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Willingness to pay and determinants of choice for improved malaria treatment in rural Nepal

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Abstract

A logit model is used to estimate provider choice from six types by malaria patients in rural Nepal. Patient characteristics that influence choice include travel costs, income category, household size, gender, and severity of malaria. Income effects are introduced by assuming the marginal utility of money is a step function of expenditures on the numeraire. This method of incorporating income effects is ideally suited for situations when exact income data is not available. Significant provider characteristics include wait time for treatment and wait time for laboratory results. Household willingness to pay (wtp) is estimated for increasing the number of providers and for providing more sites with blood testing capabilities. Wtp estimates vary significantly across households and allow one to assess how much different households would benefit or lose under different government proposals.

Keywords: Malaria treatment; Willingness to pay; Step-income effects; Provider choice; Nepal

Introduction

The goal of the paper is two fold: (1) To demonstrate that much of the variation in provider choice for malaria treatment in rural Nepal can be explained in terms of observed characteristics of the patient, characteristics of his or her household, and characteristics of the providers. Significant determinants of choice include travel costs, wait time for blood tests, severity of the malaria, the age and gender of the patient, and household income category. (2) To estimate the willingness to pay (wtp) for four different proposals for improving malaria treatment in rural Nepal and show how these estimates vary dramatically across households as a function of patient and household characteristics. Income effects are incorporated into the model using the available data on income category in a manner that is both consistent with consumer theory and simple.

Choice of provider type is modeled and estimated using a discrete-choice random utility model that incorporates provider and patient characteristics, and that allows individuals in different income categories to have different marginal utilities of money (Morey, Sharma, & Karlstrom, 2003).

Sixty percent of Nepal's population is considered to be at risk of contracting malaria, but in any given year only a small percent of the at-risk population contracts malaria. Between 1990 and 1993, the number of confirmed cases varied between 16,000 and 29,000 (Department of Health Services, 1994). Individuals can receive treatment from a number of different government providers or private providers, including faith healers (FH), and choice varies significantly across individuals. An important issue is what patient and provider characteristics determine the choice of treatment. The government's malaria control program is its oldest and most widely available rural health care program, but there is little information on how patients choose between public and private providers, how

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patients choose among the different types of government providers, and the benefits the patients receive from the availability of different treatment options.

The focus on malaria allows us concentrate on the determinants of provider choice that are specific to that illness, rather than on healthcare quality in general.[1] Studies that incorporate provider characteristics include Schwartz et al. (1988), Litvack and Bodart (1993), Mwabu et al. (1993), Ellis et al. (1994) and Akin et al. (1995).[2] We find a number of provider characteristics to be important determinants of choice.

Characteristics of the patient and household, including their constraints (for example, severity of illness) are also important determinants of provider choice. Severity is determined by the species and density of malaria parasites infecting the patient.[3] There are two species of malaria parasites in Nepal: *Plasmodium vivax* (PV) and *Plasmodium falciparum* (PF). PV is the most common form of malaria and typically does not result in complications. If PF is untreated it can lead to complications such as brain and kidney damage and can be fatal. The incidence of PF varies significantly in Nepal. The intensity of malaria's symptoms (shivering, fever, and headache) is positively correlated with the density of parasites in the blood.

Choices with respect to treatment for tropical diseases can differ by gender for economic, social, and cultural reasons, see Rathgeber and Vlassoff (1993).[4] Nepal is one of the few countries where life expectancy is lower for females (Ali, 1991). Literary rates, infant mortality rates, maternal mortality rates and rates of utilization of health care services are all lower for females.[5]

The government of Nepal has proposed or initiated a number of programs to expand and improve primary care services in rural areas. These include providing each village with a health care volunteer, providing each group of villages with a health care facility, and providing more health care facilities with blood testing capabilities. An important issue is how such programs in rural areas benefit patients. We estimate a patient household's wtp for each of these proposals, which measures, in money, our expectation of the extent to which different households would gain or lose under these different proposals. We allow wtp to be a function of income category.

Many discrete-choice random utility models assume that wtp is not a function of income; that is, the marginal utility from expenditures on the numeraire is assumed a constant. For example, Lee and Cohen (1985), Luft et al. (1990), and Adams, Houschens, Wright, and Robbins (1991) all assume away income effects in their studies of provider choice in the USA Models of provider choice that incorporate non-linear income effects include Gertler et al. (1987), Dor et al. (1987), Ching (1995), and Dow (1999). Gertler et al. (1987) ignores the income effects when approximating wtp. The rest of these studies do not estimate wtp.[6]

Income effects are introduced into our model by assuming the marginal utility of money is a step function of expenditures on the numeraire. This method of incorporating income effects is ideally suited for situations when exact income data is not available. Data on exact income is always difficult to obtain, and this is particularly true in the rural areas of developing countries where household production activities abound.[7] Data was available on household wealth but not income. This data was used to categorize households as either poor, rich or other. The empirical results from our model indicate that all that matters is whether the household is or is not poor.

Before proceeding, a few caveats are in order. (1) The wtp estimates presented are conditional on malaria infection and are for faster and more convenient treatment, not for programs that will increase the

[1] Three other studies of provider choice have modeled a single illness or service: de Bartolomé and Vosti (1995) for malaria in Brazil, Schwartz, Akin, and Popkin (1988) for infant delivery in the Philippines, and Akin, Griffin, Guilkey, and Popkin (1986b) who estimate separate models for a number of different aspects of infant treatment. In contrast, Dor, Gertler, and van der Gaag (1987), Gertler, Locay, and Sanderson (1987), Mwabu, Ainsworth, and Nyamete (1993), Ellis, McInnes, and Stephenson (1994), and Akin, Guilkey, and Denton (1995) model either outpatient or inpatient services broadly.

[2] Studies that use only provider-specific dummies to represent quality of care are Akin, Griffin, Guilkey, and Popkin (1986a), Akin et al. (1986b), Dor et al. (1987), Gertler et al. (1987), and Ching (1995).

[3] Species is determined by the infecting mosquito, and the density of parasites depends primarily on the parasite species and the patient's immune response.

[4] Akin et al. (1986a, b), Akin et al. (1995), Ching (1995), Ellis et al. (1994) and Paul (1992) find gender a significant determinant of choice in developing countries. In contrast, de Bartolomé and Vosti (1995) and Mwabu et al. (1993) find it insignificant.

[5] See Ali (1991), Allen (1990) and Bennett (1983) for social and cultural insights into the status of women in Nepal.

[6] Mwabu and Mwangi (1986) approximate welfare effects with areas under a curve that shows the relationship between user fees and choice probabilities.

[7] Gertler et al. (1987) exclude rural households of Peru from the sample because income information is not reliable. Ellis et al. (1994) use household consumption expenditures, instead of income, to account for abundant economic activities that are carried out in the informal and household sector in rural areas of Egypt. Mwabu et al. (1993) use cash income in a study on Kenya. Paul (1992) uses land holding as a measure of income status in Bangladesh. Akin et al. (1986a, b, 1995) use assets, type of house construction, ownership of vehicle, type of toilet in the household, and such other variables as proxies of income in their studies in the Phillippines and Nigeria.

treatment rate. In Nepal practically everyone with Malaria is eventually treated due to the routine monthly house-to-house surveillance program of the government to identify and treat malaria patients. (2) The estimated wtp associated with faster treatment do not include the benefits of reduced contagion to individuals who are not members of the patient's household, or benefits to non-malaria households of having new treatment options available.[8] Aggregated over malaria households they are therefore a lower bound estimate of social benefits. (3) It is also assumed that while malaria reduces household income the amount it is reduced is not a function of provider choice. This is a restrictive assumption that we share with many other models of provider choice. Data was not available to assume otherwise.

The data is old—1984—so one cannot assume our specific results hold today. However, the model and estimates show that provider choice and wtp for improvements in provider choice can be largely explained in terms of individual and household characteristics that are as likely to be relevant today as they were in 1984.

The remainder of the paper is organized as follows. The next section describes data and the institutional environment, and the following section develops the model. Next, the results of estimation are presented. Finally, the estimated household wtp for a number of health care proposals are reported and discussed.

Data and institutional environment

The population consists of the 905 individuals in 26 clusters of villages, called Village Development Committees (VDCs), who were confirmed by a blood test to have had malaria in 1984–1985.[9] The intent was to interview each of these 905 patients within two weeks of when their malaria was detected. The two-week limit was imposed to insure accurate recall. 695 were successfully interviewed.[10]

The data (Mills, 1994) was collected in 1984–1985 in 11 VDCs in Dhanusha district and in 15 VDCs of Nawalparasi district. These 26 VDCs were chosen because they had experienced difficulties in controlling malaria, so had significant numbers of cases.

The surveyors recorded choice of provider, the cost incurred to visit that provider, severity of malaria, and numerous individual and household characteristics. The model was estimated on the choices of the 489 individuals (314 from Dhanusha and 175 from Nawalparasi) for which there was complete data.[11] The survey of patients was supplemented with data on the locations and attributes of providers collected by the second author.

There are six distinct types of malaria treatment providers: four types of government providers and two types of private providers. Public treatment of malaria is coordinated by the Nepal Malaria Eradication Organization (NMEO) and the Department of Health Services (DOHS).[12] NMEO providers comprise malaria offices (MO), malaria workers (MW), and malaria volunteers (MV). There are two MO in the areas sampled in each district. Most villages have a malaria volunteer. Because of the regular house-to-house monthly visits of MW, a patient has the option of receiving treatment at home by waiting for the next visit of the malaria worker. No treatment and self-care are not available options.

The DOHS staffs health posts (HP) that treat all illnesses, including malaria. There are two types of private providers: private practitioners (PP) and FH.

Only the initial visit is modeled. We also model choice of provider by type, not the specific provider. Except for location, providers of a given type are quite homogenous in terms of their characteristics. Patients are assumed to visit the nearest provider of each type—the provider who can be reached in the minimum amount of time. Among all providers, MO and HP are the fewest in number and, therefore, the farthest for most patients. The average two-way travel time to these providers is approximately 2.5 h (see Table 1).[13] On the other hand,

[8] When choosing a provider the household takes account of the choice of provider on illness duration and the effect of that duration on household contagion, but not its effect on contagion outside of the household.

[9] Of the six types of health care providers available, three types (MW, MV and MO) test blood for malaria infection. Under a routine surveillance program, MW visits every home once a month to detect and treat malaria. The worker asks whether anyone in the house had fever or malaria symptoms since the worker's last visit. If any fever or symptom is reported, the malaria worker takes a blood sample. So, even if an individual was already treated by a provider who did not test blood, the individual would be tested by the malaria worker on his next visit. The population and sample do not include individuals who sought treatment incorrectly thinking they might have malaria. Therefore, the population of 905 includes all individuals who tested positive for malaria and, practically speaking, includes everyone who had malaria and no one who did not.

[10] Detections often came in clumps, which made it impossible for the surveyors to interview all of the 905 patients within the two-week time limit. Data on the household characteristics of the 210 patients not interviewed were collected at a later date. These 210 patients do not significantly differ from the sample in terms of household characteristics (Mills, 1994).

[11] In terms of the data available for those dropped from the sample, the sample of 489 patients is representative of the 695 in terms of patient characteristics, costs, and choices.

[12] Activities of the NMEO have now been integrated with the activities of the DOHS; they were separate entities in 1985.

[13] All travel in Nawalparasi is by foot or ox cart on dirt roads. The main highway through Dhanusha is paved and has bus

Table 1
Summary statistics for patient and provider characteristics

Variable	Mean of the whole sample (standard deviation)	Mean of patients who chose MW	Mean of patients who chose HP	Mean of patients who chose MO	Mean of patients who chose MV	Mean of patients who chose PP	Mean of patients who chose FH
Patient's age in years	24.42 (12.21)	23.68	26.35	27.75	24.56	22.95	19.83
Patient's gender (female 1, male 0)	0.25 (0.43)	0.29	0.47	0.10	0.28	0.19	0.25
Patient's years of schooling	1.17 (2.28)	0.85	1.41	0.78	1.18	1.97	2.04
Patient's household wealth, Rs.	23,436 (39,786)	19,744	22,556	14,208	20,807	46,084	15,407
Patient's household size	6.16 (3.02)	5.86	6.47	6.13	5.72	7.71	5.75
Parasite species infecting the patient (PF 1, PV 0)	0.08 (0.27)	0.06	0.12	0.06	0.01	0.26	0.17
Density of parasites in patient's blood (count per ml)	0.85 (0.67)	0.78	0.58	1.12	0.91	0.78	0.38
Patient's residence (Nawalparasi 1, Dhanusha 0)	0.36 (0.48)	0.21	0.65	0.22	0.24	0.91	0.58
Patient works or goes to school (yes 1, no 0)	0.93 (0.26)	0.90	0.94	0.96	0.94	0.94	0.92
One-way travel time to bring patient's blood slide to lab, hours	4.15 (3.21)	3.29	5.25	2.84	3.53	7.80	5.96
No. of days between the onset of symptoms and MWs expected visit	11.67 (10.11)	7.14	12.88	14.18	12.54	15.19	19.58
Private practitioners rove around the village of patient (yes 1, no 0)	0.27 (0.44)	0.17	0.35	0.07	0.21	0.69	0.58
Drug charges of PP, Rs.	5.83 (3.12)	4.89	7.70	4.93	5.07	0.41	7.29
Drug charges of FH, Rs.	1.07 (1.44)	0.64	1.94	0.66	0.73	2.73	1.75
Drug charges of other providers, Rs.	0.00 (0.00)	0.00	0.00	0.00	0.00	0.00	0.00
Travel time to PP, hours[a]	1.13 (0.84)	1.18	1.37	0.92	1.31	0.85	0.87
Travel time to FH & MW, hours	0.00 (0.00)	0.00	0.00	0.00	0.00	0.00	0.00
Travel time to HP, hours	2.60 (1.85)	2.44	2.01	1.36	2.52	4.14	3.63
Travel time to MV, hours	0.85 (1.05)	1.24	1.14	1.03	0.52	0.54	0.04
Travel time to MO, hours	2.53 (1.90)	2.40	2.09	1.30	2.38	4.14	3.63
Travel fare to PP, Rs.[a]	0.10 (0.39)	0.13	0.00	0.05	0.15	0.00	0.14
Travel fare to HP, Rs.	1/04 (1.13)	1.18	0.06	1.50	1.29	0.13	0.54
Travel fare to FH, MW & MV, Rs.	0.00 (0.00)	0.00	0.00	0.00	0.00	0.00	0.00
Travel fare to MO, Rs.	0.52 (0.78)	0.71	0.36	0.46	0.62	0.02	0.54

[a] Travel time and fare assume patients travel to private practitioners. For those villages where private practitioners rove around and provide on-site treatment, time and fare are later converted to zero while calculating cost of care.

(*footnote continued*)
service, but the rest of the roads are dirt. Distances between patients and providers were measured along the most generally traveled routes using village maps. These were converted to travel times using the typical travel mode (foot, bus, etc.) for each segment of the route. Time costs for *working* patients are converted into money costs using the market wage rates for farm workers at the time: Rs. 1.50 per hour for an adult male, Rs. 1.20 for an adult female, and Rs. 1.00 for a child. Infants, the chronically ill, the very old, and the disabled patients are considered *non-working*, and to be conservative, their value of time is assumed to be zero. As an alternative to this approach, we also estimated the opportunity cost of time both as a proportion of the market wage and as a separate parameter for

FH are the most accessible providers, as they are available virtually in every village. In contrast, round-trip travel time for MV is 0.85 h (50 min) and for PP 1.13 h (70 min). Although there is no travel to MW, patients have to wait until the next scheduled surveillance round; the average wait time is 12 days. Columns three through eight of Table 1 present the means of the variables for each group of patients who choose a

(*footnote continued*)
men, women, and children, but neither generalization improves the explanatory power of the model, and the opportunity cost of time parameters were, as expected, highly correlated with the parameter on residual income.

Table 2
Days of wait for radical treatment by NMEO malaria patients (1984)[a]

Number of days between blood collection and radical treatment	% of patients in Dhanusha	% of patients in Nawalparasi
7 days or less	72	59
8–14 days	22	30
More than 14 days	6	11

[a] Nepal Malaria Eradication Organization (1987).

specific type of provider. Note, for example, how variations in travel costs for the different providers influence the choice of provider as do patient gender, household size and wealth. Services and drugs from all public providers are free. Cost of faith healing is negligible. PP do not explicitly charge a consultation fee, but charge for drugs.

Cost is generally an important determinant of provider choice, and the total cost of visiting a provider includes fees for services or drugs, travel costs, and the opportunity cost of time, including the cost to escort a child. Columns 2 and 4 of Table 4 report the proportion of patients in Dhanusha and Nawalparasi choosing each type of provider. Note that only 2% of the patients in Dhanusha chose PP as compared to 40% in Nawalparasi. Besides costs, choice of provider may also be influenced by quality of care.

The three types of NMEO providers treat only malaria. If an individual has a fever, malaria is suspected and the NMEO providers take a blood sample, which is sent to the district headquarter to test for malaria. This generates a delay between the initial visit and the confirmation of malaria. Because of this delay, NMEO providers initially treat the suspected malaria patient with a standard broad-based treatment that temporarily eliminates symptoms and the potential for transmission, but does not cure the patient, so symptoms and contagiousness are likely to reoccur, sometimes in a matter of days. If the blood sample confirms malaria, the NMEO provider brings to the patient's home a drug treatment tailored to the species of malaria. This radical treatment usually cures the patient. The length of time between the initial visit and final treatment is a function of the waiting time for test results, which can be long. See Table 2. The wait time depends on the distance and road quality between district headquarters and the site of the initial visit.[14]

The other providers—HP, PP, and FH—treat all kinds of disease, including malaria. The government HP might refer a patient to a malaria office, but rarely take a blood sample. They typically provide a drug treatment similar to what a patient would receive when initially visiting a NMEO provider.

PP diagnose symptoms, use stethoscopes, give injections, and sell drugs. They treat all diseases, but do not take blood samples or conduct laboratory tests. If a private practitioner suspects malaria, he immediately provides a drug treatment that he feels will cure the disease. Since there is no blood test, the treatment might be inappropriate. PP also provide pain killers and vitamins, which NMEO providers do not. In addition, PP from India cross the border into Nawalparasi, which adjoins India, and rove from village to village on bicycles soliciting and treating patients.

FH neither prescribe nor give drugs. They perform religious rituals to drive away the evil spirits that cause disease.

A model of provider choice

Suppose an individual is infected with malaria and the household is choosing the patient's health care provider from among J alternative types of provider. Let u_{ij} be the level of utility the household of patient i associates with a visit to provider j.[15] $u_{ij} = v_{ij} + \varepsilon_{ij}$ where v_{ij} is a function of the characteristic of provider j and individual i that the researcher can observe, and ε_{ij}, while known to the household, is a random variable from the researcher's perspective. v_{ij} is a conditional indirect utility function, conditional in that it identifies maximum utility *conditional* on the choice of provider j and *indirect* in that it is a function of variables exogenous to the household. As is well known, the logit probability that individual i will choose alternative j is

$$p_{ij} = \mathrm{e}^{v_{ij}} \Big/ \left(\sum_{k=1}^{6} \mathrm{e}^{v_{ik}} \right) \quad j = 1, 2, \ldots, 6. \tag{1}$$

Specifically, assume

$$\begin{aligned} V_{ij} &= f(Z_j, S_i, H_i) + g(y_i - p_{ij}, H_i) \\ &= \alpha_{oj} + A_1' X_{1ij} + A_2' X_{2ij} + g(y_i - p_{ij}, H_i), \end{aligned} \tag{2}$$

where Z_j is a vector of provider characteristics, S_i is the severity of malaria $(y_i - p_{ij})$ is the level of consumption of the numeraire, and H_i is a vector of other patient and household characteristics. v_{ij} has two components: the utility from provider services, $f(.)$, and the utility from expenditures on the numeraire (income remaining after paying for provider services, $g(.)$. Utility from

[14] Other factors, such as the frequency of the courier service and the workload at the laboratory, also influence wait time, but these other factors produce similar delays for all patients.

[15] Preferences are defined for the household and the household chooses the most preferred bundle in its budget set. See Haddad, Hoddinott, and Alderman (1997) for a review of models of intrahousehold resource allocation in developing countries.

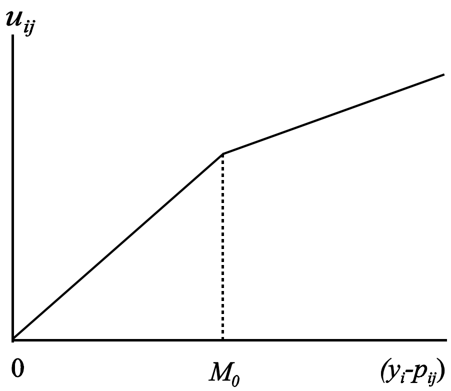

Fig. 1. Piece-wise linear spline.

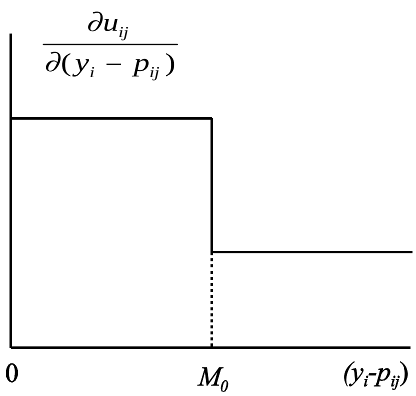

Fig. 2. Step function.

expenditures on the numeraire can depend on H_i, but is assumed to not depend on Z_j or S_i. Examining the right term, X_{1ij} is a vector of provider characteristics (elements of Z_j) interacted with patient characteristics H_i, and X_{2ij} is a vector of provider characteristics interacted with severity of illness S_i. Except for the g function, Eq. (2) is a standard linear in parameters conditional indirect utility function. Notice that Eq. (2) assumes, as is typical, that utility from expenditures on the numeraire is not a function of the choice of provider. The g function is assumed a piece-wise linear spline function of $(y_i - p_{ij})$, where the slope of each linear segment is a function of H_i; that is the marginal utility from expenditures on the numeraire is assumed a step function, where the height of each step is a function of H_i. Figs. 1 and 2 are possible examples of Eq. (2).

Specifically, we assume

$$g(y_i - p_{ij}, H_i) = \begin{pmatrix} \beta_1 + \beta_3(\text{1 if adult male, otherwise 0}) \\ +\beta_4(\text{household size}) \end{pmatrix}(y_i - p_{ij}) \quad \text{if}(y_i - p_{ij}) \leqslant M_0 \qquad (3)$$

and

$$g(y_i - p_{ij}, H_i) = \begin{pmatrix} \beta_1 + \beta_3(\text{1 if adult male, otherwise 0}) \\ +\beta_4(\text{household size}) \end{pmatrix} M_0 + \begin{pmatrix} \beta_1 + \beta_2 + \beta_3(\text{1 if adult male, otherwise 0}) \\ +\beta_4(\text{household size}) \end{pmatrix} \times (y_i - p_{ij} - M_0) \quad \text{if}(y_i - p_{ij}) > M_0.$$

M_0 is the poverty line.

As is well known, if zero-income effects are assumed (a constant marginal utility of money), the probability of choosing alternative j, Eq. (1), is not a function of income. This explains the appeal of assuming zero-income effects; one does not need income data to estimate the model. In our specification, with income effects, specifically step-income effects, the probabilities are also not a function of household income. The relevant marginal utility of money is the marginal utility for the household's segment (poor or not poor). So, as in a zero-income effects model, estimation does not require detailed income data or specification of the proportion of that income that is available in the period when a provider is chosen.[16] But, the influence of costs depends on whether the household is poor, as do the choice probabilities and wtp estimates.

If household wealth (the total value of houses, land and livestock) is less than or equal to Rs. 30,000, the household is assumed to be poor.[17] Recollect that like in most studies of rural households in developing countries, detailed income data was not available.

One can reject the null hypotheses of *zero income effects*.[18] The household's estimated marginal utility of

[16] Continuous-income-effects models require detailed income data and specification of the proportion of income available in the period when a provider is chosen. Dor et al. (1987) and Ching (1995) use monthly income, which implies a provider is chosen approximately once a month. Gertler et al. (1987) estimate the proportion of available income. Schwartz et al. (1988), Mwabu et al. (1993), and Ellis et al. (1994) use annual income.

[17] In rural areas, poverty is almost universal among landless households and marginal farmers (those owning less than 2.5 acres of farmland). The poverty level in Nepal in 1985 was considered about Rs. 126 per person per month, when the average monthly household income of marginal farmers (average household size 5–7) was about Rs. 736 (Nepal Rastra Bank, 1989). We consider Rs. 30,000 of household wealth a reasonable estimate of the poverty line. In our sample, 100% of landless households and 96% of marginal farmers have household wealth less than Rs. 30,000. By this estimate of poverty, 78% of the surveyed households are poor.

[18] Rich was also defined in terms of wealth. A model was estimated with steps at the poverty line and the rich line but it did not significantly improve the fit.

Table 3
Parameter estimates

Maximum likelihood estimation of a logit model of choice of provider
Mean log-likelihood −1.14659
Number of cases 489

Explanatory variables	Parameter	Estimate	*t*-statistics
Intercept on malaria office (one type of NMEO provider)	α_{0mo}	4.0879	8.7
Intercept on malaria worker (another type of NMEO provider)	α_{0mw}	4.1605	9.1
Intercept on malaria volunteer (another type of NMEO provider)	α_{0mv}	3.7675	8.5
Intercept on health post	α_{0hp}	1.8725	4.6
Intercept on private practitioner	α_{0pp}	2.4069	4.4
Intercept on faith healer (normalized)	α_{0fh}	0.00	xxx
(NMEO provider)[a] * (one-way travel time to the district headquarters for lab test)	α_{11}	−0.2990	−4.8
(Malaria worker)[a] * number of days between the onset of symptoms and when a malaria worker is expected to visit	α_{12}	−0.1214	−6.4
(Malaria worker)[a] * number of days between the onset of symptoms and when a malaria worker is expected to visit * child patient (17 years or younger)[a]	α_{13}	0.0339	1.6
(Patient of Nawalparasi)[a] * (private practitioner)[a]	α_{14}	3.4666	6.0
(Female patient)[a] * (malaria office)[a]	α_{15}	−1.2485	−2.9
(PF species infection)[a] * (NMEO provider)[a]	α_{21}	−1.2905	−3.1
(Density of parasites in patient's blood) * (NMEO provider)[a]	α_{22}	0.4451	2.2
Residual income (consumption of the numeraire) marginal utility of residual income is $\beta_1 + \beta_4(\text{household size}) + (\beta_2 \text{ if not poor}) + (\beta_3 \text{ if the patient is an adult male})$	β_1	0.5911	8.9
	β_2	−0.0827	−2.0
	β_3	−0.0873	−2.5
	β_4	−0.0113	−2.0

[a] A dummy variable that takes a value 1 if true, else 0.

income is a function of whether the household is poor, its size, and the patient's gender.

The estimated model

The likelihood function was maximized to find those values of the parameters that generate the estimated probabilities (Eq. (1)) that maximize the likelihood of observing the vector of observed choices. Table 3 lists the specific provider and household characteristics in the model and reports their estimated parameters and asymptotic t-statistics. Likelihood ratio tests confirm the significance of all of the included variables, both individually and collectively. Cost is the most significant determinant of choice, and the impact of cost on choice is greater for the poor, and for women and children.

Households where the patient is a male have, across the board, a lower estimated marginal utility of income than household where the patient is a female, supporting the evidence that males are more important in the Nepalese family. An explanation is that sickness of a family member casts a pale over the household depressing the enjoyment the household receives from the consumption of goods and services, and, in a male-dominated society, the effect is strongest when the patient is the male head of household. However, this is a cautious interpretation. Because our model assumes income is independent of the choice of provider, we can not estimate the influence of provider choice on income as a function of the patient's gender, which also might cause provider choice to vary by gender.

Cost sensitivity also decreases with household size. Given the infectious nature of malaria, a larger family may consider itself more at risk of infection by transmission, so willing to spend more for swift treatment.

The second most significant determinant of choice is the expected number of days one would have to wait for a malaria worker to visit the home. The probability of waiting for a malaria worker decreases as the expected number of days increase. However, ceteris paribus, the household will wait longer if the patient is a child.

The more remote the patient's closest NMEO provider is from the district headquarters, the less likely he or she is to choose a NMEO provider, indicating that households place a premium on the speed of treatment. Wait time for the results of the blood test are positively correlated with the travel time to the district headquarters. These travel times are significantly higher in Nawalparasi where the roads are very poor. The probability of choosing a NMEO provider is also smaller for individuals with PF malaria (complicated cases).[19] Given the severity of this type of malaria, patients do not want to wait for final treatment, and want immediate relief from pain - NMEO providers do not provide pain killers.

Together, these two factors explain much, but not all, of the difference between the shares for NMEO providers in the two districts. Holding constant travel time to the district headquarters and type of malaria, households in Nawalparasi are still more likely to choose a private practitioner. This might be because PP from India cross the border into Nawalparasi and rove from village to village on bicycles soliciting and treating patients. Aside from the fact that this makes travel times effectively zero for the PP, it allows patients the convenience of obtaining services at home.

Ceteris paribus, the probability of choosing a malaria office is smaller for female patients. This might be attributed to a greater hesitation on the part of women in developing countries to visit unfamiliar places or people.[20] MO are the least familiar of all provider types: they

treat malaria only and are typically not the closest provider. In contrast, MW provide treatment in the patient's home, and PP, MV, and FH are generally local, so known to the patient. Although HP are often distant, they are familiar because they provide prenatal care, vaccines for children, and contraceptives.

Table 4 reports the predicted shares for each provider type in each district. The variation is explained in terms of the above-mentioned characteristics of the patient, his or her household, and the providers.[21] The predicted shares closely match the actual shares, except for MO and MV in Nawalparasi. The estimated model correctly predicts 57% of the actual choices. A modified R^2 indicates that the estimated model is explaining 36% of the choices.[22]

[19] An interaction between species and density was not found to be a significant determinant of choice, neither were species interacted with the non-NMEO provider dummies.

[20] Stone (1986) and Subedi (1989) find social, cultural, and psychological accessibility, or social distance, of providers an important determinant of utilization of health care services in Nepal. In a study specific to women and malaria, Reuben (1993) points to sociocultural and physiological factors that make access to malaria care unequal between men and women in developing countries.

[21] An alternative hypothesis is that the observed variation in the choice of providers is better explained by preference heterogeneity than by variations in patient and household characteristics. Choice of providers differs significantly across the two districts. An issue is whether this is because preferences vary significantly across the two districts and/or because costs and characteristic levels are significantly different in the two districts. Multicollinearity in the data set makes it difficult to separate out preference differences from constraint differences. Both are possible explanations for the variations in provider choice. Preferences are never homogenous, even though assuming so is a standard assumption in economic modeling. Costs and characteristics levels do vary significantly across the two districts and these differences explain a lot of the variation in choices across the two districts without assuming that preferences are different in the two districts.

While costs vary across households in both districts, travel costs to HP and MO are significantly greater in Nawalparasi, so is wait time for blood tests. The remoteness of Nawalparasi is reflected in these higher costs and wait times for blood tests. The almost absence of PF malaria in Dhanusha is also an important determinant of provider choice, and is included in the model. Pooling across districts makes it easier to identify these effects.

The two districts are also different in terms of the presence of roving PP. This is included in the model in terms of costs for PP and in that the intercept on PP is allowed to differ between the two districts. Average levels of other characteristics (age, gender, household size and wealth) also vary across the two districts and these are included in the model.

We estimated a separate model for each district and this significantly improved the fit in statistical sense but not visibly in terms of Table 4. The question is which is the "better" model. In the separate models, the coefficients on the provider intercepts differ and are significant but the coefficient on lab test wait time is no longer significant. Neither is the parameter on malaria worker wait time interacted with whether the patient is a child. The loss of significance on these two potentially important determinants of choice is not surprising. Wait time for blood tests varies a lot more across districts than within districts, so does the incidence of malaria in children. Therefore both effects are highly correlated with district of residence, and allowing the provider intercepts to differ across the two districts obscures the effects of these two determinants of choice.

Of course it could be the case that lab test wait time and incidence of malaria in children have little to do with choice and the different rates of provider choice in the two districts are because residents of the two districts have different preferences. While possible, we have no data to support this. The areas sampled in both districts are rural, and most of the population is poor farmers. We therefore choose to go with the assumption that preferences are the same in the two areas and a lot of the differences in behavior can be explained in terms of observed variation in costs (travel and wait time for blood tests) and observed household characteristics. We find the assumption of unexplained heterogeneity less appealing, even though it achieves a better statistical fit.

[22] Modified $R^2 = 1 - (\ln L/\ln L_0)$, where $\ln L$ and $\ln L_0$ are the maximized log-likelihood values of the estimated model and the *equal-shares* model, respectively. The equal-shares model assigns each provider an equal choice probability.

Table 4
Actual and predicted shares of providers (%)

Providers	Dhanusha actual	Dhanusha prediction	Nawalparasi actual	Nawalparasi prediction
Malaria office	17	18	9	6
Malaria worker	38	39	19	18
Malaria volunteer	39	36	22	28
Health post	2	2	6	6
Private practitioner	2	2	40	40
Faith healer	2	2	4	3

Estimated wtp for health care proposals

Each patient household's wtp is estimated for each of the following four proposals:

(1) Installing one malaria office in each village. This increases the number of MO from 2 to 11 in Dhanusha and from 2 to 15 in Nawalparasi. (2) Enlisting one malaria volunteer in each village. This increases the number of volunteers from 19 to 69 in Dhanusha and from 40 to 140 in Nawalparasi. (3) Upgrading the two existing MO in each district with blood testing capabilities. (4) Replacing the routine monthly surveillance program of MW with Proposals (1) and (2).[23]

Wtp is the amount of money that would have to be subtracted from the household's income in the proposed state to make the household indifferent between the original state and the proposed state with this compensation. It is a random variable from the researcher's perspective, positive for improvements and negative for deteriorations of the original state. Its expectation is accurately approximated using the standard log-sum formula, calculated using the appropriate marginal utility of money.[24]

$$wtp_i = \frac{1}{\beta_i}\left(\ln\left[\sum_{j=1}^{6}\exp(v_{ij}^{\text{new state}})\right] - \ln\left[\sum_{j=1}^{6}\exp(v_{ij}^{\text{orig. state}})\right]\right), \quad (4)$$

[23] To represent the withdrawal of the surveillance program under Proposal (4), the number of wait days had to be made large enough to make the probability of choosing a malaria worker effectively zero. With wait set at 100 days, this probability is 0.0002 or less for all patients. Increasing the number of wait days beyond 100 does not change the wtp estimates.

[24] It is exact if a no-income effects logit model is assumed. Given our spline specification, it is an approximation, albeit a good one, because there is always some very small probability that paying the compensation will cause the household to switch income categories. For details see Morey et al. (2003).

where $v_{ij}^{\text{orig. state}}$ is the deterministic component of utility from provider j's services in the original state (when the proposal is not implemented), $v_{ij}^{\text{new state}}$ is the deterministic component of utility from provider j's services in the new state (when the proposal has been implemented), and β_i is the patient household's marginal utility from expenditures on the numeraire, which is (Eq. (3)) $\beta_i = \beta_1 + \beta_3(1 \text{ if adult male, otherwise } 0) + \beta_4(\text{household size})$ if the household is poor, and $\beta_i = \beta_1 + \beta_2 + \beta_3(1 \text{ if adult male, otherwise } 0) + \beta_4(\text{household size})$ if the household is not poor. Table 5 presents the estimated wtp for each proposal.

The unit of currency is the Nepalese Rupee (Rs.). For comparison, the average wage rate for farm workers was, in 1984, Rs. 1.50 per hour for an adult male. Except for Proposal (4), all of the sample means of the wtp estimates are significantly greater than zero, but the amounts are not large. Keep in mind that these are not wtp for avoiding malaria, nor wtp for providing a cure. Most individuals in Nepal with malaria will eventually be effectively treated even if none of these proposals is adopted. Rather, these proposals reduce either the cost of treatment or the time until final treatment.

Converted to units of time, using the average wage rate for farm workers, the means of the wtp estimates for additional MO and MV are 16 and 24 min for Dhanusha, and 14 and 9 min for Nawalparasi. For upgrading the existing MO, the mean of the wtp estimates are 35 min for Dhanusha and 2 h for Nawalparasi.

Note how much wtp for a proposal varies across households (the ranges reported in Table 5). For example, the wtp for Proposal 3 varies from 0.44 to 4.98, an over ten-fold difference. This variation is completely due to differences on the characteristic of the patient and his or her household, including wait times and income level. The household with the minimum wtp of 0.44 is poor. The patient is an adult male infected with the PV species of malaria. Proposal 3 does not have much effect on this patient's wait time for test results. The household with the wtp of 4.98 is not poor and saves a significant amount in terms of wait

Table 5
Estimated wtp for health care proposals (Rs.)

Proposal	wtp in Dhanusha	wtp in Nawalparasi
1.One malaria office in each VDC		
Mean (95% CI)[a]	0.41 (0.34–0.49)	0.35 (0.28–0.44)
Minimum	0.00	0.00
Maximum	3.60	2.16
2. One malaria volunteer in each village		
Mean (95% CI)[a]	0.60 (0.52–0.67)	0.23 (0.19–0.27)
Minimum	0.00	0.00
Maximum	3.15	2.39
3. Upgrade existing malaria offices with blood testing capability		
Mean (95% CI)[a]	0.88 (0.52–1.30)	3.07 (1.66–4.91)
Minimum	0.44	0.96
Maximum	2.67	4.98
4. Replace surveillance by proposals 1 and 2		
Mean (95% CI)[a]	0.23 (−0.07 to 0.46)	0.17 (0.00–0.31)
Minimum	−1.66	−0.98
Maximum	4.38	3.16

[a] The 95% confidence intervals are constructed by bootstrapping. Using the estimated parameter values and their variance-covariance matrix, 1000 sets of parameter values are randomly generated. The generated values are then used to estimate 1000 sets of mean of the wtp. The 95% confidence interval is found by excluding the 25 top and bottom estimates.

time. The patient is an adult male with the PV species. Ceteris paribus, a household will pay significantly less to reduce wait time if the patient is a girl.

The confidence interval on the mean of the wtp estimates for Proposal (4) indicates that one cannot reject the null hypothesis that households are indifferent between the status quo and Proposal (4). The mean of the wtp estimates for Proposal (4) by income and gender indicate no adverse distributional implications.

The estimated wtp for providing the existing MO with the training and microscopes to test blood are significantly higher than the estimated wtp for the other proposals. If proposal (3) were initiated, blood samples would not have to go to the district headquarters for testing. This would significantly reduce the delay between a visit to a NMEO provider and final treatment, which would significantly improve the welfare of the patient's household. Mean wtp for this proposal is larger in Nawalparasi because it is, on average, more remote. Within a district the wtp estimates for Proposal (3) vary significantly across patient households as a function of how far the household's NMEO provider is from the district headquarters.

Multiplying the mean of the wtp estimates for each proposal by the number of malaria cases in each sample area (534 in the Dhanusha sample area and 371 in the Nawalparasi sample area) provides a lower bound estimate of how much these malaria households, in aggregate, would have paid that year, for the adoption of each proposal. These estimates are lower bound because they are for the first visit only; some patients visit providers more than once. In addition to the confirmed 905 malaria patients, other households likely have some wtp for the proposals. Therefore, the total of the wtp estimates for 905 patients understates the social benefits of the proposals.

The total wtp amounts are small. For proposal (1), it is Rs. 220 for the Dhanusha area and Rs. 130 for the Nawalparasi area. For proposal (2), it is Rs. 320 for the Dhanusha area and Rs. 85 for the Nawalparasi area. For proposal (3), the amount of annual aggregate wtp is Rs. 470 for the Dhanusha area and Rs. 1139 for the Nawalparasi area.

Summary and conclusions

This study estimates a model of provider choice by malaria patients in rural Nepal and uses the model to estimate household wtp for different health care proposals. Characteristics of the household that influence choice include travel costs, income category, household size, the patient's age and gender, and severity of malaria. Costs of services are the most significant determinants of choice, and the poor are more cost sensitive. Ceteris paribus, cost sensitivity is less if the patient is an adult male.

Significant provider characteristics include the wait time for initial treatment and the wait time for the results of blood tests. NMEO providers do not provide radical drug treatment until after the species of malaria parasite is confirmed by a blood test, and the wait time for these test results can be substantial. Currently, blood work must be sent to the district headquarters for testing.

Malaria patient's household wtp is estimated for increasing the number of providers, and for providing MO with blood testing capabilities. The wtp estimates for providing all MO with the capabilities to test blood are significantly higher than the wtp estimates for increasing the number of providers.

We have only estimated the patients' choice of provider for their first choice after the onset of symptoms. A richer model would incorporate both the sequence and timing of the patient's provider choices. If better data were available, one could also model how household income is affected by malaria and the choice of provider.

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