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Health Systems for Outcomes Publication

53122

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Results from a Discrete Choice Experiment

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April 2008

HSO | Human Resources for Health (HRH)

Health worker preferences for job attributes in Ethiopia: Results from a discrete choice experiment[1][2]

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April 23, 2008

[1] This is a preliminary draft, not for citation.

[2] The survey for this study was financed by a grant from the Bill and Melinda Gates Foundation and Norad, administered through the World Bank. We thank Dr Tedros, Dr Kebede and Dr Nejmudin of the Ministry of Health, and the Government of Ethiopia. We are grateful to Dr. Aklilu Kidanu for providing invaluable assistance to the authors, and for leading the survey team of the Miz-Hasab Reserach Center in Addis Ababa. Thanks also to Joost de Laat, Christopher H. Herbst, Magnus Lindlow, Gebreselassie Okubagzhi, Pieter Serneels, Agnes Soucat, and Kate Tulenko for comments and assistance. The opinions expressed in the paper are those of the authors and do not reflect the position of the Government of Ethiopia or the World Bank Group.

Abstract

This paper estimates the effectiveness of a range of policy interventions aimed at improving the supply of health workers to rural areas in Ethiopia. Using data from a survey of 861 health workers, it employs stated preference techniques to predict labor market responses of doctors and nurses to changes in rural wages, working conditions, housing benefits, and training opportunities. Doubling wages in areas outside the capital would increase the share of doctors willing to work there from about 7 percent to more than 50 percent. Providing high quality housing would increase physician labor supply to about 27 percent, which is equivalent to paying a wage bonus of about 46 percent. Doubling wages paid to nurses for work in rural areas outside cities increases their labor supply from 4 percent to 27 percent, while the non-wage attribute that is most effective in inducing them to relocate to rural areas is the quality of equipment and drugs. The same impact could be achieved by increasing rural nursing wages by about 57 percent for men and 69 percent for women.

1 Introduction

The supply and geographic distribution of health workers are major constraints to improving health in low-income countries. A number of recent studies have highlighted the shortage of skilled health workers in many settings (WHO, 2006), the impact this has on health outcomes (Anand and Barnighausen, 2004), and the risk this poses for the achievement of the Millenium Development Goals (WHO, 2006; Joint Learning Initiative, 2004). However, there remains limited evidence about what sorts of policies will attract nurses and doctors into medical training, improve the retention of trained health workers, and encourage them to work in rural areas where problems of inaccessibility of services are most acute.

A number of strategies have been employed to address the human resources challenge in low- and middle-income settings: these include compulsory rural service for new graduates (e.g. in South Africa); payment of incentives or "hardship allowances" for those posted to rural areas (as proposed in Rwanda); or encouraging self-selection by those with a commitment to rural service (as practiced, for example, in Thailand, Wilbulpolpraser and Pengpaibon, 2003). Yet few of these strategies have been systematically evaluated, and the effectiveness of each will likely reflect country-specific labour market conditions, political systems, and culture and tradition.

The challenges of human development are particularly extreme in Ethiopia, a country with a population of over 70 million people, 85% of whom live in rural areas. It is one of the poorest countries in the world, with per capita income of about $150, and although the poverty rate has fallen by 8 percentage points over the last 10 years, it nonetheless remained at 37% in 2006. The country faces acute challenges in reaching all of the Millenium Development Goals, including the three goals relating to health - to reduce child mortality, improve maternal health, and combat HIV/AIDS, malaria, and other diseases. In 2005 the infant mortality rate was 77 per 1,000, the under-5 mortality rate was 123 per 1,000, and the maternal mortality rate was 673 per 100,000. In 2006 about half of all mothers received some kind of antenatal service, and 15% of deliveries were attended by a health worker. Ethiopia has escaped the ravages of HIV/AIDS compared with other countries in Africa, and had an adult prevalence of 2.1% in 2006.

The WHO reports that in 2003 there were 1,936 physicians in Ethiopia, representing a population-physician ratio of approximately 38,000, or 0.03 physicians per thousand individuals.[1] This is the fifth highest population to physician ratio among African countries, and compares pitifully with the ratio of 10,000 as recommended by the WHO. If anything near this ratio is to be attained, there will clearly need to be a sustained long term increase in the net supply of physicians to the Ethiopian market. The shortage of nurses is less acute,[2] but similar expansions will be necessary. The recruitment and retention

[1] See www.who.int/research/.

[2] The WHO estimated that there were 14,270 nurses in Ethiopia in 2003, or about one nurse for every 5,250 people.

of health workers in both the public and private sectors of the local market depends on the financial and non-fanancial rewards that they expect to reap, relative to alternatives (such as non-health sector work, or migration). On the other hand, the allocation of a given supply of health workers across geographic regions, as well as to tasks and specialties, often depends on the relative rewards in the public and private sectors. Attracting health workers to remote areas is a particular challenge if the WHO-recommended ratios are to be met in a meaningful way.

Rural and remote areas of Ethiopia are particularly underserved by health workers. We do not have nationally representative data on health worker location by rural and urban areas, but Ministry of Health data indicate that in 2004 about 20% of the approximately 1,000 doctors classified as operating in the "public sector" worked in Addis Ababa, home to about 5% of the population (Ministry of Health, 2005). It is likely, of course, that physicians in other regions are also located in urban centers, so the share of public sector doctors in rural areas would be far less than 80%. To add further to this rural-urban disparity, Ministry of Health data suggest that a further 1,500 doctors work for NGOs, other governmental organizations (e.g., the military), the "central" government, and in the private sector. We do not have specific data on their location, but we believe that few of them serve the rural population. By some estimates, half of the physicians in Ethiopia serve the residents of the capital, Addis Ababa.

During the 1980s and most of the 1990s, health workers trained in Ethiopia were typically assigned to their first jobs by the central government. This assignment was by means of a lottery system, and the prevailing belief among officials we interviewed is that the control exercised by the state was such that most health workers accepted their assignments. Workers were required to serve a fixed number of years before being "released" and permitted to apply for other positions. During the past five years Ethiopia has embarked on a radical decentralization program across all areas of the public sector, with much of the responsibility for service delivery being devolved to lower levels of government. In each of the 10 regions, plus Addis Ababa, a regional health bureau has responsibility for the hiring and deployment of public sector health workers.

As competition between regions for health workers has grown, anecdotal evidence suggests that the lottery system has become increasingly ineffective. It is believed that many new graduates do not register for the lottery, and those who do participate are prone to disregard their assignment if they so wish, knowing that they can apply directly to the regional health bureau for a job. The regions compete on salaries, time to release (which allows work in the burgeoning private sector, at least in Addis Ababa), and other attributes. Some regions, for example Oromia, have recently introduced explicit financial incentives to attract individuals to remote areas *within* the region. Similarly, regions that are themselves remote (in terms of being far from Addis Ababa) have attempted to attract health workers by providing certain training options and financial incentives.

In this paper we estimate health worker preferences over different job at-

tributes in an attempt to identify the factors that are important to health workers in influencing their labor supply decisions. One approach to this problem is to study actual choices made by health workers. However, this method may suffer from a range of selection and endogeneity problems, leading to biased parameter estimates. In addition, there is often limited variation in key job attributes (pay and non-pay), making it challenging to estimate the effects of these parameters on labour market choices and to predict the effects of changes in job attributes that lie outside the existing range over which these attributes vary in practice. Of course, the obvious downside to this approach is that we might have more confidence in choices people actually make, not in the choices they might say they would make.

Stated preference techniques have been widely used in health and environmental economics applications to study preferences for non-marketed commodities. Discrete choice experiments (DCEs) have examined the valuation of different attributes of health care service provision , dimensions of health benefit beyond health outcomes, and quality of care attributes (for reviews see Ryan and Gerrard 2003a and 2003b). Studies of health worker valuations of job attributes have also adopted DCE methods, both in the UK (Scott 2001) and in a variety of low- and middle-income settings (Chomitz et al., 1998; Mangham and Hanson, 2007; Penn-Kekana et al., 2005). Chomitz et al. provide a useful review of the benefits and shortcomings of the approach. A study of recent medical and nursing school grauduates currently underway in Ethiopia (Lindlow and Serneels) elicits direct measures of the cost of taking a rural job, but does not employ the DCE technique.

2 Data and DCE methodology

In this section we report out sampling strategy and the details of the discrete choice experiment we conducted.

2.1 Sampling

Our sampling strategy aimed at obtaining representative samples of doctors and nurses from three of Ethiopia's eleven regions – the capital city of Addis Ababa, Tigray, and Southern Nations and Nationalities Peoples Republic (SNNPR). Addis is a city of about 3 million people and is located in the central highlands. Tigray has a population of about 4 million people and lies in the extreme north of the country, bordering Eritrea, while SNNPR, with a population of 14 million borders Kenya to the south. Our sample is representative within these geographic areas.[3] The design over-sampled doctors in SNNPR and Tigray due to the small number of doctors outside Addis Ababa: all doctors in these rural

[3] Other regions, such as Oromia (which surrounds Addis Ababa) and Amhara (which is immediately north of Oromia) are larger (with 26 and 19 million residents respectively) and less remote, at least in terms of direct distance measures, but we have no reason to expect this to have introduced systematic biases in our estimates.

	Addis Ababa	SNNPR	Tigray	Total
Facilities	40	39	18	97
Hospitals	6	12	11	29
Health centers and clinics	34	27	7	68
Health workers	362	206	293	861
Doctors	91	72	56	219
Nurses	271	221	150	642

Table 1: Facilities and health workers surveyed in Addis Ababa

regions were sampled, while only about one third of doctors in Addis were. Our final sample included 219 doctors and 645 nurses working in health centers and hospitals.

A random sample of 1/3 of doctors was achieved in Addis Ababa by (a) randomly sampling facilities of the various types with sampling weights corresponding to the estimated proportion of doctors working across the different facilities; and (b) interviewing all doctors at the sampled facilities. In SNNPR and Tigray, all doctors were included in the sample. This was achieved by sampling all public hospitals in SNNPR and Tigray (there are generally no doctors in non-hospital health facilities in these regions and there were no private hospitals).

A random sample of approximately 1/6 of all nurses was achieved in Addis Ababa by having the enumerators randomly select half of all nurses at the sampled facilities. In SNNPR and Tigray we (a) randomly selected 1/6 of all nurses working in government hospitals; (b) randomly selected 1/6 of the sub-regional districts or woredas which have a hospital, visited all health centers in these woredas, and interviewed all nurses in these health centers; and (c) randomly selecting 1/6 of the woredas without hospitals, visited all health centers in these woredas, and interviewed all nurses in these health centers. Although for logistical and budget reasons (to minimize transport costs) the sample was selected using a cluster approach (with the facility as the cluster), as there is no strong reason to expect health worker preferences within a facility to be correlated we have not adjusted for clustering in the analysis. A summary of our sample is provided in Table 1.

Amongst doctors, the interview response rate varied widely across regions. In Tigray it was very high (88%), while in SNNPR and Addis Ababa it was lower – 58% and 66% respectively. In Addis, the response rates differed in public and private facilities. At public facilities, all doctors present agreed to be interviewed, although 40% of sampled doctors were absent on the day of the interview (28% for unexplained reasons, and 12% for planned leave). However at private facilities, no unexplained absences were recorded, while 18% of doctors were absent on planned leave. In contrast to public facilities, the share of sampled doctors who were present but refused to be interviewed was 27%. In Tigray, non-response arose because one sampled facility no longer existed, and

one was inaccessible for security reasons, but at visited facilities absenteeism and refusal rates were very low. In SNNPR, 42% of doctors listed as being employed were absent at the time of the facility visit, although nine out of ten of them were reported as being absent for training purposes.

For nurses, we do not have data on refusals to be interviewed, but we have calculated response rates as the ratio of the numbers of nurses interviewed to our initial target sample.[4] These calculated rates varied by region: in Tigray, nurses at both hospitals and clinics appear to have been over-sampled, leading to an interview rate of 143% (i.e. 43% more nurses were interviewed than initially targeted), while in SNNPR about 70% of the target number were interviewed. Most of the under-sampling seems to have occurred at health centers, which may have been under-staffed compared with our pre-survey estimates. In Addis there was a small degree of over-sampling – the sampling protocol appears to have been followed in hosptials (where 50 percent of nurses in sampled facilities were to be interviewed), with slight over-sampling in health centers.

2.2 The discrete choice experiment

Each health worker interviewed was presented with a questionnaire with two modules, the first of which solicited factual data on the worker's circumstances, incomes, household characteristics, etc., and the second of which contained a series of hypothetical choices that the respondent was asked to make. The second module provides the underlying data for our discrete choice analysis. We characterized a job in the public sector by discrete values of each of six attributes. These attributes were chosen based on their perceived relevance to health worker decisions in Ethiopia, following discussions with officials from the Federal Ministry of Health and the heads of regional health bureaux in Addis Ababa, Mekele (the capital of Tigray) and Awasa (the capital of SNNPR). The choice of attributes was also informed by focus group discussions undertaken as part of a similar study in another low-income country in sub-Saharan Africa, Malawi (Mangham and Hanson, 2007). The attributes chosen are shown in Table 2.

The attribute *values* or *levels* were chosen both to be realistic, and to provide a wide enough range of variation to enable predictions about relatively large policy changes to be made. The values of the location attribute differed for doctors and nurses. In practice, very few doctors work outside towns, so for them we allowed the location attribute to be either "Addis Ababa" or "Regional Capital". For nurses however, this attribute took on the values "City" and "Rural".[5] At the time of the study, public sector health workers were paid on the basis of a pay scale based on experience, qualifications, etc. We used the

[4] The total number of nurses interviewed in each region was determined by budgetary constraints. Following this, and based on pre-survey estimates of the number of nurses working at each facility, the datafirm was provided with an estimated proportion of nurses to be interviewed at the facilities (but could revise this in the field if the pre-survey estimates did not match the actual size of the regional population of nurses).

[5] A full description of the instructions given to respondents is in the appendix.

Doctors		
	Attribute	Possible levels
X^1	Location	Addis Ababa vs Regional Capital
X^2	Net Monthly Pay ($Base = 2,500$)	$1 \times Base; 1.5 \times Base; 2 \times Base$
X^3	Housing	None, Basic, Superior
X^4	Equipment and Drugs	Inadequate vs Improved
X^5	Time Commitment	2 years vs 1 year
X^6	Private Sector	Yes vs No
Nurses		
	Attribute	Possible levels
X^1	Location	City vs Rural
X^2	Net Monthly Pay ($Base = 1,250$)	$Base; 1.5 \times Base; 2 \times Base$
X^3	Housing	None, Basic, Superior
X^4	Equipment and Drugs	Inadequate vs Improved
X^5	Time Commitment	2 years vs 1 year
X^6	Supervision	High vs Low

Table 2: Job attributes and levels

(unweighted) average monthly salary from these scales to determine a "base" salary for doctors and nurses separately, and let the pay attribute take on values each to 1, 1.5, and 2 times this value. The third (housing), fourth (equipment and drugs), and fifth (time[6]) attributes in Table 2 took on the same values for doctors and nurses. For doctors, the final attribute was permission to work in the private sector (taking the values yes and no). Since opportunities for providing nursing services outside regular hours are limited, the opportunity to work in the private sector is of limited use for nurses. However, experience from other countries has suggested that active and supportive supervision is an important job attribute for these health workers. This is the sixth attribute we included for nurses.

Our questionnaire presented individuals with a series of pairs of jobs, and asked them to choose the one they preferred from each pair. There are in principle 144 ($= 2 \times 3 \times 3 \times 2 \times 2 \times 2$) distinct jobs charactized by the 6 attributes, and hence 20,592 ($= 144 \times 143$) distinct pairs. However, using SPSS software, we generated a main effects fractional factorial design with just 16 job scenarios. These jobs are shown in Table 3. This design satisfies the criteria of orthogonality, minimum overlap and level balance (Huber and Zwerina, 1996). To simplify the cognitive task for respondents we elected to use a questionnaire with one job with "middling" attributes as a constant comparator and paired the remaining scenarios to it, giving 15 choices altogether for each respondent. This number of choices is consistent with practice in the health economics literature (Ryan and Gerard, the AHEHP paper).

[6] Time refers to the number of years that an individual is required to work at an institution per year of further training sponsored by that institution, after the training is completed.

	Location	Pay	Housing	Equipment and drugs	Pay-back time	Private sector/ Supervision
Job 1	Addis	1.5	Basic	Inadequate	1	Yes/High
Job 2	Addis	1.5	Superior	Inadequate	2	Yes/High
Job 3	Rural	1	Superior	Improved	2	Yes/High
Job 4	Rural	1	Basic	Improved	1	Yes/High
Job 5	Addis	1	None	Improved	1	Yes/High
Job 6	Rural	1.5	None	Improved	2	No/Low
Job 7	Rural	1.5	None	Improved	1	No/Low
Job 8	Addis	1	None	Inadequate	2	No/Low
Job 9	Rural	2	None	Inadequate	2	Yes/High
Job 10	Addis	2	Superior	Improved	1	No/Low
Job 11	Rural	1	Superior	Inadequate	1	No/Low
Job 12	Addis	1	None	Improved	2	Yes/High
Job 13	Rural	1	Basic	Inadequate	2	No/Low
Job 14	Addis	2	Basic	Improved	2	No/Low
Job 15	Rural	2	Basic	Inadequate	1	No/Low
Job 16	Addis	1	Basic	Inadquate	1	Yes/High

Table 3: The constant job, Job 1, and the 15 comparator jobs

To examine whether the placement or ordering of scenarios affected responses we administered the questionnaire in four formats. In two of these, the "constant" job was first (on the left-hand-side) in each of the 15 choices, and in the other 2 it was the second (on the right-hand-side). Similarly, in two formats, the series of 15 pairs were presented in the reverse order. While we did not identify any major effects of the questionnaire version on results, it did allow us to identify a small number of errors in the final versions of the questionnaires.

Rationality of responses was investigated by including one scenario that was clearly superior to the other, assuming that individuals prefer Addis Ababa (doctors) or urban (nurses) location, higher pay, better housing, more equipment and drugs, shorter time commitment, ability to work in the private sector (doctors), and more supervision (nurses). We found that over 95% of respondents chose the clearly superior job. As it is very possible that some doctors or nurses would have a preference against Addis or urban areas, we chose to retain the full sample of respondents in our analysis.

3 Specification and estimation

We label individuals by an index $q = 1, ..., Q$. Each potential job is characterized by a set of $a = 6$ *attributes*, and we label the jobs $i = 1, ..., 16$. A pair of possible jobs is called (i, j). To motivate our analysis of the data, let $y_{(i,j)q}$ be defined

by

$$y_{(i,j)q} = \begin{cases} 1 & \text{if } q \text{ chooses } i \text{ over } j \\ 0 & \text{otherwise} \end{cases} .$$

Let X be an a-dimensional column vector of attribute levels with kth element X^k, and let X_i be the vector of attribute levels that characterize option i. Similarly, let Z_q be a c-dimensional column vector of personal *characteristics* for individual q, with lth element Z_q^l We hypothesize that individual q derives some utility from option i given by

$$\begin{aligned} U_{iq} &= \alpha + \beta^T X_i + \gamma^T Z_q + \delta \otimes X_i Z_q^T + u_{iq} \\ &= \alpha + \beta^T X_i + \gamma^T Z_q + \delta \otimes X_i Z_q^T + (e_i + v_q + \varepsilon_{iq}) \end{aligned} \tag{1}$$

where e_i is a job-specific shock, v_q an individual specific shock, and ε_{iq} are uncorrelated shocks, independent of the Xs, the Zs, and e_i and v_q. We allow interactions between all pairs of Xs and Zs. δ is an $(a \times c)$-dimensional matrix of coefficients with (k,l)th element δ^{kl}, and we define the operation $\otimes$ by $\delta \otimes X_i Z_q^T \equiv \sum_{k=1}^{a} \sum_{l=1}^{c} \delta^{kl} X_i^k Z_q^l$. If we suppose $e_i = 0$, then the difference in utility earned by individual q between options i and j, $\widetilde{y}_{(i,j)q}$, is

$$\begin{aligned} \widetilde{y}_{(i,j)q} &= U_{iq} - U_{jq} \\ &= \beta^T (X_i - X_j) + \delta \otimes (X_i - X_j) Z_q^T + \mu_{(i,j)q}. \end{aligned} \tag{2}$$

where $\mu_{(i,j)q} = \varepsilon_{iq} - \varepsilon_{jq}$. Notice there is no constant in this expression. We assume then that individual q chooses option i over j (when given this binary choice) if and only if $\widetilde{y}_{(i,j)q} > 0$. This occurs with probability

$$\begin{aligned} P_{(i,j)q} &= \text{prob}(\widetilde{y}_{(i,j)q} > 0) \\ &= \text{prob}(\beta^T (X_i - X_j) + \delta \otimes (X_i - X_j) Z_q^T + \mu_{(i,j)q} > 0) \\ &= \text{prob}(\mu_{(i,j)q} < \beta^T (X_i - X_j) + \delta \otimes (X_i - X_j) Z_q^T) \\ &= F(\beta^T (X_i - X_j) + \delta \otimes (X_i - X_j) Z_q^T) \end{aligned} \tag{3}$$

as long as $F(t) = \text{prob}(\varepsilon_{iq} - \varepsilon_{jq} < t)$ is such that $f(t) \equiv F'(t)$ is symmetric about zero. The parameters β and δ are estimated using a random effects probit estimator to capture the within-individual correlation among choices. Where functions of estimated parameters are interpreted, 95% confidence intervals are estimated using the bootstrap method, which has been shown to produce accurate and robust estimates of willingness-to-pay measures (Hole 2007).

3.1 Interpretation of estimated coefficients

With this specification, individual q's **marginal utility** of the kth job attribute (which, due to our linearity assumption, is independent of the attribute levels associated with alternative i, X_i) is

$$\frac{\partial U_{iq}}{\partial X^k} = \beta^k + \sum_l \delta^{kl} Z_q^l.$$

More meaningfully, the **marginal rate of subsitution** between the kth and hth attributes (which again, with this specification is independent of the attribute levels associated with alternative i) is

$$\begin{aligned} MRS_{iq}^{kh} &= -\frac{\partial U_{iq}}{\partial X^h} \Big/ \frac{\partial U_{iq}}{\partial X^k} \\ &= -\left(\frac{\beta^h + \sum_l \delta^{hl} Z_q^l}{\beta^k + \sum_l \delta^{kl} Z_q^l}\right) \end{aligned} \tag{4}$$

If X^k is pay (i.e., $k = 2$), then the absolute value of MRS_{iq}^{kh} is the marginal value of attribute h to individual q, or individual q's *marginal willingess to pay* for attribute h.

In the special case where Z_q is a binary scalar variable (e.g., sex) taking on the values 0 (male) and 1 (female), the marginal rate of substitution between the kth and hth attributes is

$$MRS_{iq}^{kh} = -\frac{\beta^h}{\beta^k}$$

if $Z_q = 0$ (i.e., for men) and

$$MRS_{iq}^{kh} = -\left(\frac{\beta^h + \delta^h}{\beta^k + \delta^k}\right)$$

if $Z_q = 1$ (i.e., for women).

3.2 Attribute interactions

Under the specification in (1), the marginal rate of substitution between different attributes is independent of the attribute levels (see 4) - that is, indifference curves are straight lines, and the attributes are perfect substitutes. The marginal rate of substitution can be allowed to vary with the mix of attributes by introducing non-linear terms in (1). The simplest way to do this is to include a complete set of interaction terms between the different components of X_i. (We assume that of the interaction terms between attribute levels and individual characteristics, only the linear ones are potentially significant - i.e., there are no terms of the form $X_i^k X_i^h Z_q^l$.) This yields a utility level for person q in job i of

$$U_{iq} = \alpha + \beta^T X_i + \phi \otimes X_i X_i^T + \gamma^T Z_q + \delta \otimes X_i Z_q^T + u_{iq}$$

where ϕ is an $(a \times a)$ upper triangular matrix of coefficients, with (k,h)th element ϕ^{kh}.[7] The difference in utility levels obtained by individual q between jobs i and j is

$$\begin{aligned} \widetilde{y}_{(i,j)q} &= U_{iq} - U_{jq} \\ &= \beta^T (X_i - X_j) + \phi \otimes \left(X_i X_i^T - X_j X_j^T\right) + \delta \otimes (X_i - X_j) Z_q^T + \mu_{(i,j)q}. \end{aligned} \tag{5}$$

[7] $\phi^{kh} \geq 0$ for $k \geq h$, $\phi^{kh} = 0$ for $k < h$.

Following (3), the probability that individual q will choose job i over j is

$$\begin{aligned} P_{(i,j)q} &= \text{prob}(\widetilde{y}_{(i,j)q} > 0) \\ &= F(\beta^T(X_i - X_j) + \phi \otimes \left(X_i X_i^T - X_j X_j^T\right) + \delta \otimes (X_i - X_j) Z_q^T), \end{aligned} \tag{6}$$

and the parameters are estimated using maximum likelihood methods for a given assumption about F.

The **marginal rate of subsitution** between the kth and hth attributes is now

$$\begin{aligned} MRS_{iq}^{kh} &= -\frac{\partial U_{iq}}{\partial X^h} \Big/ \frac{\partial U_{iq}}{\partial X^k} \\ &= -\left(\frac{\beta^h + \left[\sum_{m=1}^{h} \phi^{mh} X_i^m + \sum_{m=h}^{a} \phi^{hm} X_i^m\right] + \sum_l \delta^{hl} Z_q^l}{\beta^k + \left[\sum_{m=1}^{k} \phi^{mk} X_i^m + \sum_{m=k}^{a} \phi^{km} X_i^m\right] + \sum_l \delta^{kl} Z_q^l} \right) \end{aligned} \tag{7}$$

As an example, consider the effect that job location might have on the relative valuation of private practice and money for doctors. The attribue X^1 can take on two values, $X^1 = 1$ if the job is in Addis and $X^1 = 0$ if it is in another city, and similarly the attribute X^6 can take on two values, $X^6 = 1$ if private sector work is permitted and $X^6 = 0$ if it is not. If we find that the coefficient ϕ^{16} is positive, and that all other $\phi^{kh} = 0$, then the marginal rate of substitution between private sector work and money for a job in Addis is

$$MRS_{Addis,q}^{26} = -\left(\frac{\beta^6 + \phi^{16} + \sum_l \delta^{hl} Z_q^l}{\beta^2 + \sum_l \delta^{kl} Z_q^l} \right),$$

and the MRS between private sector work and pay for a job outside Addis is

$$MRS_{Non-Addis,q}^{26} = -\left(\frac{\beta^6 + \sum_l \delta^{hl} Z_q^l}{\beta^2 + \sum_l \delta^{kl} Z_q^l} \right).$$

Similarly, the valuation of housing could well depend on the location of the job under consideration. The marginal rate of substitution between housing and money being

$$MRS_{Addis,q}^{23} = -\left(\frac{\beta^3 + \phi^{13} + \sum_l \delta^{hl} Z_q^l}{\beta^2 + \sum_l \delta^{kl} Z_q^l} \right),$$

in Addis, and

$$MRS_{Non-Addis,q}^{23} = -\left(\frac{\beta^3 + \sum_l \delta^{hl} Z_q^l}{\beta^2 + \sum_l \delta^{kl} Z_q^l} \right).$$

for a job outside the capital.

3.3 Wage equivalents

We will find it useful to measure the supply response to changes in non-wage attributes in terms of equivalent changes in wage rates. If a change in say rural housing is estimated to have a certain impact on rural labor supply, we calculate the change in the rural wage that would have the same quantitative effect on the willingness of health workers to take rural jobs. This sub-section outlines the methodology we employ.

Suppose that a standard or typical job in Addis Ababa is described by a certain bundle of characteristics, X_A, and that the typical rural job is described by a vector X_R. A policy intervention that is aimed at attracting workers to rural areas might improve one or more of the attributes typically found in a rural job, such as improved housing, etc. The vector of attributes defining the average rural job under this policy is denoted X_P. A particular example of a policy intervention involves a change in just the wage earned in rural areas, keeping other attributes at the levels typically found in rural jobs. We think of this policy intervention as an equivalent wage policy. Denote such a vector of attributes by X_E - each component of X_E is the same as the corresponding component of X_R, except for the wage.

These bundles are represented by the following vectors, with the values of the numerical components derived from the survey:

$$X_A = \begin{pmatrix} 1 \\ w_A \\ 0 \\ 1 \\ 2 \\ 1 \end{pmatrix}; X_R = \begin{pmatrix} 0 \\ w_R \\ X_R^H \\ X_R^E \\ X_R^T \\ X_R^P \end{pmatrix} = \begin{pmatrix} 0 \\ w_R \\ h \\ 0 \\ 2 \\ s \end{pmatrix}; X_P = \begin{pmatrix} 0 \\ w_P \\ X_P^H \\ X_P^E \\ X_P^T \\ X_P^P \end{pmatrix}; X_E = \begin{pmatrix} 0 \\ w_E \\ X_R^H \\ X_R^E \\ X_R^T \\ X_R^P \end{pmatrix} = \begin{pmatrix} 0 \\ w_E \\ h \\ 0 \\ 2 \\ s \end{pmatrix}.$$

Note that both h and s will typically vary between doctors and nurses: for doctors, $s = 0$ as there is effectively no private practice in rural areas, but for nurses s represents the prevailing level of supervision that nurses enjoy in rural jobs, which might be non-zero. Similarly, about 40% of doctors in our sample outside Addis report receiving a housing allowance, but less than 10% of nurses in these regions do so (see Table 5 below).

The attribute differences between the rural job under the policy intervention and the Addis job are

$$dX_{PA} = X_P - X_A = \begin{pmatrix} -1 \\ w_P - w_A \\ X_P^H \\ X_P^E - 1 \\ X_P^T - 2 \\ X_P^P - 1 \end{pmatrix}$$

while the differences between the rural job with the equivalent wage policy (X_E)

and the Addis job are

$$dX_{EA} = X_E - X_A = \begin{pmatrix} 0 \\ w_E - w_A \\ X_R^H \\ X_R^E - 1 \\ X_R^T - 2 \\ X_R^P - 1 \end{pmatrix} = \begin{pmatrix} -1 \\ w_E - w_A \\ h \\ -1 \\ 0 \\ s - 1 \end{pmatrix}$$

In the base attribute-only model, the shares of respondents taking job P over job A, and job E over job A, are respectively

$$P_{PA} = F(\beta^T(dX_{PA})) \quad \text{and} \quad P_{EA} = F(\beta^T(dX_{EA})).$$

If these are set equal, then $\beta^T(dX_{PA}) = \beta^T(dX_{EA})$, or

$$-\beta^L + \beta^W(w_P - w_A) \qquad +\beta^H X_P^H + \beta^E(X_P^E - 1) + \beta^T(X_P^T - 2) + \beta^P(X_P^P - 1)$$

$$= -\beta^L \qquad +\beta^W(w_E - w_A) + h\beta^H - \beta^E + \beta^P(s - 1)$$

or

$$\beta^W(w_P - w_A) + \beta^H(X_P^H - h) + \beta^E X_P^E + \beta^T(X_P^T - 2) + \beta^P(X_P^P - s) = \beta^W(w_E - w_A).$$

Alternatively,

$$\begin{aligned} \Delta w &= w_E - w_P \\ &= \frac{1}{\beta^W} \begin{pmatrix} \beta^H \\ \beta^E \\ \beta^T \\ \beta^P \end{pmatrix} \cdot \begin{pmatrix} X_P^H - h \\ X_P^E \\ X_P^T - 2 \\ X_P^P - s \end{pmatrix}. \end{aligned}$$

This is the extent to which a simple wage bonus would need to exceed the wage in the rural bundle to have the same impact on labor supply. Note that in general, the wage equivalent of a policy change that improves a single non-wage attribute will not be the same as the marginal value of, or marginal willingness to pay for, that attribute. This is because the MRS between two attributes is calculated holding all other attributes constant, while the wage equivalent compares two jobs with different attribute levels.

In a model with characteristic interactions, the same attribute vectors are used, but to find the wage equivalent for a given type of person we now equate the differences in mean latent utilities for that person type. The shares of respondents with characteristics Z taking job P over job A, and job E over job A, are now respectively

$$P_{PA} = F(\beta^T(dX_{PA}) + \delta \otimes dX_{PA}Z^T) \quad \text{and} \quad P_{EA} = F(\beta^T(dX_{EA}) + \delta \otimes dX_{EA}Z^T).$$

These are equal if

$$\beta^T(dX_{PA}) + \delta \otimes dX_{PA}Z^T = \beta^T(dX_{EA}) + \delta \otimes dX_{EA}Z^T$$

or

$$\beta^T (dX_{PA} - dX_{EA}) + \delta \otimes [dX_{PA} - dX_{EA}] Z^T = 0.$$

In the case where Z has just one component, sex, $(0 = male, 1 = female)$, this reduces to

$$\Delta w_{male} = w_E^{male} - w_R = \frac{1}{\beta^W} \begin{pmatrix} \beta^H \\ \beta^E \\ \beta^T \\ \beta^P \end{pmatrix} \cdot \begin{pmatrix} X_P^H - h \\ X_P^E \\ X_P^T - 2 \\ X_P^P - s \end{pmatrix}$$

for men, and

$$\Delta w_{female} = w_E^{female} - w_R = \frac{1}{\left(\beta^W + \delta^W\right)} \begin{pmatrix} \beta^H + \delta^H \\ \beta^E + \delta^E \\ \beta^T + \delta^T \\ \beta^P + \delta^P \end{pmatrix} \cdot \begin{pmatrix} X_P^H - h \\ X_P^E \\ X_P^T - 2 \\ X_P^P - s \end{pmatrix}$$

where δ^W is the coefficient on the wage-sex interaction, δ^H is the housing-sex interaction, δ^E is equipment, δ^T is time, and β^P is private/supervision.

In general, the wage equivalent for individuals with a given characteristic vector Z is

$$\Delta w(Z) = w_E(Z) - w_R = \frac{1}{\left(\beta^W + \sum_l \delta^{Wl} Z^l\right)} \begin{pmatrix} \beta^H + \sum_l \delta^{Hl} Z^l \\ \beta^E + \sum_l \delta^{El} Z^l \\ \beta^T + \sum_l \delta^{Tl} Z^l \\ \beta^P + \sum_l \delta^{Pl} Z^l \end{pmatrix} \cdot \begin{pmatrix} X_P^H - h \\ X_P^E \\ X_P^T - 2 \\ X_P^P - s \end{pmatrix}$$

where δ^{Xl} is the coefficient on the interaction term between attribute X and characteristic l. If we want to know the wage equivalents for men and women separately, just substitute $Z^{sex} = 0$ or 1, and use the mean values of the other characteristics in the Z-vector.

4 Results

4.1 Summary statistics

A summary of facility-level information is provided in Table 4. This table includes information provided by a facility administrator in response to a the facility survey, as well as information provided by individual health workers in response to questions about the quality of the facility. Both data sources indicate that workers and patients operate in facilities of generally poor quality, and that on some dimensions at least rural facilities face particular challenges.[8]

[8] The facility administrators paint a somewhat rosier picture of conditions than workers. Our interviewers did not independently verify conditions as reported by the administrators: but we could speculate that their relatively positive evaluations might have been due to strategic mis-reporting (due to a sense of pride perhaps), or due to incomplete information (if the administrators did not face the realities of poor working conditions on a daily basis).

Private facilities in Addis Ababa appear to be ranked consistently better quality than public facilities there and in rural areas. Within the public sector, differences between Addis and rural areas are not large, and indeed sometimes favor the rural areas. As well as physical infrastructure, the work environment is conditioned by underlying work practices. One indicator of this is the level of supportive supervision that health workers reported, which at less than 50 percent, is rather low.[9]

Descriptive statistics regarding health workers, and indicators of their labor market status, are reported in Table 5. In economic terms, doctors in Addis do better than those in the regions. As reported in panel II of Table 5, asset ownership is higher in Addis, with one half and one quarter the doctors working in private and public facilities respectively reporting ownership of a car, compared with less than two and five percent, respectively, in SNNPR and Tigray. House ownership is higher among private sector physicians in Addis (35%), but the rates among other doctors are similar (10-16%). These patterns of asset ownership naturally match the patterns of earned incomes.

Doctors working in the public sector in Addis earn salaries about 50% more than the average doctor in the regions, while salaries of private sector doctors are three times as much. Part of this differential likely reflects the return to experience (Addis doctors are older) and specialization (they are more likely to be specialized). However, we find that the rates of specialization in the public and private sectors in Addis are virtually identical, suggesting that training is not the sole driver of observed income differentials. Nurses in Addis earn significantly smaller premiums over regional salaries – about 14 percent if they work in the public sector and 36 percent in the private sector.

The gap between private sector salaries in Addis and those of other doctors is partly offset by additional sources of income: public sector doctors in Addis earn additional income equal to 21% of their salaries, while the figures in SNNPR and Tigray are 17% and 33% respectively, and between a third and a half of doctors in the regions outside Addis report receiving housing allowances (although we do not have data on the monetary value of these allowances). Indeed, significant shares of doctors working outside the Addis private sector report holding more than one job – from 23% in the Addis public sector, to 12% in Tigray. On the other hand, private sector doctors in Addis supplement their (much higher) salaries by only 3 percent. Although 20% report holding more than one job, we expect that these multiple jobs are in some sense considered together to make up the worker's primary occupation, which accounts for the small amount of supplemental income. Finally, physician household incomes are higher in Addis than elsewhere.

4.2 Direct effects model

We first estimated a model containing only the direct effects of the job attributes, running this separately on the data for doctors and nurses. The results, shown

[9] In our analysis we include the level of supervision as a job attribute for nurses, but not for doctors.

	All regions		Addis Ababa				SNNPR		Tigray	
Facility survey			Public		Private*					
Number of facilities	77		8		31		21**		17	
Reliable elec./phone (%)	92		100		100		97.3		97.6	
Functioning laboratory (%)	100		100		100		100.0		100.0	
Sufficient water supply (%)	74.2		20.2		96.3		87.2		85.7	
Sufficient medicine (%)	78.6		92.5		71.5		88.1		50.0	
Sufficient equipment (%)	86.3		87.3		82.6		100.0		69.1	
Individual survey (%)	Doc	Nurse	Doc	Nurse	Doc	Nurse	Doc	Nurse	Doc	Nurse
Availability of supplies										
Soap	75.0	69.0	68.7	69.1	100	100	63.8	59.7	53.5	67.1
Water	75.0	75.2	82.5	79.9	98.0	100	59.0	61.8	44.2	77.2
Plastic gloves	88.7	85.7	84.3	84.8	100	100	92.2	84.3	68.6	82.8
Facial mask	58.7	43.0	57.8	51.8	88.9	92.5	49.1	32.1	16.2	23.5
Sterile syringes	93.7	91.8	91.1	92.1	100	100	94.7	92.1	84.4	87.2
Medicines	73.9	70.9	61.3	76.1	97.8	91.3	79.3	73.0	42.2	50.8
Workload										
Often not time to do tasks	55.1	48.2	67.3	58.2	22.0	20.3	82.1	61.2	61.6	31.5
Usually time to do tasks	43.0	51.1	32.7	40.4	72.0	79.8	18.0	38.8	38.4	67.1
Idle time common	2.0	0.6	0.0	1.0	6.0	0.0	0.0	0.0	0.0	1.3
Condition of facility										
Good	43.4	40.9	30.3	24.2	58.0	79.8	39.3	37.0	40.7	46.3
Fair	42.1	45.6	48.5	53.2	38.0	18.6	38.5	51.6	45.4	41.6
Bad	14.5	13.5	21.2	22.6	4.0	1.6	22.2	11.4	14.0	12.1
Supervision										
Supervisor reprimands	31.1	40.3	34.7	39.5	36.0	49.0	34.2	38.8	12.8	38.9
Supervisor supportive	45.3	46.1	32.0	38.3	62.0	68.8	50.4	45.2	26.7	45.0

Table 4: Facility level information, based on interviews with an administrator ("facility survey") and individual health workers * Includes for-profit and non-profit NGO and missionary facilities ** Includes 3 private facilities

	Doctors					Nurses				
	All	Addis		SNNPR	Tigray	All	Addis		SNNPR	Tigray
Demographics		Public	Private				Public	Private		
Female (%)	18.2	30.0	16.0	2.6	26.7	64.3	73.8	84.4	53.0	61.8
Married (%)	56.6	61.3	74.0	33.3	45.2	63.3	65.3	65.5	50.2	79.3
Age (years)	36.1	39.2	41.2	29.3	31.5	33.4	34.5	35.3	31.0	34.7
	(0.88)	(1.64)	(1.78)	(1.16)	(1.61)	(0.49)	(0.73)	(0.86)	(1.25)	(0.71)
Primary job priv. (%)	34.9	*	*	9.4	0.0	14.0	*	*	5.4	0.0
Specialist (%)	27.8	40.4	38.0	6.8	19.8	*	*	*	*	*
Income										
Salary (US$)	284.5	244.6	480.5	156.4	176.6	100.9	106.8	128.3	87.7	100.8
	(17.4)	(10.5)	(39.0)	(14.8)	(13.9)	(2.0)	(2.1)	(9.6)	(2.7)	(1.96)
Other compensation with job (%)	52.7	29.3	46.0	85.5	53.5	47.0	15.5	35.9	73.3	48.7
Housing (%)	18.9	0	0	52.1	34.8	5.9	0	0	11.7	6.7
Total health worker income (US$)	320.9	297.0	496.8	181.4	233.1	102.6	109.3	130.1	87.7	103.7
	(24.8)	(24.8)	(40.1)	(29.7)	(38.2)	(2.1)	(1.7)	(9.5)	(2.70)	(3.7)
Total household income (US$)	443.8	509.2	696.9	196.3	264.3	201.2	298.8	263.9	139.4	157.5
	(28.1)	(49.1)	(55.7)	30.0	(46.8)	(12.8)	(22.1)	(25.6)	(10.9)	(10.0)

Table 5: Demographic characteristics and incomes of sampled health workers

	Doctors		Nurses		III. Value as %
Variable	I Coef	II. S.E.	I Coef	II. SE	of base salary
Pay ×1000	0.620	0.029	0.992	0.033	Doctors Nurses
Location	0.415	0.052	0.895	0.031	26.8 72.1
Housing	0.501	0.036	0.582	0.020	32.4 46.9
Equipment	0.409	0.056	0.619	0.033	26.4 49.9
Payback Time	-0.282	0.053	0.144	0.030	-18.2 -11.6
Private/Super	0.743	0.059	0.404	0.033	48.0 32.6
% correctly predicted	79%		81%		
Log likelihood	-1383.52		-4038.84		
LRT	$p < 0.001$		$p < 0.001$		
n	216		640		216 640

Table 6: The direct effects model, for doctors and nurses

in Table 6, confirm that all job attributes significantly influence job choice in the expected directions. Columns I and II of the table report the coefficients and their standard errors respectively. Column III reports the marginal value of each non-wage attribute, as a percentage of average base public sector wages (2,500 Birr, or $275, per month for doctors and 1,250 Birr, or $140, per month for nurses). These values are equal to the marginal rates of substitution between the corresponding attribute and pay, as calculated in (4) (with each $\delta = 0$).

These results suggest that on average, the extra value of a job in Addis relative to one in a regional city for doctors amounts to about one quarter (27%) of the base public sector physician salary, the value of improved housing is about one-third (32%), the value of equipment is about one quarter (26%), and the value of reduced time commitment is about one fifth (18%). The most highly prized attribute for doctors is however, the ability to work in the private sector, which has a value of about half (48%) the base salary.

For nurses the most valuable job attribute is location. Indeed, location appears to be valued more by nurses than by doctors, especially when the value is measured as a share of the base salary. This partly reflects the fact that "location" means something different in the questions nurses were presented with than it does for doctors - switching a job from a rural area, which in principle can be very remote, to a regional capital, increases its value by 72% of the base public sector nurse's salary. (The other factor is of course the fact that the base nurse salary is only half the base doctor salary, 1,250 Birr, or about $140.) The least valued attribute for nurses appears to be payback time, as it is for doctors - having to pay back an extra year after receiving training is equivalent to a pay-cut of about 12% of base salary. Improved supervision is valued, but not as highly as the other non-time attributes.

4.3 Full model with characeristic and attribute interactions

We extend the direct effects-only model by incorporating interactions with characteristics that we expect might be correlated with marginal attribute valuations, and by including attribute-attribute interactions to assess non-linearities and synergies between attributes. We are particularly interested in exploring which attribute changes are likely to induce individuals to move to a rural posting, and which types of people are more likely to respond to a particular policy intervention. The demographic characteristics of greatest interest marital status, number of children, and sex. We are also interested in the effects on attribute valuation of characteristics of the respondent's *current* job, including its location, housing benefits, and for nurses the level of supervision provided.

We adopt a data-driven approach to model construction, in which we first sequentially add interactions of a particular characteristic with pay and non-pay attributes; we then estimate a full model including all the interactions that are individually significant (at the $p = 0.10$ level); finally we remove from this full model all the interactions that are no longer statistically significant (at the p=.05 level). Note, however, that because the MRS and other key model outputs are functions of multiple parameters, some otherwise insignificant interactions are retained in the model in order to calculate standard errors around these functions. Table 7 present the results for doctors and nurses.

Our estimates in the full model allow us to examine the heterogeneity of attribute valuations across health workers with different demographic characteristics. Table 8 reports selected marginal valuations for doctors, expressed as a percentage of the average base salary of all doctors (2,500 Birr per month). Note that the table includes only marginal valuations of those attributes with statistically significant characteristic interactions.

We find that married doctors value a job in Addis twice as highly as single doctors (38% versus 19% of base salary). The most natural explanation for this effect is a combination of joint-career issues, and children (although see below on the latter). Also, younger doctors are seen to value shorter payback periods following training – at first this seems surprising, as the young have "time on their hands," and we might expect them to be willing and able to pay back more time after training. The result likely arises from the fact that age is confounded with experience and training, so that older doctors, relatively many of whom are already specialized, do not place a high value on the training offered. Alternatively, younger doctors might feel more able to take advantage of their training, say by entering the private sector, or seeking future promotions. The future stream of benefits associated with training, even accounting for the length of career over which those benefits will accrue, may be greater for younger, more adaptable, doctors, than for older generations.

The impact of children seems perhaps surprisingly small, particularly the impact of the first child: Doctors with one child value an Addis job (presumably with better schools etc.) just 2 percentage points of base salary more than doctors without children, and there is virtually no difference in the value of housing

Doctors	I. Coef	II. S.E.	**Nurses**	I. Coef	II. S.E.
Direct effects			**Direct effects**		
Pay ×1000	0.623	0.154	Pay ×1000	0.816	0.090
Location	-0.026	0.209	Location	0.082	0.103
Housing	0.611	0.064	Housing	0.246	0.048
Equipment	0.448	0.116	Equipment	0.890	0.066
Time	-0.822	0.285	Time	-0.120	0.045
Private/Supervion	0.626	0.115	Private	0.207	0.063
Characteristic interactions			**Characteristic interactions**		
Income ×1000 * location	0.030	0.017	Income ×1000 * location	0.053	0.019
Married * location	0.402	0.160	Married * location	0.011	0.071
Sex * location	0.082	0.182	Sex * location	0.236	0.065
Child * location	-0.022	0.082	Child * location	0.050	0.029
Addisnow * location	-0.181	0.007	Citynow * location	0.343	0.074
Sex * pay ×1000	-0.016	0.095	Supervision * location	0.173	0.096
Child * pay ×1000	-0.074	0.042	Sex * pay ×1000	-0.179	0.069
Married * pay ×1000	0.066	0.083	Child * pay ×1000	-0.023	0.031
Age * pay ×1000	-0.002	0.004	Married * pay ×1000	0.187	0.076
Sex * housing	0.016	0.120	Citynow * pay ×1000	0.268	0.071
Child * housing	-0.061	0.046	Housenow * pay ×1000	-0.398	0.130
Sex * equipment	0.190	0.189	Married * housing	0.088	0.042
Child * equipment	0.035	0.073	Citynow * housing	0.305	0.043
Sex * time	0.130	0.177	Housenow * housing	-0.145	0.080
Age * time	0.016	0.008	Married * equipment	-0.091	0.067
Child * time	0.058	0.075	Married * time	0.036	0.062
Child * private	-0.004	0.077	Married * supervision	0.069	0.070
Sex * private	-0.026	0.200	**Attribute interaction**		
			Housing * location	0.356	0.065
Attribute interaction			Equipment * location	-0.241	0.075
Private * location	0.442	0.205	Supervision * location	0.291	0.078

Table 7: Full model with interactions for doctors and nurses

		Marginal attribute value (percent of average base salary)		
Characteristic		Location	Housing	Payback time
Age *	24			-23.2
	34.6			-13.0
	40			-8.0
Marital status	Single	19.1		
	Married	38.6		
Number of children	0	28.6	33.7	-13.0
	1	30.6	33.8	-11.0
	2	33.0	33.9	-8.4
Sex	Male	28.3	33.4	-14.1
	Female	33.5	35.1	-7.1

* Ages are the 10^{th} percentile, mean, and 90^{th} percentile.

Table 8: Heterogeneity in attribute valuations: doctors

by number of children. Having a child reduces the value of reduced payback time following training, but from a relatively small base (13 percent). These results on the effects of children should however be interpreted with caution as the median number of children in our sample of doctors was zero, so extrapolations to larger numbers of children are likely to be imprecise. Nonetheless, taken together with the effect of marriage, they suggest that joint career concerns (and perhaps the *prospect* of children) are more important barriers to rural labor supply than parenthood. Finally, in terms of differences by sex, women are observed to value work in the capital more than men (33% versus 28% of base salary), while men value reduced payback time about twice as much as women.

In contrast, as reported in Table 9, married nurses value urban work, and housing, *less* than single nurses. We do not know why marriage should affect nurses' valuations differently to those of doctors. One difference is, of course, that "location" means something different in our estimation of the preferences of nurses and doctors.[10] Married nurses value reduced payback time half as much as singles, suggesting mobility might be more valuable to the latter. The impact of children seems somewhat larger for nurses than doctors (in terms of the percentage of base salary), but again, having children does not seem to be an especially impenetrable barrier to rural work.

5 Policy experiments

Our basic policy concern is over what the government can do to induce health workers to take jobs in underserved locations. The specification in (1) allows

[10] Perhaps it is more important for single nurses to be in a city "marriage market" than it is for single doctors.

		Marginal attribute value (percent of average base salary)		
Characteristic		Location	Housing	Payback time
Marital status	Single	74.7	56.6	-12.2
	Married	61.3	52.9	-6.9
Number of children	0	60.4		
	1	66.5		
	2	72.9		
Income	25th percentile	65.4		
	Mean	66.5		
	95th percentile	72.4		
Lives in a city now	No	61.4	30.2	
	Yes	70.8	45.3	
Works in private sector now	No	63.4		
	Yes	73.7		
Receives housing allowance now	No		53.8	
	Yes		72.7	

Table 9: Heterogeneity in attribute valuations: nurses

us to infer the estimated probability of accepting one job (i) over another (j). We use this information in section 5.1 to calculate the probability that a worker will accept a rural job over an urban job, and how this probability varies both with other job attributes and across different people, for example by sex. In section 5.2 we convert the effects of job attributes on labor supply to equivalent wage changes by asking what wage change would have the same effect on the probability of accepting a rural job as a given attribute change. Finally in section 5.3 we illustrate graphically the impact of job attribute improvements on the effect of rural wage bonuses in increasing rural labor supply. Note that in our simulations we do not report the impact of allowing doctors to engage in private sector work outside of Addis Ababa. This is due to the fact that while respondents reported a high valuation of working in the private sector, there are few opportunities to do so outside Addis at this time (although the situation is likely to be changing rapidly), so application of the corresponding coefficients to rural jobs would be misleading.

5.1 Impact of attribute changes on rural labor supply

First we estimate the impacts of changes in job attributes on the probability that an individual will accept a job in a rural area over a job in Addis Ababa (for doctors) or in a zonal capital (for nurses). For doctors we define job j to be in Addis Ababa, with the prevailing attributes of an average job there set at levels approximating those reported by health workers in the first part of the survey instrument (and similarly for nurses in zonal capitals). Holding public sector wages constant (i.e., without introducing wage bonuses), we calculate the

	Doctors			Nurses		
	p	95% CI	Increase	p	95% CI	Increase
Baseline	0.074	(0.029,0.122)	–	0.046	(0.034,0.058)	–
Basic housing	0.109	(0.046,0.173)	47%	0.097	(0.080,0.115)	112%
Superior housing	0.269	(0.137,0.400)	262%	0.192	(0.152,0.233)	319%
Equipment	0.167	(0.105,0.229)	125%	0.198	(0.165,0.231)	332%
Pay-back time	0.114	(0.047,0.180)	53%	0.056	(0.041,0.072)	22%
Equip & housing	0.226	(0.144,0.308)	204%	0.323	(0.284,0.362)	605%
Supervision	-	-	-	0.075	(0.055,0.095)	64%

Table 10: Impact of non-wage attribute improvement on probability of accepting a rural job, for doctors

change in the estimated probability of an individual accepting a rural job when one non-wage attribute is improved. The results of this exercise are reported in Table 10. Our point estimates indicate, for example, that about 7.5 percent of doctors would be willing to take a rural job over a job in Addis under prevailing conditions, if they had the choice. Providing incentives in the form of superior housing increases the chance of accepting a rural job to more than one-in-four, while provision of basic housing, and training incentives (measured by a reduction in time commitment to one year) have relatively small effects, each increasing the likelihood from 7.5 percent to about 11 percent. The effect of improving the availability of equipment is in the middle of the range, increasing the probability of choosing a rural job to 17%.

For nurses, the non-wage attribute with the single biggest impact on the share of workers willing to take a rural job is the provision of adequate equipment. At baseline levels, only 4.4 percent of nurses would choose a rural job over a city job, but this jumps to 20 percent if they can be guaranteed adequate levels of equipment. The provision of basic housing, reducing pay-back time and providing better supervision have substantially smaller effects on the probability of choosing a rural job, increasing it to levels in the range of 5-8%.

5.2 Wage equivalents

Without information on the costs of making attribute improvements it is difficult to use this information for decision-making purposes. One step in that direction is to calculate the rural wage increases that would yield equivalent labor supply responses for each attribute improvement considered. For example, we ask how much rural wages would need to be increased, holding current non-wage attributes fixed, to induce the same increase in the number of doctors willing to take a rural job that we found for each attribute improvement in Table 10. Using the full model estimates reported in Table 7, we calculate these wage equivalents (as percentages of the base salary) for men and women separately, as discussed in sub-section 3.3. The 95 percent confidence intervals around the estimated wage equivalents (again measured in percent of base salary) are

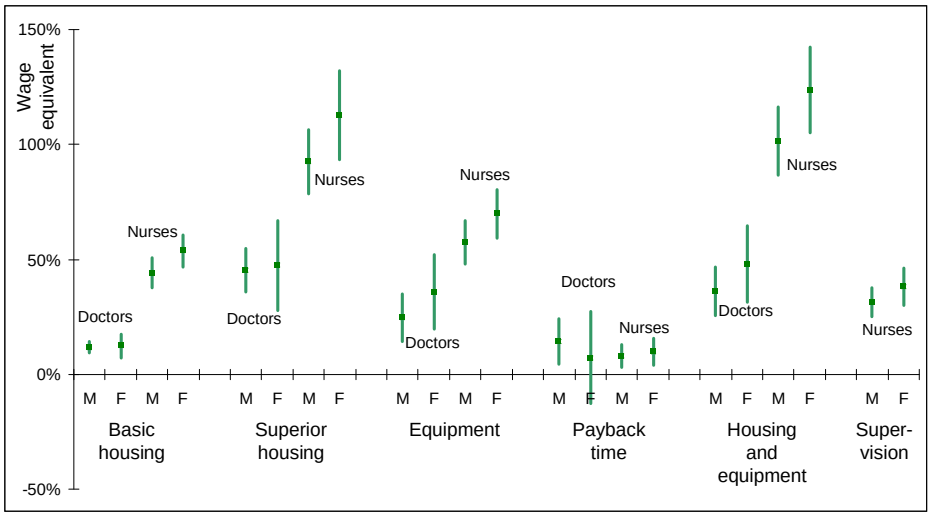

Figure 1: Estimated wage equivalents for each attribute, by doctor/nurse and by sex (M/F), as a percentage of the base wage.

bootstrapped, in light of the fact that the quantities of interest are non-linear functions of the underlying parameter estimates. The results are presented in Table **??** for doctors and nurses separately. A striking result is that while the point estimates of wage equivalents for most attributes tend to be higher for women, the difference is rarely statistically significant. Only for pay-back time amongst doctors does the confidence interval around the estimated wage equivalent for men $(25.7 - 46.8)$ not overlap that for women $(31.4 - 64.6)$. This is illustrated in Figure 1.

5.3 Rural wage bonuses and attribute incentives

Finally, we investigate the impact of increases in rural pay on predicted health worker labor supply based on our regression results above. In particular, we estimate the probability that an individual will accept a rural job as a function of the excess of pay over the base pay rate. This is the most obvious way to induce greater labor supply, but we also calculate the impact of such wage increases when coupled with attribute improvements. The results, for doctors and nurses respectively, are presented graphically in Figures 2 and 3, respectively. For doctors, doubling pay while keeping other attributes constant increases the probability of accepting a rural job from 7% to 57%. Alternatively, to induce half of doctors to locate in rural areas under current conditions, a rural bonus of approximately 89% (2,225 Birr) is required. Providing basic housing does not affect the impact of wages to a large extent, probably because most doctors already have at least basic housing. On the other hand, providing superior

Doctors								
	Male				Female			
	W.E. (% base)		p (rural)		W.E. (% base)		p (rural)	
	Est.	95% CI	Est.	95% CI	Est.	95% CI	Est.	95% CI
Baseline			0.080	(0.029,0.131)			0.050	(0.000,0.119)*
Basic house	11.7	(9.3,14.2)	0.116	(0.046,0.187)	12.3	(7.2,17.3)	0.077	(0.000,0.119)*
Superior house	45.2	(35.8,54.6)	0.280	(0.139,0.421)	47.3	(27.9,66.8)	0.213	(0.000,0.443)*
Equipment	24.6	(14.2,34.9)	0.169	(0.100,0.237)	35.7	(19.6,51.9)	0.157	(0.036,0.279)
Pay-back time	14.1	(4.2,24.0)	0.125	(0.053,0.198)	7.1	(-12.8,27.1)	0.065	(0.000,0.166)*
Equip & house	36.2	(25.7,46.8)	0.228	(0.139,0.317)	48.0	(31.4,64.6)	0.216	(0.060,0.372)
Nurses								
	Male				Female			
	W.E. (% base)		p (rural)		W.E. (% base)		p (rural)	
	Est.	95% CI	Est.	95% CI	Est.	95% CI	Est.	95% CI
Baseline			0.063	(0.047,0.078)			0.038	(0.027,0.050)
Basic house	44.1	(37.4,50.7)	0.126	(0.100,0.152)	53.7	(46.7,60.6)	0.084	(0.064,0.104)
Superior house	92.6	(78.6,106.4)	0.237	(0.189,0.285)	112.7	(93.5,131.9)	0.171	(0.131,0.211)
Equipment	57.4	(48.2,66.6)	0.244	(0.207,0.281)	69.9	(59.4,80.5)	0.176	(0.142,0.210)
Pay-back time	8.0	(3.0,13.0)	0.076	(0.056,0.095)	9.8	(3.8,15.7)	0.048	(0.033,0.062)
Equip & house	101.5	(86.5,116.5)	0.380	(0.337,0.423)	123.6	(105.0,142.3)	0.294	(0.251,0.337)
Supervision	31.3	(25.0,37.7)	0.099	(0.074,0.124)	38.2	(30.2,46.1)	0.064	(0.045,0.083)

* Confidence intervals in these cells to be recalculated.

Table 11: Demographic characteristics and incomes of sampled health workers

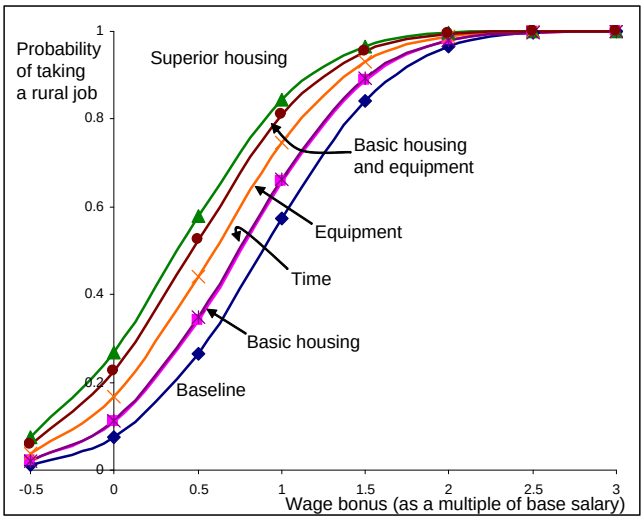

Figure 2: Share of doctors willing to accept a rural job as a function of the rural wage bonus (horizontal axis), with alternative in-kind attribute incentives.

housing means that doubling wages increases the probability of accepting a rural job from 27% to 84%.

Our results suggest that nurses are much less responsive to proportionate wage bonuses than doctors – a doubling of pay increases the probability of accepting a rural job from 4% to only 27%, and inducing half of the nursing workforce to locate in rural areas would require a wage bonus of about 155% of the base salary. This bonus amounts to 1,937 Birr, and is only marginally smaller than that needed to induce a similar proportion of doctors to take jobs in rural areas. The impact of adequate equipment, both on willingness of nurses to take a rural job in itselt, and on the impact of higher pay on such willingness, is of particular interest, especially since this attribute does not reflect personal consumption as such. Indeed, the impact of equipment is not only greater than that of basic housing, but it exceeds that of *superior* housing also. By itself, adequate equipment increases the likelihood of accepting a rural job from 4% to 21%, while coupled with a doubling of rural pay, this probability increases to 61%.

6 Conclusions

Our analysis provides evidence that the locational labor supply decisions of health workers are responsive to both wage and non-wage factors, and that for some of these attributes the responses can be large. Proportionate wage bonuses for rural service increase labor supply, but these effects seem to be larger

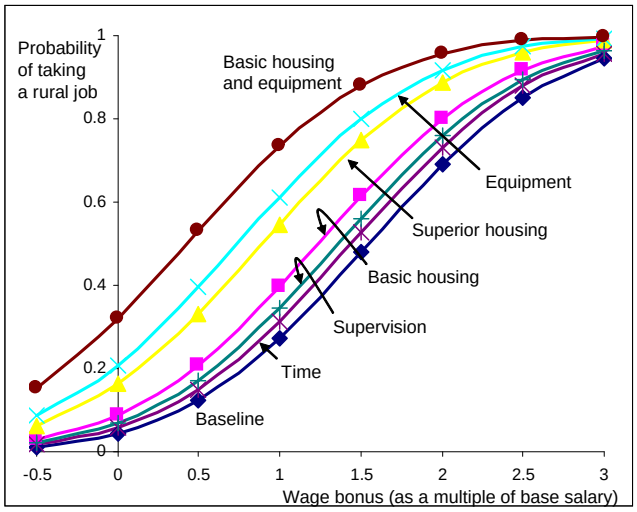

Figure 3: Share of nurses willing to accept a rural job as a function of the rural wage bonus (horizontal axis), with alternative in-kind attribute incentives.

for doctors than for nurses. For example, under current working conditions in urban and rural facilities, attracting 50% of doctors to work in regional towns would require a wage bonus of approximately 89% over the base salary. Inducing the same rural labor supply from nurses to rural settings (which are on average more remote than regional towns) would require a bonus of about 155%.

For both doctors and nurses, the joint provision of superior housing *and* equipment induce significant increases in the probability of accepting a rural job. Provision of basic housing, reduced pay-back time and (for nurses) improved supervision all have positive but smaller effects on the likelihood of choosing a rural post. Our broad-brush interpretation of these results is that health workers want to be paid more and to be better able to do their jobs, but that in-kind inducements in the form of accelerated training and improved supervision are valued somewhat less. The fact that superior housing is an effective inducement likely reflects the fact that this would represent a large cash equivalent.

These results can be usefully compared with two similar studies of stated preferences of health workers in developing countries. Chomitz et al. (1998) found that the promise of specialist training was an effective, if expensive and inefficient, way of inducing doctors from Java to relocate to the remote islands of Indonesia. They found that individuals *from* remote areas were more likely to take jobs *in* remote areas, and that modest financial incentives could induce relocation to moderately (but not extremely) remote areas.

Serneels et al (2005) report results from a survey of nursing and medical students in their final year of study in Ethiopia. They find that at the then prevailing starting wage of 700 Birr, fully one-third of nursing students reported

that they would choose to work in a rural area (defined as 500km from Addis), and that a rural bonus of just 31% would be sufficient to induce *all* student nurses to take such jobs. To get all graduating doctors to move to the rural areas requires a bonus of just 39% of the starting salary. These results stand in contrast to those of this paper: we found above that doctors in our sample would need to be paid a bonus of about two and a half times the base salary in order to induce (nearly) all of them to work in a rural area, while the corresponding figure for nurses is about three time. The difference may stem from the fact that our samples were very different: Serneels et al. interviewed students, while we surveyed health workers at various stages of their careers. Finally, Serneels et al. report that the availability of children's educational opportunities was one of the main attractions of work in Addis Ababa. Somewhat surprisingly, we find only weak evidence of this effect in our data: the number of children a health worker has does not appear to have an economically significant influence on her/his valuation of alternative job attributes (including location). We speculate that this may be due to the widespread practice of sending children to boarding school amongst Ethiopia's upper classes.

These results can provide guidance to policy-makers about the potential trade-offs between alternative policies to encourage health workers to accept rural jobs. However, without detailed information on the costs of altering the specified attributes, it is impossible to rank the alternative policy interventions in terms of any cost-effectiveness measure.[11] However, our wage-equivalent analysis is a first step towards allowing such a comparison. In addition, the limitations of stated preference studies should be kept in mind, and ideally we would seek to validate our results by comparing them with evidence from revealed preference analyses.

[11] Note that cost-effectiveness is a useful measure if the objective of increasing labor supply is taken as given. It does not inform the question of whether such changes in labor supply are warranted - we take this as self-evident in this case.

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8 Appendix: Description of job attributes for doctors and nurses

Here we report the descriptions of job attributes and possible levels that were presented to respondents.

8.1 Doctors

For doctors, the job attributes and possible levels were described to the respondents as follows:

- Geographic Location

This attribute specifies whether your place of work is in Addis Ababa or in a zonal capital of one of the zones. If the latter, you should think of the job as being randomly situated in one of the zonal capitals in Ethiopia, or alternatively, in "an average zonal capital".

- Net Monthly Pay (including regular allowances)

This attribute takes on different Birr levels. The first represents the base salary for a physician at an "average" grade in the civil service pay scale, while higher levels are multiples of this average base level. Note that the base salary does not necessarily reflect your current actual salary.

- Government-provided Housing

This attribute measures the existence, and quality, of government-provided housing, and has three possible levels. "None" means there is no housing provided by the government as part of the conditions of employment. "Basic" housing means the government provides housing for the health worker, but that it is rudimentary, having no electricity or running water, and with at best an outside toilet. "Superior" housing means the government provides housing of higher quality, including the presence of electricity and running water, including an inside flush toilet.

- Availability of Equipment and Drugs

This attribute simply takes on two values – "inadequate" and "improved". "Inadequate" is the standard of equipment and availability of drugs that you might expect in a poorly equipped public facility in the given location. "Improved" is that level of supplies that would result from a doubling of the budget currently spent on equipment and drugs.

- Time Commitment following Training

Suppose your employer provides or sponsors training on your behalf. This attribute measures the number of years you are required to work for the sponsor for each year of training provided. It can take on two values: 1 and 2.

- Permission to hold a Second Job in the Private Sector

This attribute is 1 if you are permitted work in the private sector (either using the public facility or not), and 0 if you are not permitted to do so.

8.2 Nurses

For nurses, some of the job attributes and possible levels differ to those offered to doctors:

- Geographic Location

This attribute specifies whether your place of work is in a City (i.e., a zonal or regional capital, or Addis Ababa), or in a Rural area. If the job is a "City" job, you should think of it as being randomly situated in one of the zonal capitals or larger cities in Ethiopia, or alternatively, in "an average city". If the job is a "Rural" job, you should think of it as being randomly situated in a town or village outside of the zonal capitals and larger cities.

- Net Monthly Pay (including regular allowances)

This attribute takes on different Birr levels. The first represents the base salary for a nurse at an "average" grade in the civil service pay scale, while higher levels are multiples of this average base level. Note that the base salary does not necessarily reflect your current actual salary.

- Government-provided Housing

Same as for doctors.

- Availability of Equipment and Drugs

Same as for doctors.

- Time Commitment following Training

Same as for doctors.

- Level of supervision

This attribute attempts to measure the degree of professional interaction you have with your superiors, and takes on two values – high and low. A high level of supervision could result from regular and productive interaction with a supervisor who works in the same facility as you, or from regular visits (say every one or two weeks) from a more senior health worker from another facility, such as a zonal hospital. A low level of supervision could arise due to lack of interaction by more senior health workers who work at your facility, or because of infrequent visits (say once every six months or less) by such superiors from other institutions.

This paper estimates the effectiveness of a range of policy interventions aimed at improving the supply of health workers to rural areas in Ethiopia. Using data from a survey of 861 health workers, it employs stated preference techniques to predict labor market responses of doctors and nurses to changes in rural wages, working conditions, housing benefits, and training opportunities.

This paper was produced by the World Bank's Africa Region Human Resources for Health team, with funding from the Government of Norway and the Gates Foundation.

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