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an Example from Urban Senegal

Christopher J. Cronin; David K. Guilkey and Ilene S. Speizer

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Christopher J. Cronin[*], Department of Economics, University of Notre Dame

David K. Guilkey, Department of Economics and Carolina Population Center, University of North Carolina at Chapel Hill

Ilene S. Speizer, Gillings School of Global Public Health, Department of Maternal and Child Health and Carolina Population Center, University of North Carolina at Chapel Hill

Abstract:

A number of authors have utilized health facility choice models to determine how individuals in developing countries evaluate the tradeoff between the price, quality, and indirect costs of obtaining medical care. A common problem in this literature is that researchers only observe the type of facility that individuals report visiting (e.g., public or private hospital, health center or dispensary, or traditional healer) and, therefore, must assume individuals visit the nearest facility of the type they report. This matching procedure creates measurement error in the choice variable, which may introduce bias in parameter estimates. In this research, we use a data set from urban Senegal that allows for a precise individual-health facility match to estimate consumer preferences for health facility characteristics related to maternal health and family planning services. Using actual rather than imputed choices, we find that consumers prefer high quality health facilities that are nearby. Given the preference for quality, our findings indicate that in contrast to the typical assumption in the literature, individuals frequently bypass the facility nearest their home. When we estimate models using the mismeasured choice variable, the results show a significant bias in preference estimates; most notably, these models systematically overestimate distaste for travel. To highlight a potential consequence of biased preference estimates in this setting, we conclude by simulating the impact of an actual policy that took place in 2014; namely, the opening of a new facility in a previously underserved area of Dakar, Senegal.

Keywords: Measurement Error, Discrete Choice, Health Facility Choice, Maternal Health, Family Planning, Senegal

JEL Classification: I12, I15, I18, J13, C35

I.   Introduction

Many developing countries have attempted to improve the health of their populations through government policies that enhance the quality and/or accessibility of healthcare (Dzakpasu et al., 2012; Yates, 2009). Given resource constraints, politicians and public health officials regularly evaluate competing policies by comparing projected costs and benefits. These projections require an understanding of how individuals evaluate the tradeoffs between the price, quality, and indirect costs (e.g., travel costs, wait times, etc.) faced in obtaining care. For example, consider a government that wishes to extend services to an underserved population and must decide between constructing a new health facility and improving an existing one(s). In evaluating these alternatives, policy makers would benefit from information on patient preferences for travel costs relative to preferences for facility quality, wait times, and price sensitivity.

The choice models frequently employed in the economics literature are particularly well suited to extract such preference information from individual-level choice data (Train, 2009). However, the facility choice models that have been estimated in developing country settings have suffered from a common data limitation; namely, researchers have been unable to match individuals to the actual health facility that they visit. Most commonly, researchers observe only the type of facility that an individual reports visiting (e.g., public or private hospital, health center or dispensary; or traditional healer) and, therefore, estimate choice models that define the alternative set by the nearest facility of each type (Akin et al., 1986; Dor et al., 1987; Mwabu et al., 1993; Leonard et al., 2003; Mariko, 2003; Habtom, 2007; Erlyana et al., 2011) or average facility of each type (Akin et al., 1995).[1] This strategy may not be a major issue in rural areas with very limited choice sets but could be more important in urban areas. Regardless of the setting, estimates produced by these models vary considerably, offering no clear conclusions as to how

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[1] Average facility of each type implies that a facility characteristic (e.g., number of doctors) for a particular facility type (e.g., public hospitals) is calculated as the average of that characteristic across all facilities of that type within some distance band. Several other papers use patient-reported facility characteristics from the visited facility to fit hedonic price and quality models, which are then used to assign facility characteristics to particular facility types (Gertler et al., 1987; Bolduc et al., 1996; Borah, 2006).

individuals evaluate the tradeoffs faced in obtaining medical care. For example, most researchers have found that individuals are more likely to select nearby facilities with lower prices and higher quality (Gertler et al., 1987; Akin and Hutchinson, 1999; Leonard et al, 2003; Borah, 2006; Habtom, 2007), yet numerous papers find that individual choice is not affected by the distance they must travel for care (Akin et al., 1986; Mwabu et al., 1993; Mariko, 2003; Erlyana et al., 2011) or that in some cases, individuals actually prefer longer distances (Akin et al., 1995; Bolduc et al., 1996). There is also wide variation in the magnitude of estimated effects.[2]

In conflict with the existing literature are several studies which show that individuals, particularly those in urban environments, frequently bypass nearby health facilities to obtain higher quality care (Akin and Hutchinson, 1999; Leonard et al, 2003). We confirm this finding in our own data as well. As such, both the choices and alternative sets assigned to individuals in much of the existing research do not represent the true choices made and alternative sets faced by the individuals being studied. These data deficiencies represent a form of measurement error that may bias existing estimates of consumer preferences for health facility characteristics. Ultimately, correcting this bias is important for health officials who utilize these estimates to design policies that alter the price, quality, and/or indirect costs of both private and public health facilities.

In this paper we utilize a novel data set of over 9,600 urban dwelling women in Senegal linked to a census of health facilities in these urban areas that they could potentially visit for maternal health and family planning services. We use survey data to measure quality of care at each of the 231 available health facilities and 533 pharmacies, as well as GPS coordinates to measure the distance each woman must travel to each facility. Together, this information allows us to estimate a choice model that (i) matches women to the specific facility they visit and (ii) allows choices from the full set of alternatives. To our knowledge, no other work in the economics literature estimates consumer preferences for health

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[2] For example, Erlyana et al. (2011) find that for a rural population of uninsured adults in Indonesia, the price elasticity of demand for both community health centers and private doctors is insignificantly different from zero; however, a similarly rural population of adults in Benin studied by Bolduc et al. (1996) has an estimated price elasticity of demand of -2.48 for community health centers and -4.27 for private doctors.

facility attributes in a developing country by matching individuals to the actual health facilities that they visit. Thus, the primary contribution of this paper is that it provides facility preference estimates in a developing country setting that are free of bias due to measurement error in the choice variable.

In our empirical analysis, we utilize a random utility framework to estimate a series of health-facility choice models, employing a selection-on-observables approach to control for the possible non-random self-selection of individuals into care. Our preferred parameter estimates are derived from a mixed logit model, which relaxes the independence of irrelevant alternatives (IIA) assumption that is characteristic of the standard conditional logit model by allowing variation in the weight individuals place on facility characteristics when making facility choice decisions. Because we observe a complete census of facilities that offer sexual and reproductive health services, we are able to mimic the literature by estimating an additional model that (i) restricts the individual's health facility alternative set to those nearest them that are of a particular type and (ii) matches the individual to a facility according to the type we observe them select. By comparing the two sets of estimates, we are able to document that the typical measurement error in the existing literature leads to a bias in preference parameter estimates.

Our main findings indicate that patients have a preference for facilities that are nearby and facilities that are of high quality such as facilities that are public, offer a greater number of services, offer educational materials and conduct community outreach, and have modern amenities (e.g., electricity, piped water, telephones, and modern rooms). The preference for quality does mean that in many circumstances, patients are willing to bypass the closest facility for one of higher quality. We also find evidence to suggest that measurement error is a significant source of bias in the existing literature. Among the health facility characteristics that are under/over valued by the models estimated using data that is measured with error, the bias in preferences for distance is notable. Our findings suggest that, for urban settings, the matching procedure commonly used by researchers significantly limits the possibility that women travel long distances to obtain care, which leads to a systematic overestimate of distaste for travel. We highlight a potential consequence of this bias in preference parameter estimates by comparing how our preferred model and the measurement error model predict individual responses to two policies; the

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first of which was actually implemented in 2014, after our data were collected – a new public facility was added in an underserved area of Dakar, Senegal – and the second of which is hypothetical, but can be viewed as having been a viable alternative to the implemented policy – providing electricity to facilities in Dakar without it. We find that the differences in the predictions produced by the two models are statistically significant and economically meaningful, suggesting that the bias in preference parameter estimates caused by measurement error could have significant effects on public policy.

Our paper also contributes to a large literature on how individuals in *developed* countries evaluate the tradeoff between the price, quality, and indirect costs of obtaining medical care. While this literature does not struggle with the measurement error challenges discussed above, frequent use of administrative facility choice data creates the potential for endogenous sample selection – typically, a researcher only observes individuals who choose to visit a facility (e.g., Luft et al., 1990; Burns and Wholey, 1992; Hodgkin, 1996; Chernew et al., 1998; Mukamel et al., 2004; Dranove and Sfekas, 2008). In our survey data, we observe women that both visit and choose not to visit a facility, allowing us to model and ultimately test for endogenous selection of women into visiting a facility. We do not find evidence of endogenous selection into visiting a facility, providing some support for the exogenous sample selection assumption made frequently in the developed country health facility choice literature.

The rest of the paper is organized as follows. In the next section, we detail the random utility model that guides our empirical specification and provide information on the statistical specification of the model. In Section III, we provide information and descriptive statistics on the individual and facility level data sets from urban Senegal that we use to estimate our model. These statistics show that for both maternal health and family planning services, an overwhelming majority of respondents bypass the closest facility for one of higher quality. We present estimation results, robustness checks, and policy simulations in Section IV. In Section V we summarize our findings and contributions to both the developed and developing country health facility choice literature.

II.   Model and Methods

We model the choice of health facility for maternal health and family planning services. The following random utility model, originally developed by McFadden (1974), serves as a baseline:

$$U_{ij} = X_{ij}\beta + Z_i\gamma_j + \epsilon_{ij} \qquad (1)$$

where U_{ij} is the utility that individual $i = 1, 2, …, N$ receives from facility $j = 1, 2, …, J$. The X_{ij} represents a $1 \times L$ vector of choice specific attributes such as the distance individual i's place of residence is from facility j. The Z_i represents a $1 \times K$ vector of individual specific variables such as age and education. The baseline model assumes that the ϵ_{ij}'s follow a Type 1 Extreme Value (T1EV) distribution, are independent across alternatives, and have the same variance.

There are three problems with the baseline model. First, in order to allow individual-specific variables, Z_i, to impact choice probabilities directly in this specification we must estimate $(J - 1) \times K$ parameters, γ_j. In our model, $J = 231$ for the maternal health model and $J = 764$ for the family planning model (the latter includes pharmacies, as well as health facilities), so the number of parameters that we would need to estimate to include even one main effect of an individual-specific variable is unfeasibly large. As such, we do not allow for Z_i to impact facility choices directly in our preferred model, though we do include interaction effects (between X_{ij} and Z_i) in some specifications (discussed below).

Second, a nice feature of random utility models with T1EV errors is that they yield choice probabilities that have a closed form. However, a well-known critique of this distributional assumption is that the resulting probabilities display Independence of Irrelevant Alternatives (IIA), which imposes on the model strict substitution patterns between alternatives (Chipman, 1960; Debreu, 1960). In general, if there is any correlation between the unobserved preferences for alternatives (i.e., $Cov(\epsilon_{ij}, \epsilon_{ik}) \neq 0$), then these substitution patterns will be inappropriate. Our preferred model adopts an extension of the random utility model that is sometimes referred to as the mixed logit model (see Train 2009, Ch. 6). Specifically, we assume that preferences for facility attributes vary across the population, such that $\beta_i \sim N(\beta, \Sigma)$ where

β is an $L \times 1$ vector of means and Σ is an $L \times L$ unrestricted covariance matrix.[3] By allowing for random taste variation we implicitly allow for correlation between the model's error terms, which relaxes the IIA property and the strict substitution patterns characterizing the baseline model. The mixed logit specification also gives us a straightforward way to allow individual-level characteristics to impact choices in our model, while still allowing for preference heterogeneity. In one specification, we allow the mean of the parameter distribution, β, to vary by an individual's level of education (e.g., more educated individuals may prefer facilities with more doctors and fewer midwives) and only requires the estimation of L additional parameters.

The third potential problem with the baseline model stems from the fact that we only observe facility choices for a non-randomly selected sub-sample of the population. For both family planning and maternal health services, women in the survey data can choose not to visit a health facility, $S_i = 1$; visit a health facility that we do not observe, $S_i = 2$; or visit a health facility that we do observe, $S_i = 3$. We are only able to model the choice of a health facility if $S_i = 3$. Let's assume that this selection is influenced by an individual's characteristics, Z_i; the characteristics of health facilities that she is likely to visit conditional on visiting any facility, X_{ij} (where $j \in J^i$ and J^i is a set of such facilities); and some random component η_i. In such a setting, Wooldridge (1999) shows that the parameters of the baseline model (i.e., Equation 1) can be consistently estimated via maximum likelihood using only the selected sample as long as S_i and ϵ_{ij} are uncorrelated (i.e., there are no unexplained determinants of selection that would lead an individual who visits a facility to choose a different facility from an observationally equivalent individual who does not visit a facility). This condition may not hold true in our setting, particularly because we cannot estimate the baseline model (Equation 1) due to the size of the alternative set. Instead, we estimate

$$U_{ij} = X_{ij}\beta_i + \omega_{ij} \qquad (2)$$

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[3] We also estimated a mixed logit model with a discrete mixing distribution (Pacifico and Yoo, 2012) and the results were similar for the main variables of interest. However, the standard errors of the estimates we quite a bit larger than the standard errors that assumed multivariate normality and so we report results based on this parametric assumption in the tables.

where our error term is $\omega_{ij} = Z_i\gamma_j + \epsilon_{ij}$. Therefore, by excluding the main effects, $Z_i\gamma_j$, we increase the likelihood that selection into the sample, S_i, and the unobserved determinants of facility choice, ω_{ij}, are correlated (i.e., $E[\omega_{ij}|X_{ij}] \neq E[\omega_{ij}|X_{ij}, S_i = 3]$), which could cause bias in the estimation of the parameters of Equation (2).

We address this problem using a selection-on-observables approach described by Wooldridge (2002, 2007) and Imbens (2014). Specifically, assume S_i is also determined by a random utility model with T1EV error. The probability of selecting into any of the three groups is then

$$P(S_i = s) = \frac{\exp(\delta_{1,s}f(X_{ij}) + \delta_{2,s}Z_i)}{\sum_{s'=1}^{3} \exp(\delta_{1,s'}f(X_{ij}) + \delta_{2,s'}Z_i)} \qquad (3)$$

where $f(X_{ik})$ is a summary statistic of the characteristics of facilities in J^i (e.g., the average characteristics of facilities within a 1 km radius of individual i's home). The parameters of Equation 3 can be consistently estimated using maximum likelihood. We then weight the choice probabilities in the likelihood function by the inverse of the predicted probability (IPW) that the individual visits a facility that we observe.

$$IPW = \frac{1}{\hat{P}(S_i = 3)} \qquad (4)$$

Wooldridge (2002) compares and contrasts the weighted and unweighted estimators. Under a set of regularity conditions, the unweighted estimator is consistent and asymptotically more efficient than the weighted estimator, if selection is *ignorable* conditional on control variables (i.e., $P(S_i = 3|d_{ij}, X_{ij}) = P(S_i = 3|X_{ij})$ where d_{ij} is an indicator variable that equals 1 if individual i selects facility j and 0 otherwise). Given our exclusion of individual level controls, Z_i, from the facility choice model, we view this assumption to be too strong. Consistency of the weighted estimator requires that the same set of regularity conditions hold, but the ignorability assumption is weaker – selection must be *ignorable* conditional on control variables, X_{ij}, and additional observables, W_i (i.e., $P(S_i = 3|d_{ij}, X_{ij}) =$

$P\left(S_i = 3 \middle| X_{ij}, W_i\right)\right)$. We define W_i using individual-level controls, Z_i, and interactions between individual and facility-specific controls.

This estimator is intuitive. One way to describe the sample selection problem is that, without correction, our estimates will not capture the preferences of individuals not visiting a facility. By weighting choice probabilities by the inverse of the probability of inclusion, we give the choices/preferences of included individuals who look like (i.e., have similar observable characteristics as) excluded individuals greater weight in the estimation of the model's parameters. The estimated parameters then capture the preferences of the entire population, which is comprised of individuals both visiting and not visiting health facilities.

The existing developing country facility choice literature, which generally utilizes survey data featuring a subsample of people not visiting a facility, addresses sample selection using a different strategy. Researchers typically design choice models that (i) designate "no facility" as a choice alternative and (ii) allow individual-level characteristics (i.e., Z_i from our model) to have a separate impact on the indirect utility received from *every* choice alternative (Akin et al., 1986; Dor et al., 1987; Gertler et al., 1987; Mwabu et al., 1993; Akin et al., 1995; Bolduc et al., 1996; Mariko, 2003; Borah et al., 2006; Habtom and Ruys, 2007; Erlyana et al., 2011). This method controls for endogenous sample selection only if unobserved preferences for facilities, ϵ_{ij}, are independent across the sample conditional on the individual-level characteristics – a strong assumption. We prefer our weighting method to this alternative strategy for two reasons. First, the alternative strategy requires the estimation of $(J - 1) * K$ additional parameters, where J is the number of alternatives and K is the number of individual-level controls. Thus, the method cannot be implemented with a large choice set, nor can the method accommodate a large number of controls. Second, the alternative strategy does not allow the conditioning individual-level characteristics to include variables that are endogenous to selection. Both Wooldridge (2010, Ch. 19) and Moffitt et al. (1999) note that consistency of the weighted estimator does not require that W_i and ω_{ij} are uncorrelated. In other words, control variables that are endogenous to the facility choice model can be

included in the selection equation to help satisfy the ignorability assumption. We include such variables (e.g., pregnant, gave birth recently, frequency of sex, fertility desires, etc.) in W_i.

Given our assumptions, it is straightforward to construct the likelihood function for this problem (see, for example, Train, 2009, Ch.6 and Hole, 2007). We use Stata's *mixlogit* package to estimate the model, which uses simulated maximum likelihood. Results presented here use 50 Halton draws, which Bhat (2001) shows provide better accuracy with fewer draws and lower computational time than does a pseudo-random method.[4]

III.   Data and Descriptive Statistics

Our empirical analysis focuses on urban areas in the West African country Senegal. Senegal is characterized by high fertility rates (5.1 children per woman in 2013; World Bank), high infant mortality rates (45 per 1,000 live births in 2012; Unicef), high maternal mortality rates (370 per 100,000 live births in 2008-2012; Unicef), and low rates of family planning use (21.2% of women in union ages 15-49 were using a modern method in 2015; DHS). Use of modern family planning in urban areas is double what it is in rural areas (30% vs. 15%, respectively), however, in both urban and rural areas, there is still a high need for family planning with about 21%-23% of women in unions reporting a desire to space or stop childbearing and not using any method of family planning (DHS).

Women in Senegal access health care predominately through the public sector; this is true for both family planning services as well as maternal and child health services. Market and government forces determine prices for healthcare services. In urban areas, a "ticket" fee that averages (roughly) $0.80 must be paid prior to seeing a provider. Most contraceptive prices are fixed by the government and do not vary across facilities. For most methods, these prices do not serve as a barrier to use (e.g., condoms are

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[4] Our two main mixed logit models (i.e., results presented in Table 5) have also been estimated using 400 Halton draws. Parameter sign and significance is very similar to the 50 draw findings; however, magnitudes vary slightly. We have chosen to present the 50 draw results because estimating the model with 400 draws is computationally expensive, preventing robustness testing. Using a Dell Precision T1600 workstation with 8 Intel Xeon 3.4GHz processors, the maternal health and family planning models with 400 Halton draws took 70 and 81 days to converge, respectively.

free, pills are $0.2 per month, etc.); however, longer acting methods can be more expensive and vary by facility (e.g., implant or IUD can range from $4.80 to $8.00).

We use baseline household and facility data from the Measurement, Learning & Evaluation (MLE) project collected as part of the evaluation of the Initiative Sénégalaise de Santé Urbaine (ISSU) in Senegal. The study includes six urban sites: Dakar, Guédiawaye, Pikine, Mbao, Mbour, and Kaolack. At baseline, in 2011, a multi-stage sampling design was used to select a representative sample of women ages 15-49 from each site. In the first stage, between 32-64 primary sampling units (PSUs) were selected with different numbers based on the size of the urban site. PSUs were created based on the 2002 census sampling frame that was updated in 2009; details of the sampling frame can be found in the MLE baseline report (MLE and Initiative Sénégalaise de Santé Urbaine, ISSU, 2011). In the second stage, using a comprehensive listing of all households in a selected PSU, a random sample of 21 households were selected for the women's interview; men were also surveyed in half of the selected households. Household heads were asked to provide written consent prior to the household interview; for any eligible woman under age 18, the household head also provided consent to interview the young woman. All eligible women provided written consent (assent if under age 18) to participate in the survey. In total, 9,614 women from 4950 households were surveyed; this represents women from 263 primary sampling units across the six cities. The final response rate among women was 88.9%.

At baseline, data were collected from all public and private health facilities that offer maternal, newborn, child, and family planning services in each of the six cities. This included high capacity public and private hospitals as well as health centers and dispensaries. Across the six cities, of a total of 269 health facilities on the master list, 231 were identified and survey data were collected from 205. Sixty-four facilities were not included due to reasons such as striking providers, being merged with another facility, not offering the relevant services, refusal, no longer in existence, and unavailable provider for interview. Likewise, of a total of 576 pharmacies on the master list, 533 were identified and 518 completed surveys; similar scenarios were found for those pharmacies where an interview did not take

place.[5] At each health facility and pharmacy, an audit was performed to obtain information on services offered, family planning methods available, and stockouts. At all health facilities, a provider interview was undertaken with up to four providers depending on the size of the facility. (For details, see the ISSU Final Report, 2012.)

III.a   Choice Data

Women were asked in the individual interview to provide the name and address of the health facility that they visit "most frequently" for a number of health services, which were then matched to the facility survey. In our analysis, we focus on the choice of a facility for maternal health services, which includes prenatal and postpartum care, and a facility to acquire family planning methods and services. This choice data is summarized in Table 1. Of the 9,325 women in our sample, 7,034 report not visiting any facility for maternal health services in the past 12 months and 7,941 report not visiting for family planning services.[6] Among those visiting facilities, 1,830 report visiting a surveyed facility for maternal health services and 1,073 report visiting a surveyed facility for family planning services.

As mentioned above, these data are unique in that women can be matched to the specific facility that they visit for care, rather than the closest facility of a particular type (e.g., public or private hospital, health center or dispensary; or traditional healer).[7] Table 1 shows how the "closest facility" strategy can

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[5] In our choice models, we distinguish between non-identified and non-participating facilities. Surveyors failed to identify 38 health facilities and 43 pharmacies on the master list. We do not observe any information about these facilities in the data; thus, we control for potentially endogenous selection into these facilities in the choice model in the first stage (see Section 2 above). There are 26 facilities and 15 pharmacies that surveyors were able to identify, but that refuse to participate in the survey (*participating=0)*. Among these, we observe distance and facility type (i.e., *public/private, high/low capacity,* and *pharmacy*); thus, these facilities enter the choice model as standard alternatives with all unobserved characteristics coded as 0. The control variable *participating* distinguishes preferences that are unique to these facilities.

[6] 289 of the original 9,614 women were dropped due to missing individual-level information.

[7] The distance between each facility and a woman's home is measured, using ArcGIS software, as the straight-line distance between the centroid of the PSU where the woman lives and the facility location. PSUs, on average, include about 100-150 urban households, making this a fairly accurate representation of the location of a woman's home. The fact that we measure straight-line distance, which does not consider the status of roads or transportation networks between the two points, makes our metric an imperfect measure of the "travel costs" associated with obtaining care from a particular facility. This problem is common in the literature; however, our focus on urban environments, where roads exist and public transportation is widely available, likely makes straight-line distance a reasonable measure of travel cost.

lead to measurement error in facility matches, particularly in dense urban settings. Among the women who visit a health facility for maternal health services, only 25.7% visit the facility nearest their home and 35.4% visit the nearest facility of a particular type, where types are defined as high-capacity public, low-capacity public, high-capacity private, or low-capacity private. Furthermore, the median (mean) individual bypasses 4 (17) facilities to get to the facility that she visits. Similar statistics are reported for family planning services, though bypass counts are higher as the inclusion of pharmacies greatly increases the size of the alternative set.

[Insert Table 1 Here]

One reason that some women bypass nearby facilities could be heterogeneity in preferences for distance, for example, a woman may actually prefer to go to a facility farther away from her place of residence for the sake of anonymity. Our preferred model allows for this type of variation in preferences. Another potential explanation is that women bypass nearby, low-quality facilities for higher-quality facilities, and facilities that offer more services, but are further away; we present evidence of this below.

III.b   Facility Quality

Table 2 summarizes the characteristics of the 231 health facilities that women may visit for maternal health services.[8] In columns 2 and 3, we compare the average characteristics of both chosen and nearest facilities for maternal health choices. The differences are stark; virtually every characteristic associated with quality is higher for the selected facility than the nearest facility. Most notably the

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[8] Several facility characteristics require explanation. A *high-capacity* facility (i) covers a catchment area with a large population, (ii) can serve a large number of daily clients, (iii) provides a full range of family planning (FP) methods, and (iv) employs trained personnel for FP and reproductive health services (MLE, ISSU, 2012b) – all other facilities are *low capacity*. The high/low capacity classification was determined prior to data collection. *Any IEC materials* indicates the presence of any of eight Information, Education, and Communication family planning (FP) tools (e.g., posters, brochures, demonstration models, etc.), which are visually verified by the survey administrator. In the facility survey, facility-level interviewees select all services that their facility provides from a list of 22 possible reproductive health services as well as FP methods offered from a list of 10 methods - *# services offered* and *# FP methods available* is simply the sum of these offered services and methods, respectively. Facilities are said to *provide community outreach* if they report having ever hosted health talks for the benefit of the community. Finally, a facility is said to have a *FP protocol* if providers from the facility report having facility wide "standards or protocols for FP services" in the provider interview.

average selected facility is open more days and hours, has a larger staff, offers more services, is more likely to conduct community outreach programs, and is more likely to be equipped with modern amenities than the nearest facility. Table 3 summarizes the characteristics of the 231 health facilities and 533 pharmacies women may visit for family planning (FP) services. The results are largely the same – the average selected facility tends to be of greater quality than the average nearest facility. An exception can be found in the likelihood of a 24-hour stockout in the past month, which is higher in the average selected facility than in the nearest facility. This correlation can be explained by the fact that stockouts are most likely to occur at the most popular facilities, which is precisely why the multivariate analysis that is conducted in the following section is necessary.

[Insert Tables 2 & 3 Here]

We observe limited data on healthcare prices. Given the nature of the survey, facilities are asked to report a range of prices for each type of contraceptive method sold. We see that these prices are highly correlated with facility service capacity and ownership type - low-capacity, private facilities and pharmacies are consistently more expensive. Consultation prices are not observed, but are likely to be similarly correlated with facility capacity and ownership type. Because our models specify a facility choice, rather than a choice of method, we do not control for any price measure in our models. As such, preferences for these correlated facility characteristics should be interpreted as capturing information about consumer price sensitivity.

IV.   Results

In this section, we present preference parameter estimates from a series of econometric models. We begin by estimating both weighted and unweighted conditional logit models (i.e., no random coefficients), which clarifies how weighting impacts the preference parameters. We then estimate our preferred model, the mixed logit, which relaxes the IIA assumption implicit in the conditional logit model, both with and without interactions. We then compare the preference parameter estimates produced

by data measured with and without error. The section closes with a discussion of the distance-quality

preference tradeoff implied by the various estimated models and two policy experiments.

IV.a   Unweighted vs. Weighted Conditional Logit Model.

In Table 4, we present estimates from both unweighted (columns 1 and 4) and weighted (columns

2 and 5) versions of a conditional logit model, which includes only facility characteristics as preference

shifters. Recall that the weighted model requires the estimation of a (first-stage) selection equation.

Selection is modeled as a function of demographic characteristics (e.g., age, income, education, religion,

etc.), survey responses thought to explain the likelihood that a woman would seek maternal health (e.g.,

currently pregnant, gave birth within past 2.5 years, number of children, etc.) or family planning (e.g., is

capable of getting pregnant, want's more children, partner wants more children, etc.) services, average

facility characteristics within a one kilometer radius of the woman's home, and a large set of interactions.

The results of this first-stage, and a list of specific controls used, are in Table A1 in the appendix.[9] As

explained in Section III, estimates from the unweighted model are consistent only if selection is ignorable

conditional on facility attributes, while consistency of the weighted model requires a weaker condition –

that selection is ignorable conditional on facility attributes and other controls. A test of the null hypothesis

that the weighted and unweighted coefficient estimates are the same is complicated by the fact that the

estimated coefficients are only identified to scale.[10]   Therefore, our testing strategy used 5,000 bootstrap

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[9] Two comments on the weighted estimator: First, the asymptotic variance of the weighted estimator is decreasing in the number of control variables in the selection equation. Thus, Wooldridge (2000) recommends a "kitchen sink" approach, where the selection equation (Equation 3) is saturated with any controls thought potentially relevant to selection, along with interactions and polynomials of the control variables. We have taken this approach, which explains our large set of control variables in Table A1. Second, Wooldridge (2002) proves that the asymptotic variance of the weighted estimator is smaller when inverse probability weights are formed using estimated selection probabilities (i.e., using estimated $\hat{\delta}$ from Equation 3) than when using known selection probabilities (i.e., using the true δ from Equation 3). As a result, when one corrects the standard errors of the second stage estimates of the weighted model to account for the error introduced by estimation in the first stage, the standard errors actually get *smaller*. Therefore, we chose not to correct the standard errors of weighted estimates in order to provide the most conservative (largest) standard errors possible.

[10] The preference parameters discussed throughout the results section are estimated using several classes of multinomial choice models. In general, identifying these models required that the variance of the error term, ω_{ij}, be normalized by the econometrician. Throughout, we will assume that ω_{ij} is distributed Type 1 Extreme Value, which naturally imposes the assumption that $V(\omega_{ij}) = \pi^2/6$. Given this assumption, estimated preference parameters

samples to construct an estimate for the joint covariance matrix of a set of ratios formed by dividing each

of the estimated coefficients by the estimated coefficient for distance – a highly significant variable in

both models. For the family planning model, the resulting test statistic is 17.23 which, under the null

hypothesis is chi squared with 19 degrees of freedom (p=0.57). For maternal health, the test statistic is

10.92 which is chi squared with 16 degrees of freedom (p=0.81).[11]

[Insert Table 4 Here]

These results fail to uncover a significant difference in the estimates produced by the weighted

and unweighted models, suggesting that selection into the set of individuals who actually visit a facility is

not endogenous. As a result, our remaining results focus on unweighted estimators for both maternal

health and family planning models.[12]

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should be interpreted as $\hat{\beta} = (\beta/\sigma) * \sqrt{(\pi^2/6)}$, where σ, the true variance of ω_{ij}, is unknown. For this reason, it is often said that these models are identified *up to scale*. See Train (2009, Section 2.5.2) for more details.

[11] One variable, *participate*, had to be dropped from the maternal health model. Only 3% of selected facilities failed to participate in the survey; thus, a lack of variation in caused instability in some of the bootstrap samples.

[12] In our main specification, facilities from the regions of Dakar (which contains the cities of Dakar, Guédiawaye, Pikine, and Mbao), Mbour, and Kaolack are included in every individual's choice set, regardless of which region the individual resides in. This methodology assumes implicitly that individuals know of all facilities within the three regions and select a facility optimally based on the facility's characteristics and distance from the individual's home. This assumption may be questionable, as Dakar is roughly 69 km from Mbour and 178 km from Kaolack, while Mbour is 109 km from Kaolack. If our assumption is incorrect, then parameters, particularly those on distance, will reflect some likelihood that individuals know about the facility, as well as their preference for the facility characteristic. We test the validity of this assumption by estimating two additional conditional logit models. In the first, we leave the choice sets intact, but drop the 29 individuals in the maternal care model and 13 individuals in the family planning model that are observed to leave their home region for care. Shown in columns 2 and 5 of Appendix Table A2, these models reflect a greater distaste for travel than the preferred model, which makes sense, given that long-distance travelers have been dropped; however, using a chi-squared test for a difference in the ratio of parameters in this model and our preferred model, we are unable to reject the null hypothesis that the two sets of parameter estimates are the same. In the second additional model, we again limit the sample to individuals staying within their own region, but also restrict each individual's choice set to the facilities of the region they reside in. Results from this specification are presented in columns 3 and 6 of Appendix Table A2 and are *indistinguishable* from the results of the first additional model. Therefore, these tests show that the inclusion of very distant alternatives in an individual's choice set have no bearing on the estimated parameters; however, including individuals in the analysis that travel very long distances for care has a small, statistically insignificant impact on estimated preference parameters. Given these results, the rest of our analysis includes all individuals and allows choices from the full set of observable facilities.

IV.b   Preferred Mixed Logit Model

In our preferred model, the mixed logit (ML) model (Equation 2 above), we assume that the distribution of taste parameters in the population can be represented as $\beta_i \sim N(\beta, \Sigma)$, where β is a vector containing the mean of each parameter and Σ is a covariance matrix that captures the population variance in these parameters (i.e., on-diagonal elements) as well as correlation between preferences for particular facility characteristics (i.e., off-diagonal elements). We estimate β, which is displayed in Panel A of Table 5, and Σ, the main diagonal of which can be found in Panel B of Table 5.[13] In addition to the standard conditional logit (CL) model displayed in Table 4, which restricts $\Sigma = 0$, we also estimated a version of the mixed logit model that restricts Σ to be a diagonal matrix, which allows the preference parameters to be random but uncorrelated. Both versions of the mixed logit model (Σ unrestricted and Σ restricted to being a diagonal matrix) relax the independence of irrelevant alternatives feature of standard conditional logit. Since the three models are nested, we performed likelihood ratio tests of the null hypotheses to determine if Σ could be restricted to zero or to a diagonal matrix. For both maternal health and family planning models, both null hypotheses were strongly rejected with p-values of essentially zero; thus, the unrestricted model is preferred.[14]

One issue with the likelihood ratio specification test described above is that the asymptotic distribution of the test statistic is dependent on the distributional assumption of β_i. In other words, the validity of the tests hinges on our assumption that $\beta_i \sim N(\beta, \Sigma)$ is correct, which is not desirable as we are unable to test this distributional assumption. McFadden and Train (2000) propose another test of whether mixing is necessary that relies only on the estimation of the CL model. The test is conducted using the following steps: First, we estimate the CL model to obtain preference parameters (i.e., the parameters found in columns 1 and 4 of Table 4). Second, we construct the following artificial variables,

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[13] The full covariance matrix is estimated and available upon request, but is not included because of its size (18 x 18 in the maternal health model and 20 x 20 in the family planning model).
[14] Estimates from the restricted mixed logit models are not reported, but are available upon request.

$$w_{ij} = \frac{1}{2}\left(X_{ij} - \tilde{X}_{iJ}\right)^2 \text{ with } \tilde{X}_{iJ} = \sum_{k\in J} X_{ik}\hat{P}_{ik}$$

where $\hat{P}_{ik}$ is the predicted probability that individual i selects alternative k using the preference

parameters from the first step. Third, we re-estimate the CL model with the artificial variables, w_{ij},

included and conduct a likelihood ratio test for the null hypothesis that the two models are the same. For

both maternal health and family planning models, we reject the null at the 0.001 level of significance,

again confirming the superiority of the mixed logit model.

Results from the unrestricted mixed logit models are found in Table 5. In both the maternal health

and family planning models, the (Panel A) estimates support the notion that women prefer high quality

health facilities. For maternal health, preferences for the following facility characteristics are positive and

significantly different from zero at the population mean: open every day of the week, any health social

worker, number of services offered, any IEC materials, any programs that share health information with

the community, electricity, piped water, a telephone, and private rooms. Women have negative

preferences for private facilities and low-capacity facilities in both models. For the family planning

model, preferences for the following facility characteristics are positive and significantly different than

zero at the population mean: facility age, hours a day that the facility is open, total number of FP methods

available, any FP protocol, number of midwives, number of services offered, any IEC materials, any

programs that share health information with the community, electricity, and a telephone. We also find

negative (and significant in the family planning model) preferences for the number of doctors at a facility

in both models, which seems counter-intuitive as doctors are generally thought to provide a higher quality

of service than nurses and midwives. There are several possible explanations; this finding could reflect a

negative preference for male practitioners (doctors are more likely to be men) by women seeking family

planning care or could reflect positive correlation between the doctors, prices, and waiting times, the latter

two of which are unobserved.

Mean preferences for distance are significant and negative in both the maternal health and family

planning models. Because the preference parameters from Panel A are identified only up to scale, we

calculate an elasticity of demand for distance for both models, which is independent of scale. For the maternal health model, we find that a 10% increase (decrease) in the distance one must travel to reach a particular facility decreases (increases) the probability of selecting that facility by about 20% (26%). These estimates are near, though slightly larger than, the distance elasticities reported by Luft et al. (1990) – a 12-14% increase in hospital admissions given a 10% decrease in distance.[15] That said, Luft et al.'s estimates reflect the preferences of hospital patients in San Francisco, meaning (among other possibilities) the difference in transportation networks between San Francisco and urban Senegal could explain our larger distance elasticities. From the developing country literature, our distance elasticity estimates are similar in magnitude to those reported by Dor et al. (1987) for low-income Cote d'Ivorians traveling over an hour for care; elasticities between -0.87 and -2.26. Interestingly, we find for the family planning model that a 10% increase (decrease) in the distance one must travel to reach a particular facility decreases (increases) the probability of selecting that facility by only 1% (1.2%). The smaller elasticity is somewhat surprising, given that the number of facilities offering family planning services is more than three times the number offering maternal health services. That said, the finding is consistent with fact that we observe a much higher bypass rate for family planning services than maternal health services. Moreover, these elasticities are close in magnitude to the distance elasticities reported by Mwabu et al. (1993) and by Erylana et al. (2011), the latter of which provides estimates from both urban and rural areas of Indonesia. As noted above, the estimates from these papers are biased by measurement error, which may partially explain the differences across the studies.

Panel B of Table 5 reveals wide variance in preferences for distance and a number of facility features in both the maternal health and family planning models. This heterogeneity could explain why the CL and ML models estimate seemingly opposite preference parameters for some facility features. For

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[15] Our method for calculating these elasticities is similar to Luft et al. (1990), who also estimate a mixed logit model. First, we randomly select a facility for each individual. Second, we predict the probability of selecting this facility assuming that the distance that one must travel is equal to the average travel distance observed in the data (i.e., 0.41 km). For this prediction, we integrate over the estimated parameter covariance matrix using the stata package *mixlpred* with 400 draws. Third, we predict the probability of selecting this facility assuming that the distance traveled is 10% longer (shorter) and calculate the elasticity.

example, the family planning model reveals wide variance in the preferences for pharmacies, any stockouts, and participating facilities. The CL model estimated preferences for these facility features are significant and of the opposite sign of the mean preference estimates from the mixed logit model.

[Insert Table 5 Here]

Recall that the off-diagonal elements of the covariance matrix, Σ, describe how preferences for one facility feature relate to preferences for another. Appendix Table A3 contains the parameters from the first row of Σ, which describe the relationship between preferences for distance, our only explicit measure of the cost of visiting a facility, and other facility features. Note that for both maternal health and family planning models, of the covariance parameters describing the relationship between distance and quality (i.e., in Table A3, characteristics between open 7 days a week and has private room) preferences, only positive parameters are significant at the 5% level.[16] Because preferences for distance are negative and preferences for quality are generally positive, the consistently positive relationship between distance and quality preferences suggests that individuals with below mean preferences for distance (i.e., distance is less important for them) have strong preferences for quality.[17] The reverse is also true – individuals that care a lot about distance worry less about quality.

IV.c   Preferred Model with Interactions

We expand our preferred mixed logit model to include interactions between facility characteristics and a woman's education, measured in years completed. The objective of this analysis is to determine which characteristics of a health facility are most attractive to the least educated women, as uneducated women are significantly less likely to visit a health facility for each type of service. Our

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[16] For the maternal health model, this includes open 7 days a week, number of doctors, has telephone, and has private room. For the family planning model, this includes open 7 days a week, any stockouts, any family planning protocol, number of services offered, and has telephone.

[17] This interpretation is not appropriate for number of doctors in the maternal health model and any stockouts in the family planning model, as mean preferences for these facility features are negative, though statistically insignificant.

findings are presented in Table 6.[18] For maternal health services, preferences for travel, private facilities, low-capacity facilities, longer hours, electricity, and telephone services are significantly lower for women with less education. Preferences for being open every day of the week and number of services offered are significantly higher for women with less education. Similar results are found for family planning services, though fewer of the education interaction effects are significantly different from zero.

Taken together, these results suggest that travel distance in an urban environment is a greater barrier to health facility access (for maternal care) for less educated women than for more educated women. Moreover, less educated women are most attracted to public, high-capacity facilities that are open every day of the week and offer a large number of services.

[Insert Table 6 Here]

IV.d   Facility Choices with Measurement Error

Existing research on the determinants of health facility choice in developing countries is hampered by data limitations. Many researchers analyze Demographic and Health Survey (DHS) data, which rarely report the exact facilities that a woman visits for care; rather, these data report the type of facilities that she visits (e.g., public or private hospital, health center or dispensary; or traditional healer). A popular solution to this problem is to (1) define a woman's facility alternative set by the facilities of each type that are nearest her home and (2) match her to the nearest reported type (Akin et al. 1986; Dor et al. 1987; Mwabu et al., 1993; Leonard et al., 2003; Mariko, 2003; Habtom, 2007; Erlyana et al. 2011). This strategy creates measurement error in both the alternative set and choice outcome, potentially biasing preference parameters in a direction that is ex-ante unknown. The strategy essentially eliminates the possibility that a woman travels a long distance to receive care, which may lead to an overestimation of preferences against travel; however, the strategy also removes many far off unselected facilities from the alternative set, which could lead to an underestimation of preferences against travel. Moreover, the

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[18] We only present estimates of means of the parameter distribution here. The new covariance matrix estimates are available upon request.

strategy reduces variability in the distance variable, which (by analogy to the linear model) leads to larger standard errors on the distance preference parameter, all else equal, making it more difficult to obtain significant effects.

Not only are our individual-facility matched data free of this measurement error, but our data can be manipulated to reflect the measurement error that other researchers face in order to determine the resulting bias in preference parameter estimates. To create the measurement error typically observed in the literature, we limit our sample in several ways. First, we define four facility types: high-capacity public, low-capacity public, high-capacity private, and low-capacity private. We include a fifth type, pharmacy, for the family planning choice model. Second, we limit every woman's alternative set to the 4 (or 5) facilities of each type that is nearest her home. Third, we match each woman to the nearest facility matching the *type* of facility that she actually visits, rather than the actual facility, which is generally no longer in her alternative set. Finally, we estimate a conditional logit model for both maternal health and family planning decisions and compare the results to the model without measurement error. Note that we chose to compare conditional logit, rather than mixed logit, results both for simplicity and because only one paper in the existing literature estimates a mixed logit model (Borah, 2006).

The maternal health results (unweighted, with measurement error) can be found in column 3 of Table 4; the family planning results can be found in column 6 of the same table. These results should be compared to the original unweighted, conditional logit results (measured without error), which can be found in columns 1 and 4, respectively. Note that since the competing models may be scaled differently (see footnote 9), the magnitudes of the parameters from these models cannot be compared without a formal statistical test. That said, we can compare the *signs* of preference parameters in the competing models, as well as whether or not the parameters differ significantly from zero. These comparisons reveal a number of differences. For example, the maternal health model estimated on data measured without error (column 1) reveals negative preferences for low-capacity facilities, while the model estimated on data measured with error (column 3) incorrectly suggests that women have positive preferences for low-capacity facilities. Moreover, there are several other instances of parameter sign differences between

these two models (e.g., health social worker, community outreach, piped water, private rooms, and facility participation) but the preference parameters are not significantly different from zero in one or both models. For the family planning models estimated with and without error, the signs on low-capacity facilities are again opposite and each is significantly different from zero; moreover, a total of eight other parameters differ in sign, but one or both are not significantly different from zero.

To formally test the competing models for significant differences in the estimated preference parameters we follow the same strategy that we used to test for differences in the conditional logit models with and without selection corrections. We simultaneously estimate the models with and without measurement error in order to generate a joint covariance matrix based on 5,000 bootstrap replications. We then form the ratios of all coefficients to the distance coefficients in the two models and conduct a Wald test that compares the ratios of parameters across models. For the maternal health model the test statistic is 32.4 with 16 degrees of freedom and for family planning the test statistic is 74.8 with 19 degrees of freedom. Thus, in both cases, we strongly reject the null hypothesis that the vector of ratios is the same, making it is clear that the model with measurement error yields misleading results.

IV.e   Willingness to Trade Distance for Quality

We have established above that (i) the ML model generates significantly different results than the CL model and (ii) the CL model without measurement error generates significantly different results than the CL model with measurement error. In our analysis of both (i) and (ii) we identified parameters that changed sign and significance as we moved from the less preferred to the preferred model. We did not discuss how the magnitude of preference parameters changed from one model to the next because each model is only identified up to scale, so parameter magnitudes cannot be directly compared across models. However, by forming ratios of preference parameters one can eliminate the unobserved scaling factor, allowing for differences in (relative) parameter magnitudes to be analyzed. We conduct this analysis here.

Given that distance is our only facility characteristic that measures an explicit cost of visiting a facility, it makes sense to form ratios with the (absolute value of the) distance parameter as the base.

Table 7 contains these ratios for each model and a select set of quality measures.[19] Table elements can be interpreted as the additional distance (in kilometers) that the average individual would be willing to travel to gain one additional unit of quality.[20] Note that the last three columns of the table calculate the distance-quality tradeoff for the ML model at different points in the distance taste distribution.

Five overarching conclusions can be drawn from these results. First, across all models, electricity is found to be a facility feature that women place great value on. Second, among the first three columns, the CL model (column 1) generally suggests that individuals are most willing to trade distance in favor of greater quality.[21] Maintaining our view that the ML model is most preferred, this suggests that the CL model underestimates individuals' distaste for travel. Third, among the first three columns, the CL model with measurement error (column 2) generally suggests that individuals are least willing to trade distance in favor of greater quality.[22] This suggests that the CL model with measurement error, which is widely used in the literature, overestimates an individual's distaste for travel, a finding that is consistent with the narrative provided in Section IV.d. Compared to the ML model (column 3), the CL model with measurement error overestimates distaste for travel, relative to quality, by a minimum factor of roughly 1.5 (*any IEC materials* in the maternal health model) and a maximum factor of roughly 10 (*has electricity* in both maternal health and family planning models). Fourth, by comparing columns 4 and 5, we get a sense of how much variation there is in the willingness to trade between distance and quality due to the wide variation in preferences for travel. According to our results, individuals in the 75th percentile of preferences for travel (i.e., those who like travel least) are willing to trade distance for quality at roughly half the rate as those in the 25th percentile of preference for travel. Fifth, comparing columns 5 and 2 highlights just how much the CL model with measurement error overestimates distaste for travel – the

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[19] The quality metrics included in Table 7 had to meet two criteria. First, the respective quality preference parameters must be significantly different from zero in at least two of the three models that were estimated. Second, quality preference parameters must be of the same sign in the three models.

[20] For binary quality variables, such as *open 7 days a week*, the interpretation is the additional distance that the average individual would be willing to travel for a facility with the particular feature.

[21] There are three exceptions to this claim, all found in the family planning model: any IEC materials, has electricity, and has telephone.

[22] *Any IEC materials* in the family planning model is the lone exception to this claim.

average individual in the CL model with measurement error is found to dislike travel *even more* than an individual at the 75th percentile of preferences for travel in the ML model.

[Insert Table 7 here]

IV.f   Policy Experiment

We conduct two policy experiments using the parameter estimates from our preferred mixed logit model and the measurement error model. For simplicity, we focus only on the choice of a provider for maternal health care. The first policy that we examine was enacted in 2014 in Dakar, Senegal after our data was collected – a new public facility was added along the eastern coastline of the city. The new facility, which is marked by a star in Figure 1, is located in an area that was previously underserved. Data on this facility was collected in the third round of our survey data, which was conducted in 2015; thus, facility characteristics are perfectly observable. The facility is public, low capacity, is open 24/7, and has all modern amenities. We use both our preferred mixed logit model and the conditional logit (with measurement error) model estimates to simulate how many women will visit this new facility. Given that (i) our results from Section IV.e suggest that the measurement error model over-emphasizes patient distaste for distance relative to preferences for quality and (ii) the new facility reduces the distance that some women must travel for care, we hypothesize than the measurement error model will predict that *more* women will visit the new facility than the preferred model.[23]

The second policy is hypothetical – we consider providing electricity to the 6 participating health facilities in Dakar (5 public and 1 private) that report not having electricity at the time of the survey. As public health officials are generally resource constrained, this hypothetical policy (i.e., improving the quality of existing health facilities) can be thought of as a realistic alternative to the first policy (i.e., adding a new facility), which was actually implemented. Figure 1 shows that the facilities without

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[23] Whether the measurement error model or preferred model predicts that more women visit the new facility is an empirical question that cannot be answered by simply studying at the estimated preference parameters of the two models. The relative quality of nearby facilities, as well as the distance between the new facility and nearby facilities, impacts our findings. A similar statement can be made regarding our second policy experiment.

electricity (marked by a red triangle) are spread across Dakar. We use both our preferred model and the

measurement error model estimates to predict how acquiring electricity affects the use of these facilities.

Given that (i) our results from Section IV.e suggest that the measurement error model over-emphasizes

patient distaste for distance relative to preferences for quality and (ii) the policy improves facility quality

for some facilities, but does not reduce the distance that any women must travel for care, we hypothesize

than the measurement error model will predict a smaller increase in use among the improved facilities

than the preferred model.

Policy experiment results are reported in Table 8.[24] For both experiments, we find support for our

hypothesis. For the first experiment, our preferred mixed logit model predicts that an average of 0.2

individuals (of a total of 946 individuals) visit the new facility for maternal health care, which is less than

the 3.44 individuals predicted by the measurement error model estimates; the difference is statistically

different from zero. For the second experiment, our preferred mixed logit model predicts a 460%

(average) increase in the use of the improved facilities for maternal health care, which is greater than the

63% increase predicted by the measurement error model estimates; again, the difference is statistically

different from zero.

These results highlight a potential consequence of bias in preference parameter estimates due to

measurement error. Using data on a facility that was opened in Dakar after our study data were collected,

and a hypothetical policy alternative, we show how the bias in preference parameters can lead to biased

policy simulations. In this setting, we find that the measurement error model estimates would lead policy

makers to overestimate the popularity of a new health facility and underestimate the popularity of

improving existing facilities. This finding, that preference estimates which are biased toward a strong

distaste for travel relative to preference for quality will lead policy makers to favor new facilities over

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[24] Choices are simulated for the 946 individuals living in Dakar that select a facility in our data. For the
measurement error model, we take 500 simulation draws from a type one extreme value distribution for each
individual-facility pair in Dakar. The facility generating the most indirect utility determines an individual's choice in
each simulation round. The procedure for the mixed logit model is the same, though each simulation round also
involves a draw from the parameter covariance matrix. Standard errors are calculated conditional on estimated
parameters.

improving existing ones, should be true generally, but only for facilities that reduce travel costs for some women.[25] The finding is important because policy-makers concerned with acquiring political capital already have an incentive to construct new buildings, which generally come at a high financial cost.

V.   Discussion

We estimate facility choice models for maternal health and family planning services for women living in urban Senegal. Compared to other research on health facility choice in developing countries, our research is unique in (i) its focus on women living in urban environments and (ii) our ability to match women to the health facility that they actually visit. We report two main findings from our preferred mixed logit model. First, we find that women dislike traveling long distances for medical care and that they prefer higher quality facilities. Among the many facility characteristics that women value, we consistently find strong preferences for facilities that offer a larger number of services, provide Information, Education, and Communication (IEC) materials, run community outreach programs, have electricity, and have a telephone. Moreover, our results suggest that women who are least sensitive to traveling long distances for medical care also value quality the most, and vice-a-versa. Second, we provide evidence that a particular type of measurement error that is frequently present in the literature leads to biased preference parameter estimates. In our setting, this measurement error leads to a significant overestimation of consumer distaste for travel, relative to preferences for facility quality. Using a policy experiment that compares the effectiveness of a new health facility vs. improved existing facilities, we provide an important example of consequences that can result from bias in preference parameter estimates.

Like all empirical work, this study is not without limitations. Most notably, our models of demand abstract from potential general equilibrium effects (i.e., facility characteristics are partially

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[25] A total of six new public health facilities were added in Dakar between 2011 and 2015. We conducted the simulation described above for each, individually. The measurement error model predicted that a larger number of patients would visit the new facility than the mixed logit model for each of the six new facilities.

determined by market forces, such as consumer demand). It is also possible that quality characteristics that are unobserved to the econometrician, such as client-provider interaction details and prices for particular medical procedures, are correlated with characteristics that we observe. Both of these concerns could be mitigated with an experimental design that randomly altered the characteristics of some facilities, but not others. Finding willing (facility) participants for such an experiment would be incredibly difficult, which likely explains why such random variation is rarely used for identification in this literature. That said, both our work and existing work could be improved by such a research design.

This paper contributes to a large literature on facility choice in developing countries, most notably, by quantifying the bias in preference parameter estimates due to measurement error. The paper also contributes to a large literature on facility choice in *developed* countries, despite the fact that our population of study resides elsewhere. Compared to the developing country research referenced above, the developed country literature features quality metrics that are objective and well defined, such as facility-procedure specific mortality rates (Luft et al., 1990; Burns and Wholey, 1992; Hodgkin, 1996; Mukamel et al., 2004; Dranove and Sfekas, 2008), birth rates (Bundorf et al., 2009); remission rates (Varkevisser et al., 2012); and overall quality indexes (Santos et al., 2015). Moreover, much of the literature focuses not only on whether people respond to quality, but whether publicized report cards have an additional marginal impact on patient choice (Mukamel et al., 2004; Dranove and Sfekas, 2008; Bundorf et al., 2009; Werner et al., 2012). This literature finds, quite consistently, that patients respond to facility quality, with or without report cards (Kolstad and Chernew, 2009); however, in nearly all instances studied, primary care physicians are likely to play a role in referring patients to facilities.[26] Given the medical expertise and professional network of referring physicians, it is not terribly surprising that these choice models reveal a preference for quality, even in the absence of publicly available report cards.

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[26] Santos et al. (2015) is an exception, as these authors model the choice of family doctors in England.

While there are many economic and cultural differences between the choice environments studied in this paper and those studied in developed countries, this paper contributes to the larger facility choice literature in two important ways. First, given our focus on maternal health and family planning services, it is likely that the preferences revealed by our choice model reflect those of patients and not referring physicians. Second, because we measure preferences for facility characteristics that proxy for quality, rather than developing an index of quality, our findings shed light on which characteristics patients value most and, therefore, should be useful in the future construction of quality indexes.

Facility choice research focused in developed countries also tends to extract choice information from a different type of data - namely, administrative discharge data (e.g., Luft et al., 1990; Burns and Wholey, 1992; Hodgkin, 1996; Chernew et al., 1998; Mukamel et al., 2004; Dranove and Sfekas, 2008) - than research focused in developing countries - namely, survey data. A clear advantage of discharge data is that the issue of patient-facility mismatch discussed above is avoided; however, a disadvantage is that researchers only observe individuals who choose to visit a facility. Thus, the estimation sample is non-randomly selected and could produce biased parameter estimates if individuals not visiting a facility have preferences that differ from individuals visiting a facility. Our use of survey data, which contains information on women who choose not to visit a facility, enables us to control for this sample selection problem. Moreover, we believe that our selection-on-observables strategy is particularly appropriate in our setting, which features selection into a large alternative set, and should be employed more often in similar situations. Unfortunately, absent additional information on the composition of the population that chooses not to visit a facility, researchers that choose to use discharge data to estimate choice models cannot use this technique. That said, our results reveal minimal endogenous selection into the sample in our particular setting, providing some evidence that sample selection issues in similar settings are of minor concern.

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Figures

Figure 1: Dakar, Senegal
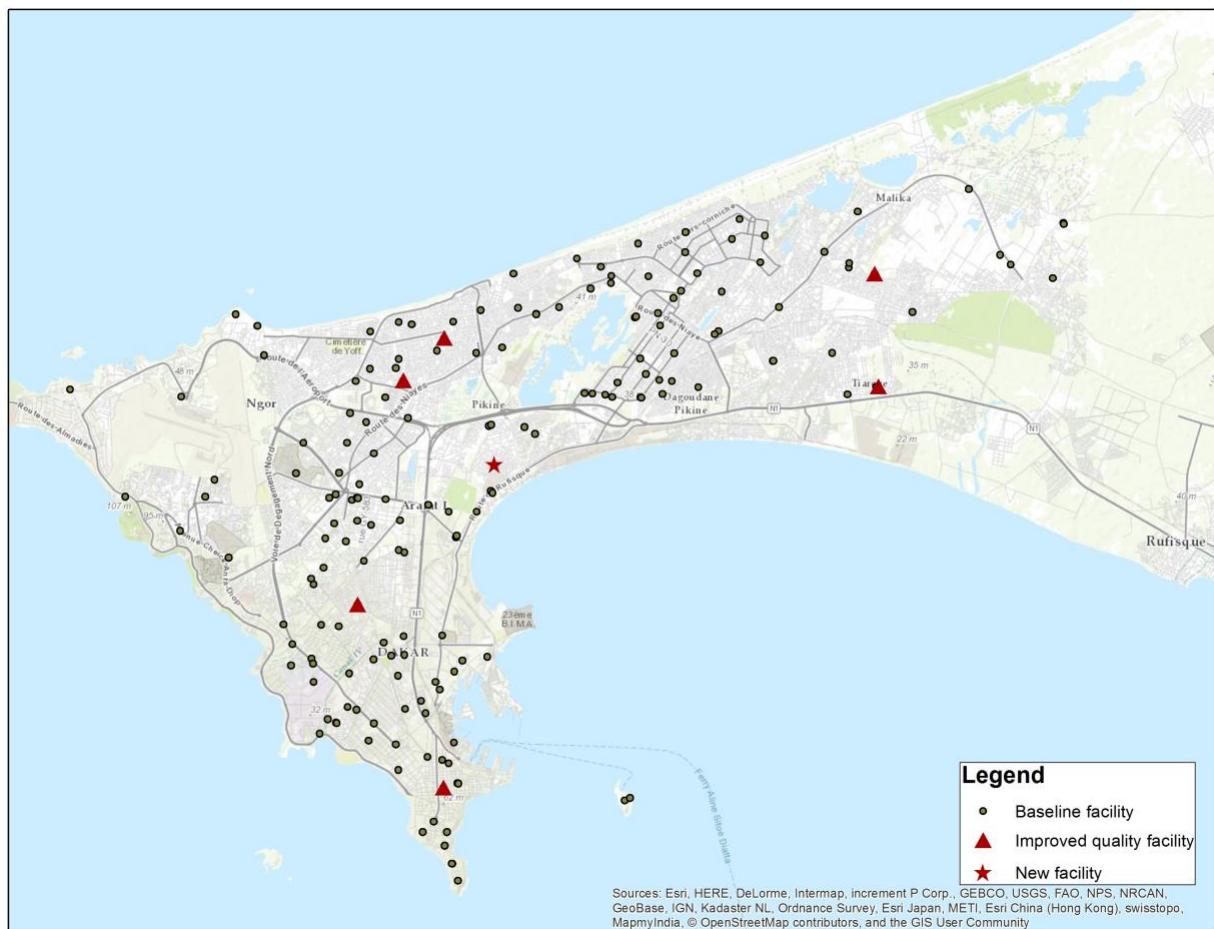
Table 1: Facility choices by service type

	Maternal Care	Family Planning
Observations	9,325	9,325
no visit	7,034	7,941
visit unobserved facility	461	311
visit observed facility	1,830	1,073
Among women visiting an observed facility		
% visiting facility nearest home	25.7	11.6
% visiting nearest facility of a particular type	35.4	36.5
Mean # facilities bypassed	17.0	52.5
Median # facilities bypassed	4.0	13.0

Table 2: Facility Characteristics, Maternal Health Choice

	All Facilities	Chosen Facility	Nearest Facility
distance	62.92	4.10	0.46
private	0.26	0.10	0.15
low capacity	0.75	0.57	0.63
age	22.70	26.87	21.26
open 7 days a week	0.51	0.71	0.55
hours a day	14.77	18.29	14.92
any IEC materials	0.61	0.81	0.75
# doctors	1.98	3.60	0.74
# nurses	3.29	5.30	2.36
# midwives	2.53	4.63	2.04
any health social worker	0.19	0.32	0.14
# services offered	14.21	17.66	15.77
provides community outreach	0.52	0.75	0.67
has electricity	0.85	0.95	0.92
has piped water	0.88	0.97	0.96
has telephone	0.72	0.78	0.70
has private rooms	0.77	0.93	0.85
participating	0.89	0.97	0.96
observations	231	1,830	1,830

*Notes: Distance to any particular facility varies by individual, so the average distance is calculated using all 9325*231 observations. Moreover, while distance and facility type are observable for all 231 health facilities, the remaining variables are only observable for facilities participating in the survey – 205 health facilities.

Table 3: Facility and Pharmacy Characteristics, Family Planning Choice

	All Facilities	Chosen Facility	Nearest Facility
distance	60.71	3.00	0.27
private	0.08	0.04	0.03
low capacity	0.75	0.53	0.62
pharmacy	0.70	0.12	0.77
age	14.52	26.14	11.95
open 7 days a week	0.34	0.60	0.31
hours a day	14.33	17.40	14.64
any stockouts last month	0.17	0.40	0.21
# FP methods available	4.26	5.54	4.53
any FP protocol	0.56	0.83	0.77
# doctors	1.98	2.43	0.52
# nurses	3.29	5.35	2.14
# midwives	2.53	4.62	2.31
any health social worker	0.19	0.35	0.07
# services offered	14.21	17.38	16.47
any IEC materials	0.25	0.75	0.24
provides community outreach	0.52	0.80	0.68
has electricity	0.85	0.94	0.97
has telephone	0.72	0.73	0.64
participate	0.95	0.97	0.98
observations	764	1073	1073

*Notes: (1) Distance to any particular facility varies by individual, so the average distance is calculated using all 9325*764 observations. (2) The variables any FP protocol – phone are not measured for pharmacies; thus, pharmacies do not contribute to the averages provided in the table for these variables. (3) While distance and facility type is observable for all 231 health facilities and 533 pharmacies, the remaining variables are only observable for facilities participating in the survey – 205 health facilities and 518 pharmacies.

Table 4: Conditional Logit Model Estimates

	Maternal Health Facility Choice						Family Planning Care Facility Choice					
	(1) Unweighted, Cond. Logit		(2) Weighted, Cond. Logit		(3) Unweighted, Meas. Error		(4) Unweighted, Cond. Logit		(5) Weighted, Cond. Logit		(6) Unweighted, Meas. Error	
Covariates	Params	P-value	Params	P-value	Params	P-value	Params	P-value	Params	P-value	Params	P-value
distance (km/10)	-1.514	0.000	-1.145	0.001	-11.310	0.000	-3.064	0.000	-3.319	0.000	-10.881	0.000
private	-0.505	0.000	-0.276	0.107	-0.975	0.000	-0.690	0.000	-0.882	0.032	-1.690	0.000
low volume	-0.480	0.000	-0.424	0.000	0.335	0.000	-0.358	0.000	0.007	0.979	0.179	0.095
pharmacy	*	*	*	*	*	*	-1.755	0.000	-0.951	0.353	-0.252	0.510
age	0.011	0.000	0.011	0.000	0.000	0.895	0.012	0.000	0.014	0.007	-0.003	0.429
open 7 days a week	0.396	0.000	0.417	0.009	0.326	0.003	-0.068	0.616	0.023	0.935	0.221	0.089
hours a day	-0.011	0.083	-0.012	0.240	-0.022	0.002	0.023	0.011	0.054	0.016	-0.004	0.674
any stockouts last month	*	*	*	*	*	*	0.258	0.004	0.334	0.036	-0.177	0.158
# FP methods available	*	*	*	*	*	*	0.118	0.000	0.178	0.100	0.076	0.008
any FP protocol	*	*	*	*	*	*	0.226	0.049	0.478	0.059	0.201	0.134
# doctors	0.015	0.000	0.008	0.175	0.056	0.084	-0.022	0.367	-0.063	0.329	0.014	0.751
# nurses	-0.004	0.399	-0.004	0.550	-0.004	0.777	-0.002	0.757	-0.003	0.725	0.005	0.774
# midwives	0.032	0.000	0.045	0.000	0.004	0.857	0.052	0.000	0.022	0.467	0.049	0.124
any health social worker	0.315	0.000	0.465	0.000	-0.014	0.918	0.600	0.000	1.562	0.009	-0.082	0.626
# services offered	0.054	0.000	0.048	0.034	0.082	0.000	-0.019	0.235	-0.043	0.124	-0.015	0.425
any IEC materials	0.178	0.024	0.258	0.030	0.932	0.000	0.164	0.110	0.422	0.010	0.777	0.000
provides community outreach	0.425	0.000	0.242	0.031	-0.130	0.184	0.458	0.000	0.321	0.196	-0.173	0.182
has electricity	1.044	0.000	0.616	0.021	0.511	0.002	0.325	0.068	0.489	0.075	0.625	0.005
has piped water	0.347	0.495	0.764	0.199	-1.863	0.004	*	*	*	*	*	*
has telephone	0.443	0.000	0.389	0.001	0.477	0.000	0.125	0.189	0.357	0.218	0.390	0.000
has private rooms	0.657	0.000	0.045	0.854	-0.166	0.253	*	*	*	*	*	*
participate	-3.490	0.000	-2.756	0.001	0.072	0.926	-1.669	0.000	-3.467	0.035	-0.650	0.120
Number of individuals	1,830		1,830		1,830		1,073		1,073		1,073	
Number of observations	422,730		422,730		7,320		819,772		819,772		5,365	
LLF	-6,911.37		-31,843.19		-1,469.32		-4,319.16		-31,156.24		-6,893.27	

*Notes: The number of individuals in each model measures individuals making a facility choice. For the weighted models, 9,325 individuals decide whether to visit no facility, an unobserved facility, or an observed facility in the first stage.

Table 5: Mixed Logit Model Estimates

Covariates	Maternal Health Facility Choice		Family Planning Facility Choice	
	Params	P-value	Params	P-value
Panel A: Mean Coefficient Estimates				
distance (km/10)	-12.392	0.000	-17.070	0.000
private	-1.562	0.050	-1.618	0.000
low volume	-0.358	0.013	-0.192	0.496
pharmacy	*	*	0.196	0.895
age	0.003	0.330	0.022	0.000
open 7 days a week	0.863	0.001	-0.140	0.583
hours a day	-0.011	0.385	0.400	0.042
any stockouts last month	*	*	-0.300	0.560
# FP methods available	*	*	0.324	0.000
any FP protocol	*	*	0.685	0.025
# doctors	-0.028	0.139	-0.248	0.000
# nurses	0.017	0.107	-0.021	0.295
# midwives	0.032	0.152	0.224	0.000
any health social worker	0.470	0.020	0.412	0.169
# services offered	0.161	0.000	0.099	0.012
any IEC materials	1.455	0.000	0.650	0.033
provides community outreach	0.637	0.000	2.530	0.000
has electricity	5.193	0.022	9.515	0.000
has piped water	8.785	0.006	*	*
has telephone	2.587	0.000	2.236	0.003
has private rooms	3.550	0.000	*	*
participate	-24.335	0.000	5.195	0.015
Panel B: Variance of Coefficient Estimates				
distance	45.454	0.000	940.995	0.000
private	5.877	0.131	1.119	0.437
low volume	0.413	0.615	8.742	0.027
pharmacy	*	*	22.633	0.103
age	0.001	0.004	0.001	0.012
open 7 days a week	3.797	0.019	3.332	0.112
hours a day	0.007	0.023	4.143	0.003
any stockouts last month	*	*	88.641	0.001
# FP methods available	*	*	0.356	0.000
any FP protocol	*	*	4.606	0.010
# doctors	0.009	0.001	0.042	0.002
# nurses	0.009	0.000	0.010	0.006
# midwives	0.034	0.001	0.108	0.003
any health social worker	6.530	0.002	7.379	0.006
# services offered	0.063	0.000	0.159	0.003
any IEC materials	5.380	0.003	9.149	0.007
provides community outreach	4.077	0.000	15.662	0.004
has electricity	14.615	0.220	100.705	0.031
has piped water	78.084	0.069	*	*
has telephone	10.070	0.012	30.883	0.032
has private rooms	8.869	0.005	*	*
participate	131.171	0.001	331.121	0.044
Number of Individuals	1,830		1,073	
Number of Obervations	422,730		819,772	
LLF	-5,516.76		-3,455.46	

Table 6: Mixed Logit Models with Interactions

Covariates	Maternal Health		Family Planning	
	Params	P-value	Params	P-value
distance (km/10)	-13.309	0.000	-17.387	0.000
private	-2.358	0.000	-3.298	0.000
low volume	-0.676	0.000	-0.227	0.498
pharmacy	*	*	-0.297	0.927
age	0.003	0.434	0.023	0.001
open 7 days a week	0.847	0.027	-0.005	0.990
hours a day	-0.019	0.338	0.516	0.111
any stockouts last month	*	*	0.715	0.362
# FP methods available	*	*	0.224	0.035
any FP protocol	*	*	1.023	0.032
# doctors	-0.041	0.028	-0.244	0.001
# nurses	0.018	0.125	-0.015	0.581
# midwives	0.014	0.608	0.182	0.006
any health social worker	0.396	0.152	-0.050	0.939
# services offered	0.211	0.000	0.155	0.011
any IEC materials	1.329	0.000	0.681	0.311
provides community outreach	0.893	0.000	2.852	0.000
has electricity	11.938	0.000	10.071	0.007
has piped water	31.997	0.000	*	*
has telephone	2.291	0.000	2.311	0.000
has private rooms	4.131	0.000	*	*
participate	-54.833	0.000	4.032	0.142
distance*edu	0.070	0.000	-0.028	0.392
private*edu	0.184	0.000	0.255	0.000
low volume*edu	0.044	0.067	0.013	0.830
pharmacy*edu	*	*	0.046	0.786
age*edu	0.000	0.354	0.000	0.767
open 7 days a week*edu	-0.058	0.066	-0.025	0.573
hours a day*edu	0.005	0.009	-0.046	0.230
any stockouts last month*edu	*	*	-0.183	0.125
# FP methods available*edu	*	*	0.023	0.109
any FP protocol*edu	*	*	-0.074	0.240
# doctors*edu	0.002	0.196	0.003	0.537
# nurses*edu	-0.001	0.520	0.009	0.150
# midwives*edu	0.003	0.385	-0.002	0.453
any health social worker*edu	0.030	0.370	0.082	0.110
# services offered*edu	-0.012	0.015	-0.011	0.194
any IEC materials*edu	-0.017	0.559	-0.050	0.413
provides community outreach*edu	-0.035	0.194	-0.064	0.468
has electricity*edu	0.276	0.063	-0.142	0.517
has piped water*edu	-0.349	0.494	*	*
has telephone*edu	0.067	0.055	-0.025	0.694
has private rooms*edu	0.001	0.986	*	*
participate*edu	0.160	0.779	0.096	0.705
Number of Individuals	1,830		1,073	
Number of Observations	422,730		819,772	
LLF	-5,445.68		-27,922.96	

*Notes: The education interaction is coded as a continuous variable 0-21, which reflects the total years of education completed.

Table 7: Willingness to Travel for One Additional Unit of Quality

| | (1) Conditional Logit | (2) Measurement Error | Mixed Logit | | |
			(3) Mean of Distance Coef.	(4) 25th Percentile of Distance Coef.	(5) 75th Percentile of Distance Coef.
Maternal Health					
open 7 days a week	2.62	0.29	0.70	1.09	0.51
# services offered	0.36	0.07	0.13	0.20	0.10
any IEC materials	1.18	0.82	1.17	1.84	0.86
has electricity	6.89	0.45	4.19	6.57	3.07
has telephone	2.93	0.42	2.09	3.27	1.53
Family Planning					
# FP methods available	0.38	0.07	0.19	0.31	0.14
any FP protocol	0.74	0.19	0.40	0.65	0.29
any IEC materials	0.53	0.71	0.38	0.62	0.28
has electricity	1.06	0.57	5.57	9.06	4.05
has telephone	0.41	0.36	1.31	2.13	0.95

*Notes: Table elements were formed by dividing the corresponding quality parameter by the distance parameter from the specified model. Table elements are interpreted as the additional distance that the average individual is willing to travel for a one unit increase in quality; thus, the top left entry suggests that, according to the CL model, the average individual is willing to travel an additional 2.62 kilometers to visit a facility that is open 7 days a week, compared to a facility that is not open 7 days a week. The last 3 columns evaluate this trade-off for individuals at different points in the distance preference distribution; thus, the denominator of the ratio is taken from the mean, 25th percentile, and 75th percentile of the distribution.

Table 8: Policy Experiments for Maternal Health Care Choices

	Mixed Logit	Measurement Error
Experiment 1: New Facility		
Ave. patients visiting new fac.	0.20	3.44
	(0.46)	(1.82)
Experiment 2: Improved Facilities		
Ave. patients visiting pre-policy	2.29	24.88
Ave. patients visiting post-policy	10.03	40.01
Ave. % change	+460.37	+63.26
	(317.59)	(21.62)

*Notes: Standard errors are provided in parethesis. Table averages and standard errors are calculated from 500 simulation draws, which are described in footnote 23.

Appendix Material

Table A1: First Stage Selection Equation

Covariates	Maternal Health Facility Choice		Family Planning Facility Choice	
	Params	P-value	Params	P-value
$S_i = 3$ (visit surveyed fac.)				
age	0.151	0.167	0.620	0.000
age squared	-0.002	0.016	-0.008	0.000
SES quartile 2	-0.393	0.349	0.102	0.423
SES quartile 3	-0.231	0.587	0.103	0.425
SES quartile 4	-0.313	0.496	0.015	0.917
SES quartile 5 (highest)	-0.874	0.104	0.038	0.813
highest edu: primary school	-0.211	0.518	0.573	0.138
highest edu: middle school	-1.054	0.031	0.991	0.048
highest edu: high school	3.229	0.235	1.009	0.527
highest edu: college	4.303	0.138	0.707	0.688
Muslim	-1.021	0.128	-1.265	0.123
# children at home	-0.010	0.942	0.262	0.000
currently pregnant	5.814	0.000	-18.899	0.984
has given birth in last 2.5 years	3.416	0.000	2.540	0.000
has seen FP message in past year	*	*	1.509	0.069
sex in last 3 months: 1-10	*	*	1.812	0.000
sex in last 3 months: 11-20	*	*	1.374	0.007
sex in last 3 months: 21-30	*	*	1.530	0.008
sex in last 3 months: 30+	*	*	1.943	0.004
have partner	1.693	0.166	1.359	0.093
partner has otherwives	0.211	0.599	0.016	0.971
is capable of getting pregnant	3.121	0.431	4.051	0.000
want more children	0.136	0.840	1.252	0.102
partner wants more children	-0.052	0.908	1.157	0.044
partner RARELY accompanies to HF	-0.459	0.341	-0.005	0.971
partner SOMTIMES accompanies to HF	0.109	0.810	0.076	0.503
partner OFTEN accompanies to HF	-0.556	0.238	0.035	0.763
partner ALWAYS accompanies to HF	-0.113	0.895	-0.053	0.817
partner age	-0.002	0.931	-0.017	0.009
partner highest edu: none	0.180	0.639	-0.384	0.000
partner highest edu: primary	0.289	0.588	0.075	0.579
partner highest edu: middle	0.757	0.217	-0.058	0.724
partner highest edu: high	0.622	0.391	-0.334	0.086
partner highest edu: college	2.799	0.000	0.083	0.661
partner works	0.512	0.410	0.102	0.486
currently working	-0.437	0.153	0.175	0.028
reads newspapers and/or magazines	0.568	0.175	0.031	0.782
listens to radio	-0.670	0.026	-0.062	0.468
watches television	-0.426	0.465	0.448	0.018
has own personal cell phone	0.585	0.054	0.170	0.075
has internet access	-0.973	0.085	-0.185	0.291
owns a car	0.381	0.407	0.048	0.700
owns a scooter	0.053	0.905	0.085	0.476
owns a bicycle	0.227	0.703	-0.035	0.830
home city: Guediawaye	-0.901	0.081	-0.226	0.305
home city: Pikine	-0.809	0.152	-0.524	0.033
home city: Mbao	-0.369	0.523	-0.826	0.004
home city: Mbour	-1.167	0.022	-0.287	0.408
home city: Kaolack	-1.048	0.026	-1.169	0.003
# public facilities	0.016	0.774	-0.104	0.112
# private facilities	0.052	0.344	-0.032	0.620
# pharmacies	-0.010	0.384	0.032	0.059
all facilities not participating	-0.686	0.634	-0.293	0.843
HF: # high volume	0.132	0.004	0.097	0.060
HF: average distance	0.007	0.332	-0.004	0.663
HF: average age	0.003	0.488	-0.002	0.777
HF: # open every day	0.026	0.649	-0.064	0.355
HF: average hours open per day	-0.028	0.015	0.005	0.693
HF: average # doctors	-0.294	0.001	0.041	0.680
HF: average # nurses	-0.033	0.260	-0.030	0.381
HF: average # midwives	0.266	0.000	0.010	0.890
HF: average # staff	-0.087	0.001	0.005	0.861
HF: # health social workers	-0.146	0.058	-0.083	0.327
HF: average # services offered	0.034	0.230	0.005	0.870
HF: average # FP methods available	-0.036	0.417	0.059	0.271
HF: % with stockout in prior 30 days	-0.100	0.615	-0.493	0.035
HF: average # IEC tools per facility	-0.179	0.003	0.005	0.939

HF: # that have ever given FP talk	-0.181	0.006	0.127	0.122
HF: proportion with FP protocol	-0.287	0.100	0.013	0.953
HF: proportion with electricity	-0.821	0.087	0.476	0.451
HF: proportion with piped water	0.519	0.680	0.230	0.849
HF: proportion with telephone	-0.014	0.942	-0.244	0.267
HF: proportion with private rooms	0.683	0.043	-0.662	0.083
RX: average distance	*	*	0.443	0.153
RX: average age	*	*	0.010	0.561
RX: # open every day	*	*	-0.049	0.130
RX: average hours open per day	*	*	-0.344	0.049
RX: average # FP methods available	*	*	-0.183	0.187
RX: % with stockout in prior 30 days	*	*	0.261	0.378
RX: % employing multiple pharmacists	*	*	0.166	0.703
has no health facilities	-0.865	0.543	0.230	0.873
has no pharmacies	*	*	-5.341	0.041
age * SES quartile 2	0.013	0.332	*	*
age * SES quartile 3	0.007	0.630	*	*
age * SES quartile 4	0.012	0.413	*	*
age * SES quartile 5 (highest)	0.029	0.091	*	*
age * highest edu: primary school	0.011	0.296	-0.003	0.786
age * highest edu: middle school	0.039	0.016	-0.011	0.477
age * highest edu: high school	-0.216	0.144	-0.011	0.724
age * highest edu: college	-0.258	0.093	0.017	0.662
age * Muslim	0.021	0.313	0.031	0.204
age * # children at home	0.002	0.642	*	*
age * currently pregnant	-0.084	0.000	*	*
age * has given birth in last 2.5 years	-0.051	0.000	-0.075	0.000
age * has seen FP message in past year	*	*	-0.015	0.546
age * sex in last 3 months: 1-10	*	*	-0.031	0.033
age * sex in last 3 months: 11-20	*	*	-0.014	0.345
age * sex in last 3 months: 21-30	*	*	-0.011	0.510
age * sex in last 3 months: 30+	*	*	-0.030	0.151
age * have partner	-0.029	0.468	0.005	0.826
age * partner has otherwives	-0.007	0.549	-0.002	0.873
age * is capable of getting pregnant	-0.046	0.599	*	*
age * want more children	-0.004	0.814	-0.050	0.020
age * partner wants more children	0.003	0.806	-0.036	0.026
age * partner RARELY accompanies to HF	0.009	0.556	*	*
age * partner SOMTIMES accompanies to HF	-0.001	0.917	*	*
age * partner OFTEN accompanies to HF	0.016	0.274	*	*
age * partner ALWAYS accompanies to HF	0.008	0.770	*	*
age * partner age	0.000	0.817	*	*
age * partner highest edu: none	-0.010	0.398	*	*
age * partner highest edu: primary	-0.012	0.477	*	*
age * partner highest edu: middle	-0.015	0.420	*	*
age * partner highest edu: high	-0.020	0.370	*	*
age * partner highest edu: college	-0.089	0.000	*	*
age * partner works	-0.005	0.787	*	*
age * currently working	0.010	0.321	*	*
age * reads newspapers and/or magazines	-0.013	0.325	*	*
age * listens to radio	0.024	0.015	*	*
age * watches television	0.011	0.537	*	*
age * has own personal cell phone	-0.019	0.054	*	*
age * has internet access	0.036	0.060	*	*
age * owns a car	-0.014	0.335	*	*
age * owns a scooter	-0.005	0.744	*	*
age * owns a bicycle	-0.009	0.651	*	*
age * home city: Guediawaye	0.026	0.099	*	*
age * home city: Pikine	-0.009	0.606	*	*
age * home city: Mbao	-0.019	0.278	*	*
age * home city: Mbour	-0.002	0.868	*	*
age * home city: Kaolack	0.010	0.469	*	*
age * average HF distance	0.000	0.526	0.000	0.755
age * average RX distance	*	*	-0.015	0.123
edu * age squared	0.004	0.054	*	*
edu * SES quartile 2	-0.237	0.706	-0.098	0.891
edu * SES quartile 3	0.146	0.808	-0.133	0.847
edu * SES quartile 4	0.461	0.415	0.101	0.877
edu * SES quartile 5 (highest)	-0.394	0.508	-0.497	0.446
edu * Muslim	0.221	0.593	-0.588	0.203
edu * # children at home	-0.255	0.076	*	*
edu * currently pregnant	17.542	0.992	*	*
edu * has given birth in last 2.5 years	0.418	0.227	0.475	0.134
edu * has seen FP message in past year	*	*	-0.300	0.681
edu * sex in last 3 months: 1-10	*	*	1.003	0.018

edu * sex in last 3 months: 11-20	*	*	1.036	0.021
edu * sex in last 3 months: 21-30	*	*	0.504	0.300
edu * sex in last 3 months: 30+	*	*	1.468	0.006
edu * have partner	2.729	0.067	1.126	0.121
edu * partner has otherwives	0.037	0.926	0.492	0.182
edu * is capable of getting pregnant	-2.020	0.140	*	*
edu * want more children	0.699	0.210	0.192	0.713
edu * partner wants more children	-1.783	0.001	-0.455	0.348
edu * partner RARELY accompanies to HF	-0.024	0.960	*	*
edu * partner SOMTIMES accompanies to HF	0.356	0.451	*	*
edu * partner OFTEN accompanies to HF	-0.378	0.381	*	*
edu * partner ALWAYS accompanies to HF	0.707	0.238	*	*
edu * partner age	-0.033	0.211	*	*
edu * partner highest edu: none	0.416	0.534	-0.794	0.244
edu * partner highest edu: primary	-0.125	0.860	-0.502	0.469
edu * partner highest edu: middle	-0.679	0.304	-0.720	0.253
edu * partner highest edu: high	0.152	0.803	0.089	0.881
edu * partner highest edu: college	-0.114	0.845	-1.077	0.054
edu * partner works	0.418	0.542	*	*
edu * currently working	-0.083	0.777	*	*
edu * reads newspapers and/or magazines	-0.064	0.861	*	*
edu * listens to radio	0.352	0.269	*	*
edu * watches television	-0.587	0.569	*	*
edu * has own personal cell phone	0.825	0.300	*	*
edu * has internet access	0.175	0.590	*	*
edu * owns a car	-0.130	0.711	*	*
edu * owns a scooter	0.348	0.397	*	*
edu * owns a bicycle	0.228	0.619	*	*
edu * home city: Guediawaye	0.221	0.572	*	*
edu * home city: Pikine	-0.759	0.177	*	*
edu * home city: Mbao	0.428	0.402	*	*
edu * home city: Mbour	0.064	0.870	*	*
edu * home city: Kaolack	-0.757	0.044	*	*
edu * average HF distance	-0.015	0.198	0.011	0.207
edu * average RX distance	*	*	-0.713	0.365
constant	-5.728	0.196	-14.203	0.000

$S_i = 2$ (visit non-surveyed fac.)

age	0.617	0.531	0.473	0.000
age squared	-0.001	0.561	-0.007	0.000
SES quartile 2	0.478	0.532	-0.036	0.873
SES quartile 3	0.259	0.733	0.053	0.813
SES quartile 4	0.068	0.933	0.128	0.578
SES quartile 5 (highest)	0.680	0.447	0.067	0.800
highest edu: primary school	0.281	0.610	0.152	0.817
highest edu: middle school	0.206	0.792	-0.299	0.704
highest edu: high school	-24.679	0.994	2.587	0.247
highest edu: college	-24.149	0.994	0.230	0.922
Muslim	-0.935	0.399	-2.184	0.025
# children at home	-0.125	0.579	0.197	0.000
currently pregnant	4.758	0.000	-18.423	0.989
has given birth in last 2.5 years	4.066	0.000	2.659	0.000
has seen FP message in past year	*	*	1.854	0.197
sex in last 3 months: 1-10	*	*	1.865	0.021
sex in last 3 months: 11-20	*	*	1.385	0.125
sex in last 3 months: 21-30	*	*	2.081	0.039
sex in last 3 months: 30+	*	*	1.593	0.176
have partner	2.061	0.317	1.381	0.236
partner has otherwives	0.377	0.553	-1.006	0.275
is capable of getting pregnant	32.729	0.483	1.818	0.017
want more children	-1.073	0.320	2.332	0.072
partner wants more children	-0.686	0.329	-1.263	0.139
partner RARELY accompanies to HF	-1.858	0.017	0.257	0.230
partner SOMTIMES accompanies to HF	-0.265	0.698	-0.068	0.745
partner OFTEN accompanies to HF	0.440	0.580	0.427	0.023
partner ALWAYS accompanies to HF	-1.388	0.330	0.051	0.892
partner age	0.015	0.663	-0.014	0.258
partner highest edu: none	-0.052	0.933	-0.447	0.027
partner highest edu: primary	-1.123	0.201	0.178	0.459
partner highest edu: middle	0.107	0.918	0.155	0.572
partner highest edu: high	-1.085	0.351	0.405	0.147
partner highest edu: college	1.086	0.360	0.278	0.364
partner works	1.732	0.117	0.297	0.277
currently working	-0.495	0.345	0.191	0.150
reads newspapers and/or magazines	-0.740	0.279	-0.122	0.496
listens to radio	-0.590	0.244	-0.087	0.542

watches television	-2.393	0.045	0.187	0.542
has own personal cell phone	-0.319	0.547	0.100	0.545
has internet access	0.291	0.757	0.345	0.135
owns a car	0.498	0.491	-0.013	0.949
owns a scooter	0.918	0.246	0.160	0.415
owns a bicycle	0.466	0.593	-0.577	0.080
home city: Guediawaye	0.158	0.873	0.134	0.732
home city: Pikine	0.439	0.635	0.511	0.224
home city: Mbao	0.473	0.595	0.025	0.958
home city: Mbour	-0.239	0.788	-0.134	0.818
home city: Kaolack	-0.142	0.875	-1.238	0.069
# public facilities	-0.015	0.865	0.056	0.584
# private facilities	0.119	0.207	0.161	0.105
# pharmacies	0.015	0.449	-0.002	0.959
all facilities not participating	-2.151	0.445	-1.898	0.517
HF: # high volume	-0.117	0.144	-0.094	0.303
HF: average distance	0.005	0.628	-0.033	0.110
HF: average age	-0.002	0.810	-0.022	0.091
HF: # open every day	-0.093	0.372	-0.008	0.945
HF: average hours open per day	-0.060	0.001	-0.012	0.613
HF: average # doctors	-0.281	0.059	-0.125	0.438
HF: average # nurses	-0.048	0.344	0.054	0.356
HF: average # midwives	0.416	0.000	0.184	0.134
HF: average # staff	-0.084	0.086	0.031	0.563
HF: # health social workers	-0.004	0.977	-0.199	0.175
HF: average # services offered	0.002	0.965	-0.118	0.036
HF: average # FP methods available	0.059	0.472	0.131	0.178
HF: % with stockout in prior 30 days	0.389	0.239	-0.005	0.990
HF: average # IEC tools per facility	0.018	0.859	0.148	0.196
HF: # that have ever given FP talk	-0.094	0.384	0.131	0.332
HF: proportion with FP protocol	-1.497	0.000	-0.006	0.988
HF: proportion with electricity	-0.377	0.675	-1.273	0.204
HF: proportion with piped water	0.399	0.874	0.955	0.705
HF: proportion with telephone	-1.256	0.000	-0.711	0.057
HF: proportion with private rooms	0.598	0.295	0.226	0.741
RX: average distance	*	*	-3.355	0.054
RX: average age	*	*	-0.005	0.847
RX: # open every day	*	*	-0.084	0.151
RX: average hours open per day	*	*	-0.288	0.353
RX: average # FP methods available	*	*	-0.017	0.938
RX: % with stockout in prior 30 days	*	*	-0.516	0.286
RX: % employing multiple pharmacists	*	*	-1.356	0.062
has no health facilities	-1.447	0.604	-0.926	0.749
has no pharmacies	*	*	-6.084	0.178
age * SES quartile 2	-0.005	0.841	*	*
age * SES quartile 3	0.000	0.997	*	*
age * SES quartile 4	0.014	0.618	*	*
age * SES quartile 5 (highest)	-0.004	0.902	*	*
age * highest edu: primary school	-0.003	0.857	0.008	0.690
age * highest edu: middle school	0.000	1.000	0.030	0.201
age * highest edu: high school	-0.109	0.645	-0.018	0.669
age * highest edu: college	-0.101	0.684	0.090	0.056
age * Muslim	0.009	0.806	0.048	0.108
age * # children at home	0.003	0.694	*	*
age * currently pregnant	-0.045	0.099	*	*
age * has given birth in last 2.5 years	-0.073	0.000	-0.074	0.001
age * has seen FP message in past year	*	*	-0.021	0.613
age * sex in last 3 months: 1-10	*	*	-0.023	0.342
age * sex in last 3 months: 11-20	*	*	-0.012	0.648
age * sex in last 3 months: 21-30	*	*	-0.027	0.371
age * sex in last 3 months: 30+	*	*	-0.020	0.578
age * have partner	-0.047	0.497	-0.028	0.418
age * partner has otherwives	-0.006	0.760	0.014	0.577
age * is capable of getting pregnant	-0.666	0.494	*	*
age * want more children	0.025	0.411	-0.069	0.054
age * partner wants more children	0.028	0.211	0.027	0.275
age * partner RARELY accompanies to HF	0.056	0.026	*	*
age * partner SOMTIMES accompanies to HF	0.015	0.498	*	*
age * partner OFTEN accompanies to HF	-0.020	0.448	*	*
age * partner ALWAYS accompanies to HF	0.044	0.329	*	*
age * partner age	0.000	0.817	*	*
age * partner highest edu: none	-0.003	0.891	*	*
age * partner highest edu: primary	0.032	0.273	*	*
age * partner highest edu: middle	-0.002	0.947	*	*
age * partner highest edu: high	0.033	0.363	*	*

age * partner highest edu: college	-0.029	0.442	*	*
age * partner works	-0.045	0.154	*	*
age * currently working	0.006	0.720	*	*
age * reads newspapers and/or magazines	0.034	0.119	*	*
age * listens to radio	0.027	0.114	*	*
age * watches television	0.093	0.035	*	*
age * has own personal cell phone	0.014	0.442	*	*
age * has internet access	-0.005	0.885	*	*
age * owns a car	-0.020	0.407	*	*
age * owns a scooter	-0.039	0.164	*	*
age * owns a bicycle	0.006	0.838	*	*
age * home city: Guediawaye	0.022	0.489	*	*
age * home city: Pikine	0.007	0.800	*	*
age * home city: Mbao	0.014	0.609	*	*
age * home city: Mbour	0.009	0.736	*	*
age * home city: Kaolack	-0.012	0.684	*	*
age * average HF distance	0.000	0.517	0.001	0.289
age * average RX distance	*	*	0.072	0.062
edu * age	0.001	0.847	*	*
edu * SES quartile 2	-1.487	0.080	-0.623	0.442
edu * SES quartile 3	-1.560	0.055	-1.318	0.100
edu * SES quartile 4	-1.224	0.093	-0.904	0.205
edu * SES quartile 5 (highest)	-1.454	0.051	-1.682	0.021
edu * Muslim	1.200	0.063	-1.052	0.033
edu * # children at home	0.323	0.186	*	*
edu * currently pregnant	18.359	0.992	*	*
edu * has given birth in last 2.5 years	0.845	0.115	-0.289	0.562
edu * has seen FP message in past year	*	*	-0.176	0.882
edu * sex in last 3 months: 1-10	*	*	0.284	0.622
edu * sex in last 3 months: 11-20	*	*	0.132	0.847
edu * sex in last 3 months: 21-30	*	*	-0.086	0.912
edu * sex in last 3 months: 30+	*	*	1.089	0.147
edu * have partner	6.072	0.006	1.510	0.160
edu * partner has otherwives	0.486	0.441	-1.902	0.100
edu * is capable of getting pregnant	11.287	0.997	*	*
edu * want more children	0.102	0.903	0.773	0.347
edu * partner wants more children	-2.310	0.001	-0.983	0.203
edu * partner RARELY accompanies to HF	-0.394	0.617	*	*
edu * partner SOMTIMES accompanies to HF	0.165	0.807	*	*
edu * partner OFTEN accompanies to HF	-1.607	0.041	*	*
edu * partner ALWAYS accompanies to HF	1.369	0.095	*	*
edu * partner age	-0.100	0.022	*	*
edu * partner highest edu: none	0.374	0.732	0.021	0.988
edu * partner highest edu: primary	-0.278	0.793	0.966	0.368
edu * partner highest edu: middle	-1.201	0.319	-0.401	0.725
edu * partner highest edu: high	-0.347	0.738	-0.619	0.560
edu * partner highest edu: college	0.137	0.884	-0.077	0.938
edu * partner works	-1.044	0.268	*	*
edu * currently working	0.103	0.815	*	*
edu * reads newspapers and/or magazines	-0.668	0.218	*	*
edu * listens to radio	0.373	0.441	*	*
edu * watches television	0.125	0.934	*	*
edu * has own personal cell phone	16.616	0.986	*	*
edu * has internet access	0.672	0.194	*	*
edu * owns a car	0.018	0.972	*	*
edu * owns a scooter	-0.659	0.430	*	*
edu * owns a bicycle	-0.601	0.395	*	*
edu * home city: Guediawaye	-1.126	0.119	*	*
edu * home city: Pikine	-1.471	0.055	*	*
edu * home city: Mbao	0.382	0.518	*	*
edu * home city: Mbour	-2.151	0.003	*	*
edu * home city: Kaolack	-1.883	0.008	*	*
edu * average HF distance	-0.029	0.231	-1.285	0.153
edu * average RX distance	*	*	-0.070	0.964
constant	-33.463	0.475	-7.759	0.215
Overall chi-squared test statistic	4,128.790	0.000	2,514.350	0.000
Pseudo R-squared	0.325		0.270	
LLF	-4,284.989		-3,396.314	
Number of Individuals	9,325		9,325	

*Notes: The education interaction variable is an indicator for having obtained a highschool or college degree. Excluded category for partner's education is "don't know." Excluded city is Dakar. The baseline alternative in both models is $S_i=1$ (i.e., no visit).

Table A2: Unweighted Conditional Logit Model Estimates with Different Samples and Choice Sets

| | Maternal Health Facility Choice | | | | | | Family Planning Care Facility Choice | | | | | |
| | (1) Full Sample, All Facilities | | (2) Restricted Sample, All Facilities | | (3) Restricted Sample and Facilities | | (4) Full Sample, All Facilities | | (5) Restricted Sample, All Facilities | | (6) Restricted Sample and Facilities | |
Covariates	Params	P-value	Params	P-value	Params	P-value	Params	P-value	Params	P-value	Params	P-value
distance (km/10)	-1.514	0.000	-5.159	0.000	-5.159	0.000	-3.064	0.000	-5.354	0.000	-5.354	0.000
private	-0.505	0.000	-0.411	0.000	-0.411	0.000	-0.690	0.000	-0.637	0.001	-0.637	0.001
low volume	-0.480	0.000	-0.168	0.010	-0.168	0.010	-0.358	0.000	-0.204	0.018	-0.204	0.018
pharmacy	*	*	*	*	*	*	-1.755	0.000	-1.805	0.000	-1.805	0.000
age	0.011	0.000	0.008	0.000	0.008	0.000	0.012	0.000	0.011	0.000	0.011	0.000
open 7 days a week	0.396	0.000	0.523	0.000	0.523	0.000	-0.068	0.616	-0.026	0.848	-0.026	0.848
hours a day	-0.011	0.083	-0.010	0.113	-0.010	0.113	0.023	0.011	0.025	0.005	0.025	0.005
any stockouts last month	*	*	*	*	*	*	0.258	0.004	0.277	0.003	0.277	0.003
# FP methods available	*	*	*	*	*	*	0.118	0.000	0.135	0.000	0.135	0.000
any FP protocol	*	*	*	*	*	*	0.226	0.049	0.266	0.019	0.266	0.019
# doctors	0.015	0.000	0.022	0.000	0.022	0.000	-0.022	0.367	-0.016	0.546	-0.016	0.546
# nurses	-0.004	0.399	-0.001	0.809	-0.001	0.809	-0.002	0.757	-0.002	0.804	-0.002	0.804
# midwives	0.032	0.000	0.027	0.007	0.027	0.007	0.052	0.000	0.049	0.001	0.049	0.001
any health social worker	0.315	0.000	0.613	0.000	0.613	0.000	0.600	0.000	0.683	0.000	0.683	0.000
# services offered	0.054	0.000	0.055	0.000	0.055	0.000	-0.019	0.235	-0.026	0.112	-0.026	0.112
any IEC materials	0.178	0.024	0.489	0.000	0.489	0.000	0.164	0.110	0.237	0.022	0.237	0.022
provides community outreach	0.425	0.000	0.300	0.000	0.300	0.000	0.458	0.000	0.403	0.000	0.403	0.000
has electricity	1.044	0.000	-0.189	0.708	-0.189	0.708	0.325	0.068	0.274	0.132	0.274	0.132
has piped water	0.347	0.495	0.557	0.000	0.557	0.000	*	*	*	*	*	*
has telephone	0.443	0.000	1.034	0.000	1.034	0.000	0.125	0.189	0.134	0.167	0.134	0.167
has private rooms	0.657	0.000	0.843	0.000	0.843	0.000	*	*	*	*	*	*
participate	-3.490	0.000	-3.633	0.000	-3.633	0.000	-1.669	0.000	-1.781	0.000	-1.781	0.000
Number of individuals	1,830		1,801		1,801		1,073		1,060		1,060	
Number of observations	422,730		416,031		194,357		819,772		809,840		412,258	
LLF	-6,911.37		-5,875.94		-5,875.94		-4,319.16		-3,919.85		-3,919.85	

*Notes: The number of individuals in each model measures individuals making a facility choice. The number of observations reflects the sum of facilities which each individual has access to. We compare the estimates in columns 1 and 2, as well as those in columns 4 and 5, using a chi-squared test. We use 5,000 bootstrap samples to construct an estimate for the joint covariance matrix of the estimated coefficients where we divided each of the estimated coefficients by the estimated coefficient for distance. For the maternal health model, the test statistic is 13.01 which under the null hypothesis is chi squared with 16 degrees of freedom (p=0.67). For the family planning model, the resulting test statistic is 7.98, which is chi squared with 19 degrees of freedom (p=0.98).

Table A3: Mixed Logit Model Correlation Coefficients for Distance and Quality

Covariates	Maternal Health Facility Choice		Family Planning Facility Choice	
	Params	P-value	Params	P-value
private	5.578	0.014	-1.901	0.698
low volume	-0.585	0.567	3.706	0.261
pharmacy	*	*	-7.604	0.408
age	-58.621	0.000	-86.809	0.001
open 7 days a week	0.065	0.003	0.174	0.001
hours a day	-1.689	0.261	2.879	0.258
any stockouts last month	*	*	6.163	0.018
# FP methods sold	*	*	1.489	0.812
any FP protocol	*	*	1.634	0.014
# doctors	0.234	0.012	0.045	0.990
# nurses	-0.103	0.116	0.376	0.196
# midwives	-0.071	0.152	-0.077	0.609
any health social worker	0.032	0.813	-0.646	0.077
# services offered	1.102	0.416	13.315	0.001
any IEC materials	0.120	0.526	-0.794	0.106
provides community outreach	-2.146	0.094	3.860	0.215
has electricity	1.112	0.347	-4.544	0.321
has piped water	12.053	0.103	*	*
has telephone	33.602	0.000	17.214	0.072
has private rooms	3.736	0.027	*	*
participate	0.333	0.896	21.791	0.002
Number of individuals	1,830		1,073	
Number of observations	422,730		819,772	
LLF	-5,516.76		-3,455.46	

*Notes: These parameters are taken from the first row of the parameter covariance matrix described in Section IV.b of the paper. The first element of this row has been excluded, as it measures the variance of the distance taste distribution, which is already reported in Table 5. Table elements measure the covariance of between preferences for distance and other facility features.