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ECONOMIC ANALYSIS OF THE TREATMENT OF MALARIA: A CASE STUDY

BY

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1. INTRODUCTION

Malaria can kill, although it normally debilitates both physically and financially. Despite major eradication efforts by governments and international agencies, the disease is becoming more common and the number of infected areas is growing. Its treatment is a critical public policy issue in all countries in which it is endemic. Economic analysis of treatment choices made by individuals can aid the policy-maker in designing treatment programs. In our sample, infected individuals must choose either free treatment in public clinics, or better treatment in private clinics: the latter is expensive. Holding income effects constant, individuals who choose the expensive private treatment reveal themselves to be the individuals in greatest need. By identifying the factors which determine the demand for private treatment, we therefore identify the individuals to whom resources should be targeted if there is a limited expansion of the health-care budget.

Malaria parasites are carried by mosquitoes. A mosquito picks up the parasite when it bites an infected individual, and deposits the parasite in the blood of individuals whom it subsequently bites. Unless an infected individual seeks treatment - at either a public clinic or a private clinic - he is almost certain to die. The primary focus of the public clinic is to prevent the spread of the disease: it achieves this by dispensing drugs which kill the parasite in the blood of the infected individual, thereby breaking the transmission chain. Although the infected individual suffers from physical debilitation, the public sector provides no additional treatment for this condition, so that the recovery of the individual is

relatively slow. In contrast, stronger drugs[1] and fuller treatment (e.g. intravenous injections and vitamin supplements) are available at private clinics operated by pharmacists and doctors. The benefit of such treatment is faster recovery, but the price of such treatment is high - in a related context, Vosti (1990) finds that the price of private treatment may be as high as average monthly income. Private treatment is therefore chosen only by a minority of infected individuals.

Our data comes from the Machadinho colonization project in the Brazilian state of Rondonia. Initiated in 1985, the project sought to create a small, subsistence farming community in an area which had previously been virgin forest. Tracts of forest were cleared into plots of approximately seventy-five acres, and given free to settlers. Almost immediately, settlers became infected with malaria. Our sample is therefore composed of households who are infected with a particular disease in a particular place, and for whom treatment at either a public or a private clinic is the only feasible option. In contrast, other studies in developing countries consider general outpatient demand - in the Philippines (Akin et al. (1981) and (1986)), in Malaysia (Heller (1982)), in Latin America (Musgrove (1983)), in Mali (Birdsall and Chuhan (1986)), in Kenya (Mwabu (1986)), in urban Peru (Gertler et al. (1987)) and in rural Cote d'Ivoire (Dor et al. (1987)). In these studies, self-care and treatment from traditional sources are also possible treatment options. Our sample therefore has the advantage of all subjects having the same disease, and of making a simple binary choice. We believe that this leads to the greater (conditional) precision of our estimates.

Factors which are associated with the choice of private treatment may be divided into economic and individual factors. We find that an increase in the price of private treatment significantly deters private treatment. Although economic theory predicts price to be an important determinant of choice, studies prior to Gertler et al. (1987) and Dor et al. (1987) found the effect of price to be insignificant.[2] Our analysis differs from the latter papers in that they impose a particular function form on the utility function. As expected, and as has been found by several authors, we confirm that private health treatment is a normal good.

Our measure of wealth is consumer durables which have many permanent features, so that changes in their level are likely to lag changes in financial condition. There is a difference between wealth and liquidity. We interpret our results to suggest the importance of liquidity. It is well-known that the cost of transportation to the treatment source should function as a price, and this is confirmed by Gertler et al. (1987) and Dor et al. (1987). In our sample, the transportation cost is large - similar to the price of private treatment. In the earlier cited studies, an individual incurs a different transport cost if he chooses the public clinic than if he chooses the private clinic. In our sample the public clinic and the private clinic are both sited in the same town, so that the transport cost incurred by the individual is the same for both treatment sources. However, we find that an individual with a high transport cost is less likely to choose private treatment. We suggest that transportation expenditure is important because of its effect on liquidity - an individual who has higher transportation expenses is less likely to have the liquidity necessary to pay for private treatment. In the same way we find that an individual, who

belongs to a *household* which has experienced many recent malaria infections, is (weakly) less likely to choose private treatment. We associate this with liquidity - malaria depletes liquid family resources.

The education of the male and female head-of-household are important determinants of the treatment source - education would appear to change tastes and lead a household to place greater weight on better health. An *individual* who has suffered many recent infections is more likely to choose private treatment. It seems that repeated malaria infections reduce resistance and increase physical debilitation - increasing the need for the better private treatment. Urban individuals are more likely to seek treatment at the public clinic. We believe this reflects the importance of transportation costs: if the public treatment proves insufficient, the urban individual may seek treatment at the private clinic without incurring additional transport costs. Finally, age and sex are unimportant.

These findings are important because they provide better understanding of the determinants of treatment. They also have policy implications as to the best use of additional funds if the public sector is expanded. The importance of price suggests that the possibility of providing better care by subsidizing private treatment should be explored.[3] Individuals suffering repeated malaria infections seem to suffer debilitation and to be in greatest need of better care - the public clinics should keep records on individual histories and any discretionary resources should be targeted at providing fuller treatment to these individuals. Our interpretation of the importance of the transportation cost - that the marginal utility of liquid wealth is higher than the marginal utility of permanent wealth - suggests that the use of regular mobile clinics to

provide full public treatment to outlying farms would be beneficial.[4] Our interpretation of the greater use of private clinics by rural households strengthens this policy suggestion - many rural households currently choose the expensive private treatment because they want to avoid the additional journey into town if the weaker drugs prescribed by the public sector prove ineffective. From a health perspective, for many households this additional resource usage is unnecessary, and avoiding it by greater reliance on mobile clinics is likely to be beneficial.[5]

The paper is organized as follows. Section 2 develops a positive model of health-care choice. The model is estimated in Section 3, and the results discussed. Section 4 concludes.

2. THE MODEL

A typical household with an infected member obtains utility from household consumption c and the health h of the infected member. The severity of infection is represented by a random variable, s. Severity worsens health, or $\partial h/\partial s < 0$. An individual suffering from malaria must be treated. z is an indicator variable; $z = 0$ if the individual is treated at the public clinic and $z = 1$ if the individual is treated at the private clinic. The health status of the individual after treatment depends on the treatment chosen (z), the susceptibility of the individual to infection - measured by the individual's medical history and demographic characteristics (**d**) - and the severity of the disease (s); $h(z, \mathbf{d}; s)$. By assumption, private treatment is more effective, or $h(0, \mathbf{d}; s) < h(1, \mathbf{d}; s)$.

The household wealth is w. If the individual selects treatment at the public clinic, treatment is free but he must pay the cost t of

transportation to the clinic. Household wealth is not fully liquid so that the use of scarce liquid funds involves an additional liquidity cost: the full or shadow transport cost is $f(t)$, $1 \leq f'(t)$. The household's consumption after public treatment is $w - f(t)$. Alternatively, the individual may choose to be treated at a private clinic; the treatment is better but expensive, having price p. The illiquid nature of the household portfolio causes the full cost of the expenditure of private treatment - including the transportation cost - to be $f(t+p)$. After private treatment, the household consumption is $w - f(t+p)$.

Utility is assumed to be additively separable[6] as $U(c) + \alpha h$, where α denotes the weight placed by the household on health. We assume that α is a function of education e, $\alpha(e)$. The individual chooses private treatment

$$z = 1 \quad \text{if} \quad U(w - f(t)) + \alpha(e)h(0, \mathbf{d}; s) \leq U(w - f(t+p)) + \alpha(e)h(1, \mathbf{d}; s),$$

and chooses public treatment otherwise, $z = 0$.

ASSUMPTION : *the benefit of private treatment increases with severity,*

$$0 < \frac{\partial}{\partial s} [h(1, \mathbf{d}; s) - h(0, \mathbf{d}; s)].$$

(FIGURE HERE)

Figure 1 shows the health of the infected individual under private and public treatment. Because the health benefit of treatment is assumed to increase with the severity of the attack, each individual has a critical severity $s^* \equiv s^*(w, t, p, \mathbf{d}, e)$ such that,

$$U(w - f(t)) - U(w - f(t+p)) = \alpha(e)[h(1, \mathbf{d}; s^*) - h(0, \mathbf{d}; s^*)]. \quad (1)$$

If the severity s greater than s^*, the utility gain from private treatment exceeds the utility lost from decreased consumption, and the infected individual chooses private treatment. Conversely, if the attack intensity is less than s^*, the infected individual chooses public treatment. This is formalized in Proposition 1.

PROPOSITION: *Each individual has a critical severity* s^* *such that*

$z = 1$ *if* $s^* < s$,

$z = 0$ *otherwise*.

We assume that s^* may be approximated to a linear function of its arguments, $s^* = -\mathbf{b}\cdot\mathbf{x}$ where $\mathbf{x} = (w, t, p, \mathbf{d}, e)$. Hence

$z = 1$ if $0 \leq \mathbf{b}\cdot\mathbf{x} + s$,

$z = 0$ otherwise.

Or $\Pr(z = 1) = \Pr(-\mathbf{b}\cdot\mathbf{x} \leq s) = 1 - F(-\mathbf{b}\cdot\mathbf{x})$

where $F(\cdot)$ is the cumulative distribution function of s. The cumulative distribution is assumed to be logistic, and the coefficient vector **b** is estimated using the logit technique.

3. DATA and RESULTS

The data was collected by private interview, as part of a larger survey of settler households in the colony undertaken in August 1987 by the

Federal University of Minas. The respondent provided details about the household member suffering the most recent infection, and about the household characteristics. The sample was restricted to households who had reported a case of malaria in the preceding five months. The relevant variables, and their descriptive characteristics, are listed in the Appendix. The frequency of infection is startlingly high - a typical household (individual) suffered 15 (3) attacks in the 13 months preceding the interview.

No direct measurement of wealth was available. The interviewer instead observed the number of hierarchically-arranged consumer durables owned by the household, and this was used as a proxy for wealth. Not all respondents provided transport costs: reported transport costs were therefore regressed against distance to the urban center (measured from a map), and household wealth (wealthier households have access to better transportation). The estimated values were used. As noted in the introduction, the cost of transportation is only slightly less that the price of private treatment.

The price of private treatment was reported only if the last infected member chose to be treated at the private clinic. The actual price p paid for private treatment depends on the services prescribed after visiting the pharmacist or doctor. It is therefore unknown at the moment the individual chooses his treatment source. p is therefore a random variable. We assume that all households face the same price distribution, and that the relevant price variable is the expected price. Price variation was obtained because the price varied by month.

(TABLE 1 HERE)

The results of the logit model are presented in the Table 1. As noted in the Introduction, our results differ to many earlier studies in that we find price, wealth (proxied by goods) and liquidity (proxied by sunk transportation costs) to be significant determinants of choice. Low transportation costs, a high number of recent malaria infections suffered by the individual, high education levels of the heads of household and rural location all significantly increase the probability of private treatment. The number of recent infections in the household, and the age and sex of the individual are insignificant factors of choice.

The logit model assumes the probability distribution

$$Pr(z=1) = \frac{e^{\Sigma_i b_i x_i}}{1 + e^{\Sigma_i b_i x_i}} \quad . \tag{2}$$

(TABLE 2 HERE)

The elasticity of private demand at any pre-specified variable levels is found by differentiating Equation (2) and rearranging,

$$\epsilon_{x_i} \equiv \frac{x_i}{Pr(z=1)} \frac{\partial Pr(z=1)}{\partial x_i} = b_i \, x_i \, (1-Pr(z=1)).$$

The elasticity at the mean coefficient values are shown in Table 2. *Ceteris paribus* situations which give a large probability of treatment are less elastic. To develop a feel for the range of likely elasticity values, Table 2 also shows elasticity values at parameter values associated with a large and a small probability of private treatment.[7]

The private treatment of malaria is price inelastic, but it is not insensitive. Our price elasticity values are similar in magnitude to the values

found by Gertler et al. (1987) for the demand for private doctors to treat general illnesses in urban Peru. Private treatment of malaria is a normal good (interpreting GOODS as a proxy for wealth), and it is a necessary good.

The same transportation expense is incurred for both treatment sources. Therefore, if liquidity costs are unimportant, a unit reduction in the transportation cost is equivalent to a unit increase in wealth. To obtain the effect of liquidity costs, differentiate Equation (1) with respect to w and t, and rearrange,

$$-\frac{\partial s^*}{\partial w} = \frac{U'(w - f(t+p)) - U'(w - f(t))}{\alpha[h_s(1, \mathbf{d}; s^*) - h_s(0, \mathbf{d}; s^*)]},$$

$$\frac{\partial s^*}{\partial t} = \frac{U'(w - f(t+p))f'(t+p) - U'(w - f(t))f'(t)}{\alpha[h_s(1, \mathbf{d}; s^*) - h_s(0, \mathbf{d}; s^*)]}.$$

If liquidity costs are important, we predict $0 < f'$ and $0 \leq f''$. In addition, U is a concave function, and hence the presence of liquidity costs implies $-\partial s^*/\partial w < \partial s^*/\partial t$, or

$$\frac{\partial Pr(z=1)}{\partial w} < -\frac{\partial Pr(z=1)}{\partial t}. \qquad (3)$$

Interpreting GOODS as a proxy for wealth, Table 2 shows that the "representative" individual with mean characteristics has estimated elasticities as

$$\frac{w}{Pr(z=1)}\frac{\partial Pr(z=1)}{\partial w} = .29, \quad \text{and} \quad \frac{t}{Pr(z=1)}\frac{\partial Pr(z=1)}{\partial t} = -.19.$$

Hence Inequality (3) is satisfied for the "representative individual" if $.29/w < .19/t$, or if $t < .65\ w$. Because of the different units of GOODS and TRANSPORT, this inequality cannot be independently confirmed.[8] However, intuition would strongly suggest that it is likely. We consider this to be strong supporting evidence of the importance of liquidity.

4. CONCLUSION

Malaria is a deadly disease, endemic to many developing countries. By identifying the factors which cause an infected individual to seek better but expensive treatment in private clinics, economic analysis identifies the individuals who are in greatest need. This information enables scarce resources to be better targeted, and may be used to design new programs when the public health budget is expanded. We find that individuals who have suffered many recent infections are most likely to seek private treatment. Private treatment is price sensitive (but inelastic) and necessary. Analysis of transportation costs suggests that liquidity is important. Educated and rural households favor private treatment. These results suggest that discretionary resources should be targeted at individuals who have had many attacks, that subsidizing the private sector should be explored as a cost-effective method of providing better treatment, and that the use of mobile units to provide full public treatment to outlying farms may be beneficial. By enabling better calculation of responses, the estimates provided in this paper should assist the policy-maker in choosing between the alternatives.

APPENDIX

(TABLE A1 HERE)

(TABLE A2 HERE)

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TABLE 1: RESULTS

$$Pr(TREAT = 1) = \frac{1}{1 + e^{\Sigma_i b_i x_i}}$$

x_i	b_i	Standard Error	Significance Level
CONSTANT	-1.346**	.689	.05
Economic Variables			
PRICE	-.033**	.018	.06
GOODS	.087**	.049	.08
TRANSPORT	-.033**	.020	.09
HNUM13	-.014	.010	.17
Individual characteristics			
INUM13	.071*	.048	.14
AGE	-.000	.008	.94
SEX	.142	.241	.56
Household characteristics			
MLIT	.347*	.240	.14
FLIT	.465**	.248	.06
RURAL	1.134**	.584	.05

Notes:

*, **, *** indicates significance level at 15%, 10% and 5%.

The standard errors have not been corrected to allow for the fact that some regressors are imputed.

Model statistics:
-2 Log Likelihood: Chi-Square = 465.48, Significance = .0018.

TABLE 2:ELASTICITIES

	"Mean" Individual[1]	"High Probability" Individual[2]	"Low Probability" Individual[3]
Pr(TREAT)	.51	.72	.11
Elasticities			
PRICE	-.23	-.13	-.42
GOODS	.29	.22	.32
TRANSPORT	-.19	-.11	-.34
INUM13	.13	.13	.05.

[1] Variable values set at the mean sample values. I.e. PRICE=14.27, GOODS=6.67, TRANSPORT=11.92, HNUM13=15.27, INUM13=3.71, SEX=.63, MLIT=.52, FLIT=.57, RURAL=.94.

[2] GOODS and INUM13 set at one standard deviation above their mean values. Dummy variables set to favor the choice of private treatment. I.e. PRICE=14.27, GOODS=9.16, TRANSPORT=11.92, HNUM13=15.27, INUM13=6.66, SEX=1, MLIT=1, FLIT=1, RURAL=1.

[3] GOODS and INUM13 set at one standard deviation below their mean values. Dummy variables set to favor the choice of public treatment. I.e. PRICE=14.27, GOODS=4.18, TRANSPORT=11.92, HNUM13=15.27, INUM13=.76, SEX=0, MLIT=0, FLIT=0, RURAL=0.

TABLE A1: variable list

Choice variable

TREAT	Source of treatment of last infected member of household. TREAT = 0 if public, TREAT = 1 if private.

Economic variables

PRICE	Price of private treatment (1987 Cruzados). This is constructed by taking the mean of all prices recorded for the month in which the member was infected.
GOODS	Number of hierarchically arranged consumer durable goods owned by the household.
TRANSPORT	Transport cost of the household to the urban center (1987 Cruzados). As not all households reported a cost, this was estimated from the regression of reported transport cost on distance to the urban center (measured on from a map) and GOODS.[9]
HNUM13	Total number of all malaria infections suffered by all members of household over the 13 months preceding the interview date.

Individual characteristics

INUM13	The number of malaria infections suffered, in the 13 months preceding the interview date, by the last infected household member.
AGE	Age of last infected member of household (years).
SEX	Sex of last infected member of household. SEX = 0 if female, SEX = 1 if male.

Household characteristics

MLIT	Literacy of male head of household. MLIT = 0 if illiterate, MLIT = 1 if literate.
FLIT	Literacy of female head of household. FLIT = 0 if illiterate, FLIT = 1 if literate.
RURAL	Location of household. RURAL = 0 if in urban center, RURAL = 1 if outside urban center.

TABLE A2: sample statistics

Variable	Mean	Standard Deviation
PRICE	14.27	6.38
GOODS	6.67	2.49
TRANSPORT	11.92	6.88
HNUM13	15.27	14.96
INUM13	3.71	2.95
AGE	25.63	16.08
SEX	.63	.48
MLIT	.52	.50
FLIT	.57	.50
RURAL	.94	.24

NUMBER OF OBSERVATIONS: 462

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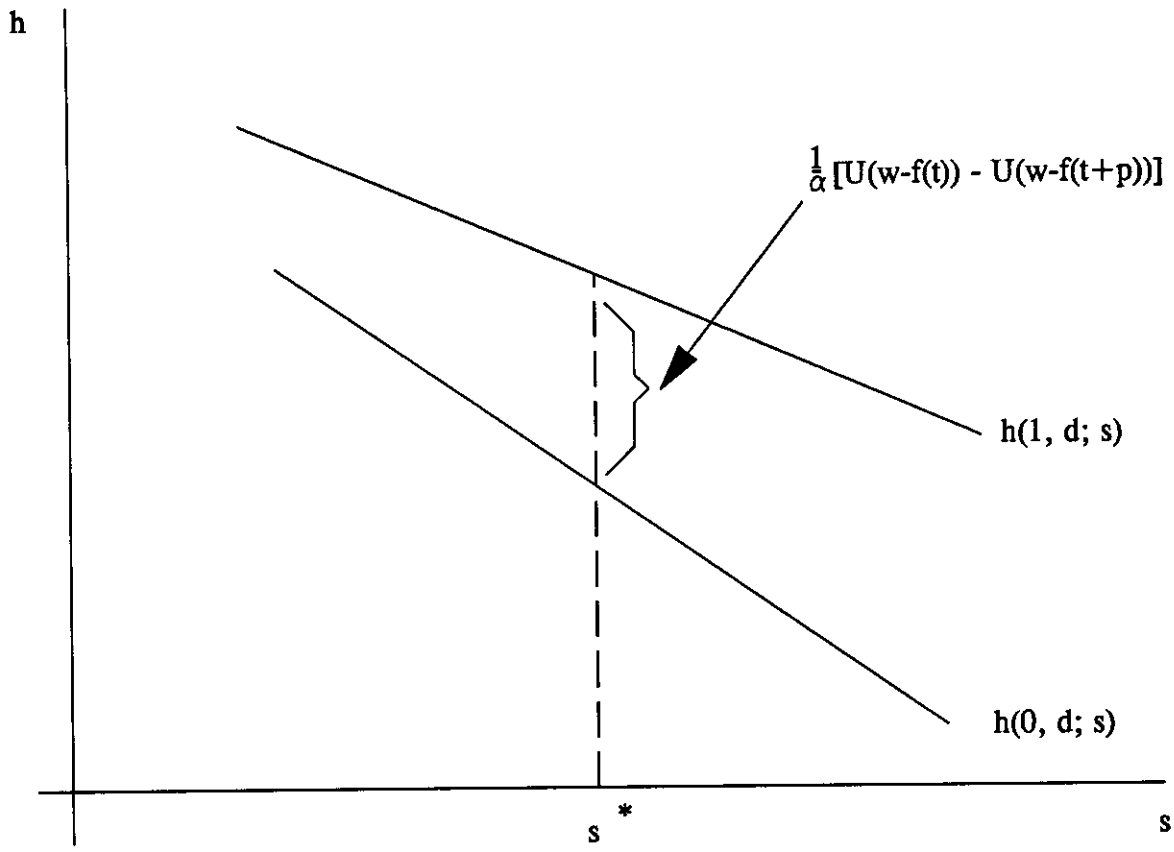

Figure: health as a function of severity.

FOOTNOTES

[1] The weaker drugs prescribed by the public sector are probably an attempt to reduce costs. However, an undesirable side-effect of the use of drugs is that strains of parasite develop which are resistant to the drugs. It is claimed that the public sector chooses to prescribe relatively weak drugs to prevent the development of parasites which require treatment by stronger, and therefore more expensive, drugs. The private sector feels no such constraint.

[2] Akin et al. (1986) find drug costs to be significant for adults.

[3] Footnote 1 mentioned that a possible reason for the availablity of only weak drugs at the public clinic is the wish by policy-makers to prevent the development of malaria strains resistant to strong drugs. If public policy wishes to avoid the use of the strong drugs, they could be excluded from the subsidy.

[4] Currently, mobile clinics visit outlying farms on an irregular basis, and provide only partial treatment. The infected individual must still visit the town to collect a full prescription of drugs.

[5] Continuing the discussion of Footnotes 1 and 3, the use of mobile clinics to preempt rural individuals from seeking private treatment has the desirable externality of reducing the use of the stronger drugs prescribed by the private clinics.

[6] Because health is unmeasured, no generality is lost by assuming the utility of health to be h. The assumption of additive separability is not necessary. If the full utility is V(c, h), a sufficient assumption for the analysis is that $0 \leq V_{ch}$.

[7] The high probability case is obtained by setting GOODS and INUM13 at one standard deviation above their mean values, and setting SEX, MLIT, FLIT and RURAL = 1. Conversely, the low probility case is obtained by setting GOODS and INUM13 at one standard deviation below their mean values, and setting SEX, MLIT, FLIT and RURAL = 0.

[8] w and t are measured in the same units.

[9] The relevant regression was

$$\text{TRANSPORT} = -3.27 + 0.6\ \text{DIST} + .91\ \text{GOODS}$$

N = 67, Adjusted R^2 = .2. Both distance and goods are significant at the 15% level.