize private consumption for a section of consumers, improve perceived quality of public production, and decrease access and other costs that consumers incur at public facilities. The first of these interventions increases the population likely to desire the good, while the other three interventions increase the probability of consumption, and hence volume and health benefits, and potentially change the respective market shares of public and private producers of the health good. This is the “strategic response situation.”

We analyze this new situation using a framework similar to the one that described the equilibrium in the initial situation, by incorporating the effect of these interventions in computing the

total knowledgable population as well as the probability of consumption. A subsidy for private consumption will, in effect, reduce the price the consumers will pay for procuring the health good from private providers. Similarly, subsidizing travel and other costs for public consumption will reduce the out-of-pocket expenses that consumers incur for procuring the good from the public providers. Improving perceived quality of the health good in the public sector would increase the value that consumers attach to public providers. Taking all these effects into account, the expected demand function and the respective market shares can be rewritten as follows:

(5)

$$D^{SR} = \sum_{i=1}^{2} \left[(a N_{iu} + N_i) \{ \text{Prob} \ (U_{kij} \geq U_k) \} \right]$$

(6)

$$D_g^{SR} = \sum_{i=1}^{2} (a N_{iu} + N_i) \{ \Pr ob \ (U_{kig} > U_{kiv} \}$$

(7)

$$D_v^{SR} = \sum_{i=1}^{2} (a N_{iu} + N_i) \{ \Pr ob \ (U_{kiv} > U_{kig} \}$$

where

D^{SR} = total demand for the health good

D^{SR}_g = demand for the health good from government providers

D^{SR}_v = demand for the health good from private providers

N_{iu} = population in income group *i* that does not have knowledge of the health good

N_i = eligible population in income group *i*

U_{kiv} = utility from consumption from private providers

U_{kig} = utility from consumption from government providers

α = fraction of the population covered by the government intervention of increasing knowledge

Next, we describe the budget of the government and note that each of the four interventions of the government has some direct and associated costs for the government. For ease of exposition, we assume that there are no fixed or lump sum costs of producing knowledge. Similarly, we assume that no scale economies exist in financing private sector price subsidies and public sector access costs subsidies. Thus, the costs of increasing knowledge are simply the product of the unit cost per individual and the number of individuals "educated," and the costs of the subsidies are the product of

unit subsidies and consumption of the health good from that source. The unit costs of intervention can be estimated to include both direct cost and the costs of administration. The associated costs of increasing knowledge arise from costs of producing the good to meet the additional demand in the public sector and the cost of subsidizing the additional consumption from the private sector. Similarly, the other three interventions also have associated costs, since they will affect the probability of consumption from either of the two providers. Since we know the respective shares of the public and the private providers, we can correctly allocate the associated costs of these interventions to the public providers.

In particular, we can write the incremental budget constraint of the government as follows:

(8)

$$dB = \sum_{i=1}^{2} \{ r a N_{iu} + s P_v D_v^{SR} + (k + h(1 + b) q_g + d T_g) D_g^{SR} \}$$

where

dB = incremental budget

ρ = cost of educating one individual

κ = cost of production of one unit of the health good in the public sector

η = cost of increasing perceived quality of public production by one unit

σ = fraction of price charged by private providers that are subsidized

P_j = price charged by provider *j*

T_j = travel and other costs incurred by consumers in procuring the good from provider *j*

δ = fraction of consumers' out-of-pocket expenditure on travel and other costs that is subsidized

β = improvement in perceived quality of the health good produced by public providers

Having described the expected demand function and the budget of the government, we compute those values of α, δ, β and σ that would maximize coverage with the intervention. This is done by maximizing (5) subject to (8), and computing the relevant first-order conditions that yield the necessary conditions for a maximum.[4]

[4] Attaching different weights to the various interventions can emphasize specific objectives. For instance, if the objective is only to improve equity among existing consumers, interventions like educating individuals can be attached a weight of zero.

In order to operationalize the model, we estimate the demand for the health intervention and substitute the function in (5). In addition, we substitute the known numerical values of all the exogenous variables, like the budget, prices, population, etc. in (8), and obtain numerical expressions for both the objective function and the budget constraint. Using appropriate non-linear optimization procedures, involving line-search iterative procedures and computer algorithms, we find numerical values of the four interventions that maximize the objective function subject to the budget constraint.

3. Estimation of the Model

$$Max \qquad D^{SR} = \sum_{i=1}^{2} \left[(a N_{iu} + N_i)\{ \text{Prob } (U_{kij} \geq U_k) \} \right] \qquad (9)$$

Collecting the results from the previous section, the maximization problem can be expressed as:

$$subject \quad to \quad dB = \sum_{i=1}^{2} \{ r a N_{iu} + s P_v D_v^{SR} + (k + h(1 + b) q_g + d T_g) D_g^{SR} \}$$

The estimation of the model essentially involves two steps: estimation of the probability of consumption; and choosing such values of α, δ, β and σ that maximize the expression in (9) above. As discussed earlier, estimation of the probability of demand requires assumptions about the distribution of the error term in the utility function. This paper presents one approach to the estimation by assuming that the error term follows the double exponential distribution.[5] The other step is essentially an iterative search so as to maximize a given expression subject to given constraints, and is discussed below and in Annex A.

The maximization problem in (9) can be stated more generally as:

$$\underset{x \in \Re^n}{Minimize} \; f(x) \qquad (10)$$

subject to : $G_i(x)=0, \quad i = 1,\ldots,m_e$

$G_i(x) \leq 0, \quad i = m_e+1,\ldots,m$

$x_l \leq x \leq x_u$

The Kuhn-Tucker equations are necessary conditions for optimality for a constrained optimization problem. Further, if f(x) and $G_i(x)$ are convex functions, then the Kuhn-Tucker equations are both necessary and sufficient for a global solution point.

Using Kuhn-Tucker equations the constrained optimization (10) can be stated as:

$$f(x^*) + \sum_{i=1}^{m} \lambda_i^* \cdot \nabla G_i(x^*) = 0 \qquad (11)$$

[5] Interested readers may refer to Berman and Chawla (1999) for an alternative approach.

$\nabla G_i(x^*)=0 \qquad i=1,\ldots,m_e$

$\lambda_i^* >= 0 \qquad i=m_e+1,\ldots,m$

Several non-linear programming algorithms are available that allow for direct computation of the Lagrangian multipliers (λ_i^*) in (11) above (see, for instance, Fletcher, 1980, and Gill, 1981). Commonly referred to as Sequential Quadratic Programming (SQP) methods, these problems involve setting up a quadratic programming sub-routine that is solved at each major iteration, in which an approximation is made of the second-order Hessian. This is then used to generate a new quadratic programming sub-routine for a line-search procedure. The solution procedure essentially involves the calculation of a feasible point (if at all one exists), and generation of an iterative sequence of feasible points that converge to the solution. Mathematical formulation and the solution methodology of the method used here are presented in Annex A.

4. Data

The health good considered for the purposes of the estimation of the model is complete antenatal care, defined in the context of Egypt as including four visits to a qualified health care provider during pregnancy. The care that a woman receives during pregnancy and at childbirth reduces the risks of illness and death for both the mother and the child. Along with child health and family planning, maternal care is identified as a priority area in the health section of government of Egypt's five-year plan for 1992-97. In line with this policy, the Ministry of Health and Population (MOHP) has introduced integrated reproductive health programs as well as programs to reduce neo-natal mortality through improving the quality of care given to newborns at home and in health facilities. The National Council of Childhood and Motherhood, co-chaired by the Prime Minister and the First Lady of Egypt, coordinates all activities between ministries implementing programs affecting children and mothers.

Data on the Egyptian health sector for the year 1995 is used to estimate the model and to compare the model predictions against observed fact. Besides the official MOHP statistics, we draw upon the household and provider surveys carried out by the Data for Decision Making Project at Harvard School of Public Health to provide valuable demand and supply information on outpatient health care in Egypt. Note that both the household and provider survey asked questions related to general health, illness, and outpatient treatment, and not specifically antenatal care. However, this is the most complete source of information available, and in the absence of focused surveys on antenatal care, we draw upon the household and provider surveys to infer the values of many parameters needed to estimate the model.

In the same year, National Health Accounts, a detailed record of flow of funds in the health sector, were prepared by a team led by Harvard School of Public Health and including representatives of the Ministry of Health and Population, Ministry of Finance, and Cairo University. The National Health Acconts statistics provide information on health expenditure by function and help to identify budgetary outlays by source and function. Finally, we use data from the Egypt Demographic and Health Survey, 1995 (EDHS95) on specific health interventions, utilization and coverage rates.

Estimation of the model is dependent on the values of several parameters, some of which are directly observable while others must be econometrically estimated. Accordingly, the remainder of this section is split into a discussion on how we obtained the values of the observable parameters and the estimated parameters.

4.1 Observable Parameters

4.1.1 Target Population

The target population for antenatal care is all expecting mothers in Egypt in 1995. Of the total population of about 59 million in 1995, 28.8 million, or about 49 percent, were women (Central Agency for Population Mobilization and Statistics). Of these, 12.6 million, or 44 percent, were in the reproductive age group of 15-44 years (EDHS95). Forty-five percent of Egypt's population lives in urban areas, equivalent to 5.7 million women in the reproductive age group living in urban areas and

6.9 million in the rural areas. The percentage of pregnant women in the reproductive age groups in urban and rural areas is 5.6 percent and 8.2 percent respectively (EDHS95), equivalent to a total of 883,580 expecting mothers in whole of Egypt in 1995.

4.1.2 Indicators of Knowledge

An indicator reflecting the percentage of the eligible population that is aware of the beneficial aspects of antenatal care is not readily available in any record. However, EDHS95 collected information on family planning awareness and knowledge of child health and illnesses, and since these and maternal health care tend to be highly related, they are used here to develop the indicator of knowledge of antenatal care.

Data for EDHS95 were gathered from a nationally representative survey of 14,779 ever-married women in the age-group 15-49. Almost all women in urban areas and 87.5 percent women in rural areas reported awareness of family planning methods (table 1). The lowest awareness levels were in the Rural Upper Egypt governorates, where only 77.6 percent women reported to have knowledge of family planning methods.

Table 1: Percentage of Women Aware of Family Planning Methods

Region	Knowledge of family planning	Number of women in the sample
Urban Governorates	0.986	3,122
Urban Lower Egypt	0.990	1,686
Rural Lower Egypt	0.956	4,050
Urban Upper Egypt	0.945	1,483
Rural Upper Egypt	0.776	3,241
All Areas	0.923	13,582

The general awareness of family planning methods is high in Egypt, largely because of population control campaigns by governmental and non-governmental agencies. Awareness of antenatal care might not be so high. Therefore, we choose the lower range of the awareness of family planning methods level as a probable indicator of awareness of antenatal health care. Accordingly, we assume that 77.6 percent women are knowledgeable about the beneficial aspects of antenatal care. In other words, there are 685,658 individuals with knowledge overall and 197,922 without knowledge.

4.1.3 Income

We obtain data on income and income quintiles from the Egypt Household Health Care Utilization and Expenditure Survey conducted in 1994-1995 by the Egyptian Ministry of Health and Population and the Data for Decision Making Project. The survey collected data on socio-demographic characteristics of the household, health status, insurance coverage, factors affecting the decision to seek care, utilization of outpatient and inpatient services, choice of provider, and out-of-pocket expenditures. The population sample was the same as that used for DHS surveys and represented Egypt's population at the national level and the five regions of the country: urban governorates, rural Lower Egypt, rural Upper Egypt, urban Lower Egypt, and urban Upper Egypt. The sampling frame consisted of 546 segments (208 rural and 338 urban) covering 21 governorates. Out of this, a self-weighted sample of 362 segments (191 urban and 171 rural) was selected for the

survey. Two survey rounds were done to capture variations relating to summer and winter, the two distinct seasons in Egypt. Half of the sample was selected from each segment for the winter round of the survey and the other half was surveyed in the summer round.

Income quintiles computed from the household survey are presented in table 2. For purposes of the estimation of this model, individuals in the first four quintiles, representing 80 percent of the country's population, were classified as "low-income" while individuals in the fifth quintile were put in the "high-income" category. In other words, there are 706,864 expecting mothers in the low-income category and 176,716 in the high-income category. The average income of all individuals earning 1,689 Egyptian pounds (LE) or less is computed to be about LE 839, while the average income of the highest quintile is LE 3,319.

Table 2: Income Quintiles for Population

Income Quintile	Average Income (LE)	Income Levels (LE)
Lowest 20%	399.59	102 – 543.75
Second 20%	665.81	544 – 792
Third 20%	934.57	793 – 1098
Fourth 20%	1,356.13	1099.2 – 1689
Highest 20%	3,319.26	1689.6 – 69096

4.1.4 Ministry of Health Budget for Antenatal Care

The pluralistic nature of health care in Egypt and the fact that a large number of government and non-government organizations are involved in the production and delivery of health care make it difficult to track even the MOHP expenditures and break them down by functions. The most detailed and accurate record of budgetary outlays by functions are those contained in the Budget Tracking System reports for eight governorates in 1995. Designed and implemented by a team led by the Data for Decision Making Project, the Budget Tracking System is a budget and expenditure monitoring system that allows classification of all MOHP and governorates' expenditures on health services by official budget accounting categories as well as functional health care categories. We use these figures to impute expenditure on antenatal care.

Data from the eight governorates indicate that the MOHP spent 6.07 percent of their budget on Maternal and Child Health (table 3). This functional category includes expenditure on monitoring pregnant women before and shortly after childbirth (prenatal, delivery, postnatal) and funds spent in the treatment of children less than six years of age.

The total MOHP budget for 1995 was LE 1,502 million, and assuming that maternal and child health programs for the whole country received 6.1 percent, the total budgetary outlay for this category comes to LE 91.2 million. It is not possible to further break this figure down into expenditures on antenatal health and child care; assuming that antenatal care gets a quarter of the maternal and child health budget, the 1995 MOHP budget for antenatal care is estimated to be LE 22.3 million.

Table 3: Expenditure by Region and Function (LE)

Governorates	Curative	Preventive	MCH	Family Planning	Admin.	Total
Alexandria	45,728,894	10,456,347	3,989,845	614,437	21,266,395	82,055,918
Aswan	14,676,804	1,998,542	1,970,038	469,141	13,285,440	32,399,965
Beni Suef	14,592,596	3,746,989	3,713,423	538,811	12,332,181	34,924,000
Dakahlia	48,781,211	5,152,973	5,858,498	1,418,337	23,105,392	84,316,411
North Sinai	6,842,689	936,877	1,225,867	426,035	6,417,383	15,848,851
Port Sinai	10,223,269	1,621,601	548,246	150,410	6,988,335	19,531,860
South Sinai	7,260,402	861,701	276,837	173,646	1,615,700	10,188,286
Suez	6,508,672	2,328,071	267,759	123,459	5,442,983	14,670,945
Total	154,614,537	27,103,101	17,850,512	3,914,275	90,453,810	293,936,235
%	52.60%	9.22%	6.07%	1.33%	30.77%	100.00%

4.1.5 Costs

It is estimated that the public sector provided antenatal care to only 68,362 expecting mothers in 1995, which, at the rate of four visits per person, is equivalent to a total of 273,448 visits to public providers.[6] Considering that the total MOHP expenditure on antenatal care was LE 22 million, the average MOHP expenditure per antenatal visit to a public provider works out to LE 80.45, and the average MOHP expenditure per person covered by antenatal care LE 321.80.

Total MOHP expenditure on antenatal care also includes capital expenditure, such as buildings and equipment, as well as expenditure on administrative staff in central, provincial, and local governments. The MOHP numbers also include expenditure on special programs that the MOHP takes up from time to time. The average MOHP expenditure per visit, therefore, is not an accurate indicator of the average cost of producing a health care service.

To get a better estimate of per visit costs, we examine the results of a costing study conducted by the Ministry of Health and Population in collaboration with the Data for Decision Making Project. The study, conducted in 19 primary health care facilities in the governorates of Alexandria, Suez, Bani Suef, Aswan, Dakhalia, Port Said, and North and South Sinai, used five cost categories: building, equipment, drugs, personnel and utility costs. Replacement costs were used for building and equipment costs. The replacement cost for a building was calculated using a rate of LE 575 per sq. meter (excluding land), which was then depreciated using an effective life of 25 years. Replacement costs of equipment and furniture also include annual depreciation costs. Recurrent costs were used for drug, personnel, and utility costs. Drug costs include medical supplies and drugs provided by the primary health care facilities, and exclude prescription drugs purchased by patients outside of the facilities. Personnel costs include take-home pay, benefits, and deductions for physicians, nurses, technicians, skilled and unskilled personnel, and administration. Utility costs include electricity, water, maintenance, food, and clothing.

[6] The Egypt Household Health Care Use and Expenditure Survey conducted in 1994-1995 indicates that only 21 percent of those reporting an illness seek care, and, of these, 47.5 percent visit the public providers. Assuming similar numbers for antenatal care, the public sector accounted for 68,362 antenatal visits.

Total costs are calculated by adding together facility-level replacement costs related to building and equipment, and recurrent costs related to drugs, personnel, and utilities. Dividing total costs by the number of consultations yields the per visit costs. Details are presented in table 4.

Costs per outpatient visit range from a low of LE 2.78 in Arbeen to a high of LE 59.97 in Sedment, for an average per visit cost of LE 11.34 in 1994.[7] For purposes of this model, we assume that costs per antenatal visit are the same as general outpatient visits. After adjusting for 10 percent inflation, we arrive at a cost per antenatal visit of LE 12.50 in 1995, equivalent to treatment cost per person of LE 50.

This figure is considerably below the MOHP expenditure per person covered by antenatal health care. Besides capital expenditures and expenses on administration and special programs, the difference also reflects the huge excess capacity in many regions of Egypt, significantly contributing to the high average MOHP expenditure on one visit. Further, many areas of Egypt are very sparsely populated and account for very few visits (Sedment and Omara are good examples), because of which the average per visit costs are very high.

Table 4: Public Outpatient Health Facilities Costs (LE, FY94)

Cost Center	Building Costs	Equipment Costs	Drug Costs	Personnel Costs	Utility Costs	Total Costs	Total Visits	Cost /visit
Ahnasia	24,699	6,812	2,656	68,117	875	103,159	4,049	25.48
Amer	17,699	5,905	92,631	39,213	641	156,089	16,205	9.63
Arbeen	23,783	11,624	56,990	87,851	2,846	183,094	65,747	2.78
El Eman	42,369	14,571	46,209	149,111	3,162	255,422	36,097	7.08
Gabalyat	16,973	5,878	35,845	49,345	2,168	110,209	13,680	8.06
Ganayan	16,312	6,956	76,840	23,132	1,559	124,799	11,720	10.65
Gen	12,212	5,318	68,906	224,399	2,025	312,860	27,344	11.44
Kabary	35,808	32,370	105,417	517,687	1,100	692,382	50,155	13.80
Kay	16,643	7,261	2,916	51,273	561	78,654	2,607	30.17
King Marlout	8,848	2,084	31,268	47,426	253	89,879	5,502	16.34
Mamalik	16,841	3,733	1,712	36,850	875	60,011	2,878	20.85
Moharam Bek	21,815	18,184	94,987	355,358	4,163	494,507	13,394	36.92
Mosalas	4,644	6,978	4,438	46,452	285	62,797	2,833	22.17
Omara	15,520	5,008	1,791	33,556	365	56,240	990	56.81
Sabah	17,247	17,274	121,715	227,872	8,432	392,540	45,370	8.65
Sedment	13,569	3,814	3,289	35,498	318	56,488	942	59.97
Shanandora	16,973	4,550	14,973	17,223	1,380	55,099	2,067	26.66
Tazment	16,606	5,640	6,750	131,478	620	161,094	6,400	25.17
Zada	44,429	2,681	2,806	55,517	420	105,853	5,258	20.13

Source: MOHP/DDM/University of California at Berkeley 1997

[7] The median and the mode costs were LE 9.58 and LE 2.78 respectively

4.1.6 Consultation Fee

Antenatal care in Egypt is provided by general physicians, internal medicine physicians, and gynecologists in public facilities as well as in private clinics and hospitals. The Egyptian National Health Care Provider Survey provides a good account of private providers' consultation fees across specialties and across regions. For the purpose of this model, we consider the median reported consultation fee in each region as the price of private providers.[8] On average, this price is LE 8.9 per visit for antenatal care.

Outpatient health care is provided free of charge in most public facilities and, besides transportation and other incidental expenses, the only patient expenditure is on registration fees. For the purpose of this model, we consider the median reported registration fee in each region as the price of public providers. On average, this price is LE 1.5 per visit for antenatal care.

4.1.7 Transportation Costs

Data on transport costs is obtained from the Egypt Household Health Care Utilization and Expenditure Survey. Forty-four percent, or 22,132 individuals in the sample reported an illness event within the previous two weeks, and 21 percent of these, or 4,685, reported seeking any kind of medical treatment outside home. About half of these visited private physicians, with the rest going to public facilities (MOHP facilities, other government facilities, Health Insurance Organizations and Curative Care Organizations), mosque clinics, pharmacies, and others, in that order.

The data on users of health care is utilized to compute transportation costs by region and by type of provider, and these are presented in table 5.[9]

Table 5: Transportation Costs (LE)

Region	Transportation Costs (public)	Transportation Costs (private)
Urban Governorates	1.7	1.9
Urban Lower Egypt	0.6	1.2
Rural Lower Egypt	1.1	2.8
Urban Upper Egypt	0.7	1.7
Rural Upper Egypt	1.4	2.8
All Areas	1.2	2.2

For purpose of estimating the demand function, we use the average transport costs of LE 1.2 and LE 2.2 for public and private providers, respectively.

[8] Several other demand estimations have also used the median reported price as reflecting the market availability. See Alderman and Gertler, 1997, for an example.

[9] The data on transportation costs is obtained from a survey of households that covers all illnesses and treatments, and not necessarily antenatal care. In the absence of any specific information on antenatal care, we use information obtained from this survey. In any case, there are no a priori reasons to believe that the transportation costs for antenatal acre from private or public providers would be much different from what is computed from the general survey, the results of which are used here.

The values of the observed parameters are presented in table 6.

Table 6. Observed Parameters of the Model

Parameters	Explanation	Value
N_L	Population in low income with knowledge	548,526
N_{LU}	Population in low income without knowledge	158,338
N_H	Population in high income with knowledge	137,132
N_{HU}	Population in high income without knowledge	39,584
Y_L	Low income (average of Q1-Q4)839 (LE)	839 (LE)
Y_H	High income (average of Q5)	3319 (LE)
P_v	Fee in private clinics for ante-natal care, per visit	8.9 (LE)
P_g	Fee in public outpatient facilities	1.5 (LE)
T_v	Transportation cost in private	2.2 (LE)
T_g	Transportation cost in public	1.2 (LE)
dB	MOHP budget for antenatal care	22.3m (LE)
k*	Per visit cost (public providers)	LE 12.50

4.2 Estimated Parameters

This section describes how the probability of consumption of the health service is estimated. Since quality is an argument in the patient's decision-making, we start by describing how we obtained an indicator of quality.

4.2.1 Perceived Quality

Data on perceived quality of care comes from the Egypt Household Health Care Utilization and Expenditure Survey conducted in 1994-1995. In collecting data on utilization of health care services, factors affecting the decision to seek care, utilization of outpatient and inpatient services, choice of provider, and out-of-pocket expenditure on health, the survey asks a number of questions related to a patient's perception of quality of care received from different providers.

In particular, two sets of questions from the household survey focus on quality. The first set of questions asks the individual the reason for choosing a given provider. Responses include short distance, suitable cost, good treatment, good reputation, prior experience, specified by employer, specialized staff, and being referred. The second set of questions asks the individual to assess their health care provider. The assessment categories are divided into three components of quality: process,

access, and structure. Process questions ask patients about the adequacy of information provided to them about their diagnosis, treatment, and the side effects of their treatment. Patients were also asked about the adequacy of the length of time that their physician spent with them and their assessment of their treatment by the staff. Access questions asked about the convenience of the provider's working days and clinic hours, if it was easy or difficult to travel to the provider, travel time, whether a prior appointment was necessary and how long it took for an appointment, and the length of waiting time for an exam. Structure questions asked the patients if the exam was conducted in a private room, whether the number of staff was adequate and whether, in the assessment of the patients, the staff and office were clean. In addition, patients were asked if the waiting area was in a hall, waiting room, passage between rooms, in front of the exam room or outside, and if the patient had to sit or stand in the waiting area. A summary of patient's responses is placed in Annex B.

Factor analysis is used to develop a composite score for quality, taking into account the responses to all the different questions mentioned above. Factor analysis consists of a collection of procedures for analyzing the relations among a set of random variables observed for each individual of a group. The purpose of factor analysis is to account for the intercorrelations among n variables, by postulating a set of common factors, considerably fewer than the number n of these variables. There will also be n unique factors, one for each variable, which do not help to account for the intercorrelations, but which do help to account for the fact that these intercorrelations are less than unity. In a factor analysis, interest centers mainly on the common factors, which are interpreted with reference to the observed variables.

Using the data described in Annex B, we use factor analysis to create a summary score for the overall attribute of perceived quality. The scores are then normalized to a value between 0 and 1. Private providers obtain a higher score overall (0.55) compared to public providers (0.42).[10]

4.2.2 Demand for Health Care

4.2.2.1 Estimating the Probability of Consumption

The demand for health care also is estimated using data from the Egypt Household Health Care Utilization and Expenditure Survey 1994-1995. The population sample represented Egypt's population at the national level and the five regions of the country: urban governorates, rural Lower Egypt, rural Upper Egypt, urban Lower Egypt, and urban Upper Egypt. The survey collected data on socio-demographic characteristics of the household, health status, insurance coverage, factors affecting the decision to seek care, utilization of outpatient and inpatient services, choice of provider, and out-of-pocket expenditures.

Tables 1 and 2 in Appendix 3 describe the socio-demographic characteristics of the sample. Roughly 20 percent of those interviewed live in the principally urban governorates of Cairo, Alexandria, Suez, and Port Said. Forty-two percent live in the Lower Egypt governorates of Gharbia,

[10] Indicators of quality using the same general data set are also computed by Yip and Orbeta (1998), who use the Egypt Household Health Care Utilization and Expenditure Survey 1995 to test whether the relative magnitude of price and quality elasticities of demand could explain how price and quality competition occurs, and their effect on cost and quality outcomes. They report scores for structure, process and outcome aspects of quality separately, and consistently find higher ratings for private providers across all measures. Our results are in general conformity with those obtained by Yip and Orbeta.

Ismailia, Dakhalia, Damietta, Menoufia, Sharqia, Beheira, and Qalyoubia, and 38 percent live in the Upper Egypt governorates of Giza, Aswan, Fayoum, Assiut, Beni Seuf, Sohag, Miniya, and Qena. About 13 percent of the sample consists of individuals less than five years of age, 31 percent in the age group five to fifteen, 23 percent in the age group sixteen to twenty-nine, 12 percent in the age group thirty to thirty-nine, 9 percent in the age group forty to forty-nine, and 12 percent fifty or older. Males make up 49 percent of the sample and females 51 percent. Of the sample, 33 percent report having no schooling, 28 percent completed up to the primary school level, 11 percent completed preparatory level, 14 percent completed secondary education, and only 6.5 percent completed higher than secondary education. Almost 75 percent of persons in the lowest income quintile live in rural areas, whereas only 25 percent live in urban areas. This pattern holds true across other income quintiles, and only 34 percent of persons in the highest income quintile living in rural areas.

Forty-four percent, or 22,132 individuals in the sample report an illness event within the previous two weeks. Of these, only 21 percent, or 4,685, seek any kind of formal medical treatment. About half of those who seek treatment visit private physicians, with the rest going to MOHP facilities, other government facilities (such as those owned by the Education Ministry, Defense, etc.), Health Insurance Organizations, and Curative Care Organizations, collectively referred to as "public" facilities, mosque clinics, pharmacies and others, in that order.

Demand for health care can be defined as the quantity of a particular type of service that people are willing to obtain over a given period of time. More important than quantity of health care, however, is the discrete phenomenon of "seeking care." In this specification, the values taken by the dependent variable are merely a coding for some qualitative outcome, where the mutually exclusive choices may be "seek treatment from provider j" and "seek treatment from provider k." The choice of provider would naturally be conditional on the decision to "seek treatment", which in turn would be conditional on being ill. Consumer decisions are based on maximizing utility, which depends on the individual's health status after consumption of the health good as well as on consumption of other goods. Estimation of demand thus takes the form of estimating these marginal and conditional probabilities.[11]

Formally, let the expected utility conditional on receiving care from provider j be defined as[12]

$$U_j = U(H_j, C_j) \qquad (1)$$

where H_j is the expected health status after receiving treatment from provider j and C_j is the consumption net of the cost of receiving care from provider j. As Gertler, Locay, and Sanderson (1987) have shown, income can influence the choice only if the conditional utility function allows for a non-constant marginal rate of substitution of health consumption.[13] Following Gertler and van der

[11] In the theoretical and empirical framework that follows, we restrict ourselves to determining the probability of seeking care conditional on an event of illness. To this extent, therefore, the estimated price elasticities may be considered to be short-term elasticities that may differ form long-term elasticities if the probability of reporting an illness is responsive to prices. Dow (1996) presents a case in which the short-term and long-term responses are not significant, and shows that there is in fact no sample selection bias in using a sample conditional on illness. Other researchers have also used such a framework (see, for instance, Gertler and van der Gaag, 1990, Lavy and Quigley, 1993, and Lavy and Germain, 1994). For a specification that uses the full sample in a sequential decision-making framework, see Chawla and Ellis, (2000).

[12] The framework that we adopt for the analysis closely follows the models developed in Gertler, Locay, and Sanderson (1987), Gertler and van der Gaag (1990), Lavy and Germain (1994) and Alderman and Gertler (1997).

[13] This is also consistent with the notion of health being a normal good.

Gaag (1990) we use a functional form in which utility is linear in health and quadratic in consumption.[14] Specifically, we express the utility function for the "seeking care" alternatives as:

$$U_{ij} = \alpha_0 H_j + \alpha_1 (Y_i - P_j) + \alpha_2 (Y_i - P_j)^2 + \varepsilon_j \quad (2)$$

When no care is sought, (2) reduces to

$$U_0 = \alpha_0 H_j + \alpha_1 Y_i + \alpha_2 Y_i^2 + \varepsilon_0 \quad (3)$$

As Alderman and Gertler (1989) note, the parameters in the equations 2 and 3 are identified only when the values of expected health and consumption vary across the alternatives.

The quality of health care providers is not introduced so far in the model. We do so by defining quality of provider j as the difference between expected health outcome from the jth provider and self-care, and express quality as:

$$Q_j = H_j - H_0 \quad (4)$$

Substituting into (2) yields

$$U_{ij} = \alpha_0 (Q_j + H_0) + \alpha_1 (Y_i - P_j) + \alpha_2 (Y_i - P_j)^2 + \varepsilon_j \quad (5)$$

Normalizing quality of self-care to zero, the utility from the self-care alternative reduces to:

$$U_0 = \alpha_0 H_0 + \alpha_1 Y_i + \alpha_2 Y_i^2 + \varepsilon_0 \quad (6)$$

Estimating (5) poses the problem that quality is not directly observable. We address this issue by letting quality of health care provider j depend on the characteristics of provider j as well as on the characteristics of those seeking treatment, insofar as their personal ability to implement the recommended treatment affects the quality of health care they obtain. Defined thus, quality is a function of such provider-specific characteristics as cleanliness, availability of waiting room, and availability of appropriate equipment, and such individual-specific parameters as age, gender, education, and marital status.

We define a reduced-form model of the utility from quality as[15]:

$$\alpha_0 Q_j = \varepsilon_{0j} + \beta_1 X + \beta_{2j} Y + \beta_{3j} Z_j + \eta_j \quad (7)$$

where X is a vector of demographic variables, Y is a vector of provider-specific factors, Z_j is a vector of characteristics that do not enter the budget function, and η_j is a random disturbance term with mean zero and finite variance. Substituting (7) into (5) produces:

$$U_j = V + \eta_j + \varepsilon_j (8)$$

where

[14] Other functional forms that have been used are the translog indirect utility function (Gertler, Locay, and Sanderson, 1987), and the Cobb-Douglas (Lavy and Germain, 1994).
[15] This functional form is adapted from Alderman and Gertler (1997)

$$V_j = \alpha_0\beta_{0j} + \alpha_0\beta_1 jX_j + \alpha_0\beta_{2j}Y + \alpha_0\beta_{3j}Z_j + \alpha_1(Y_i - P_j) + \alpha_2 (Y_i - P_j)^2 \qquad (9)$$

This model can be estimated if the stochastic distribution of the error term is known. For the purposes of this study we assume that the error terms take on a nested multinomial logit form. In this specification, the probability of not seeking care is defined as:

$$\text{Prob (no treatment)} = \exp (V_0)/\{\exp (V_0)+[\Sigma_{j>0} \exp (V_j/\sigma)]^{\sigma}\} \qquad (10)$$

and the probability of seeking care from provider j is defined as:

(11)

$$\text{Prob (seeking care from provider j)} = [1\text{-Prob (no treatment)}][\exp (V_j/\sigma)] / \Sigma_{j>0} \exp (V_j/\sigma)$$

where σ is a coefficient of dissimilarity between the "no treatment" and "seeking care from provider j" alternatives. As demonstrated by McFadden (1981), this coefficient must be between 0 and 1 for the model to be consistent with utility maximization. If $\sigma<1$, it implies that the error terms in the utility function of "seeking care from provider j" are correlated, implying that patients view the various alternatives of seeking care as being closer substitutes with each other, and not with no treatment. When $\sigma=1$, all alternatives, including that of no treatment, are treated as equally close substitutes, and the nested aspect of the model disappears. This condition, therefore, provides a formal specification test of the multinomial nested logit model.

4.2.3 Nested Multinomial Logit Model

The provider choice model is estimated for the country as a whole. Of the total sample of 50,661, 44 percent, or 22,132, report an illness. Of these, only 21 percent (4,685) seek care. Patients have a choice among two types of providers: "public" and "private." Public providers include all MOHP providers, other government providers, Health Insurance Organization, and Curative Care Organization providers. Private providers include private outpatient clinics and mosque clinics. Among all those seeking care, 59 percent visit private providers while 41 percent visit public providers.

Various individual specific and provider specific factors affect patient choice. Individual-specific factors include age, place of residence (urban or rural), gender, family size, marital status, employment status, and education. Provider-specific factors include consultation costs, transportation costs and quality. Estimation results are presented in Annex C (table C-3).

Note that the value of σ is between 0 and 1, indicating that the model is consistent with utility maximization. Further, σ is significantly different from zero. Individuals view the provider choices as closer substitutes for each other than for the no-treatment (or the self-care) alternative. The coefficients on income[16] and the square of this term are significantly different from zero, and positive for the income variable and negative for the squared term, implying that the utility function is concave in income. Consumption costs enter the model via the income terms, represented by the number of consultations, and the fact that the income terms are significant implies that health care costs are relevant to the choice of provider. However, since health care costs and income enter the

[16] For purpose of the estimation, the variable is divided by 1,000 in all the results presented in this paper.

model in a highly non-linear fashion through the income terms, it is hard to judge the magnitude of the effect of health care costs on utilization by merely looking at the coefficients. This is examined in the next section, in which we compute and present arc own- and cross-elasticities of prices by income quintiles.

Utilization of health care in Egypt increases with age, as is indicated by the positive and significant coefficient on age for both public and private providers. Women are more likely to use health care services than men, as is indicated by the positive and significant coefficient on the dummy representing females for both public and private providers. The coefficient on family size is positive and significant, suggesting that larger families are more likely to use formal health care. This is a surprising result, considering that larger families have more resources for home care compared to smaller families, and are thus more likely to use self-care.

Education influences the decision to seek care as well as the choice of provider. Individuals with higher education are more likely to seek care than not seek care, and of those with education, the higher educated persons are more likely to seek care from private providers than from public providers.

Married and widowed persons are more likely to seek home care compared to those who are single. The coefficient on the dummies indicating urban residence and employment are also negative, but insignificantly different from zero, indicating that these factors do not affect provider choice or the decision to seek care other than self-care.

Among the provider-specific variables, utilization of health care is negatively related to consultation costs and transport costs and positively related to quality of health services.

4.2.4 Price Elasticities

In order to assess the direction and magnitude of the effect or price and income on demand for health care for a specific provider, we estimate arc price elasticities of the demand for public and private providers by income quintiles. Following Train (1986), Gertler and van der Gaag (1990), and Chawla and Ellis (2000), the arc elasticities are obtained by sample enumeration. Within the specified price range, the probability of an individual choosing an alternative is predicted for every individual, holding all characteristics constant at their mean values, except price and income. The percentage change in the probability of choosing an alternative is divided by the percentage change in price to yield the arc price elasticity. In other words, an arc price elasticity of –1.0 implies that a 10 percent increase in price will result in a 10 percent reduction in demand; an arc price elasticity of –2.0 implies that a 10 percent increase in price will result in 20 percent reduction in demand, and so on. Arc price elasticities of the demand for public providers are calculated for LE 2 intervals in the range LE 0–LE 10. For private providers, the arc elasticities are calculated for LE 2 intervals in the range LE5–LE 15.

Table C-4 in Annex C describes the arc price elasticities calculated for the two alternatives. The price elasticities along a demand curve are read moving down a column holding income constant; price elasticity across demand curves is read moving across a row, holding price constant. The results show that the demand for public providers is relatively inelastic across the income groups, and falls very marginally with an increase in income. The price elasticity of the demand for private providers is also relatively inelastic across the income quintiles, though it is much higher than the price elasticity of the demand for public providers.

Reading down a column, we observe that the demand for health care is relatively inelastic in the lower price ranges and becomes more elastic in the higher price ranges. This is particularly the case for private providers, where the demand becomes particularly elastic at higher price ranges. Comparing across the alternatives, the demand for public providers is generally inelastic while the demand for private providers is generally elastic.

These results lend support to an increase in user fees in the public sector. The low elasticity numbers indicate that not only will an increase in consultation costs of public providers not reduce the utilization of health services significantly, such an increase will not be regressive either, reducing the utilization of health care by those in the lower income quintiles only insignificantly more than by those in the higher income quintiles. Increases in the consultation fees of private providers, however, will significantly reduce the demand for health care from private providers.

Also of interest in evaluating the effect of an increase in consultation fees are cross-price elasticities Annex C (table C-5). The results indicate that demand for private providers is more sensitive to changes in consultation costs of public providers than is the demand for public providers in response to changes in private fees. Thus, an increase in consultation costs in the public sector is likely to push many consumers to the private sector. Note that the own price elasticities for private providers is high while the cross-price elasticity of public providers with respect to changes in private fees is small, indicating that with an increase in private fees, patients unwilling to pay the higher private fees prefer self-care to public providers.

4.3 Other Parameters

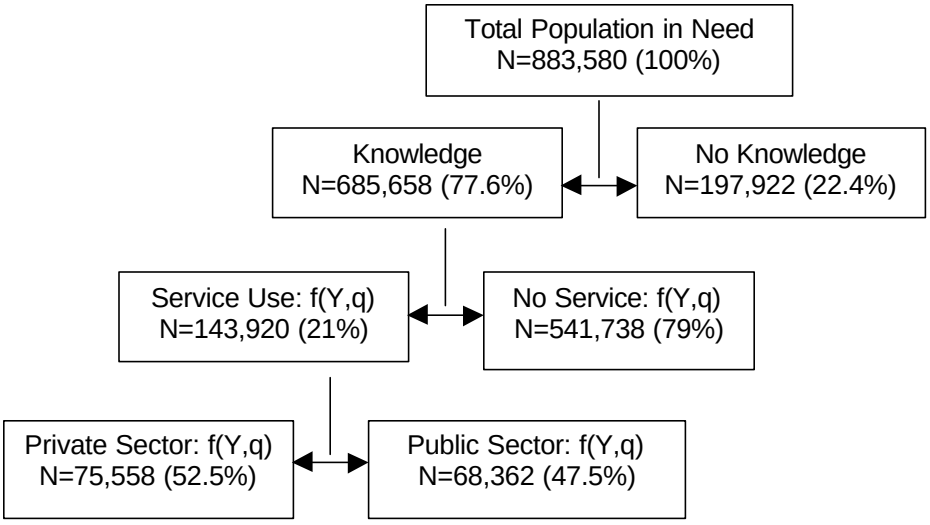
There remain two other parameters whose value we need to know in order to estimate the model. These are: (1) the cost of educating one individual and (2) the cost of increasing quality. Unfortunately, reliable information is not available on either of these. As far as the cost of education is concerned, we assume a cost of LE 5 per individual; as far as quality is concerned, we assume that it costs LE 10 to improve quality rating of public providers by 100 percent.

5. Analysis

We can now compute those values of α, δ, β and σ that would maximize the objective function of the government subject to the budget constraint. This is done by setting up the problem (equations 5 and 8) in the form of (10) above and using the sequential quadratic programming methods (discussed in section 3) to obtain a solution that maximizes the objective function subject to the budget constraint.

We start with the initial situation in which there are 706,864 expecting mothers in the low-income category and 176,716 in the high-income category. Of these, 158,338 in the low-income category and 39,584 in the high-income category do not possess knowledge of the health intervention. In other words, there are 685,658 individuals with knowledge overall and 197,922 without knowledge (figure 1).

Figure 1. Population Seeking Antenatal Care



In our model, 21 percent of those with knowledge seek care.[17] Of those who seek care, 52.5 percent prefer the private providers and the remaining 47.5 percent visit the public providers.[18] In the initial situation, therefore, the private sector provides antenatal care for 75,558 expecting mothers,

[17] This is close to, but lower than, the observed fact as reported by EDHS95, which finds that women received antenatal care in only 39.1 percent of all births in the five years preceding 1995. The EDHS figures do not, however, refer to the full package of antenatal services (four visits), coverage for which is likely to be significantly lower than 39.1 percent.

[18] However, EDHS95 reports that 79.3 percent of all antenatal care visits in the five years preceding 1995 took place in the private sector. The overestimation of utilization of public provision is probably due to the relatively little differential in the patient's assessment of quality of public and private providers. Also, note that the model is fitted using demand data on utilization of curative health services rather than antenatal care, and thus may not provide the most accurate information regarding individual assessment of public and private provision for a preventive service like antenatal care.

while the public sector provides care for the remaining 68,362 expecting mothers. Overall, only 16.3 percent of the total population in need receives antenatal care. The government's objective is to increase the number to the highest possible level, given additional resources, or to 100 percent at the lowest cost possible.

The analysis starts from the situation in which the Ministry of Health and Population receives an additional budget allocation of LE 1 million, and that it costs the government LE 5 to educate one individual. The MOHP can use these additional funds in one or more of the following different ways: finance additional production in the public sector (only if there is additional demand); increase consumer education and awareness; subsidize private sector consumption; subsidize transportation and other costs incurred by consumers at public facilities; and improve quality of the health good produced in the public sector.

The maximum that the government can usefully spend on increasing awareness and knowledge is the amount required to educate the entire population of those in need but without knowledge of the health intervention. We refer to this benchmark as "100 percent coverage." As far as subsidizing consumption from private providers is concerned, we posit that the maximum that the government spends is the amount required to subsidize all who consume from the private providers of all they spend on provider consultation fees. We refer to this benchmark also as "100 percent coverage" by this policy intervention. Similarly, the maximum that the government spends on transport subsidy is the amount required to subsidize all who consume from the public providers of all they spend on transportation to reach the provider. This is also referred to as being "100 percent coverage."

Expenditure on improving quality of the health services produced by the public providers, however, is not limited by coverage benchmarks. Recall that we have obtained a score on quality by considering consumer responses across a range of questions that deal with a variety of access-, process- and outcome-related issues. Consumer satisfaction, as indicated by this score, can, theoretically at least, double, triple, or increase manifold. In such situations, benchmarks such as "100 percent" imply only a doubling from the initial quality level, and do not indicate any coverage level.

At the same time, the level of quality reported for services provided by the private providers does provide a standard against which to judge and produce the public sector health service. Accordingly, we present and analyze the predictions of the model under two assumptions. In the first, we assume that there are no limits to potentially increasing quality of the public sector output. In the second (and more realistic) situation, we limit improvements in public sector quality to the level at which it equals the reported quality levels in the private sector.

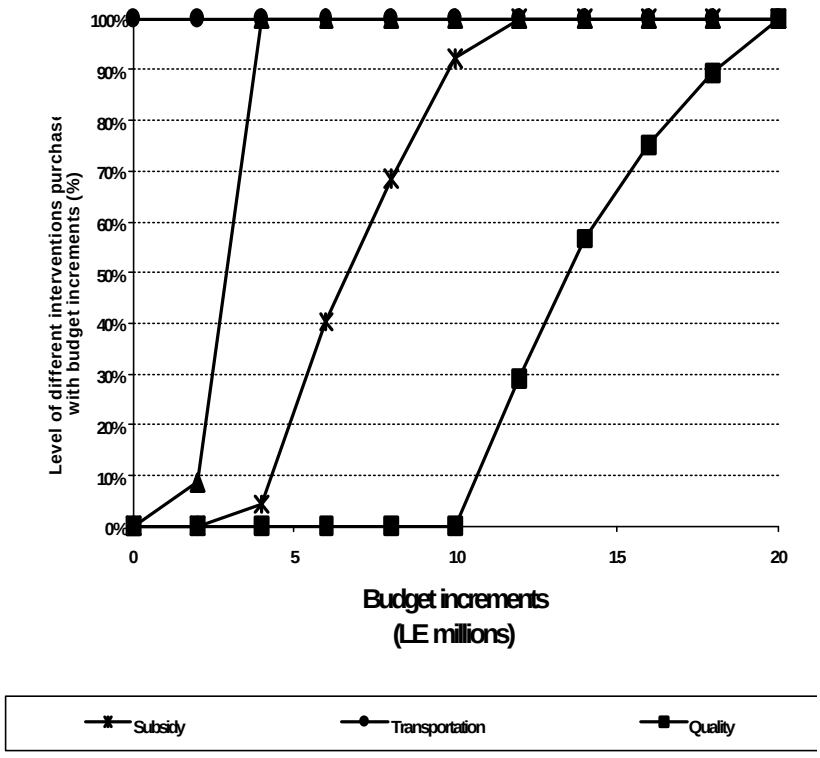
The rest of this section is organized as follows. Subsection 1 presents and discusses the interventions suggested by the model as more funds become available. Subsection 2 shows how full coverage can be attained if the interventions suggested by the model are followed and there is no budget constraint. Subsections 3 and 4 present sensitivity analysis with respect to production costs and education costs, respectively.

5.1 Suggested Interventions to Maximize Coverage at Different Funding Levels

We first consider the case in which the per-person cost of providing the complete package of antenatal care in the public sector is LE 50 and the per-person cost of education is LE 5. In later examples, both these values will vary. We also assume that there are no constraints to improving the quality of the publicly produced health good.

Optimal allocations of incremental budgets are presented in figure 2. The vertical axis measures percentage increments in the four intervention variables, while the horizontal axis depicts budgetary increases. When the budget increment is LE 2 million, the model suggests increasing the transportation subsidy to users of public providers to fully cover travel costs (100 percent), and extending knowledge of the health intervention so as to cover 9 percent of the population hitherto unaware of the beneficial aspects of the health good. When the budgetary increment is LE 4 million, the model suggests: (1) transportation subsidy to fully cover travel costs; (2) education campaigns to fully cover all those hitherto unaware of the beneficial aspects of the health intervention; and (3) subsidizing expenditure on private providers by 4 percent. With further increments in the budget, the model suggests increasing private providers' subsidy till 100 percent of the expenditure is covered, which is possible when the budgetary increment is LE 12 million. Further increments in the budget are committed to improving the quality of the public provision.

Figure 2: Levels of Different Interventions Purchased at Different Levels of Budget Increment (cost of public production per user = LE 50)



Notes: 1. "Level of Subsidy" measured on the y-axis refers to the percentage of the price of the health good procured from private providers that is subsidized by the budget increment;

2. "Level of Travel Cost" measured on the y-axis refers to the percentage of the cost of travel incurred by consumers visiting public providers that is subsidized by the budget increment;

3. "Level of Quality Improvements" measured on the y-axis refers to the extent of improvement in perceived quality of public facilities;

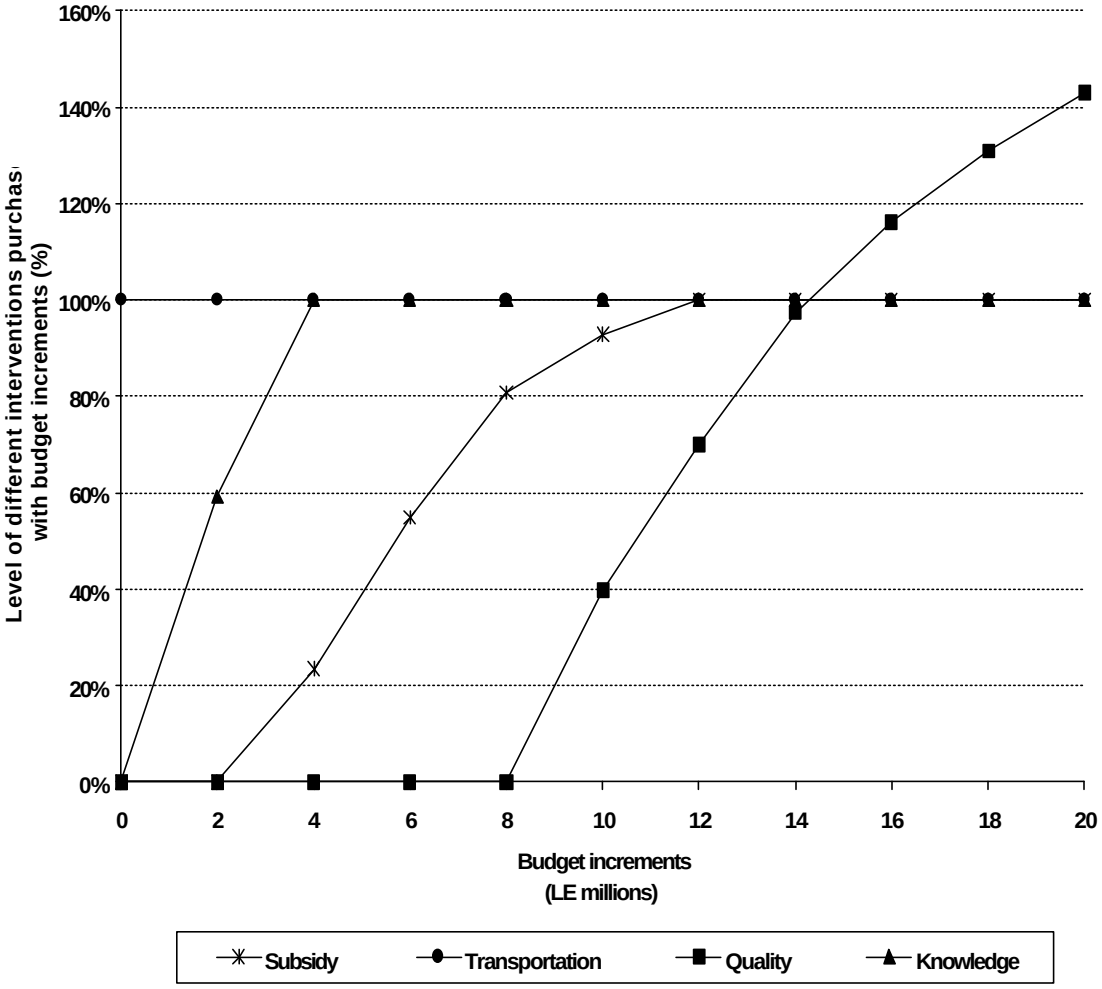
4. "Level of Education" measured on the y-axis refers to the percentage of the population hitherto unaware of the benefits of the health good that is covered by the budget increment.

Note that the model predicts the use of interventions in the following order: subsidizing consumer transportation costs to public providers, increasing knowledge of the beneficial aspects of the health good among those hitherto unaware, subsidizing private provision, and finally improving the quality of the publicly produced health good. Recall that transportation costs in the public sector are rather low—LE 1.2 per visit—and the coefficient on transportation costs in the demand function is –0.12. In other words, there is a positive probability that demand for health care from public providers will increase with a reduction in transportation costs. Of all the interventions, subsidizing public transportation costs is the least expensive, and it is therefore not surprising that the model suggests the first use of this intervention. By assumption, the demand for the health good among those without knowledge is 0, and since the per-person costs of education are only LE 5, the model's suggestion of increasing knowledge as the next intervention also appears reasonable.

In choosing between the expensive private sector subsidy and the lower-cost intervention of improving public sector quality, the model suggests first use of private sector subsidy. Recall that the public sector production costs to cover one person with four visits is LE 50. Improving public sector quality has a huge impact on the consumer demand of the publicly produced health good, as is obvious from the high positive coefficient of 7.5 on quality. Thus, investment in improving public sector quality will significantly increase demand for the public sector good, the production of which will require huge public sector outlay. Under these circumstances, the model suggests that subsidizing private sector subsidy take precedence over improvements in public sector quality.

Next, we consider the case in which the per-person cost of providing the complete package of antenatal care in the public sector is only LE 20. The nature and order of the interventions suggested by the model in this case are quite similar to the previous example in which the per-person costs were LE 50. Like in the previous example, the model suggests the use of interventions in the following order: subsidizing consumer transportation costs to public providers, increasing knowledge of the beneficial aspects of the health good among those hitherto unaware, subsidizing private provision, and finally improving the quality of the publicly produced health good. The only difference is in magnitude, since the lower production costs allow for a more greater coverage with lesser funds. In particular, the lower production costs permit bigger allocations to improving public quality, since the subsequent demand on public sector outlays is not that high. Optimal allocations of incremental budgets in this case are presented in figure 3.

Figure 3: Levels of Different Interventions Purchased at Different Levels of Budget Increment (cost of public production per user = LE 20)



Notes: 1. "Level of Subsidy" measured on the y-axis refers to the percentage of the price of the health good procured from private providers that is subsidized by the budget increment;

2. "Level of Travel Cost" measured on the y-axis refers to the percentage of the cost of travel incurred by consumers visiting public providers that is subsidized by the budget increment;

3. "Level of Quality Improvements" measured on the y-axis refers to the extent of improvement in perceived quality of public facilities;

4. "Level of Education" measured on the y-axis refers to the percentage of the population hitherto unaware of the benefits of the health good that is covered by the budget increment.

5.2 Full Coverage

In order to attain full coverage, all 883,580 expecting mothers have to demand, and be provided, the full antenatal care package comprising of four visits, from either public or private providers. Recall that with increases in the level of awareness and knowledge, the eligible population pool increases. This "new" population divides itself between public and private providers in a ratio determined by personal preferences. Using the demand function estimated earlier, it is possible to compute the change in the demand for the publicly provided goods in response to: (1) increases in

transportation subsidy and (2) improvements in quality. Similarly, we can compute the change in the demand for the private sector health good in response to an increase in private sector subsidy.

Using the allocations as suggested by the model and described earlier in figure 2 (per-person production costs LE 50), and accounting for all the changes in the demand responses for the two sectors, a total of LE 40,930,483 will be required to provide the complete antenatal care package for the eligible population. Of this amount, LE 22,616,113 (55 percent) will be allocated toward public sector production of the health intervention at the high quality level, LE 1,206,192 (3 percent) will be spent on transport subsidies, LE 989,610 (2 percent) will be spent on increasing awareness and knowledge, and the remainder LE 16,118,568 (40 percent) will be allocated to subsidizing patients visiting private providers. The public sector will provide the complete antenatal care package to 319,652 individuals (36 percent of the eligible population), while the private sector will account for the remaining 563,928 individuals (64 percent of the entire population).

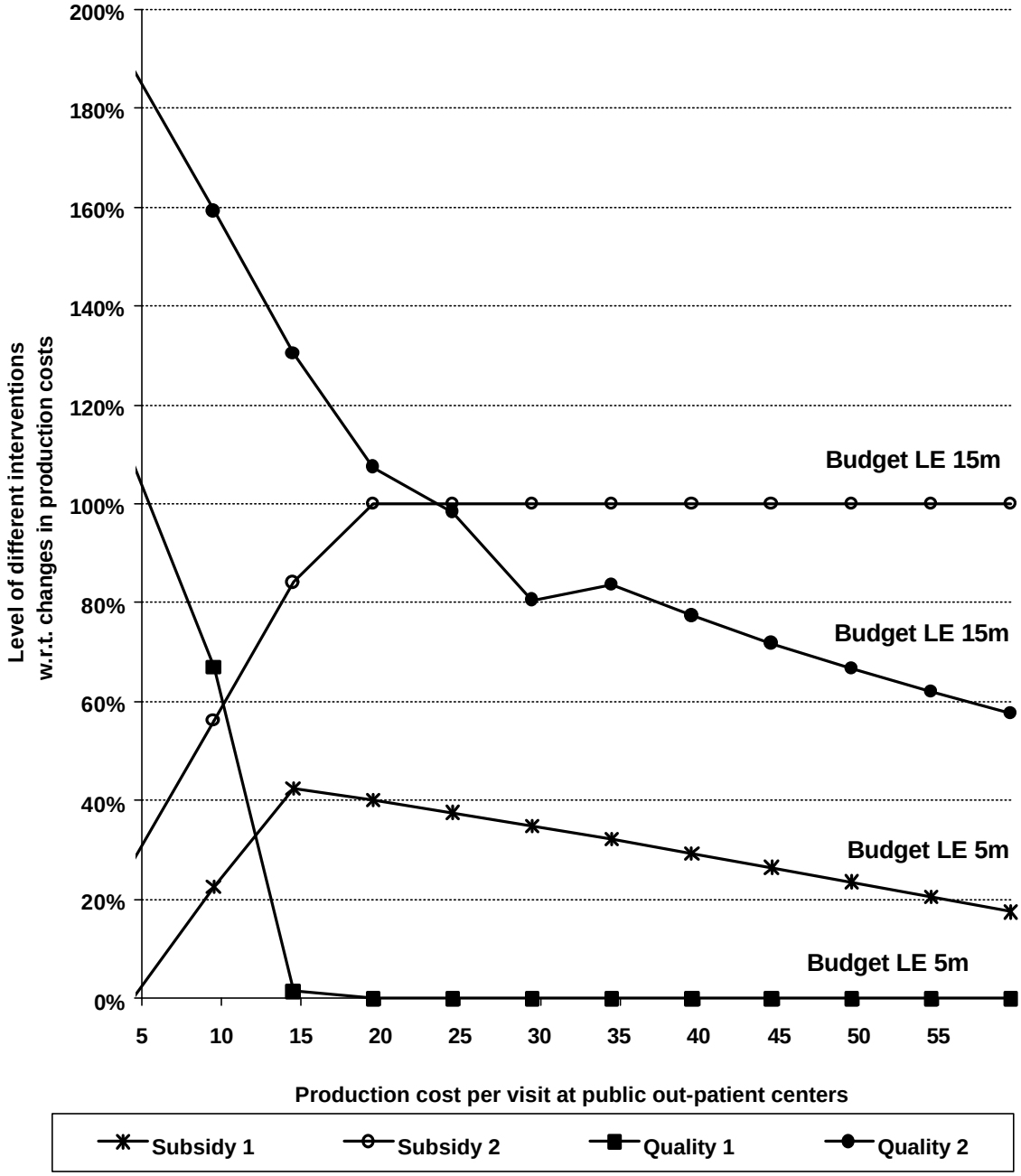
Recall that the total MOHP expenditure on antenatal care for 1995 is estimated to be LE 22.3 million, and the number of persons covered by the MOHP is only 68,362. It is, therefore, reasonable to wonder how, by doubling the budget outlay, the MOHP coverage can be increased almost five-fold and total coverage, the private sector included, to 100 percent. The answer rests on a number of implicit and explicit assumptions that we make in the analysis. Recall that the MOHP expenditure also includes the fixed costs associated with the production, management, and delivery of health services, and implicit in the analysis is the assumption that the fixed costs do not increase as more services are provided. This has the effect of spreading out the costs so that the average cost is, in fact, quite low. Further, we assume that the demand function captures appropriately the response–effect of consumer behavior to the various factors considered to be the critical determinants for such a behavioral response. These factors include price of the good at both provider-types, transportation costs, quality perception, and so on. And finally, as stated earlier, there are no binding capacity constraints to production in either sector. This means that increased production of health services in either sector does not require any special reorganization or change in the way the health facilities can be and are managed, and it is feasible to meet the required production targets.

5.3 Sensitivity Analysis: Uncertain Production Costs

As seen in previous discussions, there are huge differences between per-person expenditure by the Ministry of Health and Population on providing the complete antenatal care package, computed by dividing the total MOHP outlay by the number of persons covered, and the average production costs in the health facilities, computed by determining the total operational costs and dividing that by the number of visits recorded in the facility. In addition, there are huge differences in production costs across facilities as well. We have also seen that production costs are important determinants of the nature and magnitude of the interventions, and the model predictions are sensitive to changes in the cost figures. All of this leads us to believe that in order for the model to be applied usefully, good estimates of production costs are absolutely necessary.

This section presents the results of a sensitivity analysis undertaken to show the response of interventions to changes in per-person production costs (figure 4). It presents two examples: in the first, the total budget is fixed at LE 5 million; in the second, the budget is fixed at LE 15 million. Per-person production costs are allowed to vary between LE 5 and LE 60.

Figure 4: Purchase of Interventions as Public Production Costs Vary, All Other Costs Remaining Constant



In both cases (i.e., with budget increments of LE 5 million and LE 15 million respectively), the model suggests 100 percent coverage by education and transportation subsidies, even at the highest of

production costs.[19] Expenditure on private subsidy and improvements in public sector quality, however, vary with production costs. In both cases, the model suggests higher expenditure on improving public quality when the production costs are low, and increasing private sector subsidy as production costs increase. When the budget is LE 5 million, the model suggests zero expenditure on public quality at production costs higher than LE 15. Private subsidies also decline with higher production costs, since the increase in public sector demand due to transportation subsidy and increased education coverage place a greater demand on public sector outlays, leaving less funds for private sector subsidy. Similarly, when the budget is LE 15 million, the model suggests gradually decreasing expenditure on public sector quality as production costs increase while maintaining high levels of private subsidy.

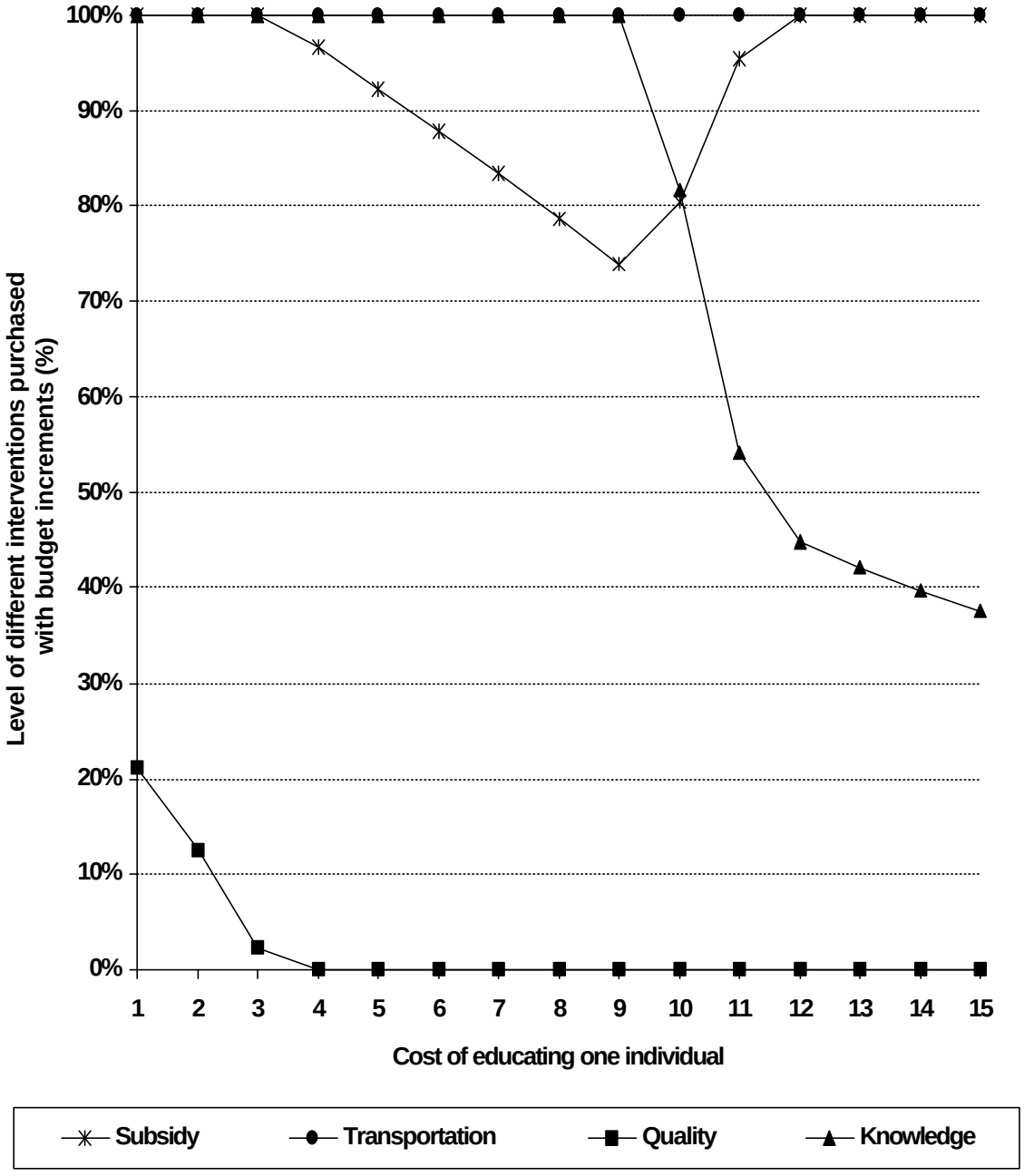
5.4 Sensitivity Analysis: Uncertain Costs of Education

An examination of the determinants of demand and profiles of users of antenatal care in Egypt also highlights the importance of education and knowledge of the potential benefits from consumption of a health good. Of the several factors that affect the likelihood of receiving antenatal care, the largest differentials are according to the mother's education level, with births to women who have a secondary or higher education more than three times as likely to receive antenatal care as births to women who never attended school (EDHS95). In practice, extensive education and awareness campaigns were behind one of the most successful government programs aimed at reducing neonatal mortality. Tetanus is a frequent cause of death in young infants in Egypt and occurs when sterile conditions are not observed during delivery. Tetanus toxoid injections, given to women during pregnancy, can potentially prevent neonatal tetanus. EDHS95 reports that tetanus toxoid coverage increased rapidly in Egypt in late 1980s and early 1990s, with the proportion of births for which the mothers received at least one tetanus toxoid vaccination during pregnancy rising from 11 percent in 1988 to 70 percent in 1995, most likely as a result of an extensive public education campaign to promote tetanus toxoid vaccinations during this period.

Figure 5 presents the optimal allocations across different interventions as costs of education vary between LE 1 and LE 15. The budget is fixed at LE 10 million and the per-person cost of producing the complete antenatal care package in the public sector is fixed at LE 50. As would be expected, investing in education ceases to be a preferred alternative at very high costs of education. As the figure indicates, the model suggests 100 percent education coverage till it costs LE 9 per person to do so, and then gradually reducing knowledge coverage as per-person education costs rise. Gradual decreases in private subsidies are seen in the initial phase of increase in the cost of knowledge, but the trend gets reversed when education coverage falls below 100 percent, making more funds available for other interventions.

[19] For clarity of presentation, we do not indicate these two interventions in figure 4.

Figure 5: Purchase of Interventions as Education Costs Vary, All Other Costs Remaining Constant



Notes: 1. "Level of Subsidy" measured on the y-axis refers to the percentage of the price of the health good procured from private providers that is subsidized by the budget increment;
2. "Level of Travel Cost" measured on the y-axis refers to the percentage of the cost of travel incurred by consumers visiting public providers that is subsidized by the budget increment;
3. Level of Quality Improvements" measured on the y-axis refers to the extent of improvement in perceived quality of public facilities;
4. "Level of Education" measured on the y-axis refers to the percentage of the population hitherto unaware of the benefits of the health good that is covered by the budget increment.

6. Discussion

In the preceding sections we have evaluated the provision of antenatal care in Egypt and demonstrated an alternative way of thinking about budget allocation. The analysis has been motivated by a set of assumptions that we believe represent many real-world situations, particularly in developing countries. Starting with the premise that the state seeks to assure universal coverage with a health care service of proven benefit, we show how governments could choose among a set of alternative uses for public funds other than additional public sector providers, especially if a significant supply of private sector providers exists, and there is a significant population that does not demand the health good either because they are unaware of the beneficial aspects of the good or because they lack the purchasing capability, or both.

The analysis provides a way of thinking about and addressing an issue that has historically been resolved by governments acting to produce services through budget financing of the public sector providers. Through explicit assumptions about the behavior of the four actors in the model: government, public and private providers, and consumers, we demonstrate a feasible application of an analytical model that can be adapted to address a variety of possible scenarios and many relevant policy questions. Significant applications of this model are feasible in developing countries that are relatively data-rich. The model utilizes data on demand, supply, and market elements. Demand-side data include information on socio-demographic and economic profile of users of the specific health services, utilization rates, prices and expenditures, mode of transportation, waiting time, etc. Supply-side data includes information on producers and financiers of health services, and cover such aspects like quality, access, costs, range of services, etc. Market elements include data on such aspects as health producing and financing institutions, and government regulation.

The results presented above are subject to a number of significant qualifications, which indeed are the basis for further investigation. The following are some of the main concerns:

- Model results in terms of the mix of interventions and their outcomes are highly sensitive to the specification of the costs of interventions, and there is great uncertainty about both the level of these costs and the shape of the cost curves. The model used the simplest possible specification, one of constant unit costs, which include both direct and indirect cost components. Little is known about the costs and impact of mass programs to educate women about the importance of antenatal care; of investment programs to improve the quality of public provision; or of the costs of running subsidy programs for transportation costs or private provider fees. The model does show, however, that under some plausible assumptions, interventions other than simply expanding public sector supply are likely to be important approaches to increasing coverage with desirable interventions.

- The definition of quality and the appropriate response to quality differences in public and private providers is a major factor in the results and one in which improvements in the analysis could be made in the future. A fundamental problem is the lack of an acceptable benchmark for quality, other than the higher perceived quality of private providers. We presented two alternatives—unconstrained improvements in public sector quality (at a constant cost) or equalizing public and private sector perceived quality. The positive basis for these alternatives is weak, except to note that they probably bracket the relevant range for policy of investments in public sector quality. A second major problem is the

measurement and interpretation of perceived quality. Again, we have used available data to demonstrate the feasibility of considering this factor and its relevance. We do not claim at all to have the best or most meaningful measure.

- This model uses results from a household survey to estimate consumer demand behavior. It predicts that even when public sector price is zero and quality is equal to or greater than private providers, some consumers will still prefer private providers. We explain this as consumer's individual characteristics. We should acknowledge that introducing demand behavior into the framework adds an important source of variability which may make full coverage impossible or very expensive to attain.

- We have used a variety of data sources that were not collected for the purpose of this model. In numerous places we have extrapolated from related data to estimates of variables we needed. Readers are urged to keep this in mind in reviewing the results. This is a test of an approach, not a carefully designed policy study. Much could be done to improve the data. We feel this is feasible although probably never perfectible.

This paper has presented a methodology for designing the optimal strategy for use of government funds in terms of supporting or expanding existing government provision, or financing existing or new private provision for a specific type of intervention, given existing conditions of supply. As it has demonstrated, simulations can be done to estimate the sensitivity of public expenditure decisions on new investment, strengthening of existing public services, or financing of private provision to the value range of key variables and parameters in the model. The results highlight the circumstances from both the supply and demand side which make the different policy choices more desirable, as well as the possible direction and magnitude of effects in terms of cost, coverage, equity, and health outcomes.

Annex A. Mathematical Formulation and Solution Methodology of the Model

Consider the problem:

Minimize $f(x)$ (1)

$x \in \Re^n$

subject to : $G_i(x)=0, \quad i = 1,\ldots,m_e$

$G_i(x) \leq 0, \quad i = m_e+1,\ldots,m$

$x_l \leq x \leq x_u$

Represent the Kuhn-Tucker equations of the above as:

$$f(x^*)+\sum_{i=1}^{m}\lambda_i^* \cdot \nabla G_i(x^*) = 0 \quad (2)$$

$\nabla G_i(x^*)=0 \quad i=1,\ldots,m_e$

$\lambda_i^* >= 0 \quad i=m_e+1,\ldots,m$

Formulate a quadratic programming (QP) sub-problem based on a quadratic approximation of the Lagrangian function:

$$L(x, \lambda) = f(x) + \sum_{i=1}^{m}\lambda_i \cdot g_i(x) \quad (3)$$

Linearizing the non-linear constraints, and assuming that bound constraints are expressed as inequality constraints, the QP sub-problem is expressed as:

Minimize $1/2 d^T H_k d + \nabla f(x_k)^T d$ (4)

$d \in \Re^n$

$\nabla g_i(x_k)^T d + g_i(x_k) = 0 \quad i=1,\ldots,m_e$

$\nabla g_i(x_k)^T d + g_i(x_k) <= 0, \quad i=m_e+1,\ldots,m$

The Sequential QP (SQP) implementation procedure consists of three main stages:

Updating of the Hessian matrix of the Lagrangian function

Quadratic programming problem solution

Line search and merit function calculation

At each major iteration a positive definite quasi-Newton approximation of the Hessian of the Lagrangian function, H, is calculated using the method developed by Broyden, Fletcher, Goldfarb and Shanno (BFGS).

$$H_{k+1} = H_k + (q_k q^T_k)/(q^T_k s_k) - (H_k{}^T H_k)/(s^T_k H_k s_k) \qquad (5)$$

where:

$s_k = x_{k+1} - x_k$

$$q_k = \nabla f(x_{k+1}) + x_k \sum_{i=1}^{n} \lambda_i \nabla g_i(x_{k+1}) - \left(\nabla f(x_k) + \sum_{i=1}^{n} \lambda_I \cdot \nabla g_i(x_k)\right)$$

where λ_i (i=1,…,m) is an estimate of the Lagrange multipliers.

At each major iteration of the SQP method, a QP problem is solved of the form where A_i refers to the ith row of the m-by-n matrix A.

$$\text{minimize } q(d)=(1/2)d^T H d + c^T d \qquad (6)$$

$d \in \Re^n$

$A_i d = b_i \qquad i=1,\ldots,m_e$

$A_i d <= b_I \qquad i= m_e,1,\ldots,m$

The solution to the QP sub-problem (6) produces a vector $d_{k,}$ which is used to form a new iterate:

$$x_{k+1} = x_k + \alpha d_k \qquad (7)$$

The step length parameter αk is determined in order to produce a sufficient decrease in a merit function. The merit function used by Han (15) and Powell (15) of the form below has been used in this implementation:

$$\Psi(x) = f(x) + \sum_{i=1}^{m_e} r_i \cdot g_i(x) + \sum r_i \cdot \max\{0, g_i(x)\} \qquad (8)$$

$i=1 \qquad i= m_e+1$

Because of the quadratic nature of the objective function, there are only two choices of step length α. A step of 1 along d_k is the exact step to the minimum of the function restricted to the null space. If such a step can be taken, without violating the constraints, then this is the solution to the quadratic programming problem. If such a step cannot be taken, the step along d_k to the nearest constraint is less than 1 and a new constraint is included in the next iteration. The procedure repeats itself till a solution is found.

Annex B. Patient Responses to Egyptian Household Health Care Utilization Survey

Household Interview Questions		Public			Private		
(Responses are for the first episode only)		Yes	No	Don't Know	Yes	No	Don't Know
Did anyone explain your diagnosis to you?		74.60%	25.40%	0.00%	91.47%	8.53%	0.00%
Did anyone explain your treatment to you?		71.72%	28.28%	0.00%	88.26%	11.74%	0.00%
Did anyone explain the side-effects of your treatment to you?		17.63%	82.37%	0.00%	23.06%	76.94%	0.00%
In your opinion, did the physician spend enough time with you?		72.70%	24.30%	3.00%	96.45%	2.82%	0.73%
Are the working hours at your physician's clinic convenient for you?		91.60%	8.40%		96.95%	3.05%	
Did you need a prior appointment?		4.96%	95.04%		7.32%	92.68%	
Was the medical examination conducted in a private room?		89.33%	10.67%		99.35%	0.65%	
In your opinion, do you think that the number of the staff is adequate to meet the clients needs?		79.94%	11.43%	8.63%	93.91%	3.22%	2.87%
Was the examination room clean?		92.65%	5.36%	1.98%	98.53%	0.96%	0.51%
Was the waiting room clean?		86.82%	7.99%	5.19%	98.02%	1.16%	0.82%
Was the toilet clean?		56.38%	11.49%	32.13%	79.99%	1.57%	18.44%
Was the equipment clean?		88.45%	4.14%	7.41%	97.61%	0.58%	1.81%
Was the appearance of the staff clean?		90.26%	6.01%	3.73%	97.40%	0.99%	1.61%
Did you find a seat or did you stand until you were examined?		74.52%	17.96%	7.52%	93.98%	1.88%	4.14%
What is your opinion about the treatment of the staff to the patients?	Excellent	9.04%			17.17%		
	Very Good	16.09%			22.00%		
	Good	55.74%			58.43%		
	Satisfactory	11.84%			1.98%		
	Poor	7.29%			0.41%		
Where did you wait until you were examined?	Hall/Waiting Room	68.10%			91.41%		
	Passage between rooms	6.47%			0.86%		
	In front of examination room	14.05%			3.04%		
	Outside	2.45%			0.31%		
	Other	8.92%			4.38%		

Was it easy or difficult to get to the clinic?	Easy	88.54%			91.34%		
	Difficult	10.54%			5.62%		
	No response	0.92%			3.05%		

Annex C. Data

Table C-1: Descriptive Statistics of the Sample

Age	23.680
	(18.873)
Family size	6.907
	(3.453)
Income(LE)	1334.196
	(1741.996)
Dummy representing female	0.506
	(0.500)
Dummy representing principally urban governorates	0.201
	(0.401)
Dummy representing upper urban Egypt	0.118
	(0.322)
Dummy representing upper rural Egypt	0.261
	(0.439)
Dummy representing lower urban Egypt	0.115
	(0.319)
Dummy representing lower rural Egypt	0.305
	(0.460)
Dummy representing marital status: Married	0.343
	(0.475)
Dummy representing marital status: Widowed	0.047
	(0.211)
Dummy representing marital status: Not married / Divorced	0.167
	(0.373)
Dummy representing education: Highest grade secondary	0.535
	(0.499)
Dummy representing education: More than secondary	0.064
	(0.245)
Dummy representing education: Never went to school	0.328
	(0.470)
Dummy representing education: Children not eligible for school	0.073
	(0.260)
Dummy representing population employed	0.232
	(0.422)
Dummy representing population with health insurance	0.356

	(0.479)
Dummy representing population reporting illness	0.437
	(0.496)
Dummy representing population seeking care	0.093
	(0.290)

Table C-2: Urban/Rural Distribution of Individuals by Income Quintiles

Income Quintile	Percent Urban	Percent Rural
Quintile 1 (< LE 544)	24.71%	75.29%
Quintile 2 (544-792)	31.26	68.74
Quintile 3 (793-1098)	40.17	59.83
Quintile 4 (1099-1689)	55.28	44.72
Quintile 5 (>1689)	65.79	34.21

Table C-3

Variables	Coefficient	t-ratios
Income x Number of consultations	0.0444	0.0145
(Income x Number of consultations)^2	-0.0011	0.0006
Sigma	0.5079	0.1418
Public Providers		
Constant*	-6.081	1.3404
Age*	0.0239	0.0029
Urban	-0.5019	0.8049
Female*	0.5459	0.0741
Family Size*	0.0955	0.0117
Married*	-1.3363	0.1169
Widowed*	-1.4090	0.2160
Employed	-0.2494	0.9382
Secondary Education*	0.1595	0.0735
High School Education	0.1271	0.1443
Price (public)	-0.0667	0.0759
Transportation (public)	-0.1185	0.0909
Quality (public)*	7.5206	2.1649
Price (private)	0.0041	0.0153
Transportation (private)	0.0121	0.0331
Quality (private)	-2.3681	2.8467
Private Providers		
Constant*	6.5395	1.2181
Age*	0.0232	0.0029
Urban	-0.8324	0.7093
Female*	0.6466	0.0704
Family Size*	0.0307	0.0125
Married*	-0.9088	0.1135
Widowed*	-0.8078	0.2016
Employed	-0.4772	0.9009
Secondary Education	-0.0602	0.0682
High School Education*	0.2561	0.1357
Price (public)*	0.0777	0.0142
Transportation (public)*	0.0760	0.0235
Quality (public)	-4.1228	2.7466
Price (private)*	-0.2983	0.0706
Transportation (private)	-0.0214	0.0299
Quality (private)	3.0902	1.8596

Table C-4: Own Price Elasticities

Public Providers					
Price	**Quintile 1 (<LE544)**	**Quintile 2 (LE544-LE792)**	**Quintile3 (LE793-LE1098)**	**Quintile4 (LE1099-LE1689)**	**Quintile5 (>LE1689)**
0-2	-.109	-.109	-.109	-.109	-.106
2-4	-.225	-.225	-.225	-.224	-.220
4-6	-.348	-.348	-.347	-.345	-.340
6-8	-.477	-.472	-.472	-.471	-.466
8-10	-.609	-.606	-.605	-.605	-.594
Private Providers					
5-7	-1.195	-1.187	-1.179	-1.167	-1.115
7-9	-2.081	-2.071	-2.060	-2.044	-1.975
9-11	-3.152	-3.144	-3.131	-3.126	-3.040
11-13	-4.301	-4.293	-4.282	-4.266	-4.208
13-15	-5.422	-5.410	-5.399	-5.399	-5.348

Table C-5: Cross Price Elasticities

Private Providers (with respect to changes in price of public providers)					
Price	**Quintile 1 (<LE544)**	**Quintile 2 (LE544-LE792)**	**Quintile3 (LE793-LE1098)**	**Quintile4 (LE1099-LE1689)**	**Quintile5 (>LE1689)**
0-2	.118	.118	.117	.117	.114
2-4	.225	.224	.224	.222	.216
4-6	.321	.320	.317	.315	.307
6-8	.403	.399	.399	.397	.383
8-10	.471	.470	.467	.462	.447
Public Providers (with respect to changes in price of private providers)					
5-7	.024	.022	.024	.024	.022
7-9	.027	.028	.029	.028	.028
9-11	.035	.035	.035	.034	.034
11-13	.040	.041	.041	.043	.041
13-15	.044	.047	.047	.046	.046

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