Choosing a Contraceptive Provider: Access, Awareness and Fertility Decisions in Urban Senegal

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Job Market Paper

January 29, 2018

Abstract

Contraceptive use is low in most parts of Sub-Saharan Africa, contributing to high fertility rates and sustained population growth in this region. As a result, there is growing emphasis on promoting family planning and improving access to contraceptives through various measures. I incorporate the most common types of interventions—implementing an awareness campaign, reducing contraceptive prices, and increasing the quantity and quality of providers—into a dynamic fertility model to compare the effectiveness of these interventions. The model includes the decisions of married women to be sexually active, to use birth control and to select a contraceptive provider among all the providers located within a given distance of their dwelling place. I estimate the model on a rich data set that includes all the contraceptive providers in three cities of Senegal, linked to a longitudinal sample of women. Simulations indicate that price reductions and quality improvements could increase contraceptive use in urban Senegal. However, travel costs and cultural barriers, including the fear of side effects and personal opposition, are greater obstacles towards using contraceptives. I find that contraceptive use increased substantially between 2011 and 2015 in the three cities, driven by a large-scale awareness campaign that addressed widespread misconceptions about the harmfulness of contraceptives. *JEL Code: I11, J13, O15.*

*Department of Economics, University of North Carolina at Chapel Hill. joneydi@live.unc.edu. I am very grateful to my advisors David Guilkey and Clement Joubert, to my committee members Erica Field, Ilene Speizer, Luca Flabbi and Simon Alder for their suggestions, support and guidance. Please download the latest version of this paper from `http://joneydi.web.unc.edu/files/2017/11/jmp_joneydi.pdf`.

1. Introduction

Fertility rates remain high in Sub-Saharan Africa, with an average of five children per women (twice the world average) and a population growth rate of 2.74% in 2016.[1] High fertility rates are associated with a number of adverse effects in this region, including elevated risks of maternal and infant mortality, land degradation and food insecurity (World Health Organization 2005, Cleland et al. 2006). As a result, family planning is rising in the list of development priorities in Sub-Saharan Africa and is a growing recipient of donor funds (Starbird, Norton and Marcus 2016).

In this context, the Gates Foundation launched the Urban Reproductive Health Initiative, a series of large-scale interventions to promote contraceptive use and urban reproductive health in Senegal, Nigeria, Kenya and India. The Senegal branch, named ISSU (Initiative Sénégalaise de Santé Urbaine), implemented two types of interventions in the cities of Dakar, Mbour and Kaolack between 2011 and 2015.[2] Supply-side interventions aimed at improving the quality of public providers by reducing contraceptive stockouts and offering additional training in family planning. Demand-side interventions employed mass media and community outreach to address the benefits of family planning, its acceptance by religious leaders, and misconceptions about the harmfulness of contraceptives.

These interventions were carried out at a large scale in Dakar, Mbour and Kaolack: 92.8% of public providers received the supply-side interventions, and 85.5% of married women were exposed to at least one of the media or community programs by 2015. In addition, the Monitoring, Learning and Evaluation (MLE) project, a collaboration between the Gates Foundation and the Carolina Population Center, collected data in these three cities between 2011 and 2015 in order to monitor changes in the supply environment (price, quantity and quality of contraceptive providers) and changes in the percentage of contraceptive users. This unique setting allows me to incorporate the most common types of family planning interventions—implementing an awareness campaign, reducing contraceptive prices, and increasing the quantity and quality of providers—into a fertility model to compare the effectiveness of these interventions.

The agents in my model are married women living in urban Senegal. At each age, a woman can decide to be sexually active and whether or not to use birth control, from the time she gets married until menopause.[3] If she opts for birth control, she selects a contraceptive provider based on price, quality and distance among all the providers that are located within

[1]The population of Sub-Saharan Africa grew at an average annual rate of 2.73% between 1960 and 2016, resulting in a doubling of the population approximately every twenty-six years (World Bank Open Data).

[2]In this article, I refer to Dakar as the inner city of Dakar and its immediate suburbs Guédiawaye, Pikine and Mbao.

[3]Birth control refers to modern contraceptive methods in this article (less than 3% of married women used traditional methods in the data).

a given distance of her dwelling place. She then becomes pregnant with a probability that depends on her reproductive and provider choices. In particular, selecting a high quality provider may increase the effectiveness of birth control and therefore reduce the probability of pregnancy. The model is dynamic and agents are assumed to be forward looking. In each period of the model, agents take into account the current cost of pregnancy as well as the value of having a child in the next period when making their reproductive and provider choices.

In addition, women may be exposed to six family planning programs implemented by the ISSU awareness campaign: radio programs, television programs, home visits, community conversations, neighborhood groups and religious talks (see data section 4.1 for more details). I allow for these programs to permanently shift a woman's contraceptive preferences. Furthermore, I incorporate permanent unobserved heterogeneity into the model to control for the endogenous exposure to family planning programs and the endogenous access to providers.

I estimate the model on a uniquely detailed data set from the MLE project. The project collected longitudinal reproductive data from a representative sample of women in Dakar, Mbour and Kaolack between 2011 and 2015. In addition, a list of all pharmacies and facilities offering contraceptives was established in each city and data were collected on the quality of care via audits, staff interviews and client exit interviews. The location of both women and providers were recorded by GPS, and the two samples were linked: we asked contraceptive users to provide the address of the health facility or pharmacy from which they obtained their contraceptive, which was matched with the addresses in our provider sample. This remarkable feature of the data makes it possible to model the choice of providers over the universe of contraceptive providers in each city.

I solve the model using backwards recursion and estimate the structural parameters by maximum likelihood. The estimated model is used to carry out several policy experiments and simulation exercises. I start by decomposing into three different factors the increase in contraceptive use that occurred between baseline (2011) and endline (2015) in the longitudinal sample of married women. During this four year period, (1) women progressed along their life cycle, aging and having children; (2) the supply environment changed, with an overall increase in provider quality, a decline in contraceptive prices, and an increase in the number of providers; (3) ISSU carried out its awareness campaign. Simulations shows that contraceptive use increased from 17.3% in 2011 to 27.2% in 2015, and that 2.9% of this increase can be explained by aging, 22.5% by changes in the supply environment, and 74.5% by the awareness campaign.

Next, I investigate which type of policies could increase contraceptive use in the present environment, given that a general improvement in quality has already occurred and most women have been exposed to at least one of the six family planning programs. I find that offering contraceptives for free or raising provider quality to the maximum would have a minimal impact, increasing the percentage of contraceptive users from 27.4% to 29.1% of married women.[4] On the other hand, entirely eliminating all travel costs or exposing women to all six family planning programs would have a large impact on contraceptives use, increasing use to 39.2% and 43.6%, respectively. Combining all four policies would increase contraceptive use to 57.0%, reducing completed fertility from 5.19 to 4.52 children per women.

These simulations suggest that further price reductions and quality improvements would increase contraceptive use in urban Senegal, but the price and quality of services are not, at their current level, the main obstacles that prevent women from using contraceptives. Travel costs and cultural barriers, including the fear of side effects and personal opposition, are greater obstacles towards using contraceptives. These results are consistent with a descriptive analysis of the data, which indicates that a large share of married women have misconceptions regarding the harmfulness of contraceptives, and the majority travel by foot to their providers.

My paper makes several methodological contributions to the existing literature on the supply-side determinants of contraceptive use. As discussed in the next section, the common approach in this literature is to aggregate provider quality variables at the cluster level and use this as a dependent variable in static models of contraceptive use. However, this approach may not capture well the quality of care that is received, as households often bypass the lowest quality providers to obtain better care (Klemick, Leonard and Masatu 2009). I take a novel approach by explicitly modeling the choice of providers, capturing the relative influence of each provider on the reproductive outcomes of women.

My paper is also part of a larger literature on the quality of health services in low-income countries. In recent years, much progress has been made in measuring the quality of care (Leonard and Masatu 2007, Das, Hammer and Leonard 2008, Das et al. 2012) and evaluating policies to improve quality (Björkman and Svensson 2009, Gertler and Vermeersch 2013, de Walque et al. 2015). But the relationship among quality, provider choice, and individual outcomes remains less well understood. I am aware of only two other papers that model the choice of health providers (Klemick, Leonard and Masatu 2009, Cronin, Guilkey and Speizer 2016*b*). In both studies, the authors analyze the static choice of providers conditional on being a patient. They find that households in urban Senegal and rural Tanzania are sensitive to travel costs, but typically bypass the nearest provider to obtain better care. Note that these studies are restricted to a sample of users and do not include how the choice of a provider subsequently affects the individual. I make a contribution to this literature by analyzing how the quality of family planning providers affects the decision to use family

[4] The average price of pills and injectables was already low at 283 CFA (about 57 cents) in 2015. Quality is measured with an index from 0 to 1 (see section 4.3 for more details). The index was high and equal to 0.752 on average in 2015. Therefore, raising it to the maximum is equivalent to a 33% increase in the average quality of services.

planning services, provider choices, and reproductive outcomes, subsequently.

Finally, my paper is related to a structural literature on the fertility decisions of women (Keane and Wolpin 2007, Keane and Wolpin 2010, Shapira 2013). The majority of the papers in this literature treat pregnancies as a decision rather than an outcome, therefore assuming perfect control over one's fertility. A few papers explicitly model sexual activity and contraceptive use (Hotz and Miller 1993, Arcidiacono, Khwaja and Ouyang 2012, Amador 2015, Forsstrom 2017), but these models do not incorporate the choice of contraceptive providers. Contraceptive prices are typically excluded from the analysis, or in the case of Amador (2015), an average price is used for all women. To my knowledge, this is the first paper to incorporate the supply of contraceptives into a dynamic model of fertility and to model the choice of contraceptive providers.

The remainder of the paper is organized as follows. Section 2 provides background by discussing related literature and describing the context of urban Senegal. Section 3 presents the structural model. Section 4 describes the data and the model variables. Section 5 discusses estimation and identification. Section 6 presents the estimation results and the model fit. Section 7 presents the policy experiments. Section 8 concludes.

2. Background

2.1 Access to Quality and Contraceptive Use

This paper is part of a larger literature that evaluates the role of the health care environment on the contraceptive use and fertility of women in developing countries. For example, Angeles, Guilkey and Mroz (1998) look at the effect of introducing a family planning provider within 30 km of a village on women's probability of giving birth in rural Tanzania. The authors make a contribution to the literature by explicitly modeling the placement of health services: they estimate the probability of having a hospital, a health center, and a dispensary near the village at time t based on observable community characteristics (e.g. population size, child mortality rate) as well as unobservable community types. The probability of conceiving in each year and the three placement equations are jointly estimated, with unobservable types correlated across the set of equations. Results show that failing to account for the endogenous access to services biases the estimates. For example, a simple logit model suggests that having a hospital within 5 km of a village significantly reduces fertility. However, the effect becomes insignificant when placement is modeled, implying that areas with hospitals had low fertility due to unobservables factors. The authors apply the same approach to rural communities in Peru (Angeles, Guilkey and Mroz 2005) and find that, in this setting, the placement of family planning programs can be treated as and exogenous determinant of fertility. Their research shows that the direction and the magnitude of the placement bias depends on the setting as well as the type of facility considered.

In contrast, most papers that evaluate the effect of provider quality on contraceptive use do not address the issue of endogenous access (Feyisetan and Ainsworth 1996, Mensch, Arends-Kuenning and Jain 1996, Ali 2001, Hong, Montana and Mishra 2006, Arends-Kuenning and Kessy 2007, Yao, Murray and Agadjanian 2013). The approach commonly taken in the literature is to estimate a logit of the form $P(C_{ij} = 1) = \text{Logit}(\alpha_0 + \alpha_1 X_{ij} + \alpha_2 Q_j + \alpha_3 Z_j + \varepsilon_{ij})$, where C_{ij} is a dummy variable that is equal to one if woman i in cluster j is using a modern contraceptive method, X_{ij} is a vector of demographic variables (mainly her age, education, number of children, wealth, marital status and religion), Q_j is a vector of provider quality variables aggregated at the cluster level, and Z_j is a limited number of community controls (e.g. the average literacy rate or the availability of pipped water in the cluster). α_2 is the main coefficient of interest in this model: it captures a reduced-form effect of provider quality on contraceptive use if $\text{E}[Q_j \varepsilon_{ij}] = 0$. However, there could be a correlation between access to quality and the unobserved determinants of contraceptive use for many reasons, including the endogenous placement of providers, selective migration or the targeting of quality improvement programs.

Another limitation of the existing literature is that the choice of provider is not modeled. Quality variables are first defined for each provider, then aggregated in some way at the cluster level to proxy the quality of the health care environment (Q_j). Some papers simply take the quality of the nearest provider in each cluster (Feyisetan and Ainsworth 1996, Hong, Montana and Mishra 2006). Others combine the quality of the nearest provider of each type (e.g. the nearest hospital, clinic and dispensary) in varying ways (Mensch, Arends-Kuenning and Jain 1996, Ali 2001, Arends-Kuenning and Kessy 2007). But Klemick, Leonard and Masatu (2009) show that households often bypass the nearest provider to improve the care that they receive. Their study was conducted in Arusha, a rural region of Tanzania that has few clinicians, sparse rural road networks and low population densities, similar to many regions in Sub-Saharan Africa.

Another aggregation method is to average the quality of all providers within a given distance of a cluster (Cronin, Guilkey and Speizer 2016*a*). But variation in distance within this buffer area are not taken into account, and low quality providers necessarily reduce the cluster average, even if women are less likely to choose them. Yao, Murray and Agadjanian (2013) go one step further by taking a weighted average of provider variables within a given radius, where weights are the inverse of distance to capture the fact that farther providers are less likely to be visited. But a cluster with several low quality providers nearby and a few good providers (possibly attracting many contraceptive users) will still be assigned a low quality score. In addition, the weight assigned to each facility is a function of distance only and the distance decay function is arbitrarily chosen.[5]

Conceptually, a woman's reproductive or health outcomes are affected by the presence of a health facility to the extent that she is likely to visit it (aside from externalities or other indirect effects). Thus, the probability of choosing a facility must be correctly modeled to determine its impact on the individual. Rather than explicitly modeling the choice of providers, the existing literature relies on simplifying assumptions that could bias results.[6] This paper takes a novel approach by explicitly modeling the choice of providers, along with contraceptive use and sexual activity. Intuitively, when deciding to use modern contraceptives, a woman takes into account individual factors as well as the quality and cost associated with each provider. The quality of a provider affects the satisfaction she derives from a visit and how effectively she uses her contraceptive method. Thus, improving provider quality raises the option value of using contraceptives, and providers that are higher in her choice list are more likely to affect her reproductive outcomes.

2.2 Quality of Care Framework

Bruce (1990) developed a framework to evaluate the quality of family planning services that is a standard in the field of family planning. It includes six aspect of services that are essential to clients: choice of methods, information given to users, technical competence, interpersonal qualities, continuity mechanisms and appropriate constellation of services.

Choice of methods refers to the variety of methods that are offered on a reliable basis by the provider. It is an essential aspect of services because reproductive needs vary along the life cycle (e.g. from wishing to delay childbearing, to spacing births, then terminating childbearing) and side effects vary by method. The second aspect of quality is the information given to users (e.g. how to use a given method, possible side effects, etc.), which affects how effectively a client will use her method. Technical competence refers to the knowledge and skills demonstrated by providers and the adherence to best-practice protocols. Interpersonal qualities are "the vehicle by which technical care is implemented and on which its success depends" (Donabedian 1988)—for example, whether the provider demonstrates empathy, honesty, and respect towards clients, seeks to establish a dialogue, encourages questions, and so on. Interpersonal qualities affect the satisfaction derived from seeing a provider, but also the transfer of information and user compliance, and therefore the effectiveness of using contraceptives. Continuity mechanisms are the systems in place to follow up clients after

[5] In the general case of Inverse Distance Weighting, the weight assigned to facility f is $w_f = 1/d_f^k$, where d_f is the distance to f and $k \in \mathbb{R}^+$. A special case is $k = 0$ (Cronin, Guilkey and Speizer 2016*a*) and $k = 1$ (Yao, Murray and Agadjanian 2013).

[6] For example, the probability of choosing a provider P_f is equal to one if f is the nearest facility and zero otherwise (nearest provider approach), P_f is the same for all facilities within a buffer area and zero beyond (simple average approach), or $P_f = (1/d_f^k)/(\sum_F 1/d_{f'}^k)$ (Inverse Distance Weighting).

a visit and to ensure the continuity of care, such as follow-up calls, appointments or home visits. Finally, an appropriate constellation of services refers to integrating family planning with other health services to better serve the reproductive and health needs of women (e.g. by combining family planning with prenatal advice, postnatal care and child health services).

Empirically, these six aspects of services have formed a useful framework to construct quality indicators. For example, choice of methods is typically measured by the number of methods in stock, technical competence by one's training in family planning, and appropriate constellation of services by the number of other Maternal and Child Health (MCH) services offered (Mensch, Arends-Kuenning and Jain 1996, Magnani et al. 1999, Arends-Kuenning and Kessy 2007). Likewise, I use the Bruce framework to define standard quality indicators based on the data available (see section 4.3). This framework also informs how provider quality enters in the model—it affects the satisfaction derived from a visit and how effectively a woman uses her contraceptive method (see section 3).

2.3 Urban Senegal Context

Senegal is a francophone country in West Africa with a rapidly growing population: the total fertility rate is five children per women and the population has grown from three million in 1960 to fifteen million in 2016 (World Bank Open Data). It enjoys a stable political environment, marked by the peaceful transition of power since gaining its independence in 1960. Nearly half of the population is living in urban areas and a quarter in the region of Dakar, the capital (Senegal Census Data 2013). The country is located in the Sahel, a region to the south of the Sahara with a semi-arid climate and a predominantly muslim culture.[7] The study of contraceptive use and fertility in this region is of particular interest since Sahelian countries, including Senegal, Mauritania, Mali, Niger, Chad, South Sudan and Eritrea, are among the countries with the highest fertility rates in the world.

The rest of this section uses the MLE data collected in Dakar, Mbour and Kaolack at baseline (2011) to describe elements of the urban Senegal context that are relevant to my model. Table 1 shows that there is limited sexual activity and contraceptive use outside of marriage in Senegal. Hence, the structural model focuses on married women. Just 24.1% of married women use a modern form of contraception (compared to 58% in the United-States, Population Reference Bureau 2015). Among this group of users, the most popular methods are injectables (40.3%), followed by pills (35.6%), implants (7.9%), condoms (7.0%) and IUDs (5.1%).

The educational attainment of married women is limited in urban Senegal. 46.2% have no education, 35.5% have primary education, 15.6% have secondary education and merely

[7] 96.1% of the population in Senegal is muslim (EDS-Continue 2015).

Table 1: Sexual Activity and Contraceptive Use at Baseline (%)

	Single	Married	All
Sexually active	4.5	82.9	45.5
Modern method	3.8	24.1	15.1
Traditional method	0.2	2.6	1.6
Observations	4284	5330	9614

2.7% have tertiary education. Education remains generally constant after marriage, thus it is treated as a permanent characteristic of married women in my model.

The data suggests that there is a desire to limit or space births among married women, despite the low prevalence of contraceptives. 60.2% of married women report an ideal number of children between three and six, and 90.5% prefer to have a two to four year interval between births. Less than 1% desire a birth interval shorter than two years. In addition, 25.6% of married women who are pregnant report that their pregnancy was unwanted when it occurred (likely a lower bound because of the sensitivity of the question). Among married women who are not pregnant, 24.6% are sexually active, not using any type of modern contraceptives, but state that it would be an issue if they became pregnant in the coming weeks. The main reasons they provide for not using contraceptives are fear of side effects (24.2%), currently breastfeeding (20.1%), health issues (11.1%), personal opposition (11.8%) and partner's opposition (11.4%).

Finally, there are widespread misconceptions about the harmfulness of contraceptives. A significant share of married women believe that people who use contraceptives end-up having health issues (58.5%); that injectables cause irreversible sterility (32.4%); and that contraceptives can hurt the uterus (35.3%), cause cancer (21.6%) or birth defects (20.2%). These descriptive results suggest that a family planning awareness campaign could have a large impact on contraceptive use by addressing misconceptions about the harmfulness of contraceptives.

3. Model

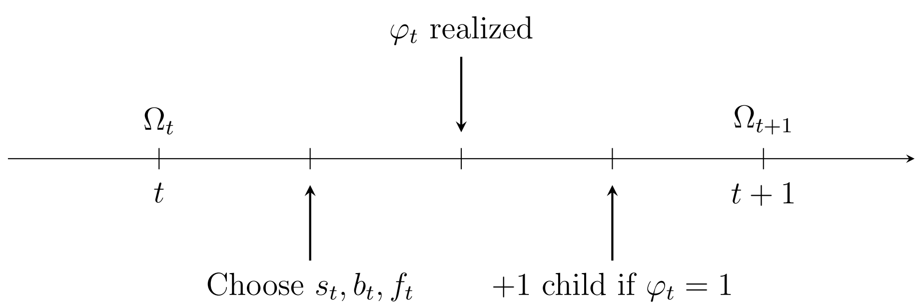
3.1 Environment and choice set

The agents in the model are married women living in the cities of Dakar, Mbour and Kaolack. A woman makes reproductive decisions annually starting at the age of marriage until she becomes infecund at a fixed age, assumed to be 47. The variables that denote her choices are:

- s_t: sexually active (1) or not (0) at time t
- b_t: using a modern birth control method (1) or not (0) at time t
- f_t: if she opts for birth control, she selects a facility f among all the health facilities that offer a contraceptive method within 7 km of her dwelling place at time t[8]

The agent chooses a combination of s_t, b_t and f_t at the beginning of the period based on her state variables Ω_t. Let $j \in \{1, 2, \ldots, J\}$ denote her choice combination among all the possible choice combinations. To reduce the number of choices, the agent is assumed to use birth control in period t only if she is sexually active during that period. Hence, her options are to be abstinent (option 1), to have unprotected sex (option 2), or to have protected sex (options 3 to J). Having protected sex is associated with selecting a contraceptive provider, therefore the size of the choice set is equal to 2 plus the total number of providers within 7 km.[9]

After making her reproductive and provider choices, the agent becomes pregnant ($\varphi_t = 1$) with a probability that depends on her sexual activity, birth control status and other reproductive factors. If a pregnancy occurs, she enters the next period with an additional child.[10] The timing of the model is summarized below:



3.2 State Variables

The agent observes the following state variables at the beginning of the period, before making her choices:

- t: age
- n_t: number of children

[8]The threshold is discussed in the data section 4.2.

[9]The size of the choice set varies across women, with a maximum of 129 providers (see section 4.2 for more details).

[10]For simplicity, the model assumes that all pregnancies are carried to term. Likewise, the death of a child is a rare occurrence that is not modeled. The under-five mortality rate is 47 per 1000 live births in Senegal and is likely lower in urban areas (World Bank Open Data 2015).

- φ_{t-1}: pregnant (1) or not (0) in the last period
- φ_{t-2}: pregnant (1) or not (0) two periods ago
- p_{ft}: price of pills and injectables at facility f at time t, averaged[11]
- d_{ft}: Euclidean distance from the facility f to her dwelling place at time t
- q_{ft}: index measuring from 0 to 1 the quality of family planning services provided by facility f at time t
- e: level of education, equal to none (0), primary (1) or secondary and above (2)
- χ: indicator function for having a good quality provider ($q_{ft} > 0.8$) within a kilometer of her dwelling place at baseline (a measure of access to quality)
- ζ: number of ISSU activities ever exposed to, from 0 to 6 (radio programs, television programs, home visits, community conversations, neighborhood groups and religious talks)
- a_k: dummies that indicate whether she got married before the age of 17 ($a_0 = 1$), between 17 and 22 ($a_1 = 1$), or after 22 ($a_2 = 1$)
- μ: her permanent type, which is known to the woman but unobserved by the econometrician

Provider variables (p_{ft}, d_{ft}, and q_{ft}) are taken from the data as given. The agent updates them in each period and make a no-change forecast when computing the future value of her choices. My assumption is that women do not take into consideration future changes in the supply environment when making their current reproductive decisions. Modeling the evolution of the supply environment (e.g. in a general equilibrium setting, with women's choices affecting the price and quality of services) would be computationally burdensome and would not change the agent's optimization problem under this assumption.[12]

[11]Three quarter of married women who use birth control at baseline choose pills or injectables.

[12]The main benefit would be to expand the range of feasible counterfactual experiments. For example, in section 7, I increase the quality of services in 2011 to the maximum and simulate women's choices until the age of menopause. In this experiment, quality is increased and maintained at the same level over time. With a general equilibrium model, one could simulate a one period increase in quality and let the system evolve. Quality might deteriorate over time as a result of an increase in demand, which would mitigate the initial increase in contraceptive use.

3.3 Preferences

In each period, the utility associated with choice j and state variable Ω_t is defined by the following function:

$$
\begin{aligned}
u_j(\Omega_t) = \alpha_1 s_t + b_t \Bigg[\alpha_2 + \sum_{k=1}^{K} \alpha_{2,k} I(\mu = k) + \alpha_3 q_{ft} + d_{ft} \left(\alpha_4 + \sum_{k=1}^{2} \alpha_{4,k} I(e = k) \right) \\
+ p_{ft} \left(\alpha_5 + \sum_{k=1}^{2} \alpha_{5,k} I(e = k) \right) + \alpha_6 \zeta \Bigg] \\
+ n_t \left(\alpha_7 + \sum_{k=1}^{2} \alpha_{7,k} I(e = k) + \sum_{k=1}^{K} \alpha_{7,k+2} I(\mu = k) \right) \\
+ n_t^2 \left(\alpha_8 + \sum_{k=1}^{2} \alpha_{8,k} I(e = k) + \sum_{k=1}^{K} \alpha_{8,k+2} I(\mu = k) \right) \\
+ \varphi_t \left[\alpha_9 + \sum_{k=1}^{2} \alpha_{9,k} I(e = k) + \alpha_{10} t + \alpha_{11} \varphi_{t-1} + \alpha_{12} (1 - \varphi_{t-1}) \varphi_{t-2} \right]
\end{aligned} \tag{1}
$$

α_1 is the marginal utility of having sex and α_2 is the marginal disutility of using contraceptives, which varies by type μ and captures such things as the inconvenience of using contraceptives, the fear of side effects, personal opposition, and so on. This disutility is allowed to decrease with the quality of her provider (α_3) and to increase with the distance traveled and the price paid to obtain contraceptives (α_4, α_5). The sensitivity to price and distance depend on a woman's level of education to capture possible income effects. In addition, I allow for the exposure to media and community interventions to permanently shift the disutility associated with contraceptives (α_6). Fertility preferences are captured by α_7 and α_8, and vary by education and type. The quadratic in n_t allows for the marginal utility of children to increase initially, then decrease passed the agent's ideal family size. If a woman is pregnant, she incurs a cost of pregnancy (α_9), which varies by education to capture the opportunity cost of bearing children. The cost of pregnancy may increase with age (α_{10}) and if her last pregnancy was one period ago (α_{11}) or two periods ago (α_{12}).

The basic mechanisms of the model are enshrined in the utility function: women tend to have unprotected sex at the beginning of their married life because the marginal utility of having sex and having a first child are both positive.[13] After a child is born, women may wish to delay their next pregnancy to avoid closely spaced births or to limit their family size.

[13]The utility function initially included a duration of marriage variable and allowed for women to be married for a certain number of years before wanting to have children. This variable was later dropped because practically no one uses contraceptives before having their first child in the data.

Abstinence provides perfect protection but women must forgo α_1. The other option is to use birth control, which reduces the probability of pregnancy but is associated with a utility cost. The decision to use birth control will depend in part on the quality of the providers that are available to women, as well as the price and travel cost associated with each provider.

3.4 Pregnancy

Denote $P_j(\Omega_t)$ the probability of becoming pregnant in period t as a function of choice j and state variables Ω_t. It is modeled according to the following logit specification:

$$\ln\left[\frac{P_j(\Omega_t)}{1-P_j(\Omega_t)}\right] = \begin{cases} 0 \quad \text{if } s_t = 0 \text{ or } t \geq 47 \\ \lambda_0 + \lambda_1 t + \lambda_2 t^2 + \lambda_3 \varphi_{t-1} + b_t(\lambda_4 + \lambda_5 q_{ft}) \quad \text{if } s_t = 1 \\ \qquad \text{and } t < 47 \end{cases} \tag{2}$$

The probability of pregnancy is equal to zero if the agent abstains from having sex or reaches the age of 47. Otherwise, the probability of pregnancy depends on a quadratic in age to capture the decline in fecundity towards the end of the reproductive life cycle. Women who were pregnant in the last period are less likely to become pregnant due to breastfeeding (λ_3). Using birth control also reduces the probability of pregnancy (λ_4), with an effectiveness that depends on the quality of the contraceptive provider (λ_5).

3.5 Initial Conditions and Types

Agents are assumed to start their reproductive life once they get married because there is little sexual activity and contraceptive use outside of marriage in Senegal. The initial number of children in the model is therefore zero. However, the age of marriage may be endogenous. For example, women with stronger fertility preferences may choose to get married younger. The model controls for this by allowing the age of marriage of a woman to determine her unobserved type, which shifts her fertility and contraceptive preferences in the utility function. Denote $P(\mu = l)$ the probability that the agent is type $l \in \{0, 1, \ldots, K\}$. Type probabilities are modeled according to a multinomial logit specification (Shen 2009, Keane and Wolpin 2010), where the coefficients for type zero are normalized to zero:

$$\ln\left[\frac{P(\mu = l)}{P(\mu = 0)}\right] = \tau_0^l + \sum_{k=1}^{2} \tau_{1,k}^l I(e = k) + \sum_{k=1}^{2} \tau_{2,k}^l I(a_k = 1) + \tau_3^l \chi + \tau_4^l \zeta \tag{3}$$

Types probabilities depend on a woman's level of education and age of marriage. In addition, access to quality and exposure to family planning programs may be correlated with the unobserved determinants of contraceptive use and fertility. χ and ζ are included in the type equation to control for these endogenous relationships, which are discussed in more detail in the identification section 5.2.

3.6 The Optimization Problem

The agent is forward-looking and assumed to maximize, at each age, the present value of her expected lifetime utility from that age onward. The optimization problem can be defined recursively in a dynamic programming framework. Let $v_j(\Omega_t)$ be the conditional value function, the expected present value of the remaining lifetime utility associated with choice j. A woman in state Ω_t will chose the choice combination j that gives her the highest utility $v_j(\Omega_t) + \varepsilon_{jt}$, where ε_{jt} is a Generalized Extreme Value (GEV) preference shock and $v_j(\Omega_t)$ is equal to:

$$v_j(\Omega_t) = P_j(\Omega_t)\Big[u_j(\Omega_t|\varphi_t = 1) + \delta V(\Omega_{t+1}|\Omega_t, \varphi_t = 1)\Big] + (1 - P_j(\Omega_t))\Big[u_j(\Omega_t|\varphi_t = 0) + \delta V(\Omega_{t+1}|\Omega_t, \varphi_t = 0)\Big] \tag{4}$$

$u_j(\Omega_t)$ is the per-period utility of choice j, $P_j(\Omega_t)$ is the probability of pregnancy conditional on choice j, δ is the discount factor, and $V(\Omega_{t+1})$ is the continuation value or future value function, which is the expected value of the best option in the next state:

$$V(\Omega_{t+1}) = \mathrm{E}\max_j \Big[v_j(\Omega_{t+1}) + \epsilon_{jt+1}\Big] \tag{5}$$

Equation 4 shows that the value of choice j is the sum of two terms. The first term is the probability of becoming pregnant conditional on j times the value of pregnancy—the current utility of being pregnant $u_j(\Omega_t|\varphi_t = 1)$ plus the discounted expected value of having a child in the next period $\delta V(\Omega_{t+1}|\Omega_t, \varphi_t = 1)$). The second term is the probability of avoiding a pregnancy conditional on j times the value of not being pregnant.

Denote $p_j(\Omega_t)$ the probability of choosing j conditional on state Ω_t. The GEV assumption on ε_{jt} provides an analytical solution for the conditional choice probabilities. In the simple logit case:

$$p_j(\Omega_t) = \frac{e^{v_j(\Omega_t)}}{\sum_J e^{v_j'(\Omega_t)}} \tag{6}$$

A well known limitation of logit probabilities is the IIA assumption. In this case, adding a new provider to the choice set would reduce the probability of all other choices (including the probability of being abstinent or having unprotected sex) by the same percentage. A more realistic assumption is that provider choices are correlated: women compare the value of the best providers to the value of abstinence ($j = 1$) and unprotected sex ($j = 2$) when making their choices. The correlation among provider choices can be capture parsimoniously with a nested logit error structure, where the conditional choice probabilities are:

$$p_j(\Omega_t) = \frac{e^{v_j(\Omega_t)}}{e^{v_1(\Omega_t)} + e^{v_2(\Omega_t)} + \left(\sum_{j=3}^{J} e^{v_j(\Omega_t)/\rho}\right)^{\rho}} \quad \text{for } j \in \{1, 2\}$$

$$p_j(\Omega_t) = \frac{e^{v_j(\Omega_t)/\rho}\left(\sum_{j=3}^{J} e^{v_j(\Omega_t)/\rho}\right)^{\rho-1}}{e^{v_1(\Omega_t)} + e^{v_2(\Omega_t)} + \left(\sum_{j=3}^{J} e^{v_j(\Omega_t)/\rho}\right)^{\rho}} \quad \text{for } j \in \{3, \ldots, J\} \tag{7}$$

where $1 - \rho$ is a measure of correlation among the provider nest. For $\rho < 1$, improving the attributes of a provider draws proportionately from other alternatives in the provider nest, but disproportionately from alternatives outside the nest. The GEV distribution also provides a closed-form solution for the value function:

$$V_j(\Omega_t) = \ln\left(\sum_{J} e^{e^{v_1(\Omega_t)} + e^{v_2(\Omega_t)} + \left(\sum_{j=3}^{J} e^{v_j(\Omega_t)/\rho}\right)^{\rho}}\right) + \gamma \tag{8}$$

where γ is Euler's constant. The solution to the optimization problem can be regarded as solving v_j for all choices and reachable states. I close the model by assuming that women die at the age of 70 (the life expectancy of women in urban Senegal, Senegal Census Data 2013) and setting the continuation value equal to zero in the terminal period. The solution method proceeds by backwards recursion starting at $T = 70$.[14] Equation 4 provides a scalar value for all $v_j(\Omega_T)$ since $V(\Omega_{T+1})$ is equal to zero. It is then possible to compute $V(\Omega_T)$ for all states in period T using equation 8. Given $V(\Omega_T)$, I can compute all $v_j(\Omega_{T-1})$ in period $T - 1$ with equation 4, and so forth the model is solved recursively back to the first period. Equation 7 provides the formula to compute the conditional choice probabilities once the model is solved.

[14]From age 47 to 70 the number of children is fixed and the only choices are to be sexually active or not.

4. Data

4.1 MLE Project

The Monitoring, Learning and Evaluation (MLE) project collected data from women living in Dakar, Mbour and Kaolack, three cities in Senegal. A multi-stage stratified sampling design was used to obtain a sample of women that was representative of each city at baseline (2011).[15] Women were then tracked and interviewed at endline (2015), with an additional sub-sample interviewed at midterm (2013) in three suburbs of Dakar (Guédiawaye, Pikine and Mbao). In each survey round, information was collected on fertility preferences, reproductive behavior, the choice of contraceptive providers, and the history of births.

In addition, a list of all pharmacies and health facilities offering reproductive health services was established in each city based on official registries and field investigation. They were audited in 2011 and 2015 to gather information on MCH services, contraceptive prices, management practices and staff qualification. In each health facility, up to four staff members involved in the delivery of reproductive health services were randomly selected and interviewed. Questions were asked regarding their qualifications, knowledge of family planning, and practices during family planning consultations. The major health facilities in each city—those who had a high-volume of activity, were well staffed and offered a wide range of methods—were also subject to client exit interviews. Fifty women were selected in each high-volume facility to collect information on their experience, following their reproductive health visit (e.g. questions asked by the provider, information given, etc.). Finally, women were linked to their contraceptive providers. Women who were using a modern method at the time of the survey reported the address of the health facility or pharmacy from which they last obtained their contraceptive. These addresses were then matched to the providers in our master list.

The purpose of the MLE project was to collect data to monitor and evaluate the ISSU project, which implemented supply-side and demand-side interventions between 2011 and 2015 in the three cities. All interventions started after the baseline data was collected. The supply-side interventions focused on training family planning providers in the public sector and implementing the Informed Push Model (IPM) to reduce stockouts. The IPM is a centralized distribution system where trained logisticians are responsible for contacting providers and re-supplying them in contraceptives on a regular basis.[16] The demand-side

[15]Clusters (the primary sampling unit) were first divided into poor and non-poor based on the overall characteristics of the cluster (types of houses, access to pipped water, etc.). An equal number of poor and non-poor clusters were then selected in each city with a probability that was proportional to the size of each cluster. The urban poor were oversampled as a result. All the statistics provided in this paper are unweighted.

[16]Daff et al. (2014) describe in detail the IPM and how it resolved issues with the previous "pull-based"

interventions raised awareness of the benefits of family planning, discussed the acceptance of family planning by religious leaders, and addressed misconceptions about the harmfulness of contraceptives. The media component of the intervention included radio and television programs, and the community component included home visits, community conversations, neighborhood groups and religious talks.

All interventions ended in 2015, except for the IPM system, which was extended to the rest of the country after 2015. The interventions were well funded by the Gates Foundation and carried across the board in the three cities: 92.8% of public providers received the supply-side interventions, representing 93.7% of the contraceptive providers chosen by women in 2015. In addition, 85.5% of married women were exposed to at least one of the six media or community programs by 2015. The average level of exposure was 1.90 programs, with a quarter of married women exposed to more than two programs.

4.2 Sample Selection

The baseline sample includes 9614 women between the ages of 15 and 49, of which 6927 were successfully interviewed at endline.[17] The sample selection process is described in table 2. A woman does not need to be observed in both waves in order to make a contribution to the likelihood function, therefore the selection process starts with all 9614 women. At each step, I delete all person-year observations that do not meet the selection criterion. For example, if a women was single at baseline but married at endline, I keep her endline observation.

16 women were dropped because their age was largely inconsistent across the two waves, and 306 were dropped because they were older than 46 at baseline (the last decision period in the model). Some contraceptive users reported an incomplete address that could not be matched with the providers in our master list. These observations are currently deleted, but the next version of my paper will incorporate their contribution to the likelihood function (the probability of having protected sex) by summing the probability of choosing each possible provider. The next version of the model will also incorporate the choice of pharmacies to avoid dropping women who chose a pharmacy instead of a health facility. The majority of contraceptive users (95% at baseline and 97% at endline) chose a provider within 7 km of their dwelling place. Thus, limiting the choice of providers to a 7 km radius reduces the size of the choice set without loosing too many observations. Finally, women were deemed to be contraceptive users if they were using male condoms, pills, injectables, implants or IUDs at

system, which relied on providers traveling to a local warehouse and using their own cash on hand to buy contraceptives.

[17] 193 women were not eligible for a follow-up because they were just visiting the household at baseline. Of the 9421 eligible women, 81.46% were tracked in the study sites, 12.9% had moved out of the study sites, 0.8% were deceased and 4.8% were not followed up. The response rate among those who were tracked was 90.27%.

Table 2: Sample Selection Process

Reason	Dropped	Remaining
Age inconsistent	16	9598
Age above 46	306	9292
Single	3441	5851
Infecund	83	5768
Chose a pharmacy	67	5701
Missing provider link	164	5537
Missing GPS coordinates	1	5536
More than 12 children	3	5533
Chose provider beyond 7 km	28	5505
Abstinent but became pregnant	18	5487
Uncommon method	12	5475
Missing other variables	79	5396

the time of the interview. A few women were using less common methods (male or female sterilization, emergency contraception, spermicides, etc.) and were excluded from the sample.

The estimation sample is broken-down by city in table 3; the descriptive statistics provided in the remainder of the paper are based on this sample of women and providers. Half of the women were living in Dakar at baseline. As the capital and largest city in Senegal, Dakar also had the largest number of contraceptive providers at baseline (122) and endline (182). The size of the choice set varies by city and across women. On average, women had 39 providers in their choice set at baseline and 54 providers at endline. The largest choice set includes 98 providers at baseline and 129 at endline.

Table 3: Estimation Sample

		Baseline Providers		Endline Providers	
City	Women	Total	Average Set	Total	Average Set
Dakar	2821	122	59	182	86
Mbour	1223	13	13	19	19
Kaolack	1352	26	22	27	24
Total	5396	161	39	228	54

4.3 Model Variables

Table 4 provides summary statistics for the demographic variables in the baseline estimation sample. A woman is considered sexually active if she had sex in the past three months. 82.7% of women are sexually active and 16.4% are using birth control. I do not model child death, thus n_t is equal to the number of births (2.96 on average). e is the highest level of education at baseline. I combine secondary and tertiary because only 2.9% of women had tertiary education.

Table 4: Demographic Variables at Baseline

Variable	Description	Average	Min	Max
t	Age	29.9	15	46
s_t	Sexually active	0.827	0	1
b_t	Using birth control	0.164	0	1
n_t	Number of children	2.96	0	12
φ_t	Pregnant in period t	0.196	0	1
φ_{t-1}	Pregnant in period $t-1$	0.218	0	1
$I(e=0)$	No education	0.436	0	1
$I(e=1)$	Primary education	0.368	0	1
$I(e=2)$	Secondary education	0.196	0	1
χ	Good access to quality	0.562	0	1
ζ	Campaign exposure[1]	1.90	0	6
a_1	Married before 17	0.191	0	1
a_2	Married between 17-22	0.515	0	1
a_3	Married after 22	0.294	0	1

[1]Endline exposure.

The timing of pregnancies is constructed by dividing the history of births into 12 month intervals. $\varphi_{t-2} = 1$ if a woman gave birth 12 to 24 months before the interview, $\varphi_{t-1} = 1$ if she gave birth in the 12 months preceding the interview, and $\varphi_t = 1$ if a child is born in the 12 months following the interview.

χ is a measure of access to quality. It is a dummy variable that equals one if the individual has a good quality provider (quality index greater than 0.8) within one kilometer at baseline. ζ is the number of ISSU programs that a woman was ever exposed to at endline, from zero to six (television programs, radio programs, home visits, community conversations, neighborhood groups and religious talks). Exposure is missing for women who were not followed up at endline. I impute exposure by regressing it on the baseline characteristics of women who were followed up.[18] Note that imputed values enter the likelihood function through the type

[18]I use the entire matched sample (6927 women) for this regression. The regressors are age, age squared,

equation: women who were not followed up after baseline only make a one-period contribution to the likelihood function and do not directly affect the estimation of α_6.

Table 5 provides summary statistics for the quality and price variables in the estimation sample. In order to construct the quality index, I divide each quality indicator by its maximum value and take the average. The six quality indicators are standard in the family planning literature and based on the Bruce framework described in section 2.2. The first indicates how many of the main methods (condoms, pills, injectables, implants and IUDs) are offered by the provider. The second is a dummy variable that equals one if pills and injectables are currently in stock. In each health facility, the family planning personnel was asked if a woman had to be within a certain age range, have a minimum number of children, or her husband's consent in order to receive contraceptives. The third quality indicator is the percentage of family planning employees who do not impose any of these restrictions on clients. Together, these first three indicators capture the choice of methods in the Bruce framework. The fourth indicator is the percentage of family planning employees who received a training in family planning in the past three years, a measure of technical competence. The fifth indicator is the number of other MCH services that are offered at the health facility, which captures the constellation of services.[19] The last indicator is a dummy variable that equals one if basic medical material (speculum, tenaculum, sponge clamps, antiseptic, cotton and gloves) is available at the health facility.

Table 5: Quality and Price Variables

	Baseline Average	Endline Average	Min	Max
Number of methods	4.06	4.55	1	5
Pills or injectables in stock	0.913	0.965	0	1
No restrictions	0.492	0.756	0	1
Recently trained	0.598	0.541	0	1
Number of other MCH services	7.89	7.80	2	11
Basic medical material	0.522	0.632	0	1
Quality index	0.676	0.752	0	1
Price	0.296	0.283	0	2.25
Observations	161	228		

number of children, number of children squared, marital status, and two dummy variables that indicate whether the individual heard family planning information on the radio and on television at baseline.

[19]This indicator includes eleven MCH services: prenatal care, delivery, emergency obstetrics, postnatal care, post-abortion care, STI diagnostic and treatment, voluntary counseling and testing, and four types of child health services (vaccination, growth monitoring, respiratory illness and oral re-hydration therapy).

The price variable is the average price of injectable and pills in thousands of CFA francs.[20] Finally, the centroid of clusters and the exact location of providers were recorded by GPS, which allows me to compute the Euclidean distance from a woman's dwelling place to each contraceptive provider.[21] The average distance is 3.06 km at baseline and 3.13 km at endline, with a minimum of 0.01 km and a maximum of 7.00 km.

4.4 Provider Choice

It can be seen in table 5 that the supply environment has improved between 2011 and 2015: the number of providers increased from 161 to 228, while the price of contraceptives declined and the quality index increased on average. Figure 2 in the appendix provides the distribution of prices for public and private providers. Public providers were cheaper on average in both waves. In addition, the government passed a decree in 2010 to set the price of contraceptives in the public sector, which resulted in a convergence of prices among public providers by 2015. Table 6 indicates that 93.5% of users in 2011 and 98.0% of users in 2015 obtained their method from a public provider. The most common choice is the health post, a relatively small and public health facility.

Table 6: Types of Health Facilities (%)

	Baseline		Endline	
Type	Available	Chosen	Available	Chosen
Hospital	4.4	10.4	4.4	4.0
Health center	19.3	24.8	11.9	17.4
Health post	55.3	55.1	48.3	70.3
Other public	10.6	3.2	14.9	6.3
Private	10.6	6.5	20.6	2.0

Table 13 in the appendix shows that less educated women are more likely to choose providers that are cheaper and closer. Notably, contraceptive users with no education are more likely to choose the nearest provider than those with secondary education (37.0% versus 31.9% at baseline). Overall, the data suggests that distance is a large determinant of provider choices. For example, client exit interviews reveal that 60.8% of women travelled by foot to their reproductive health appointments, 21.4% used public transportation, 13.7%

[20] 1 dollar equals 500 CFA francs approximately.

[21] Clusters correspond to urban census tracts and cover small areas, typically the size of a neighborhood. Women who subsequently moved from their baseline cluster were tracked and the exact location of their new dwelling place taken by GPS. For simplicity, I refer to the location of a woman as her dwelling place in both cases.

employed taxis, 1.2% used a personal car, and 2.8% used a cart, motorcycle or other form of transportation in 2011.

Nonetheless, the majority of contraceptive users (66.1% in 2011 and 59.1% in 2015) bypass the nearest provider to obtain better care. Those who bypass the nearest provider choose a provider that is on average 1.13 km farther, offers 0.67 more methods and 1.16 more MCH services in 2011 (table 7). In addition, these providers are more likely to impose no restrictions (+1.3 percentage points), have a higher percentage of recently trained staff (+7.1 percentage points) and are more likely to have basic medical material available (+1.5 percentage points).

Table 7: Nearest vs. Chosen Provider in 2011
(Among Users Who Bypass)

	Nearest	Chosen
Number of methods	3.80	4.47
Pills or injectables in stock	0.948	0.929
No restrictions	0.513	0.526
Recently trained	0.597	0.668
Number of other MCH services	7.84	8.99
Basic medical material	0.587	0.602
Quality index	0.686	0.739
Distance	0.50	1.63

5. Estimation

5.1 Likelihood Function

Given a vector of parameters θ, the likelihood function for woman i conditional on her type μ is:

$$\mathcal{L}_i(\theta|\mu) = \prod_t \prod_j \left[p_j(\Omega_{it}, \theta|\mu) P_j(\Omega_{it}, \theta|\mu)^{\varphi_{it}} (1 - P_j(\Omega_{it}, \theta|\mu))^{(1-\varphi_{it})} \right]^{d_{ijt}}$$

where d_{ijt} is a dummy that is equal to one if individual i chooses j at time t. The likelihood of the observed data is a weighted average of type-specific likelihood functions, multiplied across individuals:

$$\mathcal{L}(\theta) = \prod_i \sum_{k=0}^{K} P(\mu = k) \mathcal{L}_i(\theta|\mu = k)$$

θ is estimated by maximizing the likelihood function with a Quasi-Newton algorithm. At each iteration, a line search is performed in a direction determined by the negative inverse Hessian times the gradient of $\mathcal{L}$, where the Hessian is approximated using the Broyden, Fletcher, Goldfar, and Shanno (BFGS) method. Standard errors are computed by estimating the asymptotic covariance matrix of the maximum likelihood estimator with the Outer Product of the Gradient (OPG) method.

5.2 Identification

The parameters of the utility function are identified by covariation in sexual activity, contraceptive use and provider choices across the state space. For example, the birth spacing parameters (α_{11} and α_{12}) are identified by observing women who are otherwise comparable choosing different combinations of choices, depending on how recently they gave birth. The key parameters of interest are α_2 through α_6, which capture the effect of the supply environment and family planning programs in the utility function. There are two potential sources of endogeneity that must be addressed in this regard.

First, access to quality might be correlated with the unobserved determinants of contraceptive use for various reasons discussed in section 2.1. To illustrate this point, suppose there are two types of women. Type one is less likely to use contraceptives due to some fixed unobservable characteristics. In addition, type one is more present in underserved areas where provider quality is generally lower. In this case, there is a spurious positive correlation between contraceptive use and access to quality. As discussed in the literature review, the common approach of aggregating quality at the cluster level, controlling for a limited number of community variables, would bias results.

In contrast, my model controls for permanent unobserved differences in the disutility of contraceptives (e.g. personal opposition, fear of side effects) and in fertility preferences (e.g. stronger taste for children) with a discrete number of unobserved types. Access to quality determines the unobserved type of a woman, which shifts her fertility and contraceptive preferences in the utility function. This allows for a correlation between access to quality and the unobserved shifters of contraceptive use.

The second issue is that exposure to family planning programs could be correlated with unobserved determinants of fertility and contraceptive preferences. For example, community activities could be targeted towards women with stronger fertility preferences. This can be controlled for by explicitly modeling the probability of exposure as a function of observable characteristics (age, education, number of children, etc.) and unobserved types. Note that, by taking the inverse, one obtains type probabilities as a function of exposure. That is, the level of exposure to the intervention at endline provides information on a woman's unobserved type. I exploit this information by allowing exposure (ζ) to affect type probabilities in equation 3.

This controls for the correlation between the exposure to family planning programs and the unobserved determinants of fertility and contraceptive preferences in a reduced-form way.

6. Results

6.1 Parameter Estimates

Table 14 (appendix) reports the estimates and standard errors of the parameters in the utility function. The model is currently fit with two types. Type zero has a larger disutility of using contraceptives (-7.161) than type one (-1.586). In addition, type zero women have weaker fertility preferences: the quadratic in the number of children has little curvature between 0 and 9 children. Thus, their reproductive choices are mainly driven by the marginal utility of having sex and the cost of pregnancy (including the cost of having closely spaced births) rather than family size.[22] As expected, the parameters associated with price and distance are negative and larger for women with no education, while the parameters associated with provider quality and family planning programs are both positive. Finally, women dislike having closely spaced births (α_{11} and α_{12} are negative and large), and ρ is equal to 0.361, indicating that provider choices are correlated.

Table 15 (appendix) reports the estimates and standard errors of the parameters in the pregnancy equation. The probability of pregnancy decreases with age, if a woman gave birth in the last period, and if she uses birth control. Provider quality increases the effectiveness of birth control, but the effect is small and not significant.

Table 8: Characteristics by Predicted Type

	Type 0	Type 1
No education	48.1	41.0
Primary	31.6	39.7
Secondary	20.2	19.3
Married before 17	25.0	15.8
Married between 17-22	49.1	52.9
Married after 22	26.0	31.4
Good access	53.6	57.7
Exposure[1]	1.89	1.91
Sample percentage	36.3	63.7

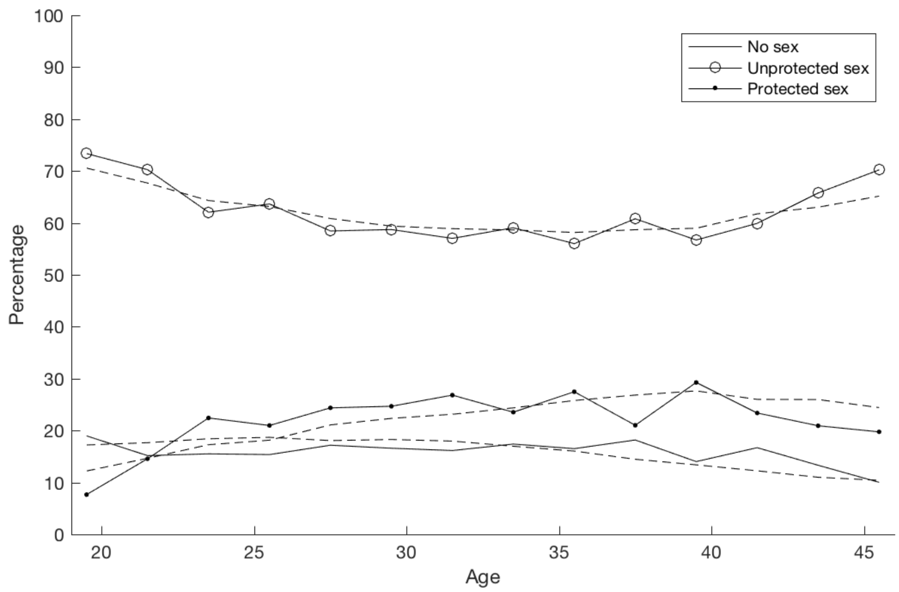
[1]Number of activities. All other characteristics are in percentage.

[22]There is evidence for this type of behavior in the data. For example, a quarter of married at baseline hadn't thought about the number of children that they wanted to have or were leaving it up to God to decide.

Table 16 (appendix) provides the parameter estimates of the type equation, with type zero parameters normalized to zero. Type one women are more likely to have primary education and get married latter. They also tend to have better access to quality, but are not significantly more likely to have secondary education or be exposed to family planning programs. Table 8 shows the average characteristics of women by simulated type, where types are drawn 200 times for each woman. Type one represents 63.7% of the simulated sample.

6.2 Model Fit

Figure 1: Choices



I assess the model fit by comparing the predictions of the model to the proportion of women who choose to be abstinent, have protected sex or unprotected sex in the data. Baseline and endline observations are pooled, and model predictions are obtained by simulating choices 200 times for each woman, conditional on her observed state variables in each period. Figure 1 shows the percentage of women who make each choice in the data (solid lines) and the simulated sample (dashed lines), averaged over two-year age bins.[23]

The model fits the data well. It can be seen in figure 1 that contraceptive use is low at younger ages and increases over the life cycle. This pattern is consistent with the parameter estimates, which imply that the cost of pregnancy increases with age and the marginal utility of children decreases with parity. On the other hand, the probability of pregnancy declines with age, which explains the uptake of unprotected sex towards the end of the reproductive

[23]The sample of married women under 19 is too small to be displayed by age in figure 1 and 4, but is included in the other model fit figures and tables.

life cycle. Figure 3 (appendix) shows that contraceptive use increases with the number of children. Notably, women do not use contraceptives before having their first child. The model fit is also good for pregnancies (appendix figure 4). As expected, the percentage of pregnant women decreases over the life cycle.

Compared to women with no education, women with primary or secondary education are more likely to use contraceptives or be abstinent (table 9). Moreover, the model fits well the relationship between contraceptive use and access to quality (appendix table 17). Women who had a good quality provider within one kilometer at baseline ($\chi = 1$) were more likely to use contraceptives. Women who were exposed to at least two family planning programs at endline ($\zeta = 1$) were also more likely to use contraceptives.

Table 9: Choices by Education (%)

	Data	Model
No education		
Abstinence	14.2	14.4
Unprotected sex	66.0	65.8
Protected sex	19.8	19.8
Primary		
Abstinence	16.7	16.9
Unprotected sex	57.5	58.0
Protected sex	25.8	25.2
Secondary		
Abstinence	19.4	19.6
Unprotected sex	58.3	59.3
Protected sex	22.2	21.1

7. Policy Experiments

The estimated model allows me to simulate choices and pregnancies over the reproductive life of women, under different types of scenarios. Model predictions are obtained by simulating choices 200 times for each woman, conditional on her baseline state variables. I start by decomposing the increase in contraceptive use that occurred between 2011 and 2015 into three factors: women progressing through their life cycle (i.e. aging and having children), changes to the supply environment, and exposure to family planning programs.

The first line of table 10 shows the predicted percentage of contraceptives users at baseline, given the observed state variables in 2011. Next, I fix the supply and exposure variables to their baseline values and simulate reproductive choices from 2011 to 2015. In this simulation, the environment is kept constant and women are aging, which isolates the effect of the first factor. In the next simulation, I update provider variables to their endline value in 2013.[24] Exposure variables are kept to their baseline values (zero) in order to isolate the effect of the second factor. In the last simulation, I update both the provider and exposure variables in 2013. I find that contraceptive use increased from 17.31% to 27.17% between 2011 and 2015, and that 2.9% of this increase can be explained by aging, 22.5% by changes in the supply environment, and 74.5% by the awareness campaign.

Table 10: Effect Decomposition

	Users (%)
Baseline	17.31
Endline	17.60
Supply change	19.82
Supply change and exposure	27.17

In the next set of simulations, I evaluate the maximum impact of the most common family planning interventions: implementing an awareness campaign, reducing contraceptive prices, and increasing the quantity and quality of providers. I apply the endline environment (supply and exposure) to the baseline sample of women as a starting point to these simulations, in order to approximate the current state of Dakar, Mbour and Kaolack.[25]

First, I simulate the reproductive choices of women from the age of interview until menopause, keeping the supply and exposure variables constant (reference). Table 11 reports the predicted percentage of contraceptive users in the first period, as well as the average number of children per women at the end of the simulation. Next, I repeat the simulation under the following scenarios: contraceptives are free, all providers have the maximum level of quality (index equals one), there is no distance to travel to obtain contraceptives, and all women receive the six family planning programs. The goal is to evaluate the maximum impact possible, the upper-bound associated with each policy.

[24]I have limited data for the years between 2011 and 2015, so I approximate the gradual change in the supply environment by updating the provider variables halfway through this period, in 2013.

[25]The baseline sample is representative of married women in 2011. Differences with a current cross-section of married women would be driven by long term demographic trends (such as younger cohorts getting married later or achieving more schooling), which shouldn't change the main results of the policy experiments. The endline supply and exposure data is recent and should approximate well the current environment.

Table 11: Maximum Impact

	Current Users (%)	Completed Fertility
Reference	27.35	5.19
Price = 0	29.09	5.15
Quality = 1	29.57	5.14
Distance = 0	39.18	4.94
Exposure = 6	43.59	4.84
All	56.96	4.52

Table 11 indicates that offering contraceptives for free and increasing the quality index to the maximum for all providers would lead to a 6.4% and 8.1% increase in contraceptive use, respectively. Note that contraceptives prices are already low at endline (283 CFA on average for pills and injectables, table 5). The quality index is also high for many providers and equal to 0.752 on average at endline. Thus, the latter simulation should be interpreted as a 33.0% increase in the average quality of services.

The descriptive analysis in section 4.4 suggests that women are sensitive to travel costs, with the majority traveling by foot to their providers. In the extreme scenario where travel costs are entirely eliminated (for instance by delivering contraceptives through home visits), the percentage of contraceptive users increases by 43.2%. As a result, the average number of children per women declines from 5.19 to 4.94. Exposing all women to the six media and community programs (the average exposure was 1.90 at endline) would have the greatest impact, increasing contraceptive use by 59.4% and reducing the average number of children per women from 5.19 to 4.52.

These simulations suggest that the price and quality of services are not the main factors that currently limit contraceptive use in urban Senegal. Travel costs, which include the time and monetary cost of traveling to a provider, and cultural barriers are greater obstacles. The latter includes personal or spousal opposition and the fear of side effects, which could be addressed through family planning programs.

I design, based on these findings, a set of polices that would be more realistic to implement (table 12). The simulation approach and the reference are similar to the previous table. The first policy is to offer contraceptives for free in the public sector. The second is to ensure that all public providers have basic medical material available, that all family planning employees have received training in family planning in the past three years, and that none impose restrictions based on age, parity or spousal consent. This policy would increase the quality index by 23.7% on average. The third simulation is to reduce the distance to each provider by

25%, which is equivalent to reducing the total cost of traveling by 25%. It could be achieved by expanding the public transportation system, which is currently limited in urban Senegal. The fourth policy is to expand the awareness campaign so that all women are exposed to at least three of the six media and community programs.

Table 12: Policy Recommendations

	Current Users (%)	Completed Fertility
Reference	27.35	5.19
Price = 0 in public sector	28.68	5.16
Improved quality in public sector	28.33	5.16
25% less travel cost	29.17	5.15
Exposure ≥ 3	32.17	5.09
Quality + travel cost + exposure	35.28	5.03

The last line in table 12 shows that combining policy 2, 3 and 4 would increase contraceptive use by 29.0%. Note that this represents the impact on all married women between age 15 and 47 in the same year the policy is implemented. Table 18 (appendix) shows that these policies would have a greater impact on younger women. For women under the age of 23, combining policy 2, 3 and 4 would increase contraceptive use by 35.6% and reduce completed fertility by 0.27 children.

8. Conclusion

In this paper, I evaluate the impact of several large-scale family planning interventions on the fertility decisions of married women in urban Senegal. Between 2011 and 2015, the Gates Foundation funded a broad range of interventions in order to increase the number of contraceptive users in Dakar, Mbour and Kaolack, three cities in Senegal. Supply-side interventions aimed at improving the quality of public providers by reducing contraceptive stockouts and offering additional training in family planning. Demand-side interventions employed radio programs, television programs, and community outreach to address the benefits of family planning, acceptance by religious leaders, and misconceptions about the harmfulness of contraceptives.

These interventions were not randomized, but they generated considerable variation in the supply and demand for contraceptives, which can be captured with a structural model. I specify a dynamic discrete choice model of fertility in which a married woman can decide, at each age, to be sexually active and whether or not to use birth control. If she opts for birth control, she selects a contraceptive provider based on price, quality and distance among all the providers that are located within a given distance of her dwelling place. The quality of a provider affects the satisfaction she derives from a visit and how effectively she uses her contraceptive method, and therefore the probability of pregnancy. In addition, a woman can be exposed to six family planning programs (radio programs, television programs, home visits, community conversations, neighborhood groups and religious talks) that reduce her aversion towards contraceptives.

The model is estimated on a unique data set that includes all the contraceptive providers in Dakar, Mbour and Kaolack, linked to a longitudinal sample of married women in each city. The estimated model is then used to carry out several policy experiments. I start by decomposing into three different factors the increase in contraceptive use that occurred between baseline (2011) and endline (2015) in the longitudinal sample. During this four year period; (1) women progressed along their life cycle, aging and having children; (2) the supply environment changed, with an overall increase in provider quality, a decline in contraceptive prices, and an increase in the number of providers; (3) the demand-side interventions were implemented. Simulations shows that contraceptive use increased from 17.3% in 2011 to 27.2% in 2015, and that 2.9% of this increase can be explained by aging, 22.5% by changes in the supply environment, and 74.5% by the awareness campaign.

In the second set of simulations, I compare the impact of different policies on contraceptive use and fertility after 2015. I find that further price reductions and quality improvements would minimally increase the percentage of contraceptive users. On the other hand, reducing travel costs and cultural barriers could have a substantial impact on contraceptive use. There remain widespread misconceptions about the harmfulness of contraceptives in urban Senegal, which can be addressed by expanding the awareness campaign that was implemented between 2011 and 2015 in Dakar, Mbour and Kaolack.

A. Appendix

Figure 2: Distribution of Prices

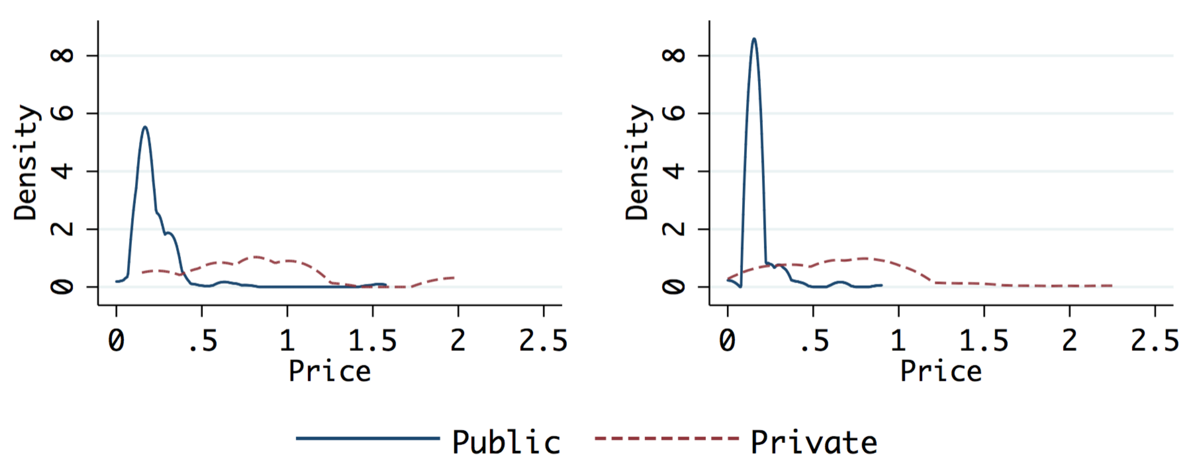


Table 13: Provider Choice by Education

	Baseline	Endline
Price (1000 CFA)		
No edu.	0.226	0.169
Primary	0.246	0.178
Secondary	0.268	0.205
All	0.242	0.179
Distance (km)		
No edu.	1.12	0.98
Primary	1.24	1.02
Secondary	1.31	1.17
All	1.20	1.03
Nearest (%)		
No edu.	37.0	45.7
Primary	32.0	40.4
Secondary	31.9	31.7
All	33.9	40.9

Table 14: Utility Function Estimates

Parameter	Description	Estimates	SE
α_1	s_t	2.113	0.3557
α_2	b_t	-7.161	1.549
$\alpha_{2,1}$	$b_t \times I(\mu = 2)$	5.575	1.4923
α_3	$b_t \times q_{ft}$	0.877	0.1686
α_4	$b_t \times d_{ft}$	-0.579	0.0989
$\alpha_{4,1}$	$b_t \times d_{ft} \times I(e = 1)$	0.057	0.0196
$\alpha_{4,2}$	$b_t \times d_{ft} \times I(e = 2)$	0.134	0.0304
α_5	$b_t \times p_{ft}$	-1.002	0.2169
$\alpha_{5,1}$	$b_t \times p_{ft} \times I(e = 1)$	0.294	0.1657
$\alpha_{5,2}$	$b_t \times p_{ft} \times I(e = 2)$	0.672	0.2044
α_6	$b_t \times \zeta_t$	0.337	0.0337
α_7	n_t	-0.500	2.5779
$\alpha_{7,1}$	$n_t \times I(e = 1)$	-0.047	0.4505
$\alpha_{7,2}$	$n_t \times I(e = 2)$	0.132	0.5316
$\alpha_{7,3}$	$n_t \times I(\mu = 2)$	1.515	0.3979
α_8	n_t^2	0.060	0.0199
$\alpha_{8,1}$	$n_t^2 \times I(e = 1)$	-0.005	0.0065
$\alpha_{8,2}$	$n_t^2 \times I(e = 2)$	-0.028	0.0122
$\alpha_{8,3}$	$n_t^2 \times I(\mu = 2)$	-0.130	0.0382
α_9	φ_t	-0.658	44.982
$\alpha_{9,1}$	$\varphi_t \times I(e = 1)$	-0.047	6.7412
$\alpha_{9,2}$	$\varphi_t \times I(e = 2)$	-0.044	8.1659
α_{10}	$\varphi_t \times t$	-0.105	0.2016
α_{11}	$\varphi_t \times \varphi_{t-1}$	-2.876	0.9857
α_{12}	$\varphi_t \times (1 - \varphi_{t-1}) \times \varphi_{t-2}$	-1.076	0.2365
δ	Discount factor	0.943	0.0215
ρ	Nest coefficient	0.361	0.0622

Table 15: Pregnancy Equation Estimates

Parameter	Description	Estimates	SE
λ_0	Constant	-3.784	0.7502
λ_1	t	0.273	0.0519
λ_2	t^2	-0.0054	0.0009
λ_3	φ_{t-1}	-0.949	0.1060
λ_4	b_t	-1.914	0.3598
λ_5	$b_t \times q_{ft}$	-0.181	0.4509

Table 16: Type One Parameter Estimates

Parameter	Description	Estimates	SE
τ_0	Constant	-0.075	0.1596
$\tau_{1,1}$	$I(e = 1)$	0.299	0.1187
$\tau_{1,2}$	$I(e = 2)$	-0.034	0.1443
$\tau_{2,1}$	$I(a_2 = 1)$	0.507	0.1223
$\tau_{2,2}$	$I(a_3 = 1)$	0.617	0.1384
τ_3	χ	0.160	0.0939
τ_4	ζ	0.004	0.0401

Table 17: Contraceptive Users (%)

	Data	Model
Baseline		
Poor Access	14.2	15.3
Good Access	18.1	18.9
Endline		
Low Exposure	25.8	22.2
High Exposure	33.2	31.8

Figure 3: Choices by Number of Children

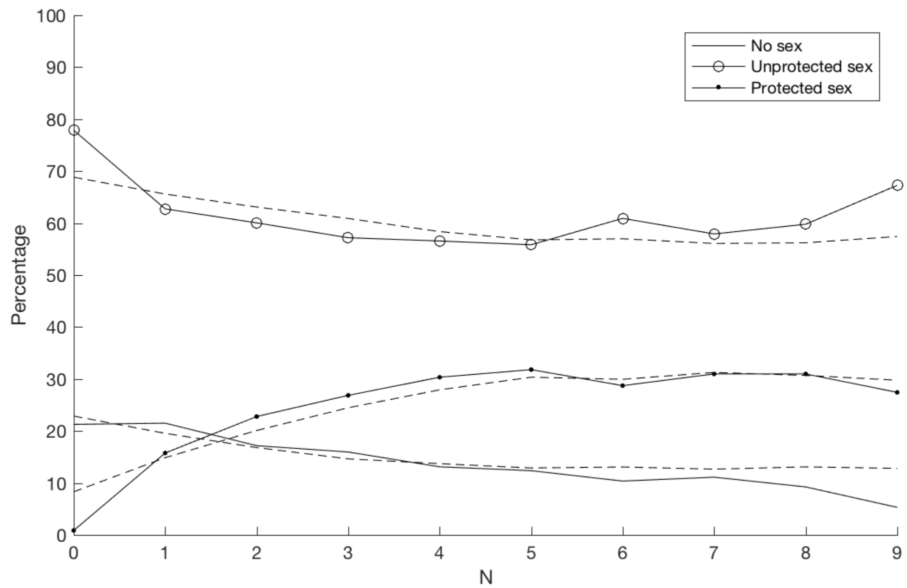


Figure 4: Pregnancies at Baseline

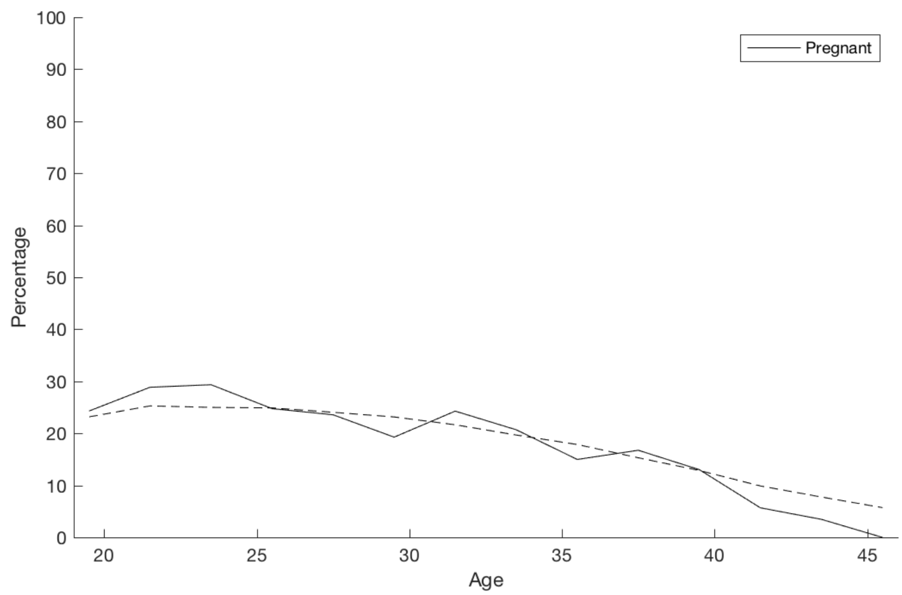


Table 18: Policy Recommendations (Women Under Age 23)

	Current Users (%)	Completed Fertility
Reference	18.75	5.51
Public sector: price = 0	19.78	5.46
Public sector: better quality	19.45	5.47
25% less travel cost	20.17	5.45
Exposure ≥ 3	22.65	5.35
Quality + travel cost + exposure	25.42	5.24

References

Agence Nationale de la Statistique et de la Démographie. 2014. Dakar, Senegal, Agence Nationale de la Statistique et de la Démographie, "Rapport Définitif: Recensement Général de la Population et de l'Habitat, de l'Agriculture et de l'Elevage (RGPHAE 2013)".

Agence Nationale de la Statistique et de la Démographie. 2016. Dakar, Senegal, Agence Nationale de la Statistique et de la Démographie, "Sénégal: Enquête Démographique et de Santé Continue (EDS-Continue 2015)".

Akin, John S., and Jeffrey J. Rous. 1997. "Effect of Provider Characteristics on Choice of Contraceptive Provider: a Two-Equation Full-Information Maximum-Likelihood Estimation." *Demography*, 34(4): 513–523.

Ali, Mohamed M. 2001. "Quality of Care and Contraceptive Pill Discontinuation in Rural Egypt." *Journal of Biosocial Science*, 33(2): 161–172.

Amador, Diego. 2015. "The Consequences of Abortion and Contraception Policies on Young Women's Reproductive Choices, Schooling and Labor Supply." PhD diss. University of Pennsylvania.

Angeles, Gustavo, David K. Guilkey, and Thomas A. Mroz. 1998. "Purposive Program Placement and the Estimation of Family Planning Program Effects in Tanzania." *Journal of the American Statistical Association*, 93(443): 884–899.

Angeles, Gustavo, David K. Guilkey, and Thomas A. Mroz. 2005. "The Determinants of Fertility in Rural Peru: Program Effects in the Early Years of the National Family Planning Program." *Journal of Population Economics*, 18(2): 367–389.

Arcidiacono, Peter, Ahmed Khwaja, and Lijing Ouyang. 2012. "Habit Persistence and Teen Sex: Could Increased Access to Contraception Have Unintended Consequences for Teen Pregnancies?" *Journal of Business and Economic Statistics*, 30(2): 312–325.

Arends-Kuenning, Mary, and Flora L. Kessy. 2007. "The Impact of Demand Factors, Quality of Care and Access to Facilities on Contraceptive Use in Tanzania." *Journal of Biosocial Science*, 39(1): 1–26.

Attanasio, Orazio P., Costas Meghir, and Ana Santiago. 2012. "Education Choices in Mexico: Using a Structural Model and a Randomized Experiment to Evaluate PROGRESA." *The Review of Economic Studies*, 79(1): 37–66.

Bessinger, Ruth E., and Jane T. Bertrand. 2001. "Monitoring Quality of Care in Family Planning Programs: A Comparison of Observations and Client Exit Interviews." *International Family Planning Perspectives*, 27(2): 63–70.

Björkman, Martina, and Jakob Svensson. 2009. "Power to the People: Evidence from a Randomized Field Experiment on Community-Based Monitoring in Uganda." *The Quarterly Journal of Economics*, 124(2): 735–769.

Bruce, Judith. 1990. "Fundamental Elements of the Quality of Care: A Simple Framework." *Studies in Family Planning*, 21(2): 61–91.

Cleland, John, Stan Bernstein, Alex Ezeh, Anibal Faundes, Anna Glasier, and Jolene Innis. 2006. "Family planning: the unfinished agenda." *Lancet*, 368(9549): 1810–1827.

Cronin, Christopher J., David K. Guilkey, and Ilene S. Speizer. 2016*a*. "The Effects of Health Facility Access and Quality on Family Planning Decisions in Urban Senegal." SSRN Working Paper 574073.

Cronin, Christopher J., David K. Guilkey, and Ilene S. Speizer. 2016*b*. "The Individual's Choice of Facility for Maternal Health and Family Planning Services in a Dense Urban Environment: The Case of Senegal." Working Paper.

Daff, Bocar Mamadou, Cheikh Seck, Hassan Belkhayat, and Perri Suttond. 2014. "Informed push distribution of contraceptives in Senegal reduces stockouts and improves quality of family planning services." *Global Health: Science and Practice*, 2(2): 245–252.

Das, Jishnu, Alaka Holla, Veena Das, Manoj Mohanan, Diana Tabak, and Brian Chan. 2012. "In Urban And Rural India, A Standardized Patient Study Showed Low Levels Of Provider Training And Huge Quality Gaps." *Health Affairs*, 31(12): 2774–2784.

Das, Jishnu, and Jeffrey Hammer. 2014. "Quality of Primary Care in Low-Income Countries: Facts and Economics." *Annual Review of Economics*, 6(1): 525–553.

Das, Jishnu, Jeffrey Hammer, and Kenneth Leonard. 2008. "The Quality of Medical Advice in Low-Income Countries." *Journal of Economic Perspectives*, 22(2): 93–114.

de Walque, Damien, Paul J. Gertler, Sergio Bautista-Arredondo, Ada Kwan, Christel Vermeersch, Jean de Dieu Bizimana, Agnes Binagwaho, and Jeanine Condo. 2015. "Using provider performance incentives to increase HIV testing and counseling services in Rwanda." *Journal of Health Economics*, 40: 1–9.

Donabedian, Avedis. 1988. "The Quality of Care: How Can It Be Assessed?" *The Journal of the American Medical Association*, 260(12): 1743–1748.

Feyisetan, Bamikale J., and Martha Ainsworth. 1996. "Contraceptive Use and the Quality, Price, and Availability of Family Planning in Nigeria." *The World Bank Economic Review*, 10(1): 159–187.

Forsstrom, Matthew P. 2017. "Abortion Costs and Single Parenthood: A Life-Cycle Model of Fertility and Partnership Behavior." PhD diss. University of North Carolina at Chapel Hill.

Gertler, Paul, and Christel Vermeersch. 2013. "Using Performance Incentives to Improve Medical Care Productivity and Health Outcomes." National Bureau of Economic Research Working Paper 19046.

Hong, Rathavuth, Livia Montana, and Vinod Mishra. 2006. "Family planning services quality as a determinant of use of IUD in Egypt." *BMC Health Services Research*, 6(1): 79–87.

Hotz, Joseph V., and Robert A. Miller. 1988. "An Empirical Analysis Of Life Cycle Fertility And Female Labor Supply." *Econometrica*, 56(1): 91–118.

Hotz, Joseph V., and Robert A. Miller. 1993. "Conditional Choice Probabilities and the Estimation of Dynamic Models." *The Review of Economic Studies*, 60(3): 497–529.

Keane, Michael P., and Kenneth I. Wolpin. 2007. "Exploring the Usefulness of a Nonrandom Holdout Sample for Model Validation: Welfare Effects on Female Behavior." *International Economic Review*, 48(4): 1351–1378.

Keane, Michael P., and Kenneth I. Wolpin. 2010. "The Role of Labor and Marriage Markets, Preference Heterogeneity, and the Welfare System in the Life Cycle Decisions of Black, Hispanic, and White Women." *International Economic Review*, 51(3): 851–892.

Klemick, Heather, Kenneth L. Leonard, and Melkiory C. Masatu. 2009. "Defining Access to Health Care: Evidence on the Importance of Quality and Distance in Rural Tanzania." *American Journal of Agricultural Economics*, 91(2): 347–358.

Leonard, Kenneth L., and Melkiory C. Masatu. 2007. "Variations In The Quality Of Care Accessible To Rural Communities In Tanzania." *Health Affairs*, 26(3): 380–392.

Magnani, Robert J., David R. Hotchkiss, Curtis S. Florence, and Leigh Anne Shafer. 1999. "The Impact of the Family Planning Supply Environment on Contraceptive Intentions and Use in Morocco." *Studies in Family Planning*, 30(2): 120–132.

Makinen, M., H. Waters, M. Rauch, N. Almagambetova, R. Bitran, L. Gilson, D. McIntyre, S. Pannarunothai, A. L. Prieto, G. Ubilla, and S. Ram. 2000. "Inequalities in Health Care Use and Expenditures: Empirical Data from Eight Developing Countries and Countries in Transition." *The Bulletin of the World Health Organization*, 78(1): 55–65.

Mensch, Barbara, Mary Arends-Kuenning, and Anrudh Jain. 1996. "The Impact of the Quality of Family Planning Services on Contraceptive Use in Peru." *Studies in Family Planning*, 27(2): 59–75.

Shapira, Gil. 2013. "How Subjective Beliefs about HIV Infection Affect Life-Cycle Fertility." World Bank Working Paper 6343.

Shen, Junyi. 2009. "Latent Class Model Or Mixed Logit Model? A Comparison By Transport Mode Choice Data." *Applied Economics*, 41(22): 2915–2924.

Skiles, Martha Priedeman, Marc Cunningham, Andrew Inglis, Becky Wilkes, Ben Hatch, Ariella Bock, and Janine Barden-O'Fallon. 2015. "The Effect of Access to Contraceptive Services on Injectable Use and Demand for Family Planning in Malawi." *International Perspectives on Sexual and Reproductive Health*, 41(1): 20–30.

Starbird, Ellen, Maureen Norton, and Rachel Marcus. 2016. "Investing in Family Planning: Key to Achieving the Sustainable Development Goals." *Global Health: Science and Practice*, 4(2): 191–210.

Sylvia, Sean, Hao Xue, Chengchao Zhou, Yaojiang Shi, Hongmei Yi, Huan Zhou, Scott Rozelle, Madhukar Pai, and Jishnu Das. 2017. "Tuberculosis detection and the challenges of integrated care in rural China: A cross-sectional standardized patient study." *PLOS Medicine*, 14(October): 1–20.

Tarozzi, Alessandro, and Aprajit Mahajan. 2011. "Time Inconsistency, Expectations and Technology Adoption: The Case of Insecticide Treated Nets." ERID Working Paper Number 105.

Todd, Petra E., and Kenneth I. Wolpin. 2006. "Assessing the Impact of a School Subsidy Program in Mexico: Using a Social Experiment to Validate a Dynamic Behavioral Model of Child Schooling and Fertility." *American Economic Review*, 96(5): 1384–1417.

Tumlinson, Katherine, Brian W. Pence, Sian L. Curtis, Stephen W. Marshall, and Ilene S. Speizer. 2015. "Quality of Care and Contraceptive Use in Urban Kenya." *International Perspectives on Sexual and Reproductive Health*, 41(2): 69–79.

World Health Organization. 2005. Geneva, Switzerland, World Health Organization, "Report of a WHO Technical Consultation on Birth Spacing".

Yao, Jing, Alan T. Murray, and Victor Agadjanian. 2013. "A Geographical Perspective on Access to Sexual and Reproductive Health Care for Women in Rural Africa." *Social Science and Medicine*, 96: 60–68.